BRITANNICA GLOBAL GEOGRAPHY SYSTEM

Overview

BGGS Overview

BGGS is the ***Britannica Global Geography System,*** a modular electronic learning system which combines the latest pedagogical approach to geography learning with interactive multi-media materials enabling students and teachers to immerse themselves in exciting geographic investigations. BGGS is made up of the following components:

- *Geographic Inquiry into Global Issues* (GIGI) Student DataBooks
- Teacher's Guides with Overhead Transparencies in a three-ring binder
- Laminated Mini-Atlases to accompany each module
- BGGS CD-ROM with User's Manual
- 3 BGGS Videodiscs with Barcode Guides
- 3 thematic posters

This section of your Teacher's Guide will examine each component and demonstrate how the components work together to facilitate some very exciting geography learning for you and your students!

I. GIGI

Geographic Inquiry into Global Issues (GIGI) is the foundation of the BGGS. GIGI is a series of modules developed at the Center for Geographic Education at the University of Colorado at Boulder. The modules are independent of one another and can be presented in any order.

They use an inquiry approach and are organized around ten world regions:

South Asia
Southeast Asia
Japan
Former Soviet Union
East Asia
Australia/New Zealand/Pacific
North Africa/Southwest Asia
Africa-South of the Sahara
Latin America
Europe

Each GIGI module is centered around a particular question, such as "Why are people in the world hungry?" and "Is freedom of movement a basic human right?" The lead question is explored in one region of the world, then, in most modules, in a second region, before being investigated in North America.

The modules can be used in geography classes, or selected modules can be used in other courses, such as Earth Science, Global Studies, or Economics. Twelve modules constitute ample material for a full year's geography course. Each module is accompanied by sets of laminated mini-atlases which students can write on with dry-erase markers (provided by the teacher), then wipe clean to be re-used by the next class. This activity works well with cooperative groups of students.

Each module comprises a Teacher's Guide in a three-ring binder which includes Handouts and Activity masters for duplication and Overhead Transparencies; twenty-five Student DataBooks (additional Student DataBooks available) and the Mini-Atlases all packaged in a sturdy box suitable for storage when the class moves on to the next module. Since the Student DataBooks are soft-covered three-hole punched, non-consumable books, we recommend that each student have a binder to protect them. BGGS binders are available from Britannica, or you might ask each student to obtain one at the beginning of the course to keep the books in good condition for the next group of students that will use them. As the class completes a module, you can collect the Student DataBooks, place them in their storage box, and distribute the next module's DataBook to be placed in the student's binder.

GIGI print materials are organized in a unique fashion. The Teacher's Guide explains procedures to use in presenting the material found in the GIGI Student DataBook. Miniature layouts of student pages show the teacher how many pages of student material correspond with a given Teacher's Guide page. The Teacher's Guide includes Activities and Handouts to be copied and passed out to the class and Overhead Transparencies to enhance each lesson. All of a module's Activities, Handouts, and Overheads are located behind the third tab divider in each Teacher's Guide.

The teacher needs to become familiar in advance with both Teacher and Student material in order to effectively engage the class in meaningful geographic inquiries. There is a comprehensive "Memo to the Teacher from the GIGI Staff" in each Teacher's Guide which explains in detail the goals and principles behind the inquiry approach to geography learning.

The electronic components of the ***Britannica Global Geography System*** further empower students and teachers alike to engage in meaningful investigations. They are explained in detail in the following section.

II. BGGS CD-ROM

The **BGGS CD-ROM** is a resource manager and reference tool designed to help both teachers and students get maximum impact from the ***Britannica Global Geography System.*** This CD-ROM contains the text of the GIGI Student DataBooks in both Spanish and English, as well as Britannica's innovative geography reference program Geopedia™ all on a single disk. Here are some of the ways you and your class can use this software:

- When preparing to teach a module, you can access the GIGI Student DataBook on the CD to find which other elements of the BGGS are keyed to that lesson. For example, if you are teaching Lesson 3 in the Population and Resources module (What is overpopulation and how is it distributed?), accessing that lesson on the CD-ROM will reveal that there is one clip on the *Economic Development* videodisc called "Population/Wealth Correlation." With this information, you can plan when to reserve your department's videodisc player to preview the clip and show it to your class.

Furthermore, you will discover that there is one GIGI mini-atlas activity related to this lesson, five articles in the Geopedia database, ten entries in

Geopedia's World Data, five maps in the Geopedia Atlas, and five learning activities in the Geopedia BrainTeasers. You may want to assign each student or small group of students a research project using these extra resources to be done over the course of the module, or you can create a set of questions which the students must complete using the information found in Geopedia.

These activities can serve as a performance-based assessment of what students have learned in studying each module.

Since many schools have a limited number of computers with CD-ROM drives available, you may wish to devise a rotating schedule or sign-up system to ensure that each student has a chance to get at the BGGS CD-ROM. If it takes 15 class periods for a class of twenty-five students to do one module, students working in pairs can each have one turn at the computer if they schedule their time at the outset of the module. Using the CD-ROM's resource managing capability, you will have a very good sense of what resources you have at your disposal and how to make the most of them.

- All GIGI lessons are indexed by word and by key topic. If your class is studying food shortages in the Hunger module, you can key in the word hunger, and immediately learn where else in the GIGI modules this word or key topic appears. You can go directly to those occurrences in the text. You will also be directed to appropriate Geopedia references and Brain Teaser activities. Figures, Maps and Tables from GIGI print modules do not appear in the CD-ROM. However, the caption describing each of them is part of the online text.
- If Spanish is the primary language of your students, GIGI lessons can be accessed and printed out in Spanish from the BGGS CD-ROM. The BGGS Videodiscs have a Spanish soundtrack as well.

III. BGGS Videodiscs

More than ever before, today's students are visual learners. The GIGI modules explore issues and regions of the world with which many students are unfamiliar. With this in mind, we have produced three videodiscs, one to correspond to each of three major strands we have identified in GIGI: *Earth's Environment and Society; Economic Development;* and *Global Political and Cultural Change.*

These videodiscs, with English and Spanish soundtracks, can take you and your class to the parts of the world you are investigating with the wave of a barcode wand. Your class will hear how Amazon native peoples feel about the exploitation of the tropical rain forests where they live, witness the eruption of a volcano, and see first-hand the environmental disasters human beings have brought about.

The Barcode Guide which accompanies each disc enables you to access with a light pen or barcode reader, segments which pertain to the lesson being investigated. The Guide includes barcodes in both English and Spanish. Teachers can use the segments to enrich lessons, and students can make use of segments to enhance a report or group presentation.

There is a full-color poster to accompany each videodisc cluster which engages the students by asking "How do these images connect to you?" The posters can provide a colorful springboard for classroom discussion.

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BRITANNICA GLOBAL GEOGRAPHY SYSTEM

GIGI

Geographic Inquiry into Global Issues

Environmental Pollution

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TEACHER'S GUIDE

Regional Case Study
Former Soviet Union

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ISBN 0-7826-0976-7

This material is based upon work supported by the National Science Foundation under Grant No. ESI 9050204. The Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors, and do not necessarily reflect the views of the National Science Foundation.

Contents

Memo to the Teacher from the GIGI Staff

You have in your hands the GIGI Teacher's Guide. Teaching with GIGI is a departure from teaching with a conventional textbook. By taking the time to study this memo—about 30 minutes—you will gain a good understanding of the kind of teaching that's needed to be successful with GIGI. We hope you have a rewarding and enjoyable experience!

Goals

The three major goals of *Geographic Inquiry into Global Issues* (GIGI) are to help you teach your students the following:

1. Responsible citizenship
2. Geographic knowledge, skills, and perspectives
3. Critical and reflective thinking

We believe you can accomplish these goals as well as others by teaching real-world issues. GIGI presents these issues with an inquiry approach, using the information, concepts, skills, and perspectives of geography.

GIGI and the Britannica Global Geography System

GIGI offers you two instructional modules for each of ten world regions (Figure 1 on pages vi and vii). There is no necessary sequence of modules; each one is independent, so you can use them in any order you wish or put together smaller clusters of modules to fit your needs. A leading question frames the issue of each module, and student inquiry proceeds through a sequence of lessons, each of which requires one or more daily periods of class time.

Color photographs at the beginning and end of each Student DataBook graphically illustrate the topic under inquiry.

Modules typically begin with a broad introduction to the global issue. Then, a major case study of three to four lessons examines the issue in a real place within the selected world region. Students also explore, usually in a single lesson, a comparative case study in a *different* region, which gives a variant of the issue and a sense of its global nature. Modules also bring the students "back home" to focus on the issue as it may appear in the United States or Canada. We do this because although North America is not one of the 10 GIGI

regions, frequent comparisons to North America throughout each module achieve additional instruction on this "home region."

Each GIGI module requires from two to three weeks of teaching time (10 to 15 class periods of 50 minutes) and contains a Student DataBook, Teacher's Guide, and Mini-Atlas. These GIGI print materials are at the heart of the Britannica Global Geography System (BGGS), which extends and enhances the inquiry approach to real-world issues with a CD-ROM and three videodiscs.

The BGGS CD-ROM puts the text of the GIGI Student DataBooks on line in both English and Spanish, then enables both teacher and students to search the text by lesson, key topic, or word to find the resources in the system that will enhance each. Geopedia™, Britannica's multimedia geography program, is provided in the CD-ROM for follow-up research. It features an atlas with more than 1,000 new maps, an encyclopedia with more than 1,200 geography-related articles, statistical information on every country from Britannica World Data Annual, a chartmaker for creating charts and graphs, a selection of video clips exploring cities and regions, and an electronic notepad allowing teachers and students to clip and edit text right on the screen.

Three videodiscs, designed to electronically transport students to the regions of the world where GIGI case studies are focused, are another part of the BGGS. The discs emphasize three major strands of the GIGI investigations: *Earth's Environment and Society, Economic Development,* and *Global Political and Cultural Change.* Each videodisc has two soundtracks, English and Spanish, and is accompanied by a Barcode Guide that enables teachers and students to access the segments that accompany the GIGI lesson with a wave of the barcode reader. A poster accompanies each videodisc to reinforce the connnections between your students and the issue being studied.

A full explanation of the Britannica Global Geography System components and how they work together is located in the BGGS overview in the front section of this Teacher's Guide.

Geographic Inquiry into Global Issues (GIGI)

Issues, Leading Questions, and Case Study Locations

South Asia	**Population and Resources**	**Religious Conflict***
	How does population growth affect resource availability?	*Where do religious differences contribute to conflict?*
	Bangladesh	Kashmir
	(Haiti)	(Northern Ireland)
Southeast Asia	**Sustainable Agriculture**	**Human Rights**
	How can the world achieve sustainable agriculture?	*How is freedom of movement a basic human right?*
	Malaysia	Cambodia
	(Cameroon, Western United States)	(Cuba, United States)
Japan	**Global Economy***	**Natural Hazards**
	How does trade shape the global economy?	*Why do the effects of natural hazards vary from place to place?*
	Japan	Japan
	(Colombia, United States)	(Bangladesh, United States)
Former Soviet Union	**Diversity and Nationalism***	**Environmental Pollution**
	How do nations cope with cultural diversity?	*What are the effects of severe environmental pollution?*
	Commonwealth of Independent States	Aral Sea
	(Brazil, United States)	(Madagascar, United States)
East Asia	**Population Growth***	**Political Change**
	How is population growth to be managed?	*How does political change affect peoples and places?*
	China	Hong Kong
	(United States)	(South Korea, Taiwan, Singapore, Canada)

* Under development

Figure 1 Matrix showing GIGI modules. Geographic issues are in bold and leading questions are in italics. Major case study locations are followed by comparison examples in parentheses.

Geographic Inquiry into Global Issues (GIGI)

Issues, Leading Questions, and Case Study Locations

Australia/ New Zealand/ Pacific	**Global Climate Change** *What could happen if global warming occurs?* Australia and New Zealand (Developing Countries, U.S. Gulf Coast)	**Interdependence*** *What are the causes and effects of global interdependence?* Australia (Falkland Islands, United States)
North Africa/ Southwest Asia	**Oil and Society*** *How have oil riches changed nations?* Saudi Arabia (Venezuela, Alaska)	**Hunger** *Why are people hungry?* Sudan (India, Canada)
Africa—south of the Sahara	**Building New Nations*** *How are nation-states built?* Nigeria (South Africa, Canada)	**Infant and Child Mortality** *Why do so many children suffer from poor health?* Central Africa (United States)
Latin America	**Urban Growth** *What are the causes and effects of rapid urbanization and urban growth?* Mexico (United States)	**Development** *How does development affect peoples and places?* Amazonia (Eastern Europe, U.S. Tennessee Valley)
Europe	**Regional Integration*** *What are the advantages of and barriers to regional integration?* Europe (United States, Mexico, Canada)	**Waste Management** *Why is waste management both a local and global concern?* Western Europe (Japan, United States)

* Under development

Figure 1 (continued)

The **Student DataBook** contains the following features:

- Memo to the Student from the GIGI Staff
- An overview of the key questions and places explored in the module
- Lesson objectives
- Data presented in a variety of forms, including text, maps, graphs, tables, photographs, and cartoons
- Questions
- Glossary
- References

Students are not expected to learn the GIGI curriculum through the Student DataBook alone. Rather, they derive meaning from the DataBook when you use the Teacher's Guide to work through the curriculum with them. You may want to explain this process to students. Point out that you will be directing them to carry out various activities that are not specified in their text but are important in the sequence of learning.

Prior to teaching the first lesson, be sure students read the "Memo to the Student from the GIGI Staff" and the two-page overview, which gives the module's objectives in question form. Point out the Glossary and encourage its use as you work through the module, noting that glossary words are listed at the beginning of each lesson. So that students will know what they are expected to learn, they need to read carefully and understand the objectives listed at the beginning of each lesson.

This **Teacher's Guide** contains the following sections:

- Preparing to Teach This Module, a synopsis of the module's leading question, themes, and activities
- Module Objectives
- Number of Days Required to Teach the Module
- Suggestions for Teacher Reading
- Extension Activities and Resources

Most lessons include the following sections:

- Time Required
- Materials Needed
- Glossary Words
- Getting Started (suggested anticipatory sets)
- Procedures (for group and individual work)
- Modifications for older or younger students (in a different type face, printed in color)
- Questions and Answers (shown in tinted boxes)
- For Further Inquiry (suggestions for extensions and/or assessments)

- Masters of Overhead Transparencies and Activity masters and keys (located at the back of the Teacher's Guide)

Each module has its own accompanying **Mini-Atlas,** which provides four-color maps designed especially for use with that module. The Teacher's Guide explains how to use these maps. No additional atlases are required to teach the module, but large wall maps are highly recommended for your classroom. In addition to the maps in the Mini-Atlas, you will find numerous maps in the Student DataBook.

Intended Grade Levels

We believe GIGI enables you to probe global issues in various degrees of depth. This allows for the modules' use both over several grade levels (7–12) and over varying lengths of time at a grade level. The Teacher's Guides suggest alternatives for modifying instruction for different grade levels where appropriate. The reading level varies within each module: The Student DataBooks are approximately at grade 9 level, but some extracts from other sources are more challenging. These extracts are important because they show students that many people have contributed to the data, but younger students may need more time and help to understand them. The Teacher's Guides also include extension activities and resources that can maximize the grade-level flexibility of each module. Using the visuals included in the BGGS videodiscs and the activities built into the CD-ROM, you can further tailor instruction to your students. Obviously, you will determine whether particular lessons suit your students' abilities. When a range of required teaching time is given for a module, for example, 10 to 12 days, the greater amount of time should be planned for younger students. If you believe a lesson might be too difficult for your students, eliminate or simplify it. Rarely will the elimination of a lesson render a module ineffective. On the other hand, try to utilize the suggested extensions if the lesson does not adequately challenge your students.

Issues-Based Geographic Inquiry

In order to foster active learning and higher-level thinking, GIGI stresses issues-based geographic inquiry. Inquiry is essentially the method of science and of good detective work: It poses questions and proposes answers about the real world and it tests its answers with real data. Students do this with GIGI. Because this approach may be different from what students are familiar with, you may wish to pre-

pare them by describing the process and its connection to the real world. Also, their reading and discussion of the "Memo to the Student from the GIGI Staff" will help them understand the inquiry approach. GIGI is based on Frances Slater's inquiry activity planning model (1993). To reach GIGI's goals, your students study specific global issues by pursuing answers to geographic questions (Figure 2). They answer these questions by analyzing and evaluating data, using geographic methods and skills. This "doing geography" approach leads to significant outcomes in knowledge, skills, and perspectives. The progression from questions to generalizations "is crucial as a structure for activity planning and as a strategy for developing meaning and understanding. Meaning and understanding define the process of tying little factual knots of information into bigger general knots so that geography begins to make sense, not as a heap of isolated facts but as a network of *ideas and procedures*" (Slater 1993, page 60).

In truly free inquiry, students work independently, but with GIGI posing questions and providing data, you and your students explore the issues together. This approach supports and encourages your students in learning geography.

By using issues-based inquiry, you promote the development of a critical perspective in your students. They learn the habits of critical and reflective thinking. Multiple and opposing positions are inherent

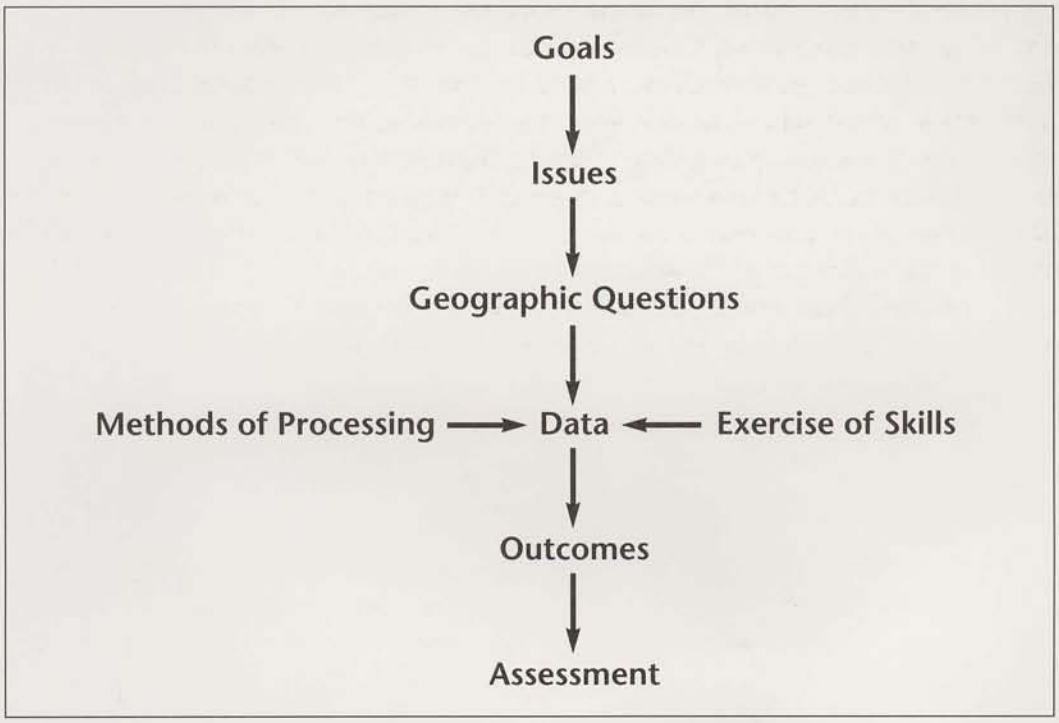

Figure 2 GIGI's model for issues-based geographic inquiry (after Slater 1993).

in these issues. Facts can be used to support different points of view. This is the context in which the habits of the critical perspective can develop, and *interpretation* is the key activity. With GIGI you foster these habits and abilities as you help your students interpret data guided by hypotheses, propositions, arguments, or questions.

An essential element of data-based, issues-oriented inquiry is to challenge your students by giving them opportunities to

- raise new questions,
- question the quality of the data,
- seek more useful or current data,
- articulate relationships they perceive,
- explain their processes of investigation, and
- defend their positions, decisions, and solutions.

Why These Issues Were Chosen

In planning GIGI, we sought timeless issues that are truly global in scope and that are of special concern to geographers. In this way, GIGI fosters what the National Geography Standards calls "the geographically informed person" needed by modern global citizenry (Geography Education Standards Project 1994).

The major case study, chosen to give solid grounding to the issue, is focused on a region where the issue is clearly expressed. The secondary case studies, based in other regions including the United States and Canada, show the *global* scope of the issue.

It is important to stress that, although GIGI contains a wide selection of case studies in all major regions (Figure 1) as well as frequent references to the global distribution of many geographic phenomena, GIGI is not a traditional regional geography. It does not attempt to provide basic geographic information for each region, such as one finds in traditional regional geography textbooks. In teaching a GIGI module, it is important to keep the emphasis on the issue and not get distracted with extraneous regional information.

Role of Questions

Each GIGI module is divided into six to eight lessons, each titled by a question; subquestions head individual sections of the lessons. Questions guide inquiry in order to merge the process of investigation with the drawing of conclusions. Directly linking questions and answers helps achieve an intellectually satisfying understanding of a problem (Slater 1993). When students are asked to learn only conclusions without learning how they are drawn, we perpetuate the tradition of an answer-centered education bereft of higher-level thinking. Therefore, it is important that students understand they are not

always expected to answer the questions when they first appear, but rather to keep them in mind as guides when they are reading or discussing.

GIGI asks both convergent and divergent questions, trying to reach a balance between the two. Supplement the questions in GIGI by asking your students many more of the types of questions suggested by Slater (1993). These are questions that encourage

- recall,
- classification and ordering,
- the use of data to draw conclusions,
- awareness of the limitations of data or of evaluation of data, and
- awareness of the processes of reasoning used.

According to the National Geography Standards, the "geographically informed person applies a comprehensive spatial view of the world to life situations" (Geography Education Standards Project 1994). In order to foster such a view of the world, GIGI asks *geographic* questions that ask where things are and why. By asking such geographic questions and by having students learn to ask them, you will reinforce GIGI's approach. A good question to begin with is: Where is this issue located? Then proceed to questions such as the following:

- Why does it take place there?
- How and why does this issue affect the people in this place?
- In what other places do people confront this issue?
- How and why are these places related?
- What alternatives do people have to improve their situation, and which alternatives do you recommend?

Fundamental Themes of Geography

In recent years, many geography teachers have learned that the five "fundamental themes" (Joint Committee on Geographic Education 1984) help them ask geographic questions. The theme of **Location** asks where things are and why things are located where they are. **Place** is the theme that inquires into human and physical characteristics of locations. **Human-Environment Interaction** examines how and why humans both adapt to and modify their environments as well as the consequences of these actions. **Movement** investigates not only how and why places are connected but also what is the significance of those interactions. The theme of **Region** seeks to identify and explain similarities and differences among areas and how and why these form and change. An extended explanation of the themes and their concepts, interrelationships, and applications is

given in Hill and McCormick (1989). The themes are useful because they encourage the kinds of questions required to help students develop the geographic perspective.

Importance of Local Examples

GIGI is a world geography, but it shows that issues work at various geographic scales—personal, local, regional, national, and global. Because it is sometimes difficult for younger students to identify with faraway places, success with GIGI in part depends upon the ability of both you and your students to relate the issues to examples in your local community. We strongly recommend that you refer in class to local examples of the issue being investigated. Just as important, we encourage you to have your students conduct local field studies related to this issue whenever possible. Issues having important geographic dimensions abound in every community (see the Extension Activities and Resources section at the end of this Teacher's Guide for examples). Peak educational experiences often come when students see things in the field that relate to their classroom studies. We discuss other reasons for local involvement in the next section.

Familiar people can be as important as familiar places in motivating students. The quality of personal engagement is at the crux of successful instruction. Using the BGGS videodisc segments that accompany most GIGI lessons is a powerful way to help your students find relevance by identifying the GIGI issues with real people. Similarly, you can connect GIGI issues to everyday life at a human scale, especially at the students' own age levels, by using current newspaper accounts or magazines that address the student's perspective.

As you gain familiarity with teaching local examples, as you develop field exercises for your students, and as you learn how to put a human face on these materials, you will begin to customize the GIGI modules to fit your particular environment. Our trial teachers reported that the more they taught GIGI modules, the more comfortable they became in adapting them to fit their needs.

Fostering Optimistic and Constructive Perspectives

The seriousness and complexity of the global issues studied in GIGI can overwhelm students unless you take care to foster optimistic and constructive perspectives toward issues. "Gloom and doom" needs to be balanced with examples of success and prospects for positive change. It is important to help your students develop a

sense of personal efficacy, an attitude that their actions can make a difference in solving global problems. The maxim, "Think Globally, Act Locally," speaks to the need to help students organize and conduct constructive actions that address local variants of the issues they are studying. As we noted earlier, student involvement in local projects enriches their educational experience. There is also good evidence that it actually produces an optimistic feeling—that their actions *can* make a difference—to help them deal with the often difficult and sometimes depressing world issues. GIGI modules often include lessons and activities to show possibilities for positive action.

Certain perspectives foster student optimism and constructive behavior. Geography students, especially, should learn to respect other peoples and lands, and they should come to cherish environmental unity and natural diversity. They should also learn to be skeptical about simplistic explanations, such as the theory that attempts to explain human characteristics and actions in terms of the physical environment alone, which geographers call "environmental determinism." Most important, optimistic and constructive perspectives accompany the development of empathy, tolerance, and open-mindedness. These traits are fostered by avoiding sexist and racist language, discouraging ethnocentricity, and challenging stereotypes, simplistic solutions, and basic assumptions.

References to Data

Unlike most textbooks, GIGI attributes its sources of data with in-text citations and full reference lists, which is another way of encouraging the critical perspective. In the Student DataBook, material that has been extracted from original sources is indented and printed in a different typeface. Long extracts are highlighted with background color. Use of these sources helps your students learn that real people construct ideas and data and that their concepts and information are not immutable. Instead, they often change through the critiques and interpretations of various people. By using these scholarly conventions, we intend to encourage your students to appreciate the tentativeness of knowledge and to value scholarship and academic integrity.

Updating

Real data quickly become obsolete. GIGI addresses this fact by discussing historical trends of data and by stressing concepts. You should reinforce this bias for concepts and also freely acknowledge the datedness of information by explaining why it is still used (for example, the lags between research and writing and publication and

use; the lack of more recent data). Whenever possible, guide students to update materials. Britannica's Geopedia, on the BGGS CD-ROM, contains data based on Encyclopædia Britannica's World Data Annual, which is also available in print form. Have students use these sources to supplement and update GIGI data.

Assessing Learning

Evaluation of student achievements with GIGI can be focused on two broad areas. The first is the developing ability of students to undertake geographic inquiry. The second is the acquisition of knowledge and perspectives about the module issue.

The ability of students to undertake inquiry in geography can be related to the primary questions that guide geographical study. They are noted earlier in this memo. As students work through the module, they are likely to become increasingly adept at asking and answering geographic questions. Seek to extend your students' competence in several clusters of skills that facilitate geographic inquiry. These clusters include the following:

- Identifying problems and issues. This may be done through observation, asking questions, brainstorming, reading, and in other ways.
- Inquiring into the problems and issues in many ways such as through map reading and interpretation, making surveys, and using results of surveys done by others.
- Making decisions and taking action, for example, through reviewing alternatives, establishing priorities and criteria, and communicating cooperatively with people in other ways.
- Reflecting at all stages of the process of inquiry, especially through careful consideration of diverse sources of evidence.

Students will acquire knowledge of the module issue as they make their inquiries. This knowledge can be tested and graded. Assessments may be based on the following:

- Knowledge and skills shown by work on Activities included in this Teacher's Guide and on questions in the Student DataBook.
- Observations of student participation in groups and in class discussions.

Specific assessment ideas are given at the end of some lessons in the section called For Further Inquiry. In addition, the Teacher's Guide ends with Extension Activities and Resources. Some of these extension activities can serve as authentic assessments.

Potential Uses

In addition to the flexibility offered by the free-standing nature of the modules, GIGI has a number of other characteristics that encourage widespread use. Modules can be extended and enhanced with the BGGS CD-ROM, videodiscs, and posters. Because GIGI's issues-based approach integrates several topics (for example, population, economic, political, physical, and cultural geography) in a single module, the modules are not conducive to using an approach in which topics are taught separately. On the other hand, GIGI may be used with a world regional approach because there are modules for each of 10 world regions. A year-long world geography or global studies course will have more than enough material by using 12 modules. Five to seven modules may constitute a one-semester, issues-based geography course covering several regions. You can define clusters of modules for your own curricular purposes. We have identified three clusters for interdisciplinary studies within the Britannica Global Geography System, each comprising six or seven GIGI modules. They are *Earth's Environment and Society, Economic Development,* and *Global Political and Cultural Change.* BGGS includes a videodisc and poster for each cluster. These strand packages could well be used in Social and Environmental Studies, Earth Science, Global Studies, and Area Studies classes. Activities in the modules also support math, language arts, and arts curricula.

GIGI encourages and facilitates the development of a variety of geographic skills that transfer widely into the natural and social sciences. Among these are skills of asking geographic questions and developing and testing geographic generalizations. These require other GIGI skills including examining and making a variety of maps; analyzing photographs; constructing and interpreting graphs and tables of spatial data; and collecting, interpreting, and presenting geographic information.

Finally, GIGI promotes a wide variety of linguistic, numeric, oral, creative, and social skills as well as geographic skills. In particular, GIGI emphasizes cooperative learning. We believe that one of the great strengths of the GIGI modules is that they give students practice in both group and individual problem solving. As students become more familiar with the global issues, they learn that finding solutions to world problems requires people to work together cooperatively.

References

Geography Education Standards Project. 1994. *Geography for Life: The National Geography Standards.* Washington, DC: Geography Education Standards Project.

Hill, A. David, and McCormick, Regina. 1989. *Geography: A Resource Book for Secondary Schools.* Santa Barbara, CA: ABC-Clio, Inc.

Joint Committee on Geographic Education. 1984. *Guidelines for Geographic Education: Elementary and Secondary Schools.* Washington, DC: Association of American Geographers and National Council for Geographic Education.

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Preparing to Teach This Module

Environmental Pollution

What are the effects of severe environmental pollution?

Pollution of the global environment is a major issue in our society. This module investigates this issue by looking at three case studies. The primary focus is on the environmental catastrophe caused by human activities in the Aral Sea basin, in Central Asia. Prior to that case study, students are introduced to the issue with a brief look at the effects of water diversion on Mono Lake, California. Comparison is also made to the degradation of the rain forests on Madagascar. The module builds awareness of these problems and concludes by asking students to make recommendations for future environmental planning worldwide.

With respect to the five fundamental themes of geography, this module focuses on how the interaction between humans and their environment alters the physical and social characteristics of places. In cases of environmental pollution, such changes are by definition negative. As a result, the information presented in this module can sometimes be rather depressing. In order not to leave students feeling pessimistic and hopeless about the future, activities have also been included that foster optimism about what can be done to reduce environmental pollution.

In Lesson 1, students begin an activity that can be run continuously throughout the module. Students conduct a survey of school or community opinion about a local pollution problem. This survey, modeled after one done by citizens concerned about Mono Lake, California, gives students a chance to gather original data and become involved in a local environmental issue of concern to them. These are valuable citizenship skills and should help give the remainder of the module more meaning.

Lesson 2 introduces the Aral Sea environmental disaster, describing the Aral's physical situation and making comparisons to bodies of water more familiar to students. Lesson 3 asks why the Aral Sea is

shrinking; students link the demands for increased agricultural production to increased irrigation and the removal of the lake's water source. In Lesson 4, the disaster is explained in detail, with readings about the effects on air, water, and soil pollution. The lesson also covers the human dimension of the problem—the economic and health problems associated with the pollution. The next lesson asks what can be done to resolve the Aral crisis. The conflict between local and central government control of resources provides the backdrop for discussion. In Lesson 6, students look at and design political statements that reflect their opinions about what has occurred in the Aral region. Lesson 7 provides the comparison to Madagascar, focusing on both why that island once had such high biodiversity and why deforestation has destroyed that diversity. Lesson 8 closes the module by having the class draft an Environmental Bill of Rights, to set guidelines by which such severe environmental pollution cannot recur.

It is assumed that students involved with these activities will have some fundamental geographic skills. Map reading and the use of an atlas are particularly important. Many of the lessons are structured around small cooperative learning groups. Depending on the students' skills, it may be necessary to modify lessons to accommodate individual classes.

Using the BGGS CD-ROM can simplify lesson planning by making it easy to access the resources the system provides for each lesson. It shows exactly which Geopedia™ data and learning activities can be used in long-range and short-term assignments, and which videodisc clips will provide visual reinforcement for each GIGI lesson. The CD-ROM can also show you ways in which a lesson in one module relates to a lesson in another module. And it indicates where to find every reference in GIGI, Geopedia™, the Mini-Atlas maps, and the videodiscs to any key topic—for example, "tsunami" or "Bangladesh." The students will also be able to use the BGGS CD-ROM for further research and short-term or long-term range assignments. The BGGS multimedia components and their uses are explained fully in the tabbed BGGS section in the front of this Teacher's Guide.

The following are general modifications recommended for younger students:

- Plan for fifteen days because the activities will require more teacher explanation and support.
- Provide directions for homework assignments and monitor students' understanding and progress.
- Prior to assigning written activities requiring students to draw conclusions and summarize their findings, ask guiding questions and develop a sample outline on the chalkboard.

Module Objectives

- Explain how intensive human changes to water systems can dramatically alter the physical characteristics of a place.
- Describe how human alterations of physical environments have had planned and unplanned consequences.
- Recognize the connection between the quality of human life and the quality of the physical environment.
- Be aware that individuals and groups in a society can express their environmental values and effect political change.
- Prepare and/or analyze tables, graphs, maps, and remote-sensing images containing information about environmental change.
- Develop and test hypotheses concerning the causes and consequences of environmental change.

Number of Days Required to Teach *Environmental Pollution*

Thirteen to fourteen 50-minute class periods

Suggestions for Teacher Reading

Kotlyakov, V. M. 1991. "The Aral Sea basin: a critical environment zone." *Environment,* 33(1): 4–9, 36–39.

Micklin, Philip. 1988. "Desiccation of the Aral Sea: a water management disaster in the Soviet Union." *Science,* 241: 1170–1176.

Ellis, William. 1990. "A Soviet sea lies dying." *National Geographic,* 177(2): 73–93.

Lesson 1

How have people influenced the fate of Mono Lake?

Time Required

One 50-minute class period. The survey project recommended in this lesson lasts several days; it is suggested that this activity be run in conjunction with the remainder of the lessons in the module.

Materials Needed

Copies of Activity 1 for all students

Glossary Words

ecosystem

environment

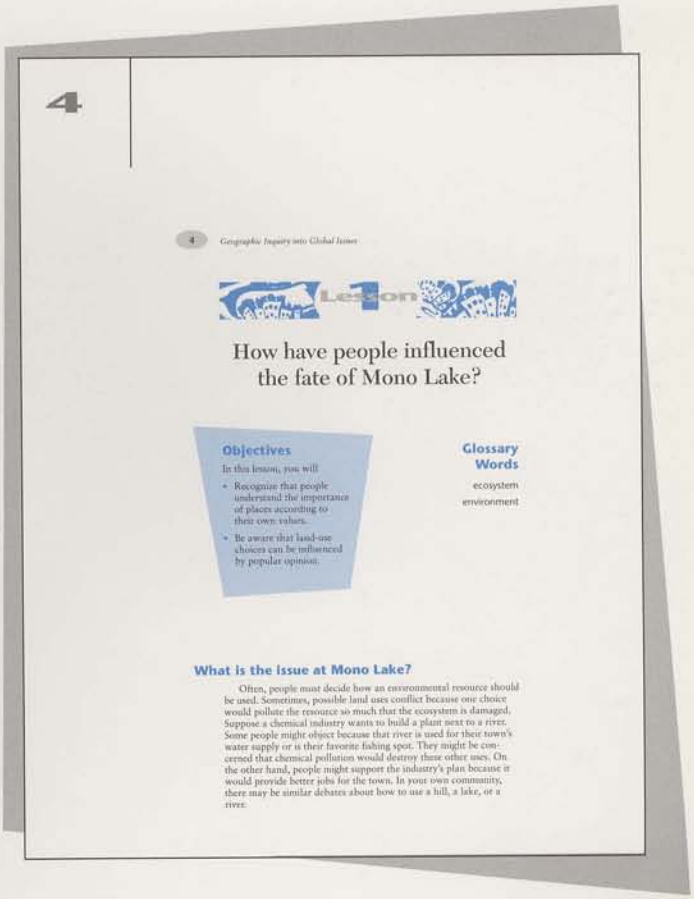
Getting Started

- Have students read the Memo to the Student and the overview on pages 2–3 in the Student DataBook prior to beginning the module. Also make sure students are aware that there is a Glossary in the back of their DataBooks.
- This lesson explores how people's perspectives can influence environmental debates. Ask students what they think the worst or most significant environmental problem is in their own community. Have students consider how they would go about finding out what other people think about this local controversy. Explain that they will see how Californians used a public-opinion survey to marshal support to save one lake's environment.

Procedures

What is the issue at Mono Lake? (pages 4–9)

A. Have students study Figure 1 (page 5). Tell them that the drawing, from a cover of a public-opinion survey, depicts an environmental controversy in California. Have students describe what the issue appears to be and speculate why it is controversial. The figure caption poses questions about the intent of the survey designers: What side of the issue is the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4 Geographic Inquiry into Global Issues

Lesson 1

How have people influenced the fate of Mono Lake?

Objectives

In this lesson, you will

- Recognize that people understand the importance of places according to their own values.
- Be aware that land-use choices can be influenced by popular opinion.

Glossary Words

ecosystem

environment

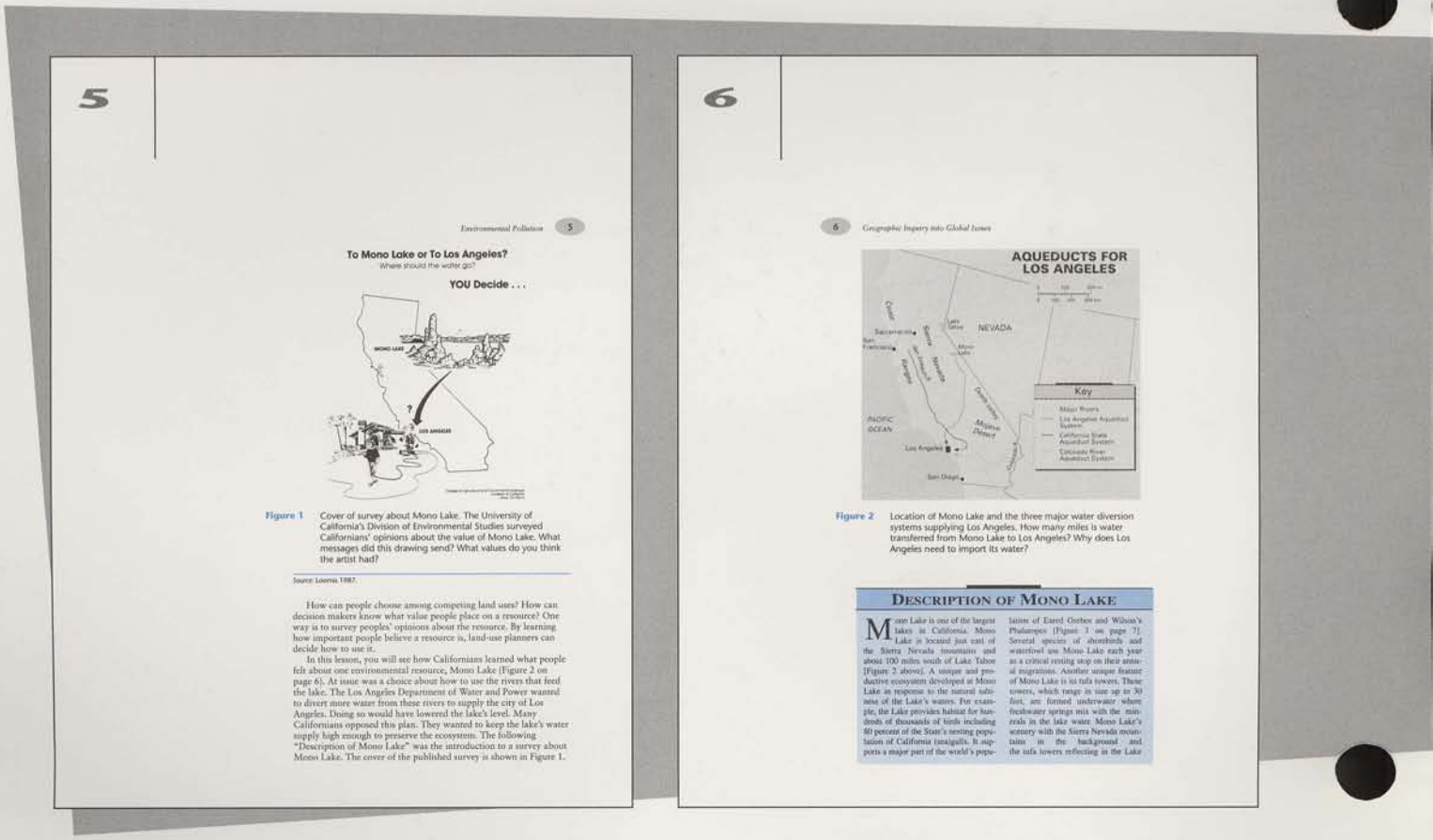
What is the issue at Mono Lake?

Often, people must decide how an environmental resource should be used. Sometimes, possible land uses conflict because one choice would pollute the resource so much that the ecosystem is damaged. Suppose a chemical industry wants to build a plant next to a river. Some people might object because that river is used for their town's water supply or is their favorite fishing spot. They might be concerned that chemical pollution would destroy these other uses. On the other hand, people might support the industry's plan because it would provide better jobs for the town. In your own community, there may be similar debates about how to use a hill, a lake, or a river.

artist on? [The survey concerns a plan to divert water from a lake in Northern California to a large city in Southern California for urban uses, such as watering gardens. The controversy arose because if the lake water was diverted to the city, the lake would shrink. This would cause major damage to the lake's ecosystem. The political position of the artist is debatable, but it seems he or she is contrasting the aesthetic value of natural scenery with the aesthetic value of suburban gardens.]

B. Choose students to read the text aloud, up to and including the extract, "Description of Mono Lake" (pages 6–7). Figure 2 on page 6 may be used if your students are unfamiliar with California geography. If you wish, have students use the map scale to estimate the distance of the Mono Lake diversion along the Los Angeles Aqueduct. Ask why Los Angeles must import its water. Figure 3 on page 7 simply illustrates how diverse the bird life is and hints at the dramatic scenery of Mono Lake, also showing what its unique tufa towers look like. [Mono Lake is approximately 300 miles from Los Angeles. Los Angeles imports its water because it lies in a semiarid region (note the proximity of the Mojave Desert), with inadequate fresh water to supply its metropolitan population of over 13 million. Students may note that all major rivers in California, except the Colorado, flow toward the northern half of the state, accounting for the three major diversion projects shown, which bring water to the southern population centers.]

C. With the class, go over Figure 4 on page 8, which describes three alternatives for diversion. Note that the present level of diversion by the Los Angeles Department of Water and Power (LADWP) will result in Alternative 3, if this diversion level is maintained. Reducing diversions somewhat leads to the lake levels described for Alternative 2, which would leave the lake at about its 1982 level, its historic low, but still above the level of Alternative 3. Alternative 1 represents a rollback in the diversions to enable the lake to be restored to pre-1982 levels. Alternative 2 is a compromise position between the diversion levels advocated by LADWP and those advocated by environmental groups, who support Alternative 1.



5

Environmental Pollution 5

To Mono Lake or To Los Angeles?
Where should the water go?

YOU Decide . . .

Figure 1 Cover of survey about Mono Lake. The University of California's Division of Environmental Studies surveyed Californians' opinions about the value of Mono Lake. What messages did this drawing send? What values do you think the artist had?

Source: Loomis 1987.

How can people choose among competing land uses? How can decision makers know what value people place on a resource? One way is to survey peoples' opinions about the resource. By learning how important people believe a resource is, land-use planners can decide how to use it.

In this lesson, you will see how Californians learned what people felt about one environmental resource, Mono Lake (Figure 2 on page 6). At issue was a choice about how to use the rivers that feed the lake. The Los Angeles Department of Water and Power wanted to divert more water from these rivers to supply the city of Los Angeles. Doing so would have lowered the lake's level. Many Californians opposed this plan. They wanted to keep the lake's water supply high enough to preserve the ecosystem. The following "Description of Mono Lake" was the introduction to a survey about Mono Lake. The cover of the published survey is shown in Figure 1.

6

6 *Geographic Inquiry into Global Issues*

AQUEDUCTS FOR LOS ANGELES

Figure 2 Location of Mono Lake and the three major water diversion systems supplying Los Angeles. How many miles is water transferred from Mono Lake to Los Angeles? Why does Los Angeles need to import its water?

Description of Mono Lake

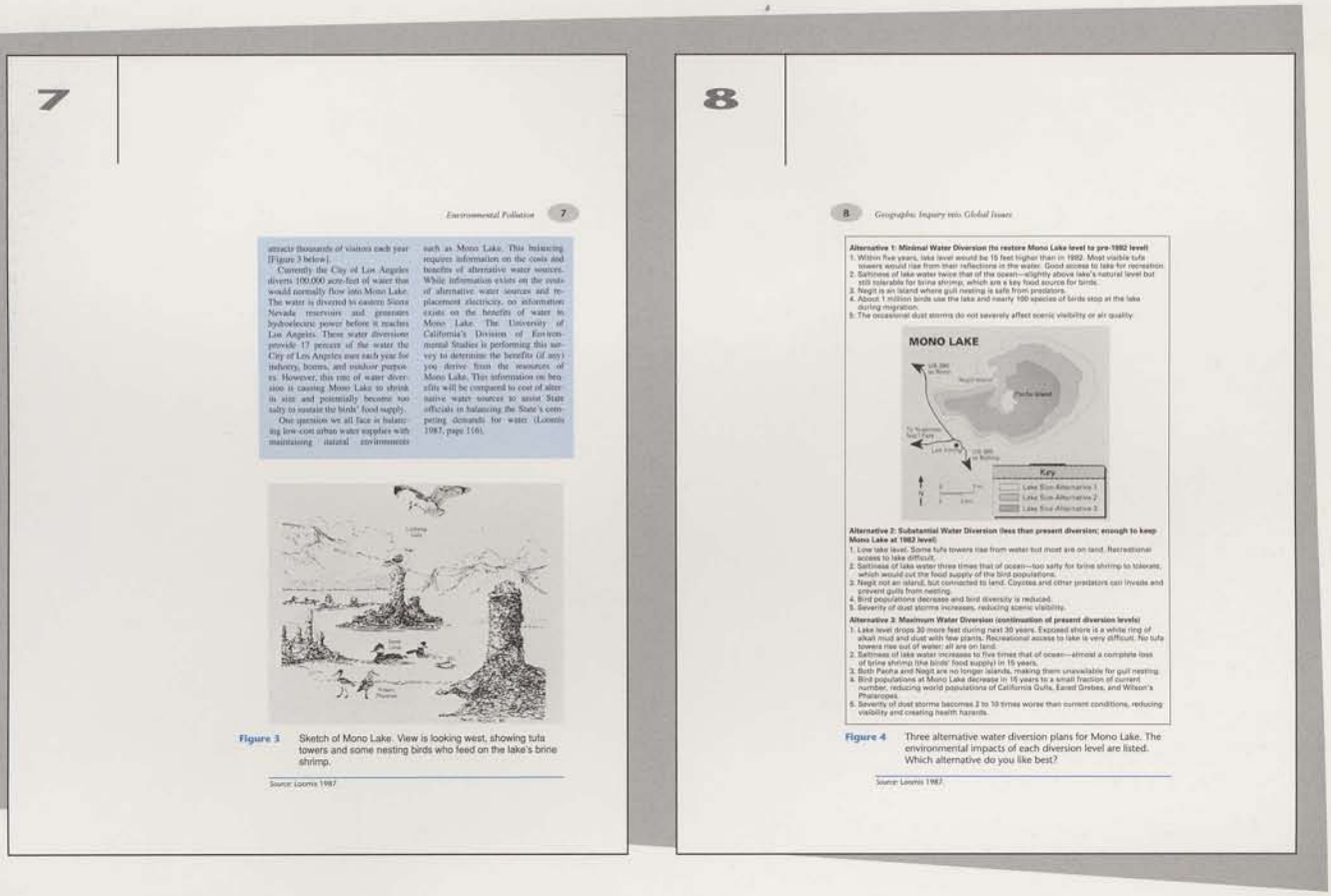
Mono Lake is one of the largest lakes in California. Mono Lake is located just east of the Sierra Nevada mountains and about 100 miles south of Lake Tahoe [Figure 2 above]. A unique and productive ecosystem developed at Mono Lake in response to the natural salinese of the Lake's waters. For example, the Lake provides habitat for hundreds of thousands of birds including 80 percent of the State's nesting population of California (seagulls. It supports a major part of the world's population of Eared Grebes and Wilson's Phalaropes [Figure 3 on page 7]. Several species of shorebirds and waterfowl use Mono Lake each year as a critical resting stop on their annual migrations. Another unique feature of Mono Lake is its tufa towers. These towers, which range in size up to 30 feet, are formed underwater where freshwater springs mix with the minerals in the lake water. Mono Lake's scenery with the Sierra Nevada mountains in the background and the tufa towers reflecting in the Lake

Most of the consequences detailed in the three alternatives relate to the fact that as the lake's water level shrinks, the salinity (salt concentration) of the water increases. Explain this if necessary, using a glass of water with salt to illustrate. Ask the class what happens if the water evaporates—students should see that the remaining water would be saltier. Emphasize the relationship between salinity and bird populations. The birds depend on the lake's brine shrimp for food, but the brine shrimp are adapted to a narrow range of saltiness. They thrive in the lake's naturally saline waters (about twice as salty as the ocean) but cannot survive the saltier waters of Alternatives 2 and 3. The islands in the middle of Mono Lake are also important. When the lake levels become so low that the islands are connected to the mainland, this enables predators to reach critical bird nesting grounds. This occurred in 1982.

D. Next, have the students work independently to complete **Activity 1.** Have students help collect and compile the results as they complete the survey. Keep a running total of the data on the board.

E. Lead discussion to clarify these results with respect to the opinions being expressed. Each question in the survey could be reviewed orally. For example, it may be instructive to see how the familiarity with a place (Question 1) relates to the attitudes toward its preservation (Questions 2 and 3). Have students identify which of the three alternatives they chose in Question 3 and explain why they picked it. What trade-offs does each choice imply? The questions in the bulleted list on page 9 may help focus this idea of trade-offs. For example, people in Los Angeles would have to conserve water or pay more for it if their supply is reduced by minimizing Mono Lake's diversions. Discuss how the perspectives of individuals within our society are important components in planning how environmental resources are treated.

Important: Because most students are probably unfamiliar with Mono Lake, their responses may be less personal. You may wish to substitute a local, more familiar issue for Mono Lake and have the class respond to the survey thinking about that place instead of Mono Lake. Any issue involving a trade-off



7

Environmental Pollution 7

attracts thousands of visitors each year (Figure 3 below).

Currently the City of Los Angeles diverts 100,000 acre-feet of water that would normally flow into Mono Lake. The water is diverted to eastern Sierra Nevada reservoirs and generates hydroelectric power before it reaches Los Angeles. These water diversions provide 17 percent of the water the City of Los Angeles uses each year for industry, homes, and outdoor purposes. However, this rate of water diversion is causing Mono Lake to shrink in size and potentially become too salty to sustain the birds' food supply.

One question we all face is balancing low-cost urban water supplies with maintaining natural environments such as Mono Lake. This balancing requires information on the costs and benefits of alternative water sources. While information exists on the costs of alternative water sources and replacement electricity, no information exists on the benefits of water in Mono Lake. The University of California's Division of Environmental Studies is performing this survey to determine the benefits (if any) you derive from the resources of Mono Lake. This information on benefits will be compared to cost of alternative water sources to assist State officials in balancing the State's competing demands for water. (Loomis 1987, page 116).

Figure 3 Sketch of Mono Lake. View is looking west, showing tufa towers and some nesting birds who feed on the lake's brine shrimp.

Source: Loomis 1987

8

8 *Geography: Inquiry into Global Issues*

Alternative 1: Minimal Water Diversion (to restore Mono Lake level to pre-1982 level)
1. Within five years, lake level would be 15 feet higher than in 1992. Most visible tufa towers would rise from their reflections in the water. Good access to lake for recreation.
2. Saltiness of lake water twice that of the ocean—slightly above lake's natural level but still tolerable for brine shrimp, which are a key food source for birds.
3. Negit is an island where gull nesting is safe from predators.
4. About 1 million birds use the lake and nearly 100 species of birds stop at the lake during migration.
5. The occasional dust storms do not severely affect scenic visibility or air quality.

Alternative 2: Substantial Water Diversion (less than present diversion; enough to keep Mono Lake at 1982 level)
1. Low lake level. Some tufa towers rise from water but most are on land. Recreational access to lake difficult.
2. Saltiness of lake water three times that of ocean—too salty for brine shrimp to tolerate, which would cut the food supply of the bird populations.
3. Negit not an island, but connected to land. Coyotes and other predators can invade and prevent gulls from nesting.
4. Bird populations decrease and bird diversity is reduced.
5. Severity of dust storms increases, reducing scenic visibility.

Alternative 3: Maximum Water Diversion (continuation of present diversion levels)
1. Lake level drops 30 more feet during next 35 years. Exposed shore is a white ring of alkali mud and dust with few plants. Recreational access to lake is very difficult. No tufa towers rise out of water; all are on land.
2. Saltiness of lake water increases to five times that of ocean—almost a complete loss of brine shrimp (the birds' food supply) in 15 years.
3. Both Paoha and Negit are no longer islands, making them unavailable for gull nesting.
4. Bird populations at Mono Lake decrease in 15 years to a small fraction of current number, reducing world populations of California Gulls, Eared Grebes, and Wilson's Phalaropes.
5. Severity of dust storms becomes 2 to 10 times worse than current conditions, reducing visibility and creating health hazards.

Figure 4 Three alternative water diversion plans for Mono Lake. The environmental impacts of each diversion level are listed. Which alternative do you like best?

Source: Loomis 1987

between economic convenience and environmental conservation would be usable. Another possibility to connect these themes to your locality is to structure the discussion around the environmental impacts involved in your own community's use of water. Where does your town's water come from? Are there other uses for that water source? What trade-offs are involved?

F. Close the lesson with a class project in which students make a public-opinion survey on a local environmental issue. Ask students if there is any local environmentally unique area threatened by human activity and worthy of protection. Brainstorm a list of possible places; write these on the chalkboard. Lead discussion of why these resources are worthy of environmental concern. Why is the resource being threatened? Must an area be environmentally unique in order to protect it? Or should all environments be worthy of some kind of protection? Continue emphasizing the concept of trade-offs.

At this point you should decide whether to have students initiate their own survey project. Although it is not integral to the module, it is strongly recommended that students do this opinion survey. Besides giving the class practical experience in designing a survey and interpreting its results, having the class focus on local environmental issues should help attract their interest to the subsequent case studies explored in the module.

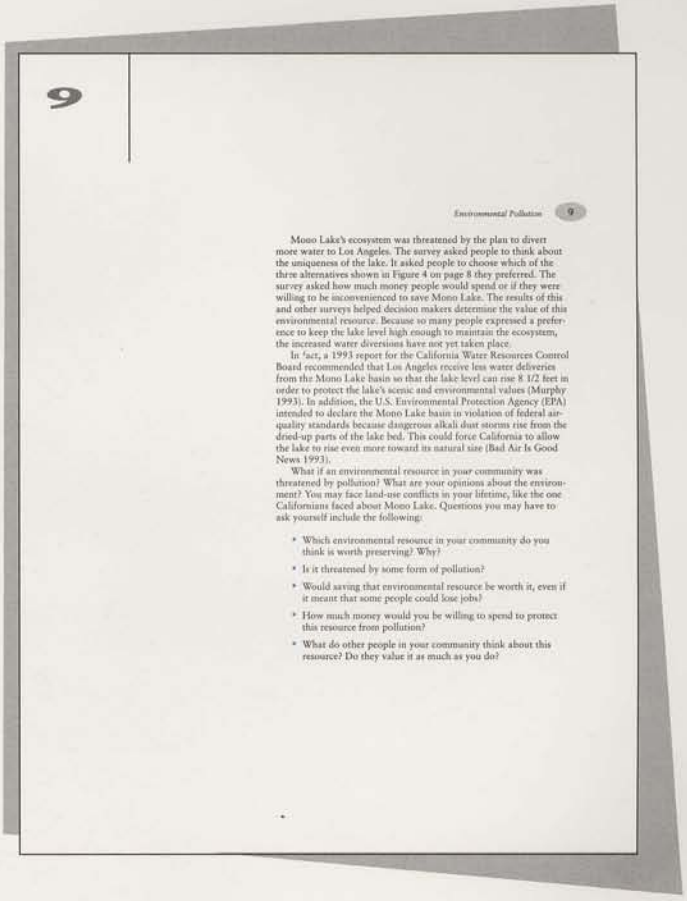
G. The project could proceed along lines similar to the Mono Lake survey, in which students conduct a poll of community or school opinions about the locally threatened environmental resource. Have students vote to select one environmental issue for the entire class to investigate.

Divide the class into working groups. Below is a list of some of the kinds of work groups that could be formed:

- *Background Information Group*—Collects the basic information about the issue.
- *Survey Development Group*—Writes the survey to poll local residents.
- *Survey Administration Group*—Polls the target audience (other students, local citizens, etc.) and compiles the survey results.
- *Maps, Graphs, and Tables Group*—Prepares maps, graphs, and tables of the area in question to summarize important information in an easy-to-read form.
- *Photography and Art Group*—Takes pictures of the area as a form of record keeping and for illustration and prepares all presentation materials.
- *Presentation Group*—Meets with local businesses, church groups, or citizen groups to present the environmental issue and survey results as well as learn these groups' positions, if any.

Working in groups, students will gather information and data to conduct the survey. This process could take several days to complete and could require homework time to collect all the needed resources. While the survey is being prepared, the other groups should be similarly engaged to provide information. Class time during the following two to three weeks can be split between the lessons in this module and time for students to work on this project.

When the survey design is complete, the students conduct the survey. It should be determined beforehand what the target areas for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Environmental Pollution 9

Mono Lake's ecosystem was threatened by the plan to divert more water to Los Angeles. The survey asked people to think about the uniqueness of the lake. It asked people to choose which of the three alternatives shown in Figure 4 on page 8 they preferred. The survey asked how much money people would spend or if they were willing to be inconvenienced to save Mono Lake. The results of this and other surveys helped decision makers determine the value of this environmental resource. Because so many people expressed a preference to keep the lake level high enough to maintain the ecosystem, the increased water diversions have not yet taken place.

In fact, a 1993 report for the California Water Resources Control Board recommended that Los Angeles receive less water deliveries from the Mono Lake basin so that the lake level can rise 8 1/2 feet in order to protect the lake's scenic and environmental values (Murphy 1993). In addition, the U.S. Environmental Protection Agency (EPA) intended to declare the Mono Lake basin in violation of federal air-quality standards because dangerous alkali dust storms rise from the dried-up parts of the lake bed. This could force California to allow the lake to rise even more toward its natural size (Bad Air Is Good News 1993).

What if an environmental resource in your community was threatened by pollution? What are your opinions about the environment? You may face land-use conflicts in your lifetime, like the one Californians faced about Mono Lake. Questions you may have to ask yourself include the following:

- Which environmental resource in your community do you think is worth preserving? Why?
- Is it threatened by some form of pollution?
- Would saving that environmental resource be worth it, even if it meant that some people could lose jobs?
- How much money would you be willing to spend to protect this resource from pollution?
- What do other people in your community think about this resource? Do they value it as much as you do?

polling are. For example, students may want to poll only people in the area, or they may want to poll only other students. Students should record and classify the information as it is collected.

In the final phase of this project, students should be asked to reflect on their original commitment to the project. Is their commitment to the issue more, less, or about the same? How have their perspectives changed, having taken part in a project of this kind? Have the results of the survey project been unexpected?

Use as many outside resource people or speakers as possible to give students the stimulation and information needed to stay involved with the project. Also, allow students school time to visit resources not in the school and provide them with the materials (or the funds to get materials) needed for the project.

Assign students to keep a journal record of the project. Students should be expected to write about ideas, impressions, successes, and failures and use the journal as a detailed record of their involvement. Alternatively, arrange to have the students report on the project to an appropriate public group, for example, the Town Planning Commission, City Council, or School Board.

Lesson 2

How is the Aral Sea changing?

Time Required

Two to three 50-minute class periods

Materials Needed

Tracing paper
Butcher paper
Marking pens or colored pencils
Transparency of Overhead 1
Mini-Atlas maps 1, 2, 3, and 4

Glossary Words

environment	remote sensing
exotic river	salinization
interior drainage	watershed

Getting Started

- This major case study deals with environmental problems in what was Soviet Central Asia. Some of these problems arose from the way planning decisions were made in the Soviet Union. It may be helpful to review the nature of the political change from the Soviet Union to the Commonwealth of Independent States. Use **Mini-Atlas map 1** to locate the Aral Sea within the former Soviet Union.
- Have students examine Figures 5 and 6 on pages 12–13. Without explaining what these photographs are, ask students to identify what kind of feature the figures show. [Students may identify a body of water with islands and a lakeshore. The Aral is called a sea, but emphasize that it is really a lake, for it has no outlet to the ocean. Ask students what characteristics distinguish a body of water as a sea. This may help emphasize the point that it is composed of salt water. Also be sure students are able to locate the Aral Sea on Mini-Atlas map 1.]
- Ask the class which picture was taken first and have students observe and describe the differences between the two photos. Make it clear to students that both images show exactly the same total area, that the scale is the same. North is at the top in both. [Figure 5 was taken in 1977; Figure 6 in 1987. The lake is noticeably smaller in 1987, especially in the extreme south and north; the islands are also much larger in 1987. Be sure students grasp the meaning of the increase in island size. See that they realize this means the lake itself must be getting smaller. Inform the class that they will be studying the causes and effects of these changes in detail.]

Procedures

What is the Aral Sea environmental disaster? (pages 10–14)

A. Having established that the Aral Sea has undergone dramatic changes, read the short paragraphs defining remote sensing. To help with discussion of the three questions following these paragraphs, pass out a sheet of tracing paper to each student. This tracing activity should be completed individually. Give the following instructions to the class:

   a. Using a pencil and tracing paper, trace an outline of the 1987 Aral Sea shoreline and islands from Figure 6. Be sure to mark the position of the two Xs, which will be used to align the outline in the next step.

b. Using the *same* piece of tracing paper, trace the outline of the 1977 Aral Sea shoreline and islands from Figure 5—*around* the first outline. Match the relative positions of the two outlines by aligning the two Xs.

c. Use two different colored pencils to show how the lake has shrunk. Use one color to fill in the lake area as it was in 1987, and use a different color to show the additional area that was present in 1977.

d. Add a title and legend, including the season and the year of each photo, and an arrow to show where north is (at the top of the page in both images). [Project **Overhead 1** for a sample of what a completed version looks like.]

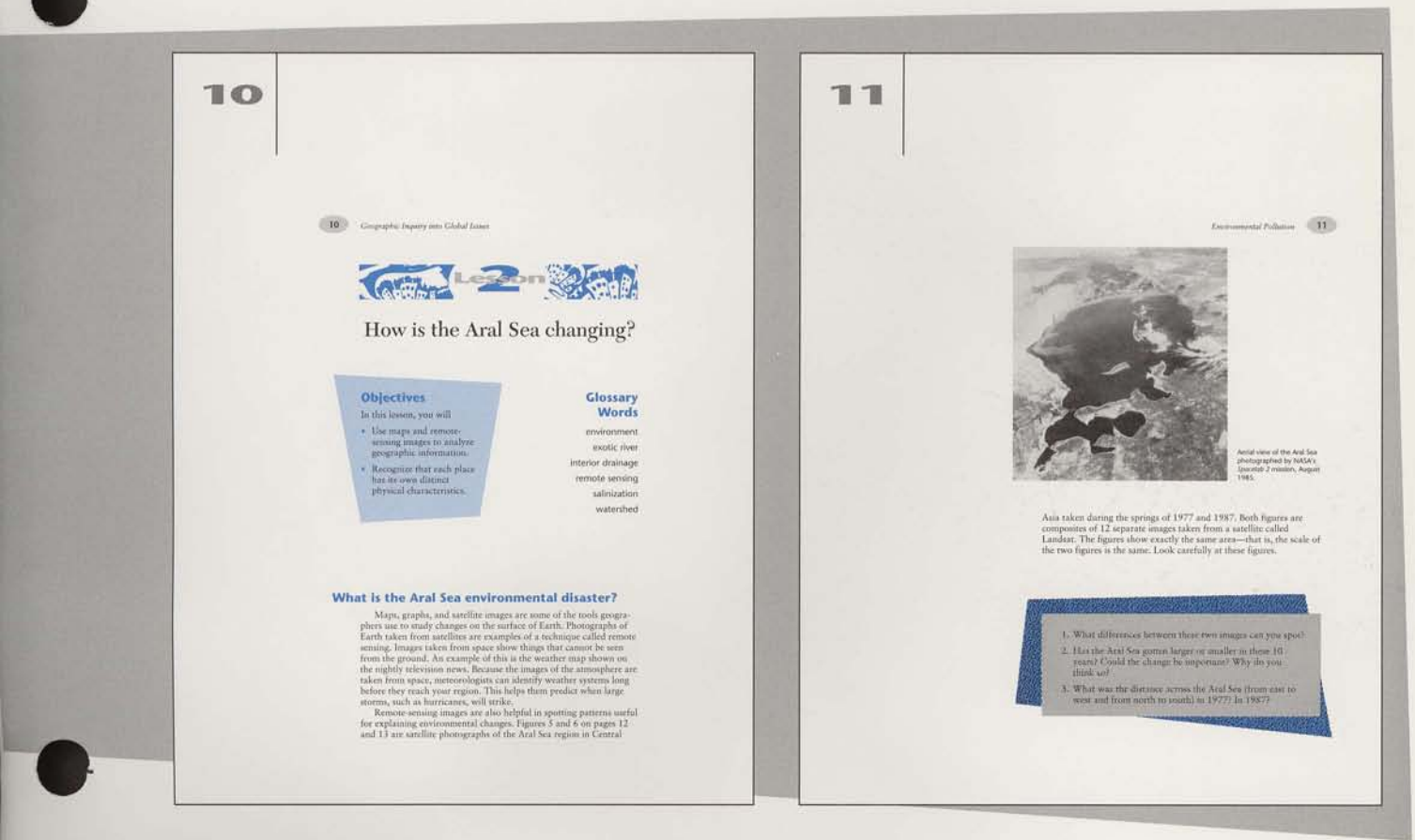
B. Ask what the maps students made in Procedure A show. [The shrinkage of the lake and exposure of the former lake bed] Have the class generate a list of the visible changes in the Aral Sea from 1977 to 1987. Have students explain which source, the photos or the tracing, provides the most information. Discuss Questions 1–3 on page 11.

Younger students may need a full period to complete their tracings. If so, the tracings can be used as a way to start the following day's lesson. Have the students speculate what their tracings show before they answer the questions.

C. Next, have a student read aloud the passage by Perera on page 14. This sets the tone for the module, describing the extent of the environmental pollution. Ask students to speculate about what might be causing the Aral Sea to shrink.

What is the Aral Sea region like? (pages 14–16)

D. It is important that students have a clear understanding of the area's physical geography to use as a frame of reference while working with the module. Break the class into pairs or small groups. Distribute **Mini-Atlas maps 1, 2, 3,** and **4** to each group. Have students read the text on pages 14–15. Refer to Figure 7 on page 15, which is a location reference map of the region. Each group should work to answer Questions 4–9 on page 16.



10

10 Geographic Inquiry into Global Issues

Lesson 2

How is the Aral Sea changing?

Objectives

In this lesson, you will

- Use maps and remote-sensing images to analyze geographic information.
- Recognize that each place has its own distinct physical characteristics.

Glossary Words

environment
exotic river
interior drainage
remote sensing
salinization
watershed

What is the Aral Sea environmental disaster?

Maps, graphs, and satellite images are some of the tools geographers use to study changes on the surface of Earth. Photographs of Earth taken from satellites are examples of a technique called remote sensing. Images taken from space show things that cannot be seen from the ground. An example of this is the weather map shown on the nightly television news. Because the images of the atmosphere are taken from space, meteorologists can identify weather systems long before they reach your region. This helps them predict when large storms, such as hurricanes, will strike.

Remote-sensing images are also helpful in spotting patterns useful for explaining environmental changes. Figures 5 and 6 on pages 12 and 13 are satellite photographs of the Aral Sea region in Central

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Environmental Pollution 11

Aerial view of the Aral Sea photographed by NASA's *Spacelab 2* mission, August 1985.

Asia taken during the springs of 1977 and 1987. Both figures are composites of 12 separate images taken from a satellite called Landsat. The figures show exactly the same area—that is, the scale of the two figures is the same. Look carefully at these figures.

1. What differences between these two images can you spot?
2. Has the Aral Sea gotten larger or smaller in these 10 years? Could the change be important? Why do you think so?
3. What was the distance across the Aral Sea (from east to west and from north to south) in 1977? In 1987?

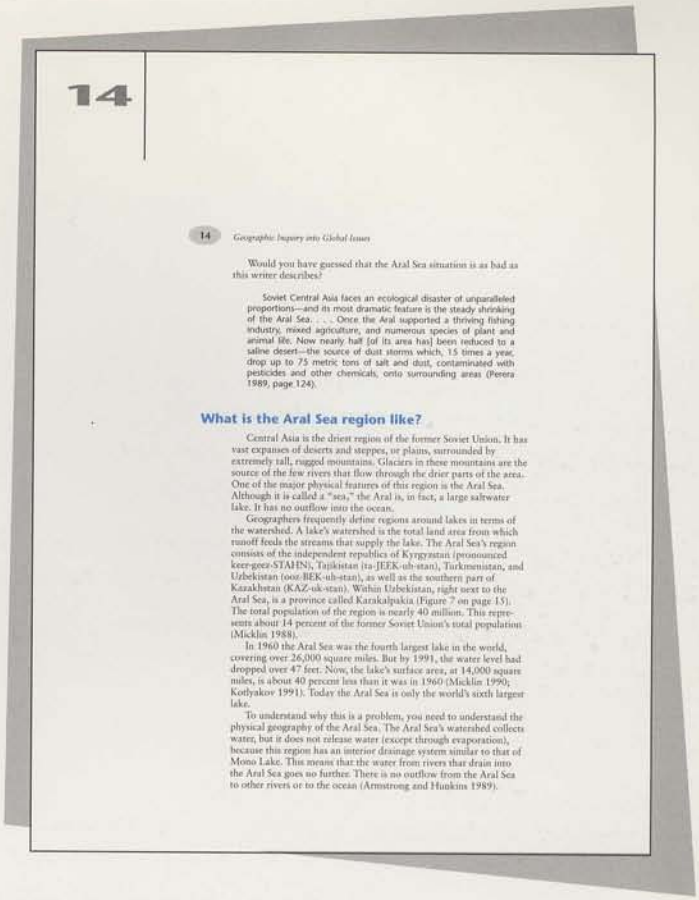
Questions and Answers for page 11

1. What differences between these two images can you spot?
   - Students should see that the eastern, northern, and southern portions of the sea are the most affected. The western shoreline has changed little.

2. Has the Aral Sea gotten larger or smaller in these 10 years? Could the change be important? Why do you think so?
   - The sea has gotten smaller. Some environmental changes that students should spot include the exposure of large parts of the former seabed and the enlargement of the islands. These changes are visible on the photos, but tracing dramatizes the changes. Encourage students to speculate on whether the change is important and why they think so.

3. What was the distance across the Aral Sea (from east to west and from north to south) in 1977? In 1987?
   - The approximate dimensions (from the scale on the figures) are N–S: 260 miles (in 1977) and 230 miles (1987); and W–E: 160 miles (1977) and 140 miles (1987).

E. Conclude the lesson by telling students that in the next lesson they will learn more about the Aral Sea. Save all of the speculations from Question 9; they can be used to introduce Lesson 3.



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Would you have guessed that the Aral Sea situation is as bad as this writer describes?

> Soviet Central Asia faces an ecological disaster of unparalleled proportions—and its most dramatic feature is the steady shrinking of the Aral Sea. . . . Once the Aral supported a thriving fishing industry, mixed agriculture, and numerous species of plant and animal life. Now nearly half [of its area has] been reduced to a saline desert—the source of dust storms which, 15 times a year, drop up to 75 metric tons of salt and dust, contaminated with pesticides and other chemicals, onto surrounding areas (Perera 1989, page 124).

What is the Aral Sea region like?

Central Asia is the driest region of the former Soviet Union. It has vast expanses of deserts and steppes, or plains, surrounded by extremely tall, rugged mountains. Glaciers in these mountains are the source of the few rivers that flow through the drier parts of the area. One of the major physical features of this region is the Aral Sea. Although it is called a "sea," the Aral is, in fact, a large saltwater lake. It has no outflow into the ocean.

Geographers frequently define regions around lakes in terms of the watershed. A lake's watershed is the total land area from which runoff feeds the streams that supply the lake. The Aral Sea's region consists of the independent republics of Kyrgyzstan (pronounced keer-geez-STAHN), Tajikistan (ta-JEEK-uh-stan), Turkmenistan, and Uzbekistan (ooz-BEK-uh-stan), as well as the southern part of Kazakhstan (KAZ-uk-stan). Within Uzbekistan, right next to the Aral Sea, is a province called Karakalpakia (Figure 7 on page 15). The total population of the region is nearly 40 million. This represents about 14 percent of the former Soviet Union's total population (Micklin 1988).

In 1960 the Aral Sea was the fourth largest lake in the world, covering over 26,000 square miles. But by 1991, the water level had dropped over 47 feet. Now, the lake's surface area, at 14,000 square miles, is about 40 percent less than it was in 1960 (Micklin 1990; Kotlyakov 1991). Today the Aral Sea is only the world's sixth largest lake.

To understand why this is a problem, you need to understand the physical geography of the Aral Sea. The Aral Sea's watershed collects water, but it does not release water (except through evaporation), because this region has an interior drainage system similar to that of Mono Lake. This means that the water from rivers that drain into the Aral Sea goes no further. There is no outflow from the Aral Sea to other rivers or to the ocean (Armstrong and Hunkins 1989).

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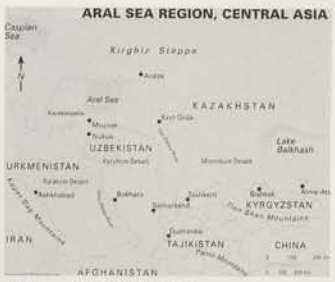

Figure 7 Aral Sea region in Central Asia.

Interior drainage systems are not uncommon—the Great Basin of the United States (covering parts of six states in the West, mainly Nevada and Utah) also has interior drainage.

Historically, about 90 percent of the water going into the Aral Sea came from two rivers: the Amu Dar'ya and the Syr Dar'ya (Figure 7). The remainder came directly from the atmosphere as precipitation (Kotlyakov 1991). In the lake's natural state, water lost through evaporation equaled the amount of water contributed by precipitation and by the two rivers (Micklin 1988). The Aral Sea's water level was maintained by this balance.

However, recent human activities have upset this balance, leading to environmental pollution. The Aral Sea is vital to the environmental and economic stability of the region. For example, the Aral Sea was once known for its commercial fishing industry. But since 1960 the fishing industry has been destroyed by the falling water level and chemical pollution from agricultural runoff. The water quality of the Aral has declined so much that it can no longer support most forms of life (Brown 1991).

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4. The Aral Sea region covers about 626,000 square miles. Describe an area of the United States that is about this same size.
5. What are the names of the mountain ranges that are the sources for the Amu Dar'ya and Syr Dar'ya rivers? Approximately how high are these mountains?
6. The Amu Dar'ya and Syr Dar'ya rivers are called exotic rivers because they flow mainly through desert regions but their water sources are in snowfields in high mountains. Find two other major rivers in the world that are exotic rivers.
7. How are the exotic rivers you identified in Question 6 different from the rivers of the Aral Sea region? How are they similar?
8. What major lake in the United States is similar to the Aral Sea in that it has no outflow and is in a region of interior drainage? Is it a freshwater lake?
9. What human activities do you suspect are causing the Aral Sea to shrink? Why do you think so?

Questions and Answers for page 16

4. The Aral Sea region covers about 626,000 square miles. Describe an area of the United States that is about this same size.

   - Have students use the map scale on Figure 7 to calculate the approximate size of the region (width and length in miles). Then groups can use the Mini-Atlas map of the continental United States to measure off a similar distance using that map's scale. The Aral region is about the same size as the states of California, Nevada, Utah, Colorado, Arizona, and New Mexico combined. Other regions of the United States could also be used for appropriate comparison. (Skip this question if is too advanced for younger students.)

5. What are the names of the mountain ranges that are the sources for the Amu Dar'ya and the Syr Dar'ya rivers? Approximately how high are these mountains?

   - Using the Mini-Atlas maps, students can identify the ranges as the Tien Shan and the Pamirs, with elevations well above 10,000 ft (3,050 m); the highest peaks are near 25,000 ft.

6. The Amu Dar'ya and the Syr Dar'ya rivers are called exotic rivers because they flow mainly through desert regions but their water sources are in snowfields in high mountains. Find two other major rivers in the world that are exotic rivers.

   - Using the Mini-Atlas world climate map and world physical map, students can find other large rivers that flow through dry climates but begin in the highlands. The best known examples are the Nile, Indus, and Colorado rivers.

7. How are the exotic rivers you identified in Question 6 different from the rivers of the Aral Sea region? How are they similar?

   - The major difference students ought to note is that the Amu and Syr Dar'ya rivers are part of the interior drainage system of the Aral basin. The Nile, Colorado, and Indus all flow into oceans. (Be sure students don't get hung up on terminology: The Nile flows into the Mediterranean *Sea,* the Indus into the Arabian *Sea,* and the Colorado into the *Gulf* of California. All these bodies of water, however, are arms of an ocean.)

8. What major lake in the United States is similar to the Aral Sea in that it has no outflow and is in a region of interior drainage? Is it a freshwater lake?

   - Students should use the Mini-Atlas U.S. map. Many lakes in the southwestern United States qualify; the best analog to the large, saline Aral Sea is the Great Salt Lake, Utah.

9. What human activities do you suspect are causing the Aral Sea to shrink? Why do you think so?

   - Groups can discuss this and make some guesses why the Aral Sea is shrinking. As each group finishes, it should select a recorder to write its speculations on the chalkboard or on butcher paper hung around the room.

Lesson 3

Why is the Aral Sea shrinking?

Time Required

One 50-minute class period

Materials Needed

Copies of Activity 2 for all students

Glossary Words

central government

environment

salinization

Getting Started

- Have students examine Figure 8 on page 18. Ask students to describe the spatial pattern of the shrinkage. Have the class determine why this is the shrinkage pattern. [The eastern and southern shores are receding more than west and north.]

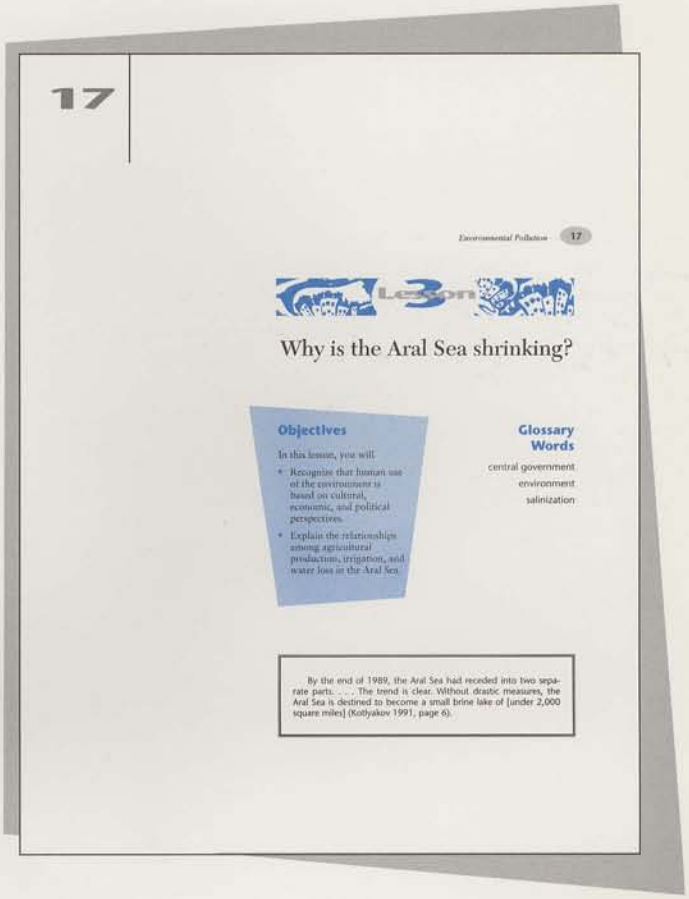
  Older students should see that the water in these areas must be shallower, since loss of water exposes land quicker. Advanced students may realize that these areas are shallower because that is where Amu Dar'ya and Syr Dar'ya rivers come in, depositing sediment. For younger students, simply mention that the lake is shallower in east and south, which is why it is receding faster.

- Also, have the class review their speculations from Lesson 2 about what is causing the Aral Sea to shrink. List these on the chalkboard.

Procedures

A. Ask a student to read aloud the short quote from Kotlyakov in the box on page 17. The text that follows mentions that the water loss is caused by "irrigation and cotton." Figure 9 on page 19 shows where the irrigation has been.

Ask students to generate some hypotheses about the relationships among irrigation, cotton, and the shrinking of the Aral Sea. Help them by giving structure to the hypothesis. For example, "As irrigation increases, the Aral Sea's level (decreases/increases)," or "As cotton production increases, the Aral Sea's level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Lesson 3

Why is the Aral Sea shrinking?

Objectives

In this lesson, you will:

- Recognize that human use of the environment is based on cultural, economic, and political perspectives.
- Explain the relationships among agricultural production, irrigation, and water loss in the Aral Sea.

Glossary Words

central government
environment
salinization

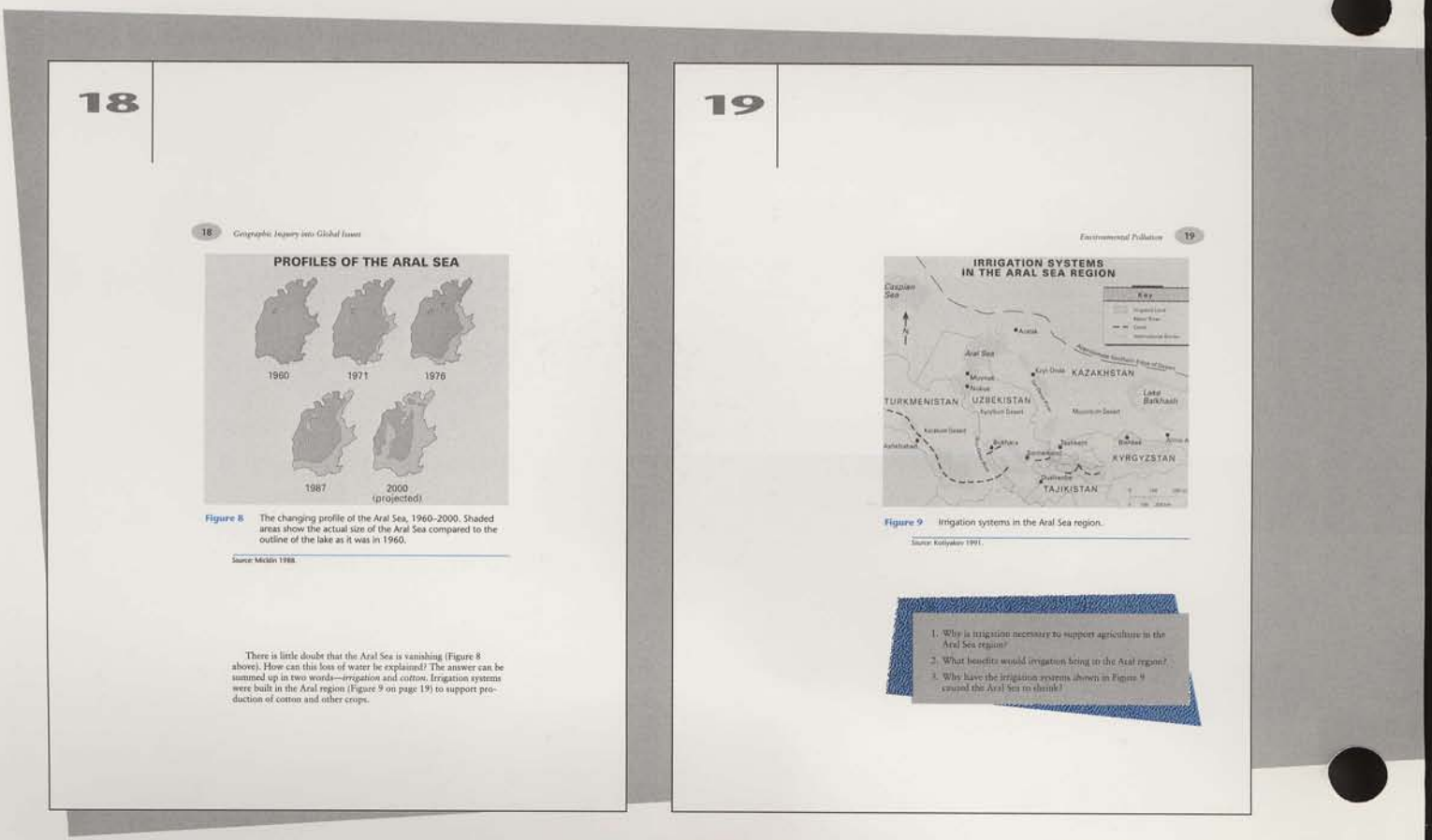
By the end of 1989, the Aral Sea had receded into two separate parts. . . . The trend is clear. Without drastic measures, the Aral Sea is destined to become a small brine lake of [under 2,000 square miles] (Kotlyakov 1991, page 6).

Questions and Answers for page 19

1. Why is irrigation necessary to support agriculture in the Aral Sea region?
   - Irrigation is needed because the region is mainly desert (refer to Figures 7 and 9). Desert soils are often fertile (that is, are rich in plant nutrients), but cannot support agriculture without having extra water.

2. What benefits would irrigation bring to the Aral region?
   - Students might note that irrigation could increase agricultural production and so bring money to the region. This rationale emerges in this lesson.

3. Why have the irrigation systems shown in Figure 9 caused the Aral Sea to shrink?
   - This question is designed for speculation; the answer will emerge later in the lesson.



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PROFILES OF THE ARAL SEA

1960 1971 1976 1987 2000 (projected)

Figure 8 The changing profile of the Aral Sea, 1960–2000. Shaded areas show the actual size of the Aral Sea compared to the outline of the lake as it was in 1960.

Source: Micklin 1988.

There is little doubt that the Aral Sea is vanishing (Figure 8 above). How can this loss of water be explained? The answer can be summed up in two words—*irrigation* and *cotton*. Irrigation systems were built in the Aral region (Figure 9 on page 19) to support production of cotton and other crops.

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IRRIGATION SYSTEMS IN THE ARAL SEA REGION

Caspian Sea
Aral Sea
Aktobe
Kzyl-Orda
KAZAKHSTAN
Lake Balkhash
TURKMENISTAN
UZBEKISTAN
Kyzylkum Desert
Muyunkum Desert
Karakum Desert
Ashkhabad
Bukhara
Tashkent
Bishkek
KYRGYZSTAN
Dushanbe
TAJIKISTAN
Key

Figure 9 Irrigation systems in the Aral Sea region.

Source: Kotlyakov 1991.

1. Why is irrigation necessary to support agriculture in the Aral Sea region?
2. What benefits would irrigation bring to the Aral region?
3. Why have the irrigation systems shown in Figure 9 caused the Aral Sea to shrink?

(decreases/increases)." These hypotheses should be compared to the groups' speculations from the previous day. Data in this lesson provide the means to test the class hypotheses. Discuss Questions 1–3 on page 19.

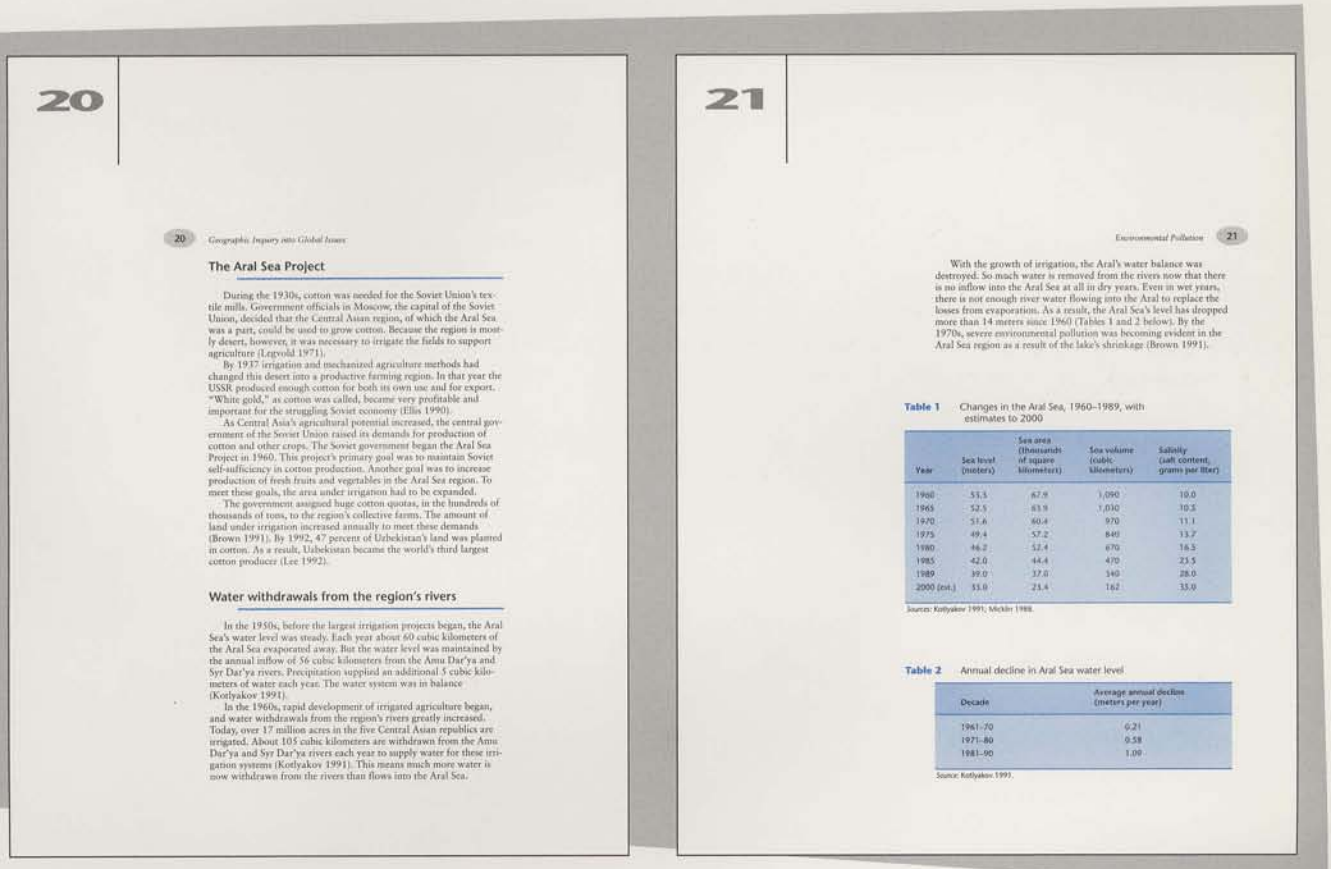
B. Have students read the text titled "The Aral Sea Project" on page 20. Have the class construct a time line of the key events mentioned in the reading. [The two periods to note are the 1930s, when the area was first exploited for agriculture, and the 1960s, when large-scale irrigation began with the Aral Sea Project.]

Next students should read the section, "Water withdrawals from the region's rivers" on pages 20–21. It is essential that students make the link that water used for irrigation necessarily removes water from rivers supplying the Aral Sea.

> For younger students, work through the arithmetical concept of water balance. The material can be discussed as a simple addition/subtraction problem. The key point is that without the rivers' inflow, the lake's water level must decline over time due to evaporation. In fact, more water is now being taken from the rivers (105 cubic kilometers) than used to flow into the lake (56 cubic kilometers), meaning that the withdrawals must be also shrinking the size of the rivers as well as the lake.

C. Table 1 on page 21 shows the changes in the Aral Sea's level, area, volume, and salinity resulting from water withdrawals for irrigation. Have students use **Activity 2** to graph these data. Be sure students include the labels for the vertical axes (giving the units of measurement) on their graphs. Students can complete all four graphs individually, or to save time, you can divide the class into quarters or halves, with each student thus actually completing only one or two graphs each. You may also want to assign the graphs for homework, allowing you to move straight to the discussion of Questions 4–10 on page 22.

D. Discuss Questions 4–10 with the class. Alternatively, you can assign these questions for homework.



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The Aral Sea Project

During the 1930s, cotton was needed for the Soviet Union's textile mills. Government officials in Moscow, the capital of the Soviet Union, decided that the Central Asian region, of which the Aral Sea was a part, could be used to grow cotton. Because the region is mostly desert, however, it was necessary to irrigate the fields to support agriculture (Legvold 1971).

By 1937 irrigation and mechanized agriculture methods had changed this desert into a productive farming region. In that year the USSR produced enough cotton for both its own use and for export. "White gold," as cotton was called, became very profitable and important for the struggling Soviet economy (Ellis 1990).

As Central Asia's agricultural potential increased, the central government of the Soviet Union raised its demands for production of cotton and other crops. The Soviet government began the Aral Sea Project in 1960. This project's primary goal was to maintain Soviet self-sufficiency in cotton production. Another goal was to increase production of fresh fruits and vegetables in the Aral Sea region. To meet these goals, the area under irrigation had to be expanded.

The government assigned huge cotton quotas, in the hundreds of thousands of tons, to the region's collective farms. The amount of land under irrigation increased annually to meet these demands (Brown 1991). By 1992, 47 percent of Uzbekistan's land was planted in cotton. As a result, Uzbekistan became the world's third largest cotton producer (Lee 1992).

Water withdrawals from the region's rivers

In the 1950s, before the largest irrigation projects began, the Aral Sea's water level was steady. Each year about 60 cubic kilometers of the Aral Sea evaporated away. But the water level was maintained by the annual inflow of 56 cubic kilometers from the Amu Dar'ya and Syr Dar'ya rivers. Precipitation supplied an additional 5 cubic kilometers of water each year. The water system was in balance (Kotlyakov 1991).

In the 1960s, rapid development of irrigated agriculture began, and water withdrawals from the region's rivers greatly increased. Today, over 17 million acres in the five Central Asian republics are irrigated. About 105 cubic kilometers are withdrawn from the Amu Dar'ya and Syr Dar'ya rivers each year to supply water for these irrigation systems (Kotlyakov 1991). This means much more water is now withdrawn from the rivers than flows into the Aral Sea.

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With the growth of irrigation, the Aral's water balance was destroyed. So much water is removed from the rivers now that there is no inflow into the Aral Sea at all in dry years. Even in wet years, there is not enough river water flowing into the Aral to replace the losses from evaporation. As a result, the Aral Sea's level has dropped more than 14 meters since 1960 (Tables 1 and 2 below). By the 1970s, severe environmental pollution was becoming evident in the Aral Sea region as a result of the lake's shrinkage (Brown 1991).

Table 1 Changes in the Aral Sea, 1960–1989, with estimates to 2000

Year	Sea level (meters)	Sea area (thousands of square kilometers)	Sea volume (cubic kilometers)	Salinity (salt content, grams per liter)
1960	53.5	67.9	1,090	10.0
1965	52.5	63.9	1,030	10.5
1970	51.6	60.4	970	11.1
1975	49.4	57.2	840	13.7
1980	46.2	52.4	670	16.5
1985	42.0	44.4	470	23.5
1989	39.0	37.0	340	28.0
2000 (est.)	35.0	23.4	162	33.0

Sources: Kotlyakov 1991; Micklin 1988.

Table 2 Annual decline in Aral Sea water level

Decade	Average annual decline (meters per year)
1961–70	0.21
1971–80	0.58
1981–90	1.09

Source: Kotlyakov 1991.

Questions and Answers for page 22

4. Why did the Soviet government want to increase agricultural production in the Aral Sea region?

   - The Soviet government sought to increase agriculture development in the region to provide national income and to supply food and fiber.

5. How has irrigation caused the Aral Sea to shrink?

   - The Aral Sea inflow depended on the rivers, which were diverted for irrigation.

6. How does the fact that the Aral Sea is a lake with no outflow in a desert region that is fed by exotic rivers contribute to this problem?

   - The problem is exacerbated because of high evaporation rates in the desert and no other drainage sources for the sea. Review the material in Lesson 2 on interior drainage if needed.

7. About how many meters has the Aral Sea's level already dropped? How many more meters of lowering are expected by 2000?

   - The sea has already dropped over 14 meters, with prospects for losing six more meters by the end of the century. (It may be helpful to relate this to a more familiar height. For example, 20 meters is about 65 feet, or the height of a five-story building.) Be sure students see the link between water level, area, and volume. As level drops, there is a smaller area; less water means less volume (sea occupies less space of basin).

8. Did the *rate* of lowering in the Aral Sea's area increase or decrease during the 1980s? What do you think is the connection between this changed rate and what was happening in the region then?

   - Reference to Table 2 highlights the point that the rate of change is increasing. The graphs in Activity 2 visually reinforce the point that there have been rapid increases in lowering of area, level, and volume since the mid-1970s. Ask the students whether this trend was easier to spot in the table or on the graph. This emphasizes the value of pictorially representing tabular data to show trends. Students might logically suggest that the rate of lowering increased because of heavier withdrawals from irrigation.

9. Why is the salinity of the Aral Sea increasing?

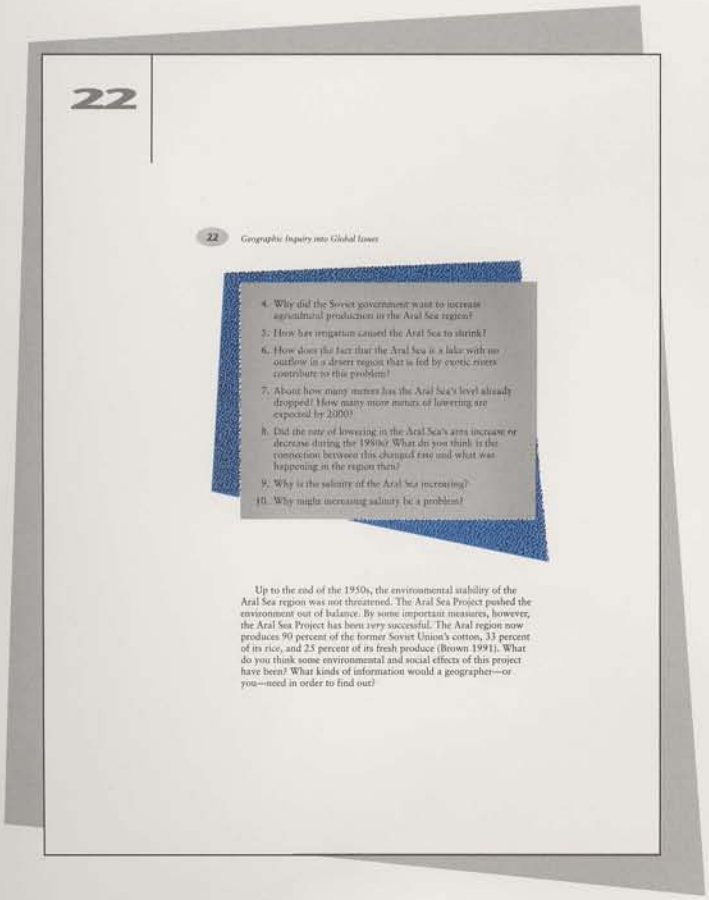
   - Salinity increases because there is less water for the salts to be dissolved in. In other words, given the same weight of dissolved solids (salts) in the solution, the solution must be stronger if there is a lower volume of water. Point out that salinity is measured in grams per liter (weight per volume) if students do not see this relationship at first.

10. Why might increasing salinity be a problem?

    - Have students speculate about the damage excessive salinity can cause; accept any reasonable guesses. Lesson 4 explores the issue more deeply.

Younger students may have difficulty with the concept of increasing salinity. Show how the concentration of a solution is related to the volume of water with a simple demonstration. Place the same number of drops of food coloring into two glasses—one full of water, the other only half full. The brighter color of the latter glass shows the stronger solution of coloring. Explain to students that salinity works the same way: As the amount of water decreases, the amount of solids relative to the water increases.

E. Close by evaluating the hypotheses that the class came up with in Procedure A. The information in the lesson supports the hypothesis that as irrigation and cotton production increased, the Aral Sea's level decreased. The final paragraph in the Student DataBook (page 22) leads to the "so what" aspect of this. It makes clear that the Aral Sea Project has had some important, tangible economic benefits for the region and for the former Soviet Union. The environmental and social costs of the Project are covered in Lesson 4.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4. Why did the Soviet government want to increase agricultural production in the Aral Sea region?
5. How has irrigation caused the Aral Sea to shrink?
6. How does the fact that the Aral Sea is a lake with no outflow in a desert region that is fed by exotic rivers contribute to this problem?
7. About how many meters has the Aral Sea's level already dropped? How many more meters of lowering are expected by 2000?
8. Did the rate of lowering in the Aral Sea's area increase or decrease during the 1950s? What do you think is the connection between this changed rate and what was happening in the region then?
9. Why is the salinity of the Aral Sea increasing?
10. Why might increasing salinity be a problem?

Up to the end of the 1950s, the environmental stability of the Aral Sea region was not threatened. The Aral Sea Project pushed the environment out of balance. By some important measures, however, the Aral Sea Project has been *very* successful. The Aral region now produces 90 percent of the former Soviet Union's cotton, 33 percent of its rice, and 25 percent of its fresh produce (Brown 1991). What do you think some environmental and social effects of this project have been? What kinds of information would a geographer—or you—need in order to find out?

Lesson 4

What are the effects of the Aral Sea environmental disaster?

Time Required

Three 50-minute class periods

Materials Needed

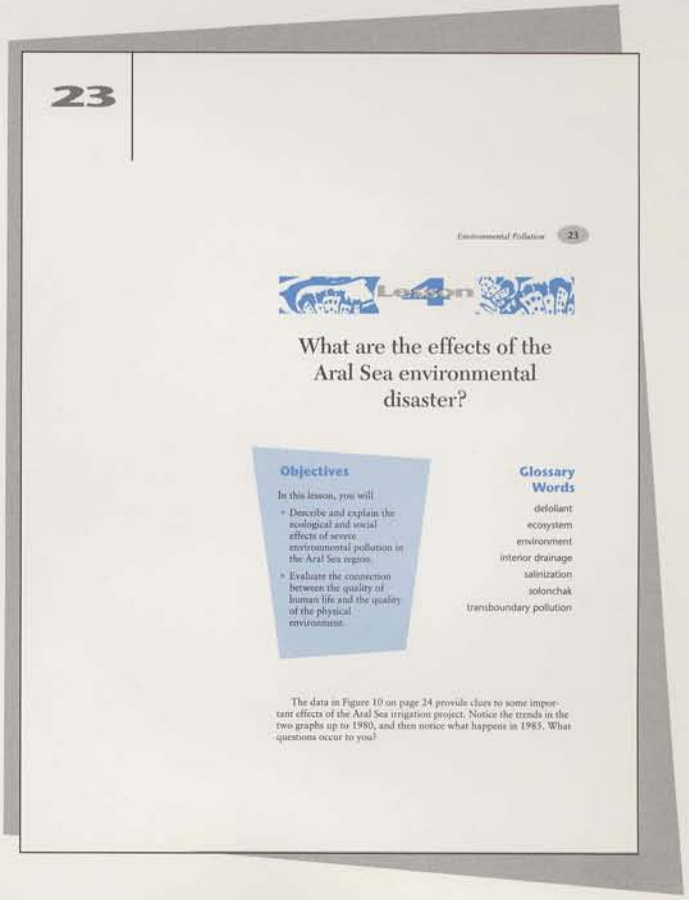
Transparency of Overhead 2

Glossary Words

defoliant
ecosystem
environment
interior drainage
salinization
solonchak
transboundary pollution

Getting Started

- Refer students to Figure 10 on page 24. Ask students to identify periods of growth and decline in cotton production and to describe the trend in irrigation. Have students speculate, based on the information in Lesson 3, about what events might have caused these changes. Next have students describe what the graphs in Figure 10 show about the relationship between cotton production and irrigation in Central Asia since the 1950s. [Cotton production increased throughout the 1960s and 1970s but began to decline in the late 1980s. The area of land under irrigation has consistently increased, especially since 1980.]
- Use the time line from Lesson 3 to review the reasons for growth in the 1960s and 1970s; the key event is the start of the Aral Sea Project. [The increase in production matches the increase in irrigation, as might be expected, until the late 1980s.] Allow speculation about why production has started to decline, despite the continued increase in irrigation. Explain that after studying this lesson, students will understand why production has declined recently.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Lesson 4

What are the effects of the Aral Sea environmental disaster?

Objectives

In this lesson, you will

- Describe and explain the ecological and social effects of severe environmental pollution in the Aral Sea region.
- Evaluate the connection between the quality of human life and the quality of the physical environment.

Glossary Words

defoliant
ecosystem
environment
interior drainage
salinization
solonchak
transboundary pollution

The data in Figure 10 on page 24 provide clues to some important effects of the Aral Sea irrigation project. Notice the trends in the two graphs up to 1980, and then notice what happens in 1985. What questions occur to you?

- *Optional Activity:* This lesson emphasizes the damage to vegetation caused by salt pollution. This is a key cause for the decline in agricultural production in the Aral Sea region. A demonstration of how excessive salt harms plants would be an effective way to spark interest, but requires a good deal of planning. The following demonstration is conducive to team-teaching situations with science classes:

  Obtain two potted plants—one that is relatively salt-tolerant and one that isn't. Nurseries or gardening shops may be able to suggest appropriate potted plants. Put the two plants before the class and explain that each has different salt tolerances. Ask the class to predict what will happen to the plants if each is watered with a strong saline solution (ask the nursery how much salt the tolerant plant can handle). Over the course of the next few days, water each plant with a strong saline solution. The tolerant plant should survive, but the intolerant one may wither and die. This simulates the effect of salinization. In fact, as the soil dries out, a thin salt crust may form on the soil surface, as occurs in salinized soils.

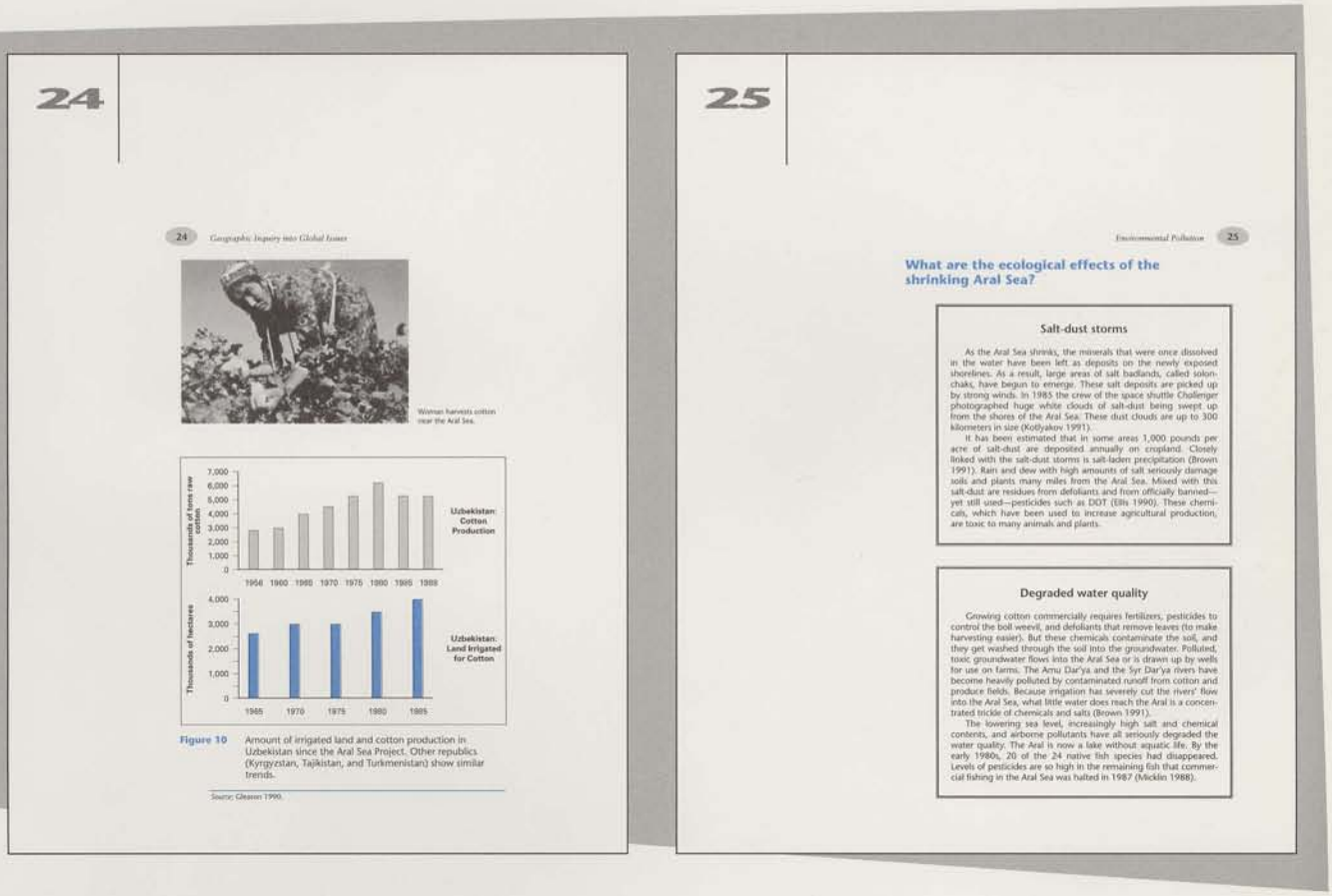
  If you wish to try this demonstration, it may be useful to initiate it a couple days before this lesson, so that the harmful effects of salinization are already apparent to students by the time they begin.

Procedures

What are the ecological effects of the shrinking Aral Sea? (pages 25–27)

A. Divide the class into groups of five students each. Within the groups, each student will be responsible for one of the five short readings in the boxes on pages 25–27. That student, now an "expert" on that subject, then briefs the remainder of his or her group about the reading.

  Each group should then work to answer Questions 1–6 on page 27. Groups should pick a recorder to write down the answers. Allow time at the end of class for debriefing the entire class together to be sure that the main points are understood by all.



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Woman harvests cotton near the Aral Sea.

Figure 10 Amount of irrigated land and cotton production in Uzbekistan since the Aral Sea Project. Other republics (Kyrgyzstan, Tajikistan, and Turkmenistan) show similar trends.

Source: Gleason 1990.

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What are the ecological effects of the shrinking Aral Sea?

Salt-dust storms

As the Aral Sea shrinks, the minerals that were once dissolved in the water have been left as deposits on the newly exposed shorelines. As a result, large areas of salt badlands, called solonchaks, have begun to emerge. These salt deposits are picked up by strong winds. In 1985 the crew of the space shuttle *Challenger* photographed huge white clouds of salt-dust being swept up from the shores of the Aral Sea. These dust clouds are up to 300 kilometers in size (Kotlyakov 1991).

It has been estimated that in some areas 1,000 pounds per acre of salt-dust are deposited annually on cropland. Closely linked with the salt-dust storms is salt-laden precipitation (Brown 1991). Rain and dew with high amounts of salt seriously damage soils and plants many miles from the Aral Sea. Mixed with this salt-dust are residues from defoliants and from officially banned—yet still used—pesticides such as DDT (Ellis 1990). These chemicals, which have been used to increase agricultural production, are toxic to many animals and plants.

Degraded water quality

Growing cotton commercially requires fertilizers, pesticides to control the boll weevil, and defoliants that remove leaves (to make harvesting easier). But these chemicals contaminate the soil, and they get washed through the soil into the groundwater. Polluted, toxic groundwater flows into the Aral Sea or is drawn up by wells for use on farms. The Amu Dar'ya and the Syr Dar'ya rivers have become heavily polluted by contaminated runoff from cotton and produce fields. Because irrigation has severely cut the rivers' flow into the Aral Sea, what little water does reach the Aral is a concentrated trickle of chemicals and salts (Brown 1991).

The lowering sea level, increasingly high salt and chemical contents, and airborne pollutants have all seriously degraded the water quality. The Aral is now a lake without aquatic life. By the early 1980s, 20 of the 24 native fish species had disappeared. Levels of pesticides are so high in the remaining fish that commercial fishing in the Aral Sea was halted in 1987 (Micklin 1988).

Questions and Answers for page 27

1. In what ways has the environment of the Aral Sea region changed? Give an example from each of the previous five short readings on environmental effects.
   - Groups should summarize the key points in the five short readings.

2. Recall that the Aral Sea is part of an interior drainage system. How does this fact contribute to the salt and chemical pollution problems of the region?
   - The Aral basin collects all of the runoff for the contributing watershed. Any chemicals used must ultimately be washed into the sea. Because the Aral Sea has no outflow, the concentration of chemicals will increase over time. Contributing to this is the reduced flow from the rivers into the lake from irrigation, causing an even more concentrated collection of pollutants. Because the Aral Sea is in a desert, high evaporation rates cause the salinity to increase.

3. Give two different reasons for the decline in cotton production in the late 1980s (Figure 10).
   - Cotton production declined because toxic salts accumulated in the soil and because the frost-free season shortened. A third reason, not presented in the readings, is that years of cotton cultivation tends to deplete soils of essential nutrients (a similar problem occurred in the cotton-growing regions of the southern United States in the last century).

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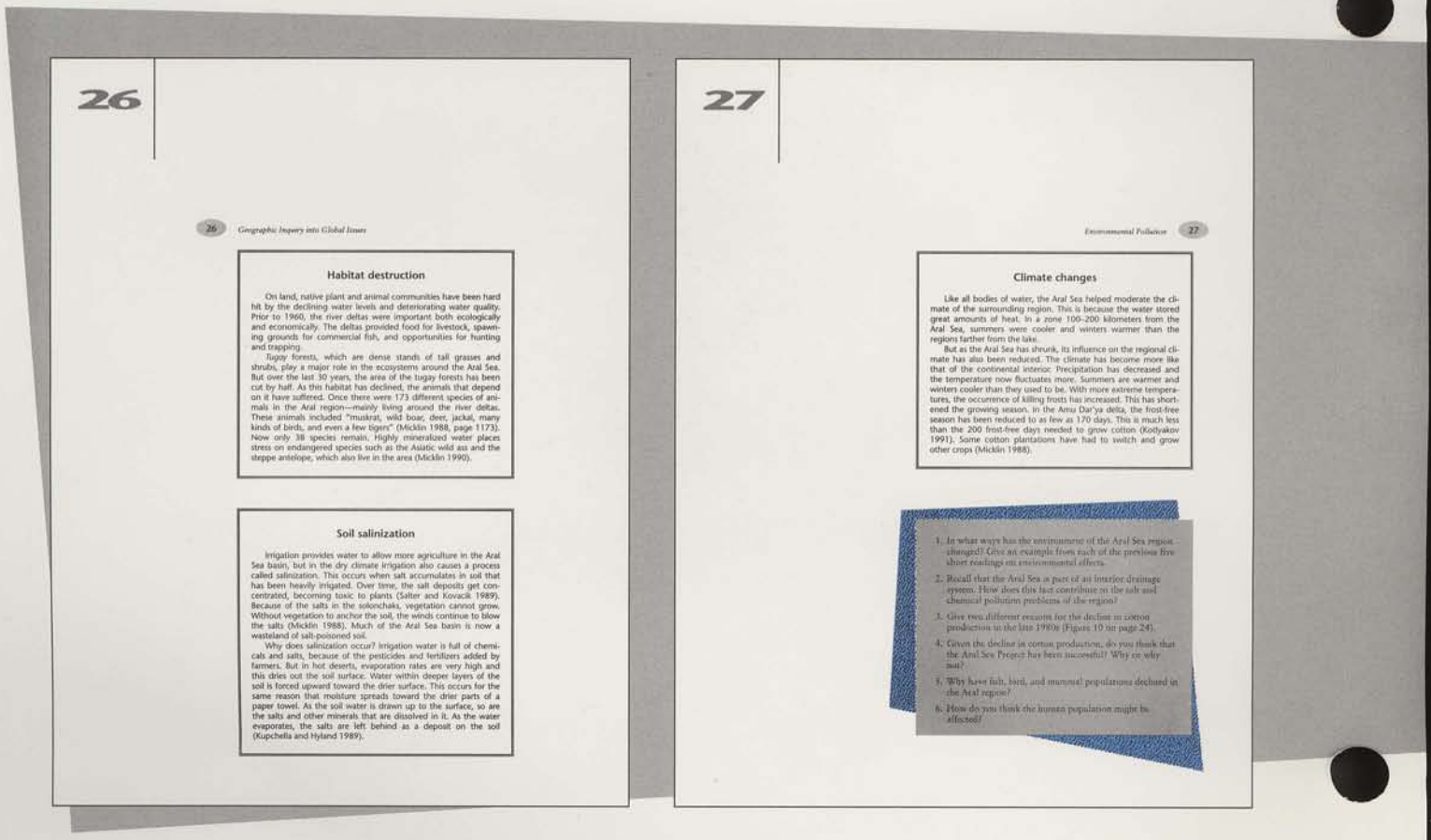

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Habitat destruction

On land, native plant and animal communities have been hard hit by the declining water levels and deteriorating water quality. Prior to 1960, the river deltas were important both ecologically and economically. The deltas provided food for livestock, spawning grounds for commercial fish, and opportunities for hunting and trapping.

Tugay forests, which are dense stands of tall grasses and shrubs, play a major role in the ecosystems around the Aral Sea. But over the last 30 years, the area of the tugay forests has been cut by half. As this habitat has declined, the animals that depend on it have suffered. Once there were 173 different species of animals in the Aral region—mainly living around the river deltas. These animals included "muskrat, wild boar, deer, jackal, many kinds of birds, and even a few tigers" (Micklin 1988, page 1173). Now only 38 species remain. Highly mineralized water places stress on endangered species such as the Asiatic wild ass and the steppe antelope, which also live in the area (Micklin 1990).

Soil salinization

Irrigation provides water to allow more agriculture in the Aral Sea basin, but in the dry climate irrigation also causes a process called salinization. This occurs when salt accumulates in soil that has been heavily irrigated. Over time, the salt deposits get concentrated, becoming toxic to plants (Salter and Kovacik 1989). Because of the salts in the solonchaks, vegetation cannot grow. Without vegetation to anchor the soil, the winds continue to blow the salts (Micklin 1988). Much of the Aral Sea basin is now a wasteland of salt-poisoned soil.

Why does salinization occur? Irrigation water is full of chemicals and salts, because of the pesticides and fertilizers added by farmers. But in hot deserts, evaporation rates are very high and this dries out the soil surface. Water within deeper layers of the soil is forced upward toward the drier surface. This occurs for the same reason that moisture spreads toward the drier parts of a paper towel. As the soil water is drawn up to the surface, so are the salts and other minerals that are dissolved in it. As the water evaporates, the salts are left behind as a deposit on the soil (Kupchella and Hyland 1989).

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Climate changes

Like all bodies of water, the Aral Sea helped moderate the climate of the surrounding region. This is because the water stored great amounts of heat. In a zone 100–200 kilometers from the Aral Sea, summers were cooler and winters warmer than the regions farther from the lake.

But as the Aral Sea has shrunk, its influence on the regional climate has also been reduced. The climate has become more like that of the continental interior. Precipitation has decreased and the temperature now fluctuates more. Summers are warmer and winters cooler than they used to be. With more extreme temperatures, the occurrence of killing frosts has increased. This has shortened the growing season. In the Amu Dar'ya delta, the frost-free season has been reduced to as few as 170 days. This is much less than the 200 frost-free days needed to grow cotton (Kotlyakov 1991). Some cotton plantations have had to switch and grow other crops (Micklin 1988).

1. In what ways has the environment of the Aral Sea region changed? Give an example from each of the previous five short readings on environmental effects.
2. Recall that the Aral Sea is part of an interior drainage system. How does this fact contribute to the salt and chemical pollution problems of the region?
3. Give two different reasons for the decline in cotton production in the late 1980s (Figure 10 on page 24).
4. Given the decline in cotton production, do you think that the Aral Sea Project has been successful? Why or why not?
5. Why have fish, bird, and mammal populations declined in the Aral region?
6. How do you think the human population might be affected?

4. Given the decline in cotton production, do you think that the Aral Sea Project has been successful? Why or why not?
   - Given that the Aral Sea Project was intended to grow cotton, there is some irony that pollution related to the project is now causing cotton production to decline. On the other hand, the Aral region is still a major cotton producer in the world, so the project has been successful by that measure.

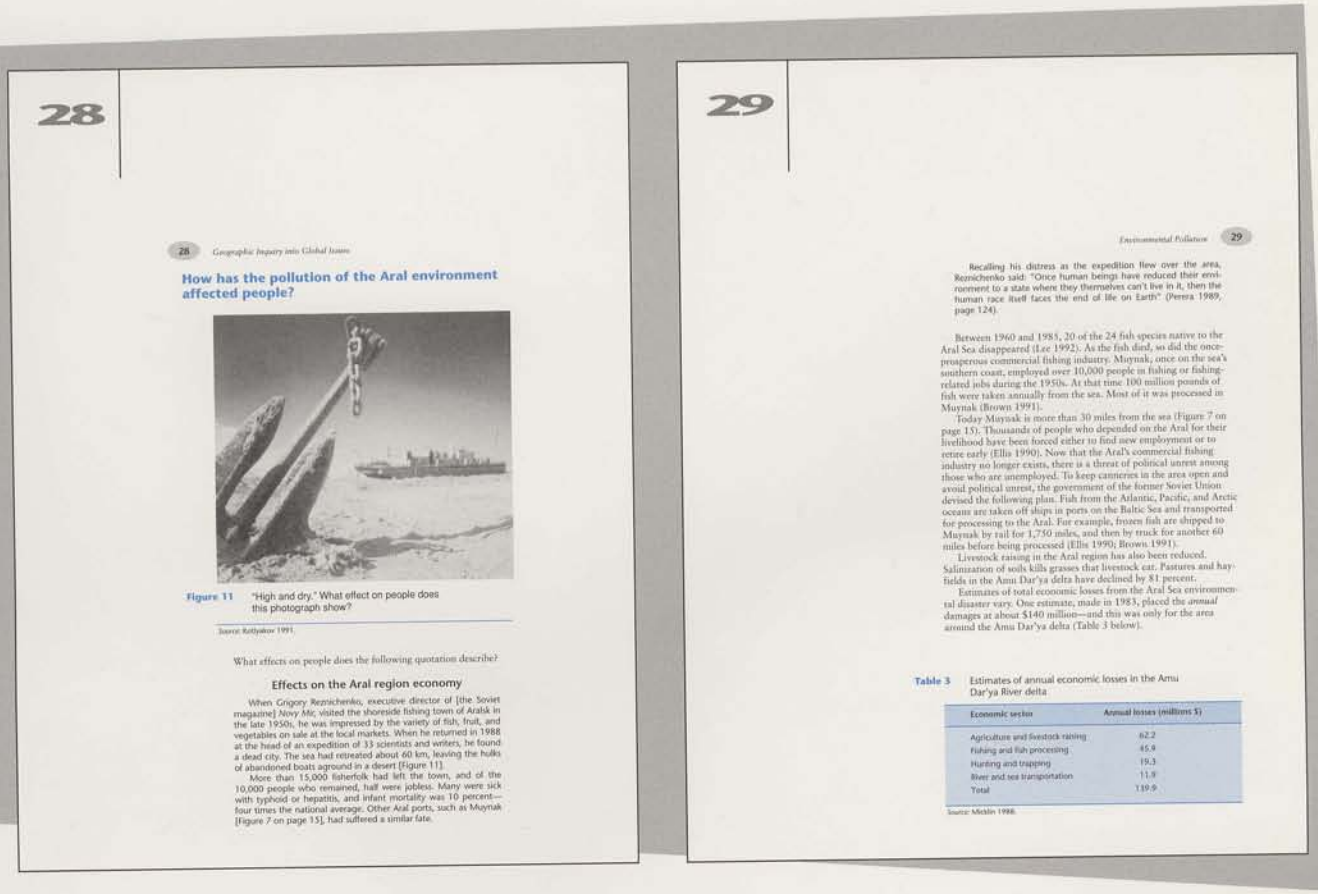
5. Why have fish, bird, and mammal populations declined in the Aral region?
   - As water quality has been ruined and plant communities have vanished, animals that live in those habitats have died out.

6. How do you think the human population might be affected?
   - Students should speculate here; answers to this question are given in the next part of this lesson.

How has the pollution of the Aral environment affected people? (pages 28–32)

B. Have students examine Figure 11 on page 28, which shows an old seagoing vessel now aground in the Aral basin. Instruct students to describe what the photo shows. Discuss what this situation implies with respect to the people who made their living from the sea.

C. Have students pair off and read the text titled "Effects on the Aral region economy" (pages 28–29) and examine Table 3 (page 29). Each pair of students should work to answer Questions 7–10 on page 30.



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How has the pollution of the Aral environment affected people?

Figure 11 "High and dry." What effect on people does this photograph show?

Source: Kotlyakov 1991.

What effects on people does the following quotation describe?

Effects on the Aral region economy

When Grigory Reznichenko, executive director of [the Soviet magazine] *Nowy Mir,* visited the shoreside fishing town of Aralsk in the late 1950s, he was impressed by the variety of fish, fruit, and vegetables on sale at the local markets. When he returned in 1988 at the head of an expedition of 33 scientists and writers, he found a dead city. The sea had retreated about 60 km, leaving the hulks of abandoned boats aground in a desert (Figure 11).

More than 15,000 fisherfolk had left the town, and of the 10,000 people who remained, half were jobless. Many were sick with typhoid or hepatitis, and infant mortality was 10 percent—four times the national average. Other Aral ports, such as Muynak [Figure 7 on page 15], had suffered a similar fate.

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Recalling his distress as the expedition flew over the area, Reznichenko said: "Once human beings have reduced their environment to a state where they themselves can't live in it, then the human race itself faces the end of life on Earth" (Perera 1989, page 124).

Between 1960 and 1985, 20 of the 24 fish species native to the Aral Sea disappeared (Lee 1992). As the fish died, so did the once-prosperous commercial fishing industry. Muynak, once on the sea's southern coast, employed over 10,000 people in fishing or fishing-related jobs during the 1950s. At that time 100 million pounds of fish were taken annually from the sea. Most of it was processed in Muynak (Brown 1991).

Today Muynak is more than 30 miles from the sea (Figure 7 on page 15). Thousands of people who depended on the Aral for their livelihood have been forced either to find new employment or to retire early (Ellis 1990). Now that the Aral's commercial fishing industry no longer exists, there is a threat of political unrest among those who are unemployed. To keep canneries in the area open and avoid political unrest, the government of the former Soviet Union devised the following plan. Fish from the Atlantic, Pacific, and Arctic oceans are taken off ships in ports on the Baltic Sea and transported for processing to the Aral. For example, frozen fish are shipped to Muynak by rail for 1,750 miles, and then by truck for another 60 miles before being processed (Ellis 1990; Brown 1991).

Livestock raising in the Aral region has also been reduced. Salinization of soils kills grasses that livestock eat. Pastures and hayfields in the Amu Dar'ya delta have declined by 81 percent.

Estimates of total economic losses from the Aral Sea environmental disaster vary. One estimate, made in 1983, placed the *annual* damages at about $140 million—and this was only for the area around the Amu Dar'ya delta (Table 3 below).

Table 3 Estimates of annual economic losses in the Amu Dar'ya River delta

Economic sector	Annual losses (millions $)
Agriculture and livestock raising	82.2
Fishing and fish processing	45.9
Hunting and trapping	19.3
River and sea transportation	11.9
Total	139.9

Source: Micklin 1988.

Questions and Answers for page 30

7. Describe why each economic sector in Table 3 is experiencing major annual losses.
   - Losses in agriculture and fisheries relate to the salt and chemical pollution of soils and water resources. Hunting and trapping declined as animal populations were lost via habitat destruction. Transport clearly suffers where there is no water.

8. Do you agree or disagree with the measures that the government took to reduce possible political unrest (e.g., bringing in fish from long distances for processing)? Why?
   - This is open to student opinion. They should question whether this strategy really gets at the *cause* of the problem.

9. What kinds of possible economic activities are *not* listed in Table 3? Could any of these types of activities be encouraged to replace the region's lost economies? Why or why not?
   - Skip this question if it is too advanced. Older students may notice that the list in Table 3 makes no reference to manufacturing or industry. Students could speculate about whether it would be helpful for governments in these countries to encourage new industries to replace the lost ones.

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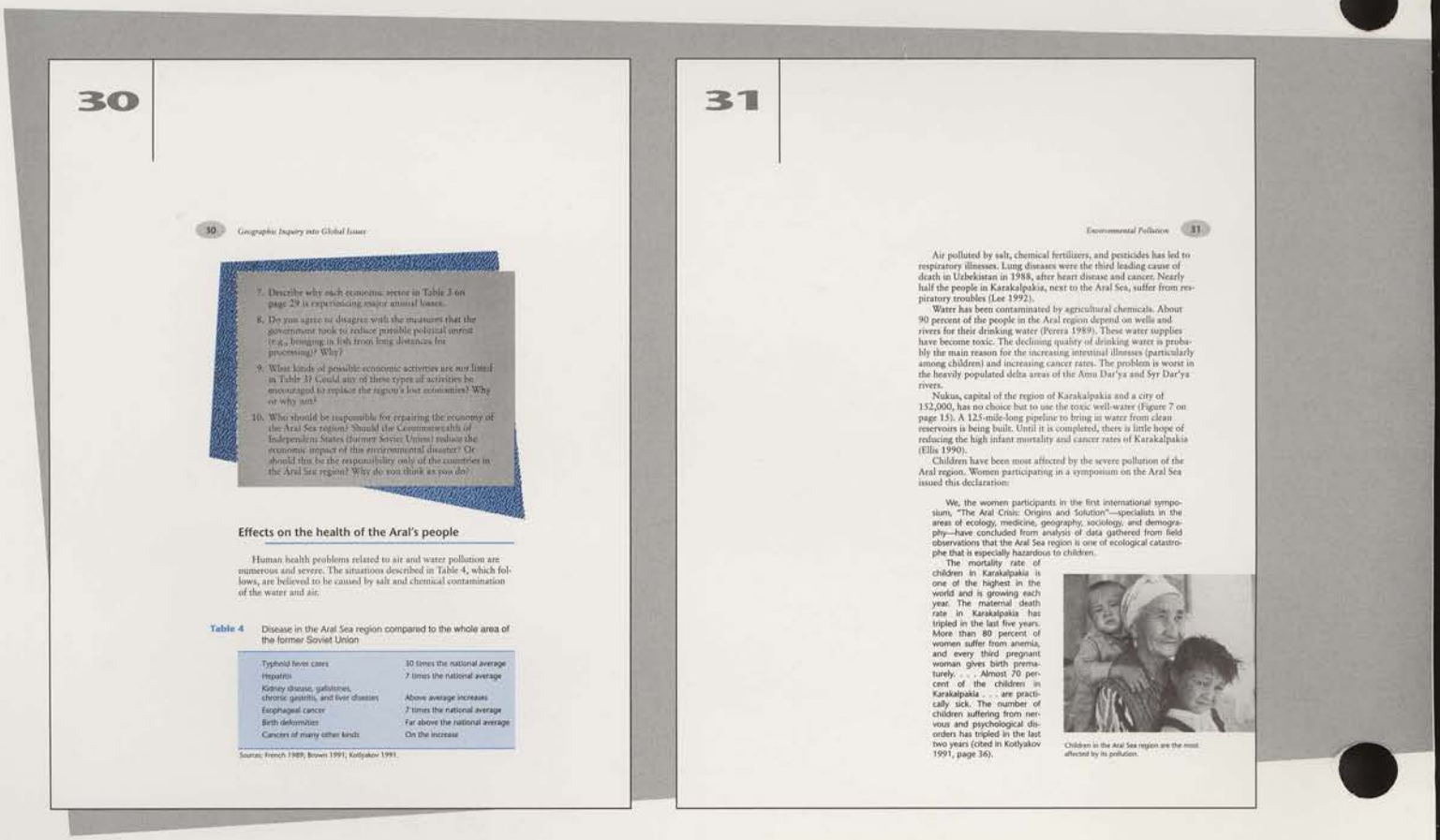

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7. Describe why each economic sector in Table 3 on page 29 is experiencing major annual losses.
8. Do you agree or disagree with the measures that the government took to reduce possible political unrest (e.g., bringing in fish from long distances for processing)? Why?
9. What kinds of possible economic activities are *not* listed in Table 3? Could any of these types of activities be encouraged to replace the region's lost economies? Why or why not?
10. Who should be responsible for repairing the economy of the Aral Sea region? Should the Commonwealth of Independent States (former Soviet Union) reduce the economic impact of this environmental disaster? Or should this be the responsibility only of the countries in the Aral Sea region? Why do you think as you do?

Effects on the health of the Aral's people

Human health problems related to air and water pollution are numerous and severe. The situations described in Table 4, which follows, are believed to be caused by salt and chemical contamination of the water and air.

Table 4 Disease in the Aral Sea region compared to the whole area of the former Soviet Union

Typhoid fever cases	30 times the national average
Hepatitis	7 times the national average
Kidney disease, gallstones, chronic gastritis, and liver diseases	Above average increases
Esophageal cancer	7 times the national average
Birth deformities	Far above the national average
Cancers of many other kinds	On the increase

Sources: French 1989; Brown 1991; Kotlyakov 1991.

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Air polluted by salt, chemical fertilizers, and pesticides has led to respiratory illnesses. Lung diseases were the third leading cause of death in Uzbekistan in 1988, after heart disease and cancer. Nearly half the people in Karakalpakia, next to the Aral Sea, suffer from respiratory troubles (Lee 1992).

Water has been contaminated by agricultural chemicals. About 90 percent of the people in the Aral region depend on wells and rivers for their drinking water (Perera 1989). These water supplies have become toxic. The declining quality of drinking water is probably the main reason for the increasing intestinal illnesses (particularly among children) and increasing cancer rates. The problem is worst in the heavily populated delta areas of the Amu Dar'ya and Syr Dar'ya rivers.

Nukus, capital of the region of Karakalpakia and a city of 152,000, has no choice but to use the toxic well-water (Figure 7 on page 15). A 125-mile-long pipeline to bring in water from clean reservoirs is being built. Until it is completed, there is little hope of reducing the high infant mortality and cancer rates of Karakalpakia (Ellis 1990).

Children have been most affected by the severe pollution of the Aral region. Women participating in a symposium on the Aral Sea issued this declaration:

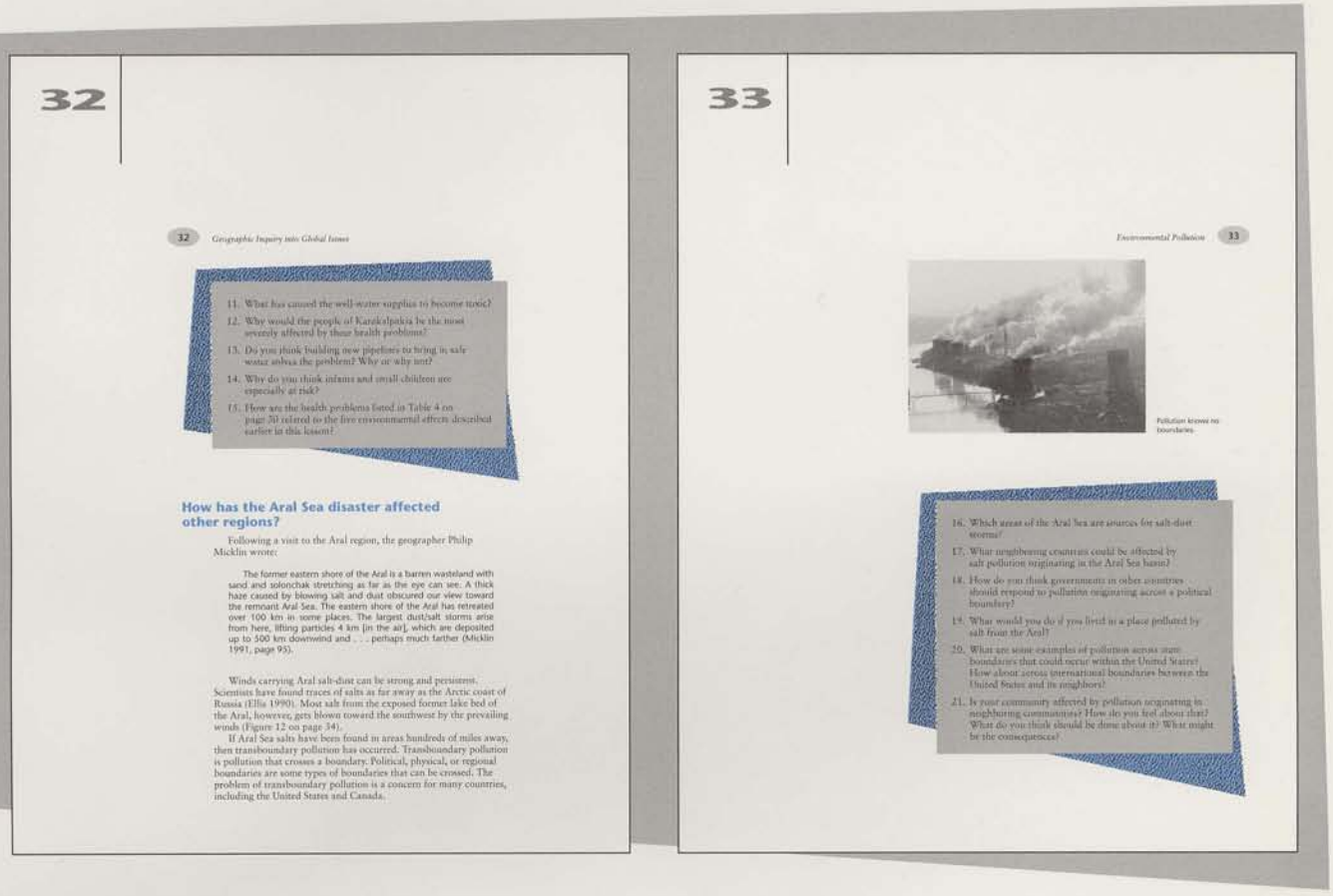
> We, the women participants in the first international symposium, "The Aral Crisis: Origins and Solution"—specialists in the areas of ecology, medicine, geography, sociology, and demography—have concluded from analysis of data gathered from field observations that the Aral Sea region is one of ecological catastrophe that is especially hazardous to children.
>
> The mortality rate of children in Karakalpakia is one of the highest in the world and is growing each year. The maternal death rate in Karakalpakia has tripled in the last five years. More than 80 percent of women suffer from anemia, and every third pregnant woman gives birth prematurely. . . . Almost 70 percent of the children in Karakalpakia . . . are practically sick. The number of children suffering from nervous and psychological disorders has tripled in the last two years (cited in Kotlyakov 1991, page 36).

Children in the Aral Sea region are the most affected by its pollution.

10. Who should be responsible for repairing the economy of the Aral Sea region? Should the Commonwealth of Independent States (former Soviet Union) reduce the economic impact of this environmental disaster? Or should this be the responsibility only of the countries in the Aral Sea region? Why do you think as you do?

    - This is an opinion question, to use at whatever level is appropriate for your class's familiarity with the former Soviet Union. At which scale should the region's economic problems be solved?
    - *Local or National:* Does responsibility for helping the Aral region's economy lie only within the governments of the newly independent countries of Central Asia?
    - *Former Soviet Union:* Because the policies that initiated the environmental and economic changes came from the Soviet Union, should the Commonwealth of Independent States, as the successor to the Soviet government, shoulder some of the responsibility? If so, how could this loose federation of states, each of which is beset by its own serious economic problems, begin to help?
    - *International:* Should governments from other countries, such as the United States, Japan, or Canada, help the Aral region?

D. Have students read the text, "Effects on the health of the Aral's people" on pages 30–31, including Table 4, either to themselves or aloud. Questions 11–15 on page 32 can be answered individually, in pairs, or in discussion with the entire class.



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11. What has caused the well-water supplies to become toxic?
12. Why would the people of Karakalpakia be the most severely affected by these health problems?
13. Do you think building new pipelines to bring in safe water solves the problem? Why or why not?
14. Why do you think infants and small children are especially at risk?
15. How are the health problems listed in Table 4 on page 30 related to the five environmental effects described earlier in this lesson?

How has the Aral Sea disaster affected other regions?

Following a visit to the Aral region, the geographer Philip Micklin wrote:

> The former eastern shore of the Aral is a barren wasteland with sand and solonchak stretching as far as the eye can see. A thick haze caused by blowing salt and dust obscured our view toward the remnant Aral Sea. The eastern shore of the Aral has retreated over 100 km in some places. The largest dust/salt storms arise from here, lifting particles 4 km [in the air], which are deposited up to 500 km downwind and . . . perhaps much farther (Micklin 1991, page 93).

Winds carrying Aral salt-dust can be strong and persistent. Scientists have found traces of salts as far away as the Arctic coast of Russia (Ellis 1990). Most salt from the exposed former lake bed of the Aral, however, gets blown toward the southwest by the prevailing winds (Figure 12 on page 34).

If Aral Sea salts have been found in areas hundreds of miles away, then transboundary pollution has occurred. Transboundary pollution is pollution that crosses a boundary. Political, physical, or regional boundaries are some types of boundaries that can be crossed. The problem of transboundary pollution is a concern for many countries, including the United States and Canada.

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Environmental Pollution 33

Pollution knows no boundaries.

16. Which areas of the Aral Sea are sources for salt-dust storms?
17. What neighboring countries could be affected by salt pollution originating in the Aral Sea basin?
18. How do you think governments in other countries should respond to pollution originating across a political boundary?
19. What would you do if you lived in a place polluted by salt from the Aral?
20. What are some examples of pollution across state boundaries that could occur within the United States? How about across international boundaries between the United States and its neighbors?
21. Is your community affected by pollution originating in neighboring communities? How do you feel about that? What do you think should be done about it? What might be the consequences?

Questions and Answers for page 32

11. What has caused the well-water supplies to become toxic?

    - Well-water supplies have become contaminated because agricultural chemicals (e.g., pesticides and artificial fertilizers) have infiltrated through the soil into the groundwater. Use the transparency of **Overhead 2** to illustrate how groundwater can become polluted to clarify this point.

12. Why would the people of Karakalpakia be the most severely affected by these health problems?

    - Refer to Figure 7 to remind students that Karakalpakia is adjacent to the Aral Sea. Being the closest to the pollution source means the people there will likely be subject to the highest concentrations of toxins. Illustrate this point by asking students whether it is better to be right next to a smoker or on the other side of the room.

13. Do you think building new pipelines to bring in safe water solves the problem? Why or why not?

    - This is an opinion question. Challenge students to decide whether this proposed "solution" really addresses the root cause of the problem. Alternative strategies would be to reduce the sources of pollution (agricultural chemicals) or stop the shrinkage of the lake (reducing the concentration of the pollutants).

14. Why do you think infants and small children are especially at risk?

    - Infants and small children are particularly susceptible to disease because their immune systems are poorly developed.

15. How are the health problems listed in Table 4 related to the five environmental effects described earlier in this lesson?

    - Students should make the connection between environmental pollution and the cancers and other health problems listed in Table 4. Soils and water contaminated with harmful chemicals pose a risk because pollutants tend to accumulate in crops and well-water supplies. To help students make this connection, you might ask what is known to cause cancer and birth deformities (e.g., smoking and drug abuse). Similarly, hepatitis and liver diseases can be caused when toxic or impure substances are ingested. The point is that if the environment contains a lot of concentrated toxins, then the risk to human health is increased. (This discussion might be held profitably in a team-teaching situation with a health or science class.)

How has the Aral Sea disaster affected other regions? (pages 32–34)

E. *Optional Activity:* If time is short, skip this section. Questions 16–21 on page 33, which comprise the discussion, can be used in any combination you wish according to the needs and interest levels of your class.

To set the tone for this section, ask students how they respond in a restaurant when asked if they would like to sit in a smoking or nonsmoking section. Ask students how the boundary between the sections is usually defined. For the students who choose to sit in a nonsmoking section, ask how they feel if

smoke from the smoking section overflows into the nonsmoking section. Write the term *transboundary pollution* on the chalkboard and ask what it might mean. Ask students how this term may be applied to the restaurant scenario.

Have students read the text on page 32. Then discuss Figure 12 on page 34 with the class, explaining the meaning of the black arrows symbolizing the direction of the prevailing winds. Have the entire class discuss Questions 16–21 on page 33 about transboundary pollution.

Questions and Answers for page 33

16. Which areas of the Aral Sea are sources for salt-dust storms?

    - Major source areas for salt-dust storms are those parts of the old lake bed that have become exposed as the Aral recedes—primarily the eastern and southern shores.

17. What neighboring countries could be affected by salt pollution originating in the Aral Sea basin?

    - Prevailing winds blow to the southwest, so Uzbekistan and Turkmenistan are directly in the path of these salt-dust storms. Neighboring countries affected by salt-dust storms originating in the Aral Sea basin include Iran, Turkey, Iraq, Syria, and other countries of southwestern Asia.

18. How do you think governments in other countries should respond to pollution originating across a political boundary?

    - This question is open to class discussion and opinions. You might focus discussion on the problems of negotiating pollution controls between countries. For example, the activity causing the pollution may be an important income source for one country. That country may not even be affected by the pollution. How can the country adversely affected convince the "offending" country to stop?

19. What would you do if you lived in a place polluted by salt from the Aral?

    - Accept any reasonable discussion on this question. Possible answers include political action (protests) and economic action (boycotts). Focus discussion on what responses would be both effective and appropriate.

20. What are some examples of pollution across state boundaries that could occur within the United States? How about across international boundaries between the United States and its neighbors?

    - Transboundary pollution can occur between neighboring states (perhaps where a polluted river crosses a boundary) or between countries (e.g., air pollution from Detroit reaching Canada). Clearly, numerous examples are possible.

continued

21. Is your community affected by pollution originating in neighboring communities? How do you feel about that? What do you think should be done about it? What might be the consequences?

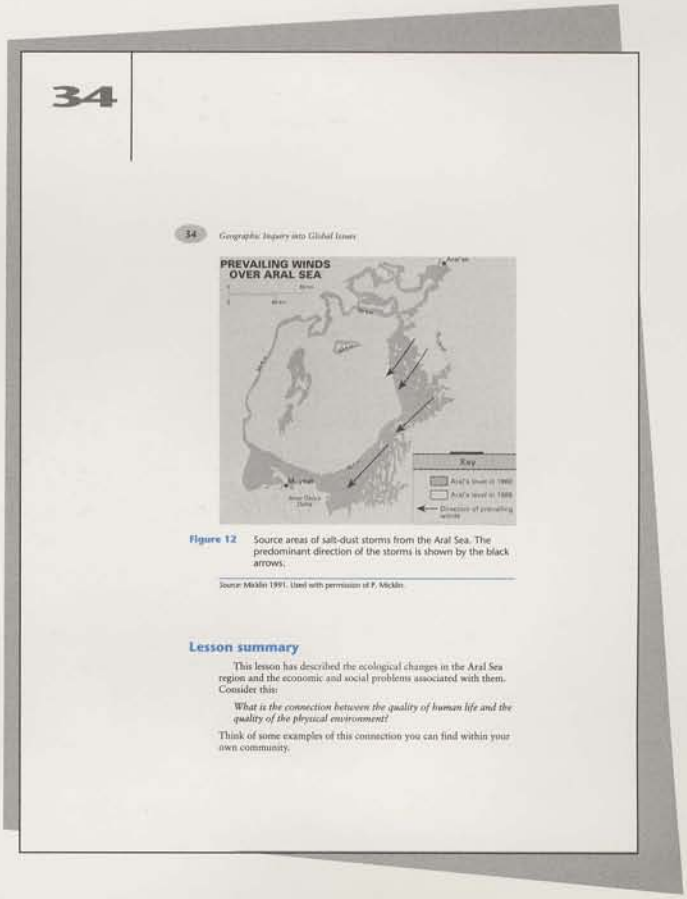
    - Answers will vary by locality, but transboundary pollution is very common. For example, areas in the Northeast might discuss acid precipitation, which originates in the Great Lakes industrial heartland. Suburban communities are frequently affected by air pollution from nearby large cities. Many communities along streams are affected by pollution sources upstream.

Lesson summary (page 34)

F. Close the lesson with a discussion on the final question. The goal of this discussion is for students to be able to relate clearly how necessary a clean environment is for both physical and economic health of human populations.

For Further Inquiry

- Assign an essay to be written overnight addressing the following questions: Should transboundary pollution be regulated? Why or why not? If so, how?
- Assign an essay in which students respond to the quote by Reznichenko that appeared in the extract on pages 28–29 of the Student DataBook: "Once human beings have reduced their environment to a state where they themselves can't live in it, then the human race itself faces the end of life on Earth." Students could use this as a springboard to write about the closing question of the lesson, comparing the environmental problems with the changes that have occurred in people's health and economies.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PREVAILING WINDS OVER ARAL SEA

Figure 12 Source areas of salt-dust storms from the Aral Sea. The predominant direction of the storms is shown by the black arrows.

Source: Micklin 1991. Used with permission of P. Micklin.

Lesson summary

This lesson has described the ecological changes in the Aral Sea region and the economic and social problems associated with them. Consider this:

What is the connection between the quality of human life and the quality of the physical environment?

Think of some examples of this connection you can find within your own community.

Lesson 5

How can the Aral Sea be saved?

Time Required

Two 50-minute class periods

Materials Needed

None

Glossary Words

defoliant

desiccation

environment

hydrological

Getting Started

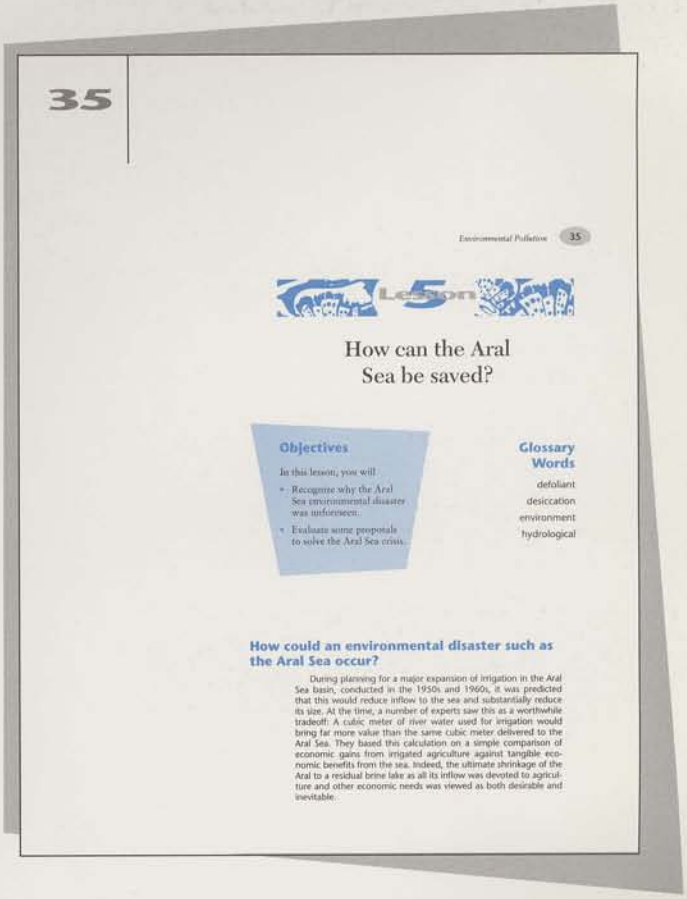
This lesson gets at the underlying questions: What is the value of an environmental resource like the Aral Sea? Is it worth sacrificing the environment for economic gain (e.g., increased agricultural production)? This is clearly an issue that depends on an individual's perspective. Ask students if they feel that the Aral Sea Project has been worthwhile. (Remind the class that in spite of the recent declines, agricultural production *has* significantly increased in the region since the 1960s.)

Procedures

How could an environmental disaster such as the Aral Sea occur? (pages 35–38)

A. Have students read about Soviet agricultural practices on pages 35–37 (up to the section entitled "Farming practices in the Soviet Union"). Then conduct discussion on the Soviet agricultural system.

Focus discussion on the role of the central government in planning crop production quotas for the Soviet Union. The Moscow central government set all quotas for cotton and other crops. Farm workers could not set or suggest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Lesson 5

How can the Aral Sea be saved?

Objectives

In this lesson, you will

- Recognize why the Aral Sea environmental disaster was unforeseen.
- Evaluate some proposals to solve the Aral Sea crisis.

Glossary Words

defoliant
desiccation
environment
hydrological

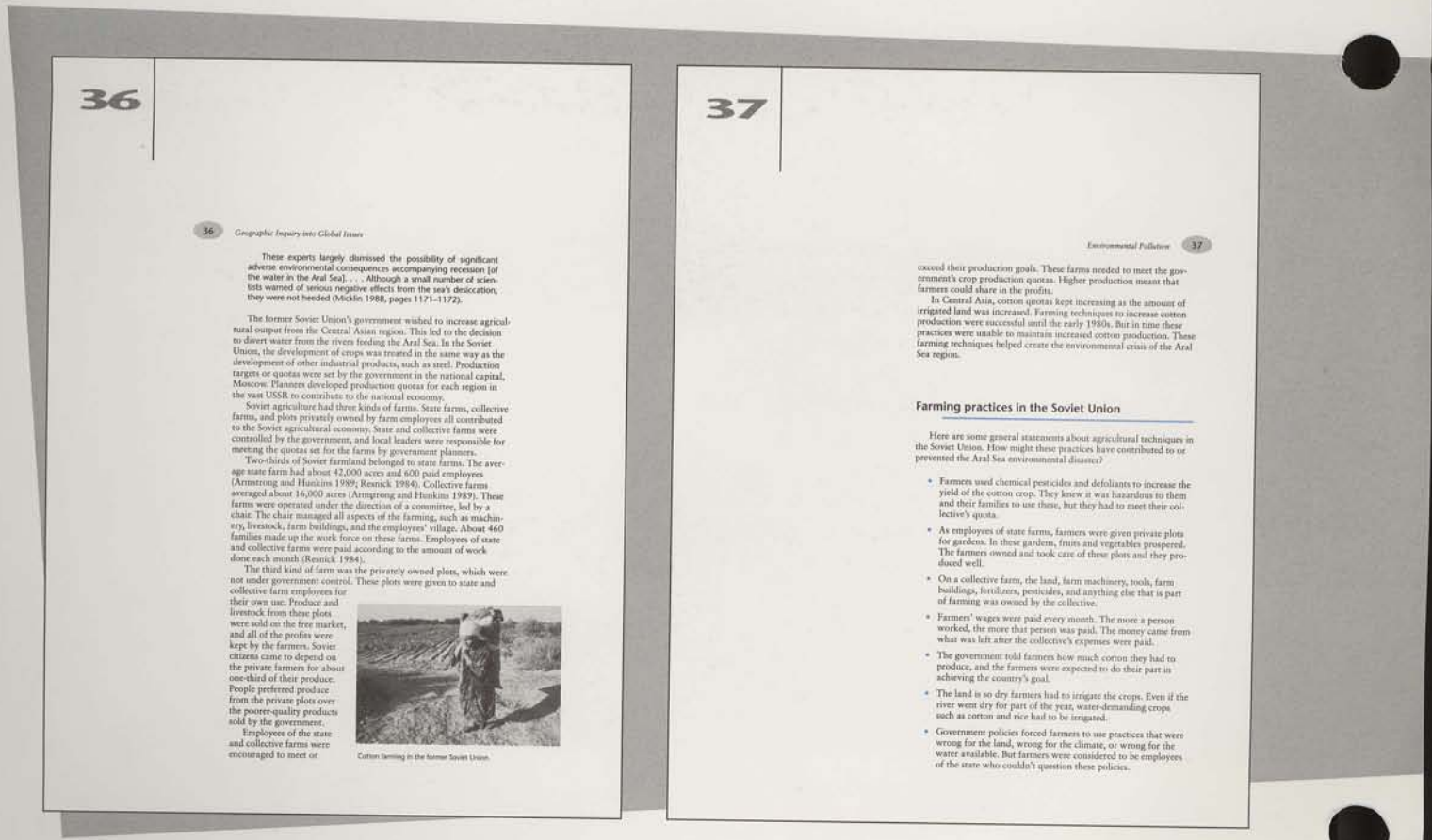
How could an environmental disaster such as the Aral Sea occur?

During planning for a major expansion of irrigation in the Aral Sea basin, conducted in the 1950s and 1960s, it was predicted that this would reduce inflow to the sea and substantially reduce its size. At the time, a number of experts saw this as a worthwhile tradeoff: A cubic meter of river water used for irrigation would bring far more value than the same cubic meter delivered to the Aral Sea. They based this calculation on a simple comparison of economic gains from irrigated agriculture against tangible economic benefits from the sea. Indeed, the ultimate shrinkage of the Aral to a residual brine lake as all its inflow was devoted to agriculture and other economic needs was viewed as both desirable and inevitable.

quotas. (Bear in mind that the system being discussed existed prior to any agricultural reforms that may transpire from the independence of the Central Asian republics.) The main point is that crop production was planned not by local farmers or even by regional agencies, but rather by planners located in a different part of the country. Contrast this system to that in the United States, in which farmers typically make decisions in consultation with county extension agents. A key theme of this lesson is that agricultural decisions made by those who know the land best are likely to be more efficient than plans made by people far removed from the local context. It may help to show the program on the Soviet Union from the *Global Geography* video series, "Why Does Planning Occur?" See "Related Videos" listed in the *Extension Activities and Resources* section.

B. Now turn to the text entitled "Farming practices in the Soviet Union" on page 37. Divide the class into pairs or small groups. For each of the seven items listed, have students determine whether each practice contributed to the origin of the problem or helped prevent it. (Alternatively, you can put the seven items up on a transparency and take a vote on each, polling the entire class.) [Opinions will of course vary here. One possible assessment is that all but the second item (describing the prosperity of the private farms) contributes to a value system wherein economic resources (that is, crops) are given priority over environmental resources (in this case, the Aral region's ecosystem and human population). However, the class may not agree with this assessment, which is perfectly acceptable.]

Discuss how these agricultural policies place different values on economic, social, and



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These experts largely dismissed the possibility of significant adverse environmental consequences accompanying recession [of the water in the Aral Sea]. . . . Although a small number of scientists warned of serious negative effects from the sea's desiccation, they were not heeded (Micklin 1988, pages 1171–1172).

The former Soviet Union's government wished to increase agricultural output from the Central Asian region. This led to the decision to divert water from the rivers feeding the Aral Sea. In the Soviet Union, the development of crops was treated in the same way as the development of other industrial products, such as steel. Production targets or quotas were set by the government in the national capital, Moscow. Planners developed production quotas for each region in the vast USSR to contribute to the national economy.

Soviet agriculture had three kinds of farms. State farms, collective farms, and plots privately owned by farm employees all contributed to the Soviet agricultural economy. State and collective farms were controlled by the government, and local leaders were responsible for meeting the quotas set for the farms by government planners.

Two-thirds of Soviet farmland belonged to state farms. The average state farm had about 42,000 acres and 600 paid employees (Armstrong and Hunkins 1989; Resnick 1984). Collective farms averaged about 16,000 acres (Armstrong and Hunkins 1989). These farms were operated under the direction of a committee, led by a chair. The chair managed all aspects of the farming, such as machinery, livestock, farm buildings, and the employees' village. About 460 families made up the work force on these farms. Employees of state and collective farms were paid according to the amount of work done each month (Resnick 1984).

The third kind of farm was the privately owned plots, which were not under government control. These plots were given to state and collective farm employees for their own use. Produce and livestock from these plots were sold on the free market, and all of the profits were kept by the farmers. Soviet citizens came to depend on the private farmers for about one-third of their produce. People preferred produce from the private plots over the poorer-quality products sold by the government.

Employees of the state and collective farms were encouraged to meet or

Cotton farming in the former Soviet Union.

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exceed their production goals. These farms needed to meet the government's crop production quotas. Higher production meant that farmers could share in the profits.

In Central Asia, cotton quotas kept increasing as the amount of irrigated land was increased. Farming techniques to increase cotton production were successful until the early 1980s. But in time these practices were unable to maintain increased cotton production. These farming techniques helped create the environmental crisis of the Aral Sea region.

Farming practices in the Soviet Union

Here are some general statements about agricultural techniques in the Soviet Union. How might these practices have contributed to or prevented the Aral Sea environmental disaster?

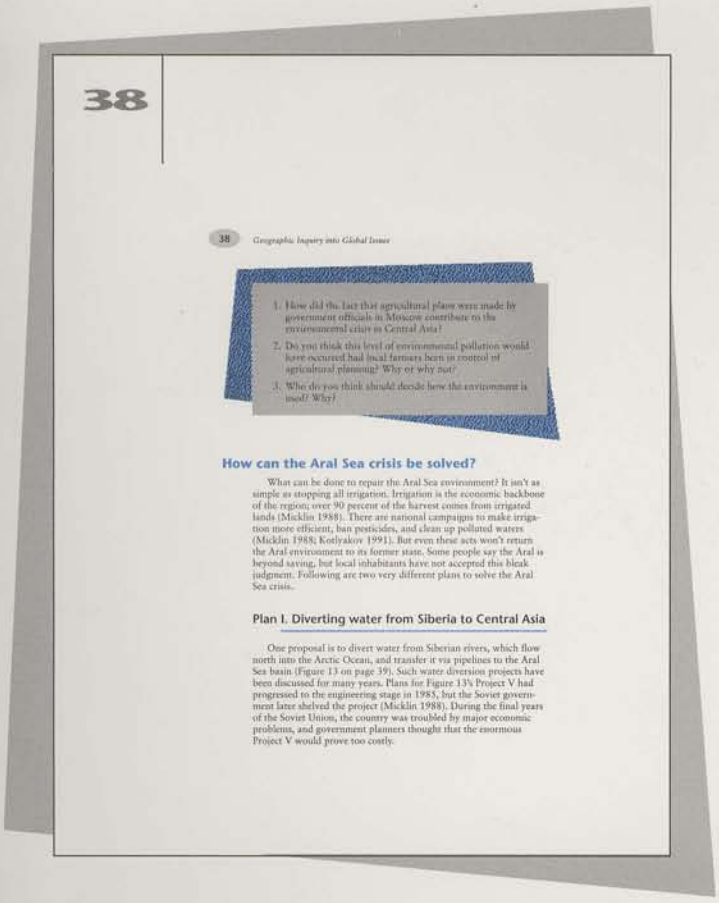
- Farmers used chemical pesticides and defoliants to increase the yield of the cotton crop. They knew it was hazardous to them and their families to use these, but they had to meet their collective's quota.
- As employees of state farms, farmers were given private plots for gardens. In these gardens, fruits and vegetables prospered. The farmers owned and took care of these plots and they produced well.
- On a collective farm, the land, farm machinery, tools, farm buildings, fertilizers, pesticides, and anything else that is part of farming was owned by the collective.
- Farmers' wages were paid every month. The more a person worked, the more that person was paid. The money came from what was left after the collective's expenses were paid.
- The government told farmers how much cotton they had to produce, and the farmers were expected to do their part in achieving the country's goal.
- The land is so dry farmers had to irrigate the crops. Even if the river went dry for part of the year, water-demanding crops such as cotton and rice had to be irrigated.
- Government policies forced farmers to use practices that were wrong for the land, wrong for the climate, or wrong for the water available. But farmers were considered to be employees of the state who couldn't question these policies.

Questions and Answers for page 38

1. How did the fact that agricultural plans were made by government officials in Moscow contribute to the environmental crisis in Central Asia?
   - Answers will vary.

2. Do you think this level of environmental pollution would have occurred had local farmers been in control of agricultural planning? Why or why not?
   - Answers will vary.

3. Who do you think should decide how the environment is used? Why?
   - Answers will vary.


38

38 Geography: Inquiry into Global Issues

1. How did the fact that agricultural plans were made by government officials in Moscow contribute to the environmental crisis in Central Asia?
2. Do you think this level of environmental pollution would have occurred had local farmers been in control of agricultural planning? Why or why not?
3. Who do you think should decide how the environment is used? Why?

How can the Aral Sea crisis be solved?

What can be done to repair the Aral Sea environment? It isn't as simple as stopping all irrigation. Irrigation is the economic backbone of the region; over 90 percent of the harvest comes from irrigated lands (Micklin 1988). There are national campaigns to make irrigation more efficient, ban pesticides, and clean up polluted waters (Micklin 1988; Kotlyakov 1991). But even these acts won't return the Aral environment to its former state. Some people say the Aral is beyond saving, but local inhabitants have not accepted this bleak judgment. Following are two very different plans to solve the Aral Sea crisis.

Plan I. Diverting water from Siberia to Central Asia

One proposal is to divert water from Siberian rivers, which flow north into the Arctic Ocean, and transfer it via pipelines to the Aral Sea basin (Figure 13 on page 39). Such water diversion projects have been discussed for many years. Plans for Figure 13's Project V had progressed to the engineering stage in 1985, but the Soviet government later shelved the project (Micklin 1988). During the final years of the Soviet Union, the country was troubled by major economic problems, and government planners thought that the enormous Project V would prove too costly.

environmental concerns. Ask the class whether they think these kinds of policies are workable over long time spans, such as 25 years (with respect to ecological stability).

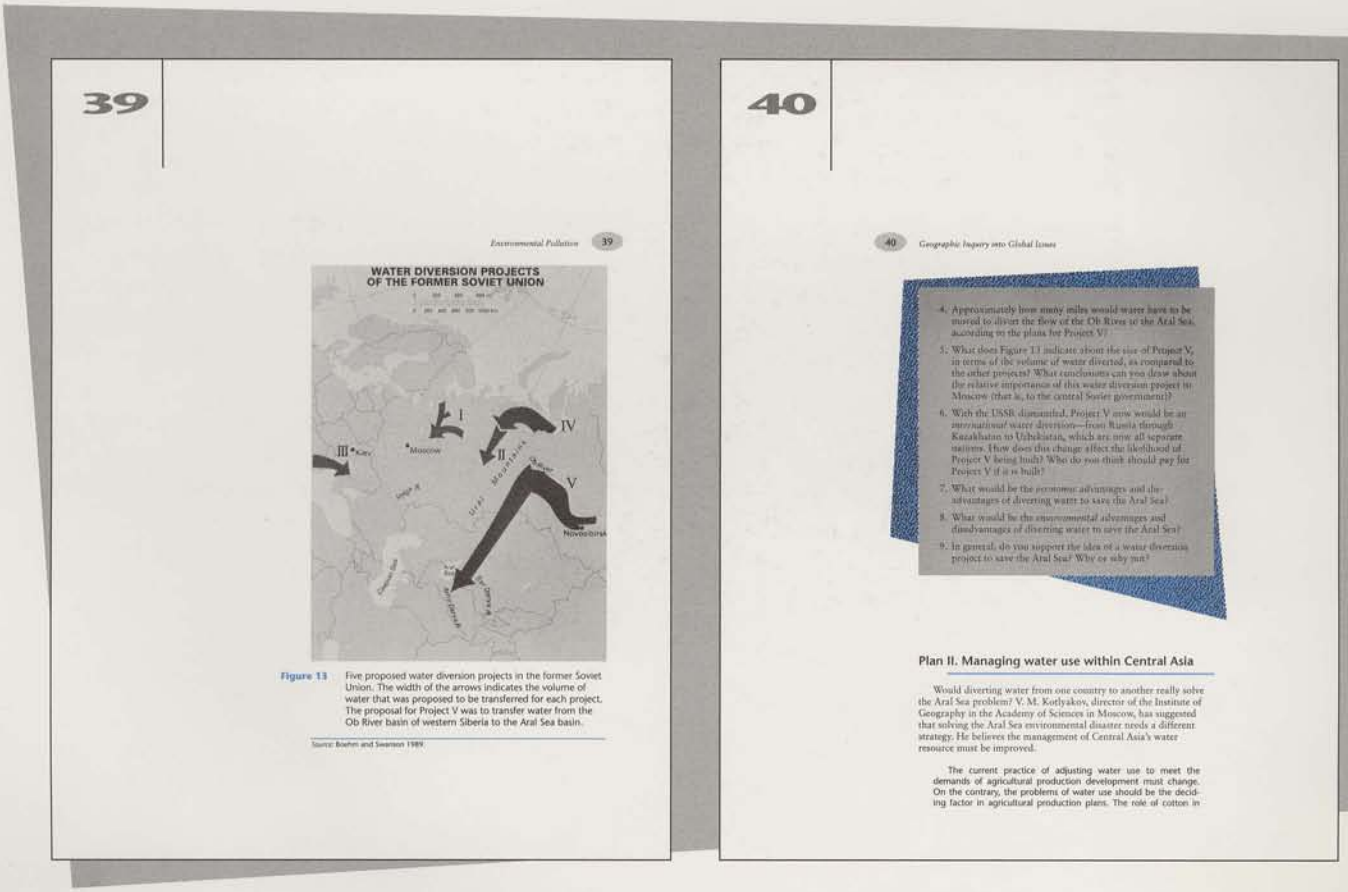
C. Conclude by discussing Questions 1–3 on page 38. Answers will vary according to the opinions of the students. Be sure to have students explain and defend their choices. (These three questions might well form the basis for a written homework assignment.) The final question, "Who do you think should decide how the environment is used?" hints at the conflict between local control and government control that is at the heart of many environmental debates in the United States as well as the former Soviet Union. [Caution must be taken here, because it is not an invariable rule that local control is better than national control. Sometimes local people can be just as eager as central governments for economic gain at the expense of an environmental resource's stability. Also, it is important not to be too critical of the Soviet system per se. Many environmental conflicts in the United States were the result of decisions made by govern-

ment officials who were unaware of the value of an environmental resource (e.g., the damming of Glen Canyon). Challenge your students to come up with local examples of environmental pollution in which a resource was damaged for the sake of economic gain.]

How can the Aral Sea crisis be solved? (pages 38–42)

D. Students should read the introductory text, "Plan I. Diverting water from Siberia to Central Asia," and Figure 13 (pages 38–39). Questions 4–9 on page 40 concern Figure 13. Answers to these questions can be discussed individually, in pairs, or in groups. However, allow time for a discussion with the entire class as well.

E. Next have the class read "Plan II. Managing water use within Central Asia" on pages 40–42. If necessary, explain the extract from Kotlyakov and the plan offered by the scientists participating at the 1990 conference. Discuss Questions 10–14 on page 42.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Environmental Pollution 39

WATER DIVERSION PROJECTS OF THE FORMER SOVIET UNION

Figure 13 Five proposed water diversion projects in the former Soviet Union. The width of the arrows indicates the volume of water that was proposed to be transferred for each project. The proposal for Project V was to transfer water from the Ob River basin of western Siberia to the Aral Sea basin.

Source: Boehm and Swanson 1989

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40 *Geographic Inquiry into Global Issues*

4. Approximately how many miles would water have to be moved to divert the flow of the Ob River to the Aral Sea, according to the plans for Project V?
5. What does Figure 13 indicate about the size of Project V, in terms of the volume of water diverted, as compared to the other projects? What conclusions can you draw about the relative importance of this water diversion project to Moscow (that is, to the central Soviet government)?
6. With the USSR dismantled, Project V now would be an *international* water diversion—from Russia through Kazakhstan to Uzbekistan, which are now all separate nations. How does this change affect the likelihood of Project V being built? Who do you think should pay for Project V if it is built?
7. What would be the economic advantages and disadvantages of diverting water to save the Aral Sea?
8. What would be the environmental advantages and disadvantages of diverting water to save the Aral Sea?
9. In general, do you support the idea of a water diversion project to save the Aral Sea? Why or why not?

Plan II. Managing water use within Central Asia

Would diverting water from one country to another really solve the Aral Sea problem? V. M. Kotlyakov, director of the Institute of Geography in the Academy of Sciences in Moscow, has suggested that solving the Aral Sea environmental disaster needs a different strategy. He believes the management of Central Asia's water resource must be improved.

The current practice of adjusting water use to meet the demands of agricultural production development must change. On the contrary, the problems of water use should be the deciding factor in agricultural production plans. The role of cotton in

Questions and Answers for page 40

4. Approximately how many miles would water have to be moved to divert the flow of the Ob River to the Aral Sea, according to the plans for Project V?

   - By Figure 13's scale, diversion from the Ob to the Aral is at least 1,500 miles.

5. What does Figure 13 indicate about the size of Project V, in terms of the volume of water diverted, as compared to the other projects? What conclusions can you draw about the relative importance of this water diversion project to Moscow (that is, to the central Soviet government)?

   - The caption indicates that there is a very large amount of water proposed for diversion relative to the other projects. This implies that there must be a great need or demand for this project from the central government planners.

6. With the USSR dismantled, Project V now would be an *international* water diversion—from Russia through Kazakhstan to Uzbekistan, which are now all separate nations. How does this change affect the likelihood of Project V being built? Who do you think should pay for Project V if it is built?

   - Exact answers here are unknown, owing to the uncertain status of the Commonwealth of Independent States and the fluidity of international cooperation among its members. That such massive projects can no longer be implemented from a powerful central authority (Moscow) reduces the likelihood of construction. Also, most of the new countries are in economic and political disarray, so cooperation to build such a project may be unlikely for now.

7. What would be the *economic* advantages and disadvantages of diverting water to save the Aral Sea?

   - Economic (and political advantages) include an increase in jobs during the construction of the diversion project, renewal of the Aral's fishing industry, and continued increases in irrigated land for crops. All this may increase the quality of life for the residents of that area, lessening social problems. Disadvantages include the high cost of the project and the fact that other parts of the former Soviet Union, particularly the regions served by the Ob River, may protest aid to another region.

8. What would be the *environmental* advantages and disadvantages of diverting water to save the Aral Sea?

   - Environmental advantages include more water in the Aral Sea, increased water for soils to reduce salinization, and a chance for vegetation to stabilize the salt badlands. Disadvantages are mainly concentrated in the regions *from* which the water is diverted: Reduced volume may cause land in the northern parts of the country to become dry, and loss of water in the Ob River may have ill effects on the fish, bird, and mammal species that depend on the river.

continued

9. In general, do you support the idea of a water diversion project to save the Aral Sea? Why or why not?

   - The key is for the class to recognize that this plan involves trade-offs between the environmental and economic conditions in two regions. Many more people live in the Aral Sea area than in the Ob River basin, so some students may feel the trade-off is acceptable. Others may feel that this plan merely transfers the problem from one place to another.

Questions and Answers for page 42

10. Kotlyakov emphasized that water use should dictate agricultural planning and not the other way around. Why? Do you agree? Why or why not?

    - The point here is that sometimes the physical environment limits what can be done. In this case, agricultural planners may have asked for too much production of water-intensive crops from this desert area.

11. What does Kotlyakov mean when he says that saving the Aral Sea "will require a new attitude"? How do you think this could be achieved?

    - Kotlyakov suggests that the root of the problem is really in the perspectives that people have about the environment and about conservation of water and other resources.

12. How would each of the four recommended steps stabilize the Aral Sea and maintain the region's environmental quality?

    - All of these steps are meant to lower water use in the region, to allow more flow back into the Aral. Cutting down irrigation will also help reverse soil salinization. Revising the type of crop that is produced shifts farming from water-hungry crops (rice, cotton) to crops more suited to the desert environment. Drainage of polluted water into the lake contributes to the salinity and chemical pollution that has killed the fish and damaged the habitats.

13–14. Which of the two proposed solutions to save the Aral—water diversion or water management—do you think is better? Why? Why do you think other people would disagree? Which plan would be more difficult to undertake? Why?

    - While these are clearly opinion questions, use the discussion to contrast the perspectives implicit in the two plans. The point here is that the Aral Sea crisis resulted from a values conflict between promoting massive economic development and sustaining a quality environment. In the water diversion plan, the problems created by the Aral Sea Project are remedied by resorting to another large-scale project, posing similar potential environmental problems elsewhere. Ask the class if this really solves the problem or merely moves it elsewhere. To achieve the water management plan would require people in the Aral region to make major changes in their use of the environment. This plan may represent a harder choice because shifts in fundamental perspectives are involved.

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the country's economy also should be reconsidered to increase the production of foodstuffs and to introduce more salt-resistant and less water-intensive crops.

The water resources of Central Asia must be inventoried. Special attention should be given to increasing the efficiency of water-[saving] systems, decreasing irrigation quotas by 15 to 20 percent, optimizing drainage systems to reduce water consumption, and improving regulation of runoff. The water freed in this way should be used primarily for resolving ecological imbalances to reinstate the normal conditions of life and health for local populations.

Saving the Aral region and resolving its tangle of ecological, hydrological, and socioeconomic problems will require a new attitude and an entirely new approach to economic activity throughout Central Asia. Agriculture and other branches of the economy should be allowed to return to their traditional forms, which have been destroyed over the past decades, and attitudes toward water use should be changed (Kotlyakov 1991, pages 36–38).

At a 1990 conference in Nukus, the capital of the Uzbekistan province of Karakalpakia, over 200 scientists met to develop a plan to save the Aral Sea. These scientists included specialists in water management, ecology, and medicine. People attended from all countries in the Aral Sea basin as well as from Russia, the United States, and over 25 other countries.

Girls and cattle at a water hole in the Aral Sea region.

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These scientists *unanimously* agreed that the water level of the Aral Sea must be stabilized to restore the ecological health of the region. They argued that the region's economy would be restored if the environmental problems were repaired. People's health would improve and social tensions would be reduced. They recommended that these four steps be taken to manage the region's water resource and stabilize the Aral Sea (Kotlyakov 1991):

- Strictly limit use of water by countries in the region and introduce water-saving technology in all areas of the economy;
- Prohibit expansion of the land area under irrigation to free river flow for preserving the Aral Sea;
- Limit rice and cotton agriculture and remove unproductive land from irrigation. Develop instead orchards, vineyards, and alfalfa crops;
- Remove systems that drain polluted agricultural runoff from irrigated land to the Aral Sea.

10. Kotlyakov emphasized that water use should dictate agricultural planning and not the other way around. Why? Do you agree? Why or why not?
11. What does Kotlyakov mean when he says that saving the Aral Sea "will require a new attitude"? How do you think this could be achieved?
12. How would each of the four recommended steps stabilize the Aral Sea and maintain the region's environmental quality?
13. Which of the two proposed solutions to save the Aral—water diversion or water management—do you think is better? Why? Why do you think other people would disagree?
14. Which plan would be more difficult to undertake? Why?

Lesson 6

How has the pollution of the Aral Sea affected people's perspectives?

Time Required

One 50-minute class period. This lesson may also be used *following* Lesson 7 as closure for the entire module, in lieu of Lesson 8. Students can thus also express their feelings about the Madagascar and Mono Lake case studies.

Materials Needed

Butcher paper
Drawing paper
Marking pens or colored pencils
Samples of political cartoons from newspapers

Glossary Word

environment

Getting Started

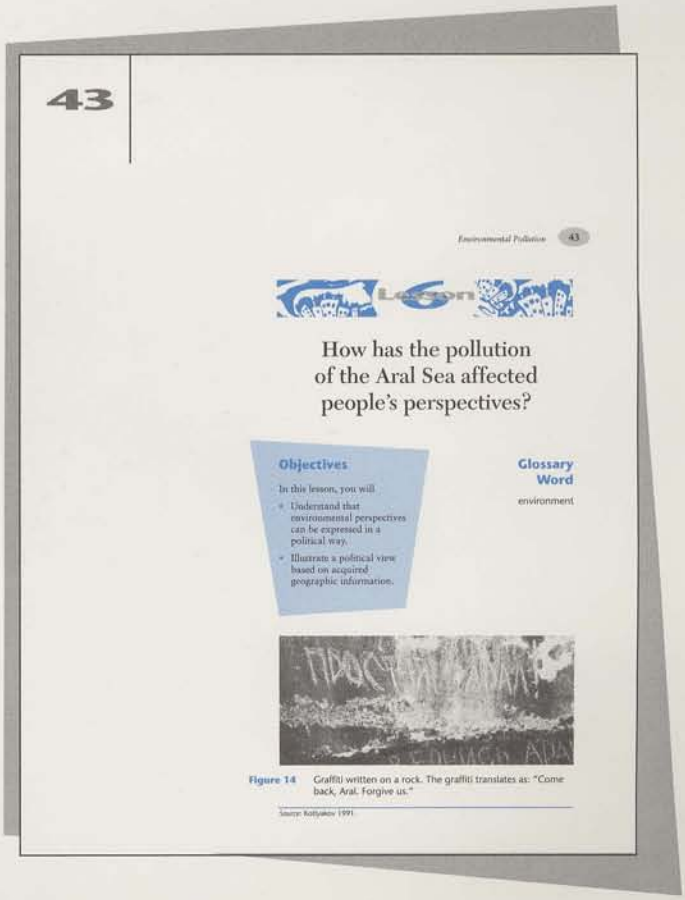
Have students look at Figure 14, the photo showing graffiti on a rock (page 43). Conduct a brief discussion challenging students to describe the perspectives of the graffiti's author. Include the following questions in the discussion:

What kinds of feelings does the author's statement seem to express?

Do you think the author reflects or expresses the sentiments of other people living in the Aral region?

Why does the author personify the Aral Sea in this graffiti message, giving it the human characteristic of forgiveness?

Who is the real audience being addressed (assuming the Aral itself cannot respond!)?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Environmental Pollution 43

Lesson 6

How has the pollution of the Aral Sea affected people's perspectives?

Objectives

In this lesson, you will

- Understand that environmental perspectives can be expressed in a political way.
- Illustrate a political view based on acquired geographic information.

Glossary Word

environment

Figure 14 Graffiti written on a rock. The graffiti translates as: "Come back, Aral. Forgive us."

Source: Kotlyakov 1991

Procedures

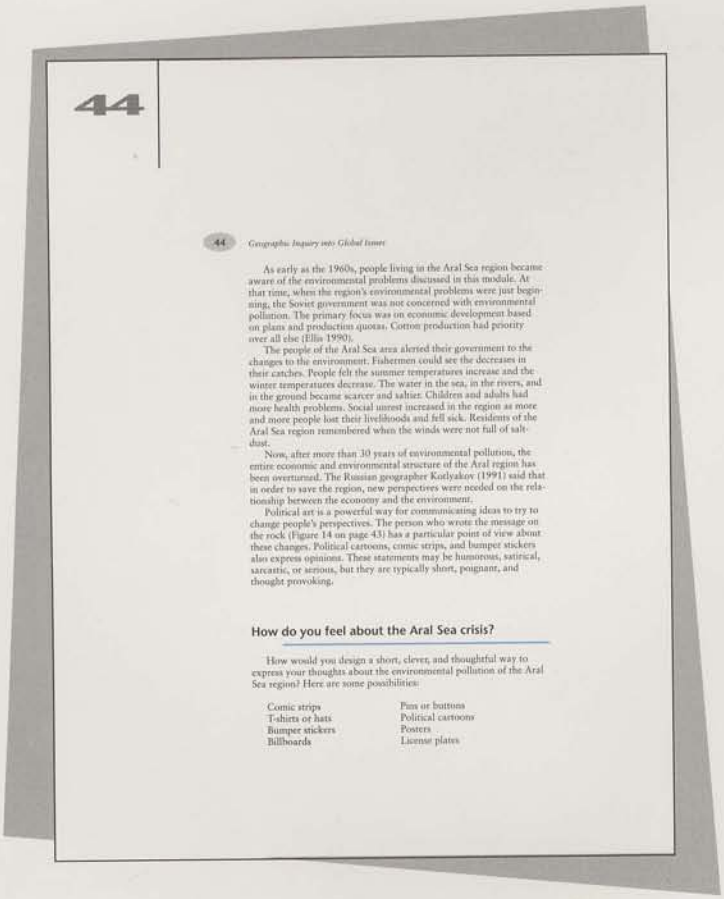
A. Have students read the text on page 44 (up to the section entitled "How do you feel about the Aral Sea crisis?"). This summarizes the issue, taking the perspective of the residents of the Aral region. It also introduces the idea of political art—art used to express a particular perspective. Bring in some examples of political art, such as newspapers to show political cartoons or comic strips.

> Older students may be challenged to identify whether this text is biased. For instance, you might ask what would be emphasized in a text trying to promote the success of the Aral Sea Project (e.g., increased income from cotton farming). Older students can also be asked to bring in (before the lesson) examples of political art related to local issues of interest.

B. Have students create a piece of political art that expresses their thoughts about the environmental crisis they have been studying. Page 44 in the Student DataBook provides a partial list of possible ways to complete this assignment.

Pass out enough drawing paper (or butcher paper) and a variety of colored marking pens or pencils so that each student has sufficient materials for the activity. Should some students be uncomfortable with drawing, they can work in pairs with another student who can do the actual artwork for the idea. In any case, all students should be responsible either for the design or for the execution of a piece of political art.

C. Post the finished work around the class for everyone to view. With the whole class reconvened, ask students to give a brief explanation of their ideas and ask for comments.



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44 *Geographic Inquiry into Global Issues*

As early as the 1960s, people living in the Aral Sea region became aware of the environmental problems discussed in this module. At that time, when the region's environmental problems were just beginning, the Soviet government was not concerned with environmental pollution. The primary focus was on economic development based on plans and production quotas. Cotton production had priority over all else (Ellis 1990).

The people of the Aral Sea area alerted their government to the changes to the environment. Fishermen could see the decreases in their catches. People felt the summer temperatures increase and the winter temperatures decrease. The water in the sea, in the rivers, and in the ground became scarcer and saltier. Children and adults had more health problems. Social unrest increased in the region as more and more people lost their livelihoods and fell sick. Residents of the Aral Sea region remembered when the winds were not full of salt-dust.

Now, after more than 30 years of environmental pollution, the entire economic and environmental structure of the Aral region has been overturned. The Russian geographer Kotlyakov (1991) said that in order to save the region, new perspectives were needed on the relationship between the economy and the environment.

Political art is a powerful way for communicating ideas to try to change people's perspectives. The person who wrote the message on the rock (Figure 14 on page 43) has a particular point of view about these changes. Political cartoons, comic strips, and bumper stickers also express opinions. These statements may be humorous, satirical, sarcastic, or serious, but they are typically short, poignant, and thought provoking.

How do you feel about the Aral Sea crisis?

How would you design a short, clever, and thoughtful way to express your thoughts about the environmental pollution of the Aral Sea region? Here are some possibilities:

- Comic strips
- T-shirts or hats
- Bumper stickers
- Billboards
- Pins or buttons
- Political cartoons
- Posters
- License plates

Lesson 7

How has Madagascar's environment been degraded?

Time Required

Two 50-minute class periods. Each day's activities can stand independently; one or both days can be omitted if you wish to cut time on the module.

Materials Needed

Butcher paper
Marking pens or colored pencils
Drawing paper
Copies of Activity 3 for all students
Mini-Atlas map 4

Glossary Words

biodiversity	hectare
ecosystem	shifting cultivation
environment	subsistence farming

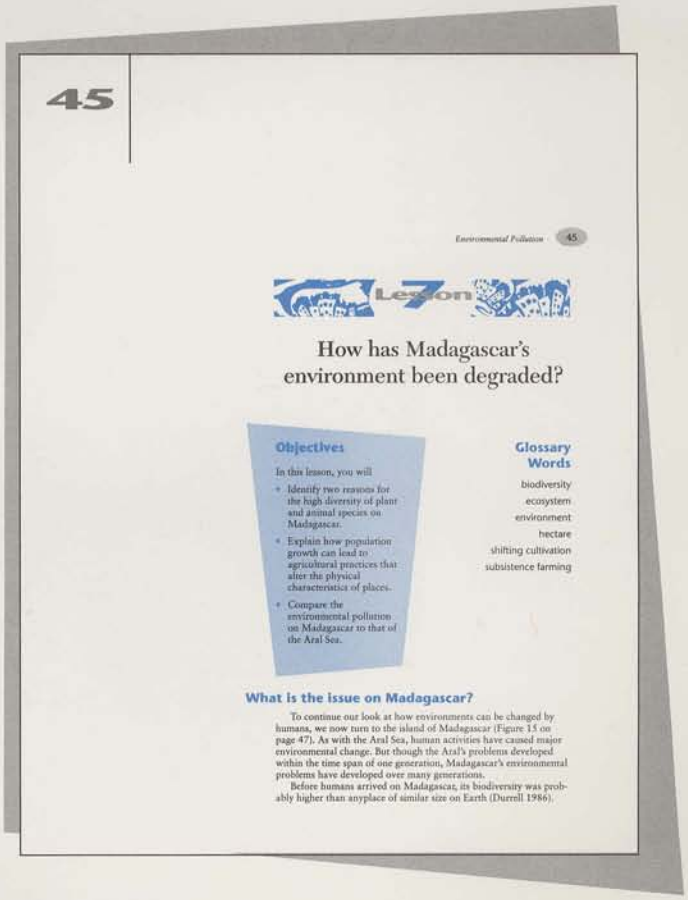
Getting Started

Prior to beginning this lesson, explain to students that, having investigated one area affected by environmental pollution (the Aral Sea), they now briefly examine the severe environmental degradation on Madagascar. Ask students to define *degradation* to stress what happens to environments that are seriously polluted. It may help to ask what it means to degrade somebody (to reduce in status, to corrupt) to equate what has happened to environments that humans have severely abused.

Procedures

What is the issue on Madagascar? (pages 45–48)

A. First, using **Mini-Atlas map 4** of world physical features, have students describe the absolute and relative location of Madagascar. Ask the class what general climatic conditions (temperature, rainfall) one would expect in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Lesson 7

How has Madagascar's environment been degraded?

Objectives

In this lesson, you will

- Identify two reasons for the high diversity of plant and animal species on Madagascar.
- Explain how population growth can lead to agricultural practices that alter the physical characteristics of places.
- Compare the environmental pollution on Madagascar to that of the Aral Sea.

Glossary Words

biodiversity
ecosystem
environment
hectare
shifting cultivation
subsistence farming

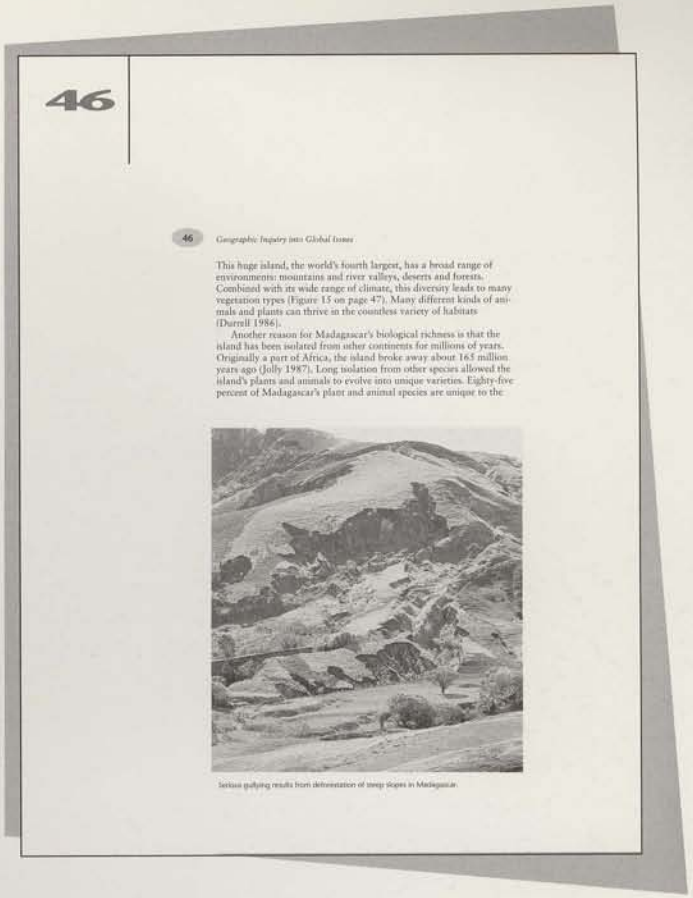
What is the issue on Madagascar?

To continue our look at how environments can be changed by humans, we now turn to the island of Madagascar (Figure 15 on page 47). As with the Aral Sea, human activities have caused major environmental change. But though the Aral's problems developed within the time span of one generation, Madagascar's environmental problems have developed over many generations.

Before humans arrived on Madagascar, its biodiversity was probably higher than anyplace of similar size on Earth (Durrell 1986).

these latitudes. [Absolute location: between 12° and 25°S latitude and 43° to 50°E longitude. Relative location: in Indian Ocean, just off the coast of southeast Africa. This is a tropical location, and students may have an image of this as a warm and wet environment the whole year round.]

B. Ask students to read the text on pages 45–48, which emphasizes that the once-diverse biota on Madagascar is threatened because of removal of the forests. Questions 1–8 on page 48 introduce some basic concepts in biogeography to help explain why the species diversity on Madagascar was once so great. Students can work in pairs on these questions, but younger students may have difficulty with some of the exercises and may need additional guidance. You may wish to lead the entire class through the questions.



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46 *Geographic Inquiry into Global Issues*

This huge island, the world's fourth largest, has a broad range of environments: mountains and river valleys, deserts and forests. Combined with its wide range of climate, this diversity leads to many vegetation types (Figure 15 on page 47). Many different kinds of animals and plants can thrive in the countless variety of habitats (Durrell 1986).

Another reason for Madagascar's biological richness is that the island has been isolated from other continents for millions of years. Originally a part of Africa, the island broke away about 165 million years ago (Jolly 1987). Long isolation from other species allowed the island's plants and animals to evolve into unique varieties. Eighty-five percent of Madagascar's plant and animal species are unique to the

Serious gullying results from deforestation of steep slopes in Madagascar.

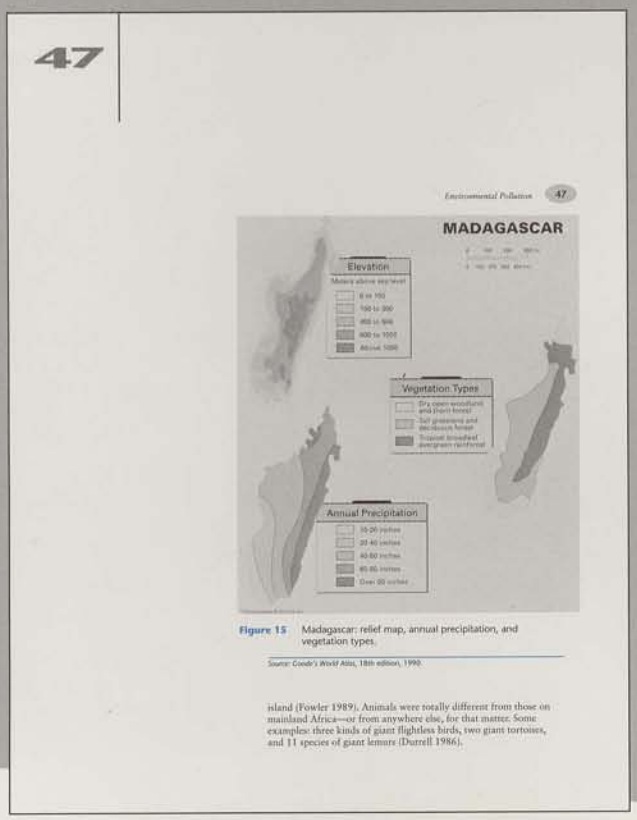

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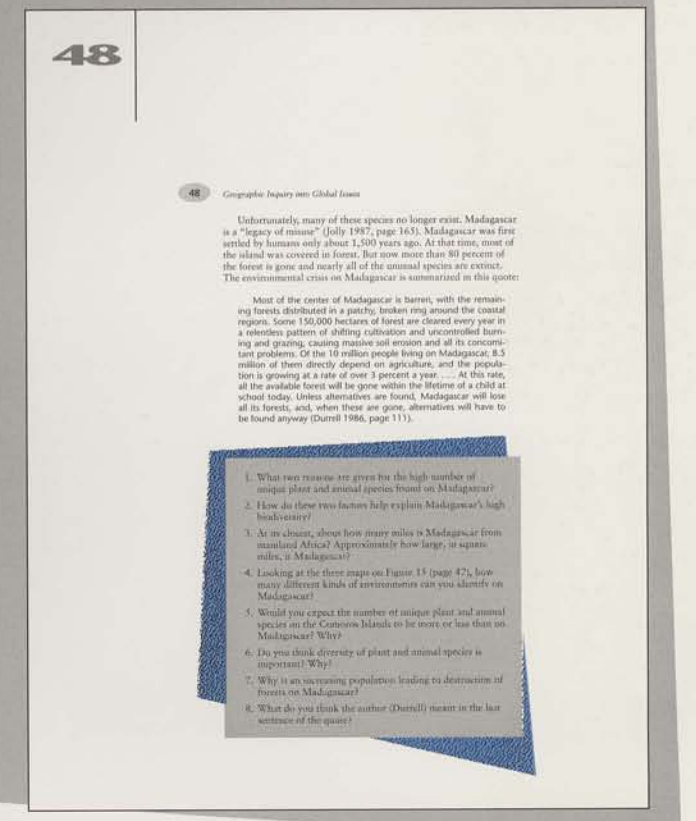
Figure 15 Madagascar: relief map, annual precipitation, and vegetation types.

Source: Goode's World Atlas, 18th edition, 1990.

island (Fowler 1989). Animals were totally different from those on mainland Africa—or from anywhere else, for that matter. Some examples: three kinds of giant flightless birds, two giant tortoises, and 11 species of giant lemurs (Durrell 1986).



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48 *Geographic Inquiry into Global Issues*

Unfortunately, many of these species no longer exist. Madagascar is a "legacy of misuse" (Jolly 1987, page 165). Madagascar was first settled by humans only about 1,500 years ago. At that time, most of the island was covered in forest. But now more than 80 percent of the forest is gone and nearly all of the unusual species are extinct. The environmental crisis on Madagascar is summarized in this quote:

> Most of the center of Madagascar is barren, with the remaining forests distributed in a patchy, broken ring around the coastal regions. Some 150,000 hectares of forest are cleared every year in a relentless pattern of shifting cultivation and uncontrolled burning and grazing, causing massive soil erosion and all its concomitant problems. Of the 10 million people living on Madagascar, 8.5 million of them directly depend on agriculture, and the population is growing at a rate of over 3 percent a year. . . . At this rate, all the available forest will be gone within the lifetime of a child at school today. Unless alternatives are found, Madagascar will lose all its forests, and, when these are gone, alternatives will have to be found anyway (Durrell 1986, page 111).

1. What two reasons are given for the high number of unique plant and animal species found on Madagascar?
2. How do these two factors help explain Madagascar's high biodiversity?
3. At its closest, about how many miles is Madagascar from mainland Africa? Approximately how large, in square miles, is Madagascar?
4. Looking at the three maps on Figure 15 (page 47), how many different kinds of environments can you identify on Madagascar?
5. Would you expect the number of unique plant and animal species on the Comoros Islands to be more or less than on Madagascar? Why?
6. Do you think diversity of plant and animal species is important? Why?
7. Why is an increasing population leading to destruction of forests on Madagascar?
8. What do you think the author (Durrell) meant in the last sentence of the quote?

Questions and Answers for page 48

1. What two reasons are given for the high number of unique plant and animal species found on Madagascar?

   - The reasons are (1) the broad diversity in habitats and (2) the isolation of the island from the mainland.

2. How do these two factors help explain Madagascar's high biodiversity?

   - Habitat diversity provides many opportunities for plants and animals adapted to different environmental conditions to exist. Students may be able to identify with this idea more easily if you ask them to name some animals and plants that live in deserts and some that live in forests—the lists are very different. If a place has *both* deserts and forests, then both sets of biota can exist, and total biodiversity is higher. Isolation from the mainland is important because, over geologic time, unique species evolve that differ from their counterparts on the mainland. The sea acts as a barrier to mixing, keeping the species separate and unique. Australia is a great example of this (kangaroos, koalas, platypuses, and so on).

3. At its closest, about how many miles is Madagascar from mainland Africa? Approximately how large, in square miles, is Madagascar?

   - Using the map scale on Figure 15's relief map, students can estimate that, at its closest, Madagascar is about 225–250 miles from the Mozambique coast. With the map scale, the approximate size of the island can be determined (very roughly) by figuring the width [About 225 miles] and the length [About 1,000 miles]. Area is equal to width times length, so the area of Madagascar is about 225,000 square miles. (If arithmetic is too advanced for your class, save time by giving this answer. You might note that this is almost as large as Texas. Students can use an almanac to make this comparison.)

4. Looking at the three maps on Figure 15, how many different kinds of environments can you identify on Madagascar?

   - Make a game of this question by giving each student a couple minutes to list different mixtures of relief and precipitation for each of the three vegetation types. For example, within the "tall grassland and deciduous forest" vegetation type, one can identify environments at both moderate and high altitudes and rainfall amounts ranging from 20 inches up to 80 inches. Within the "dry open woodland and thorn forest" type, there are both coastal plains and moderate altitudes with rainfall amounts from 10 inches up to 80 inches. The point here is that there would be plant and animal species adapted to live in many different kinds of environments—hence, high species diversity.

5. Would you expect the number of unique plant and animal species on the Comoros Islands to be more or less than Madagascar? Why?

   - Allow students to speculate on the relationships implied here. The Comoros are smaller than Madagascar and closer to the mainland. Other things being equal, one would expect fewer unique species on the Comoros because (1) there would not be the diversity of

continued

habitats available on the small islands (indeed, only thorn forest is found there), and (2) there would not be as great a barrier to migration from the mainland because the distance is not as great.

6. Do you think diversity of plant and animal species is important? Why?
   - This is an opinion question. To help focus discussion, ask: What is lost when unique species become extinct? Students are familiar with numerous threatened species: elephants, rhinos, etc. Some students may believe that every species has an inherent right to exist. Others may note that biodiversity has both aesthetic and economic value, as suggested by the numbers of medicines obtained from plants and animals. Still others may note that extinction is a natural process when species are unfit to adapt to changed environments.

7. Why is an increasing population leading to destruction of forests on Madagascar?
   - As population grows, the pressures for fuelwood and for agricultural land increase. The Durrell quote on page 48 notes that shifting cultivation, burning, and grazing are the problems leading to destruction of forests on Madagascar. Emphasize the time frame: At the present rate of use, all forests will be lost within the lifetime of today's children.

8. What do you think the author (Durrell) meant in the last sentence of the quote?
   - In the last sentence, the author is suggesting that something needs to be done because people will still be dependent on forest products even after the forests are gone. Sustaining the forests is therefore important because all animals, including humans, rely on these environments for the resources they need to live.

What is *shifting cultivation*? (pages 49–50)

C. Have students read the text on pages 49–50. Pause during the reading at the point where the text asks, "Why has the situation changed?" (end of third paragraph). Ask students to speculate about why things have changed to cause shifting cultivation to become a problem. Then have students read and discuss the extract "Why has shifting cultivation become a problem?" (pages 49–50). Students should see that population growth on Madagascar has made this historical system unstable.

D. After the students complete the reading, pass out **Activity 3.** Students should work in pairs or groups of three to complete this Activity. You will need to provide each group with a piece of butcher paper or drawing paper and colored markers or pens.

Students should follow the directions on the Activity. They should order the steps of the shifting cultivation cycle and put these steps into a diagram that illustrates this kind of farming. Have students create a circular diagram in order to illustrate the sequence of steps in the shifting cultivation cycle. See *Key for Activity 3.*

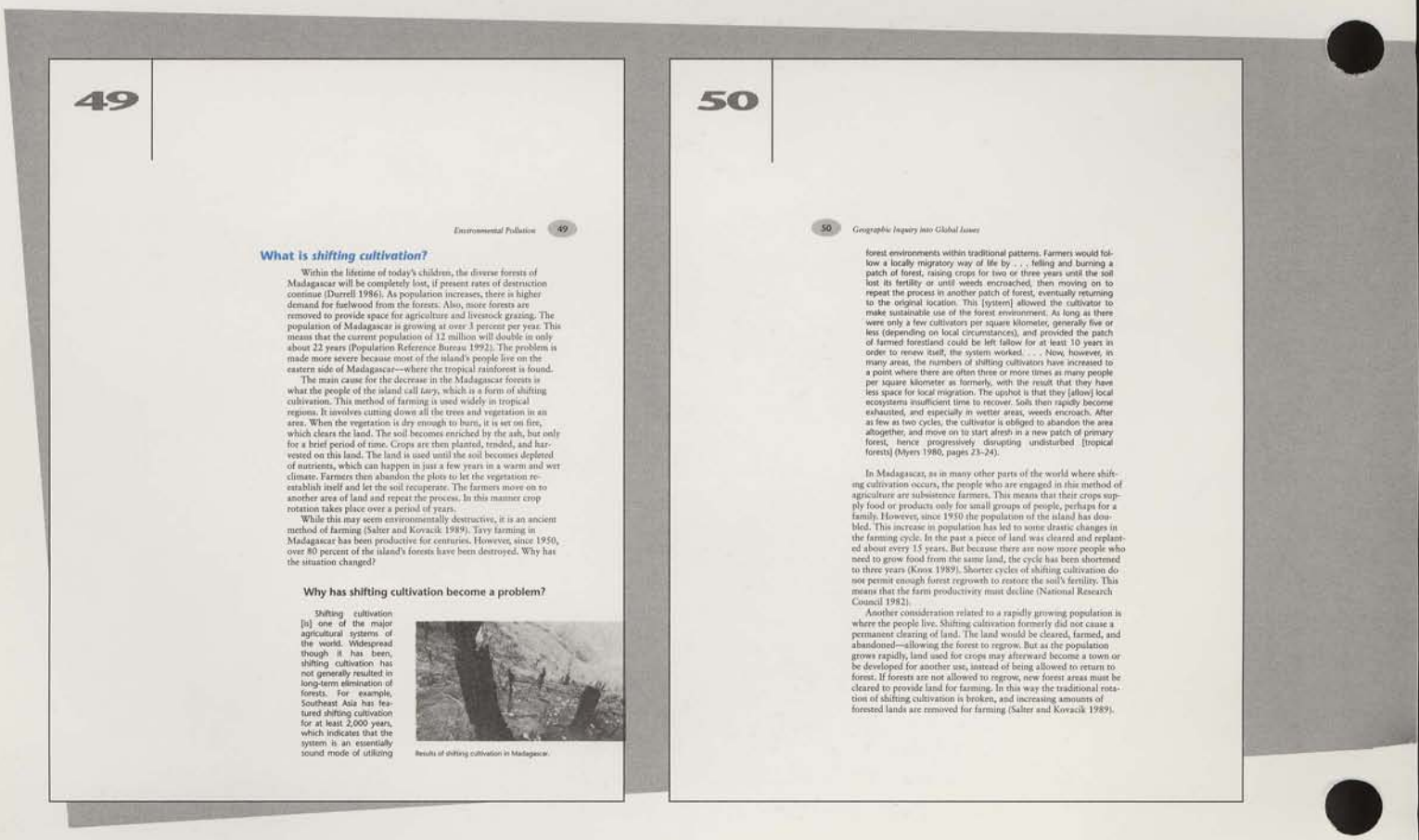
To get younger students started, it may help to create an overhead with a series of blank circles to show how to set up a circular flowchart. It is important that students grasp that the shifting cultivation system is a cycle.

E. Pairs or groups should then write short answers to Questions 2–4 on Activity 3 and share their answers with the entire class. Diagrams and answers can be posted around the room for viewing. Alternatively, each

group can select a reporter to read its answers. [The key point is that in a 3-year cycle, the forest does not have enough time to regrow. This means that in a shorter cycle of shifting cultivation, the soil does not get a chance to recuperate before the next planting. So, shorter cycles inevitably lead to a loss of productivity, which then requires that new forest lands be cleared. This accelerates the pace of deforestation. Also, land cleared but later used for something else can never return to forest.]

For Further Inquiry

- Test students' understanding of the basic biogeographic concepts covered in the lesson. Make up a hypothetical dataset of several islands of various size and distance from a mainland. Have students rank which would have the greatest number of unique species. [Larger islands, greater distance]
- Assign an essay having students compare the problems on Madagascar with those of the Aral region. What are the similarities? Are there any differences?



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Environmental Pollution 49

What is *shifting cultivation?*

Within the lifetime of today's children, the diverse forests of Madagascar will be completely lost, if present rates of destruction continue (Durrell 1986). As population increases, there is higher demand for fuelwood from the forests. Also, more forests are removed to provide space for agriculture and livestock grazing. The population of Madagascar is growing at over 3 percent per year. This means that the current population of 12 million will double in only about 22 years (Population Reference Bureau 1992). The problem is made more severe because most of the island's people live on the eastern side of Madagascar—where the tropical rainforest is found.

The main cause for the decrease in the Madagascar forests is what the people of the island call *tavy*, which is a form of shifting cultivation. This method of farming is used widely in tropical regions. It involves cutting down all the trees and vegetation in an area. When the vegetation is dry enough to burn, it is set on fire, which clears the land. The soil becomes enriched by the ash, but only for a brief period of time. Crops are then planted, tended, and harvested on this land. The land is used until the soil becomes depleted of nutrients, which can happen in just a few years in a warm and wet climate. Farmers then abandon the plots to let the vegetation reestablish itself and let the soil recuperate. The farmers move on to another area of land and repeat the process. In this manner crop rotation takes place over a period of years.

While this may seem environmentally destructive, it is an ancient method of farming (Salter and Kovacik 1989). Tavy farming in Madagascar has been productive for centuries. However, since 1950, over 80 percent of the island's forests have been destroyed. Why has the situation changed?

Why has shifting cultivation become a problem?

Shifting cultivation [is] one of the major agricultural systems of the world. Widespread though it has been, shifting cultivation has not generally resulted in long-term elimination of forests. For example, Southeast Asia has featured shifting cultivation for at least 2,000 years, which indicates that the system is an essentially sound mode of utilizing

Results of shifting cultivation in Madagascar.

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forest environments within traditional patterns. Farmers would follow a locally migratory way of life by . . . felling and burning a patch of forest, raising crops for two or three years until the soil lost its fertility or until weeds encroached, then moving on to repeat the process in another patch of forest, eventually returning to the original location. This [system] allowed the cultivator to make sustainable use of the forest environment. As long as there were only a few cultivators per square kilometer, generally five or less (depending on local circumstances), and provided the patch of farmed forestland could be left fallow for at least 10 years in order to renew itself, the system worked. . . . Now, however, in many areas, the numbers of shifting cultivators have increased to a point where there are often three or more times as many people per square kilometer as formerly, with the result that they have less space for local migration. The upshot is that they [allow] local ecosystems insufficient time to recover. Soils then rapidly become exhausted, and especially in wetter areas, weeds encroach. After as few as two cycles, the cultivator is obliged to abandon the area altogether, and move on to start afresh in a new patch of primary forest, hence progressively disrupting undisturbed [tropical forests] (Myers 1980, pages 23–24).

In Madagascar, as in many other parts of the world where shifting cultivation occurs, the people who are engaged in this method of agriculture are subsistence farmers. This means that their crops supply food or products only for small groups of people, perhaps for a family. However, since 1950 the population of the island has doubled. This increase in population has led to some drastic changes in the farming cycle. In the past a piece of land was cleared and replanted about every 15 years. But because there are now more people who need to grow food from the same land, the cycle has been shortened to three years (Knox 1989). Shorter cycles of shifting cultivation do not permit enough forest regrowth to restore the soil's fertility. This means that the farm productivity must decline (National Research Council 1982).

Another consideration related to a rapidly growing population is where the people live. Shifting cultivation formerly did not cause a permanent clearing of land. The land would be cleared, farmed, and abandoned—allowing the forest to regrow. But as the population grows rapidly, land used for crops may afterward become a town or be developed for another use, instead of being allowed to return to forest. If forests are not allowed to regrow, new forest areas must be cleared to provide land for farming. In this way the traditional rotation of shifting cultivation is broken, and increasing amounts of forested lands are removed for farming (Salter and Kovacik 1989).

Lesson 8

How can we prevent future environmental disasters?

Time Required

One 50-minute class period

Materials Needed

Butcher paper
Transparency of Overhead 3

Glossary Words

ecosystem

environment

transboundary pollution

Getting Started

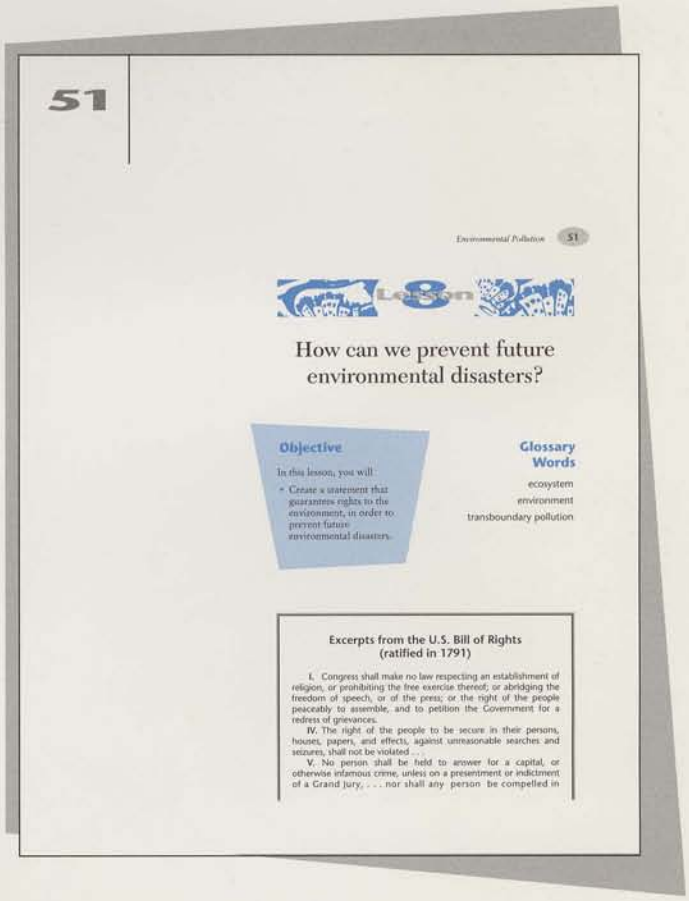
The Student DataBook provides a few examples from the U.S. Bill of Rights (pages 51–52). Review the reasons that the Bill of Rights was written. Ask whether the Bill of Rights does what it intended: Does it really protect citizens' rights? Is it still needed in today's society? Finally, open for discussion this idea: Could a similar document protect and plan for the future of Earth's environment? Whose rights should such a statement protect?

> Younger students may not have studied the Bill of Rights yet. If so, you may wish to skip this review and simply explain to the class the basic purpose of the first 10 amendments.

Procedures

Should there be an Environmental Bill of Rights? (page 52)

A. Have students read the text on page 52. In this activity the role of the teacher is to be a facilitator. First, brainstorm for ideas that students believe should be part of an Environmental Bill of Rights. Students should be encouraged to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Environmental Pollution 51

Lesson 8

How can we prevent future environmental disasters?

Objective

In this lesson, you will:

- Create a statement that guarantees rights to the environment, in order to prevent future environmental disasters.

Glossary Words

ecosystem
environment
transboundary pollution

Excerpts from the U.S. Bill of Rights (ratified in 1791)

I. Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances.

IV. The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated . . .

V. No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a Grand Jury, . . . nor shall any person be compelled in

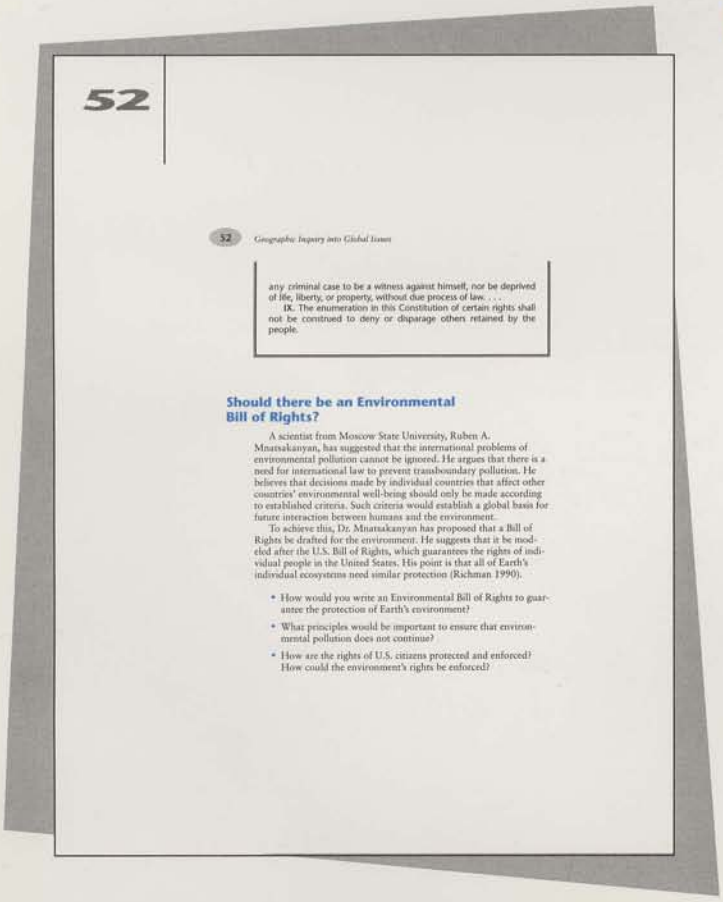
think of rights that protect the environment and the rights of future generations to have a protected environment. Record these ideas on the chalkboard or on butcher paper for reference.

Next, have the class select items from the brainstormed ideas to be included in the final draft of their Environmental Bill of Rights. New ideas may develop as students strive to clarify an item or make one more specific. Have students categorize similar rights rather than having a long list.

Finally, have students write a final draft that guarantees rights for the environment as well as for the people who interact with the environment. The final Environmental Bill of Rights should be a concise statement consisting of several principles. With each phase of the lesson conduct a discussion with the students to have the class explain and elaborate on how it made its decisions.

B. Explain that the United Nations came up with its own principles about environmental quality. These principles, known as the Rio Declaration, came from the UN Conference on Environment and Development in Rio de Janeiro in June 1992. They were based on the concept of sustainable development, stating that both economic growth and environmental quality are necessary to improve the lives of all humans. The point, however, is that economic development must not pollute the environment such that future generations cannot survive (hence, *sustainable* development).

Overhead 3 lists 8 of the 27 principles comprising the Rio Declaration. Make a transparency of this and project it after your class has created its own principles. Have the class compare the two and discuss the differences and similarities. What does each statement emphasize and why? What, if anything, is missing from either statement? Is environmental protection a "human right," inasmuch as it affects the health and well-being of people? Is environmental protection treated only in terms of its needs for human survival, or is the survival of other species included? For example, just as the U.S. Bill of Rights protects the rights of individual people, should an Environmental Bill of Rights protect all species? These and other leading questions can be used to bring closure to the lesson and module as a whole.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any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law. . . .

IX. The enumeration in this Constitution of certain rights shall not be construed to deny or disparage others retained by the people.

Should there be an Environmental Bill of Rights?

A scientist from Moscow State University, Ruben A. Mnatsakanyan, has suggested that the international problems of environmental pollution cannot be ignored. He argues that there is a need for international law to prevent transboundary pollution. He believes that decisions made by individual countries that affect other countries' environmental well-being should only be made according to established criteria. Such criteria would establish a global basis for future interaction between humans and the environment.

To achieve this, Dr. Mnatsakanyan has proposed that a Bill of Rights be drafted for the environment. He suggests that it be modeled after the U.S. Bill of Rights, which guarantees the rights of individual people in the United States. His point is that all of Earth's individual ecosystems need similar protection (Richman 1990).

- How would you write an Environmental Bill of Rights to guarantee the protection of Earth's environment?
- What principles would be important to ensure that environmental pollution does not continue?
- How are the rights of U.S. citizens protected and enforced? How could the environment's rights be enforced?

For Further Inquiry

Assign an essay answering the question, "Is it necessary to have some kind of international agreement designed to protect Earth's environment?"

1 2 3 4 5 CP 99 98 97 96 95

Extension Activities and Resources

1. **Related GIGI Modules**
   - Lesson 3 makes note of the high infant mortality rate in Central Asia. For a series of lessons on the issue of infant mortality, use the GIGI module *Infant and Child Mortality.* Focusing on the problem in the region of subSaharan Africa, this module provides a wealth of socioeconomic data to show the complex causes of this problem.
   - Much more detail on the problems of agriculture in the developing world is contained in the GIGI module *Sustainable Agriculture,* which focuses on Malaysia, but includes further discussion on shifting cultivation.

2. **Britannica Global Geography System (BGGS)**

   BGGS provides myriad extension activities to enhance each GIGI module. For a complete description of the BGGS CD-ROM and videodiscs and how they work with the GIGI print modules, please read the BGGS Overview in the tabbed section at the beginning of this Teacher's Guide.

3. **Related Videos**
   - EBEC offers these videos about the issues and regions explored in this module: "Population Story: Collision with the Future"; "Africa: Central and Eastern Regions"; and "Rivers in Danger: The Zambezi and the Nile."
   - Other related videos include: "Running Water" (*Spaceship Earth,* PBS), "Why Does Planning Occur?" (*Global Geography* series, Agency for Instructional Technology), "Disappearing Forests" (*Spaceship Earth* series, PBS), and "Using Forest Resources" (*Global Geography* series, AIT).

4. **Additional Activities**
   - Suggest to your class that they get involved in local environmental cleanup efforts. Such programs include the familiar "adopt a highway," various stream cleanup projects, and so on.
   - Pursue the concept of transboundary pollution. Have students investigate local, state, or national examples of this problem.

Have students develop strategies for resolving these disputes. The case of acid rain, and the Canadian diplomatic efforts to reduce United States pollution sources, probably provide the most easily available information.

- There are abundant opportunities for students to investigate U.S. environmental debates. Students could study debates about livestock grazing on public lands in the West; any number of large dam projects (historical studies on the Hetch Hetchy or Glen Canyon dams might be particularly instructive); or logging of old-growth forests in the Pacific Northwest (e.g., the spotted owl controversy). Challenge students to analyze the values issues underlying these debates.
- Students could also examine local development projects that were controversial. Have the class investigate local papers for stories about housing developments built during the 1950s and 1960s (when there was little opposition to growth in most communities). Students could assess if any changes in local opinions have occurred in the conflict between economic and environmental interests.
- The issue of endangered biodiversity, only briefly touched upon in this module, may prove interesting for students to investigate on their own. The biannual series, *World Resources* (published by the World Resources Institute), is a good source of data on habitat destruction and species loss.
- Assign students to investigate treaties and agreements among countries to protect Earth's environment. Students should note if the agreements are specific to certain environmental issues or if the agreements encompass Earth's environment as a whole. For example, students could study the entire Rio Declaration (only a few of its principles are reproduced on Overhead 3). International agreement has also been reached recently regarding ozone depletion (the Montreal Protocol).
- The class could turn their political art designs from Lesson 6 into buttons, bumper stickers, T-shirts, or hats. These could be used for fund-raising projects to assist environmental or other causes.
- Coordinate the Environmental Bill of Rights activity in Lesson 8 to coincide with Earth Day or Geography Awareness Week. Post and/or publish a copy of your class's Environmental Bill of Rights in the local or school newspaper.

5. **Writing**

- Use Figure 14 as the basis for a writing activity. Students could write (a) a play or a story set in the Aral Sea region that tells

about the kind of person who would write the graffiti comment on the rock; (b) a reply from the Aral Sea that would either accept or reject the request for forgiveness; or (c) a poem about the situation in the Aral region.

- Have students write to the following organizations to learn more about water-quality issues and how these problems can be resolved.

  Adopt-a-Stream (P.O. Box 435, Pittsford, NY 14534-0435) organizes volunteer programs to help clean up streams and monitor local water quality.
  America's Clean Water Foundation (650 First St., NE, Suite 911, Washington, DC 20002-4241) creates and distributes educational materials about water quality.
  The Izaak Walton League of America (1401 Wilson Blvd., Arlington, VA 22209-2318) runs the "Save Our Streams" program.
  The *Water Education Foundation* (717 K St., Suite 517, Sacramento, CA 95814-3408) provides information about water issues in the West.

6. **Role Playing**
   - Design a role-playing simulation in which the class conducts a conference on an environmental problem, such as the Aral Sea. Students can be designated as scientists, doctors, local citizens, fishers or farmers, government planners, and so forth. The goal of the simulation would be to have the class arrive at a consensus for resolving the environmental crisis.

Mono Lake Survey

1. Before you discussed Mono Lake in this lesson, had you ever heard of or read about Mono Lake from any of the following sources? (Circle all letters that apply.)

   A. Television programs
   B. Newspapers or magazines
   C. Books, pamphlets, or brochures
   D. Visiting Mono Lake
   E. Other (Specify) _____
   F. Knew nothing about Mono Lake

2. There may be several reasons for protecting Mono Lake. For each of the reasons listed below, circle the number that indicates if it is important to you or not.

Possible reasons for protecting Mono Lake	Not important	Somewhat important	Very important	No opinion
Protecting the quality of water, air, and scenery at Mono Lake	1	2	3	4
Protecting the habitat of Mono Lake bird populations	1	2	3	4
Providing me with current recreation uses such as bird watching, picnics, canoeing	1	2	3	4
Knowing that in the future I have the option to go there if I choose	1	2	3	4
Just knowing Mono Lake exists and is protected	1	2	3	4
Knowing that future generations will have Mono Lake as it exists today	1	2	3	4

3. According to Figure 4, there are three alternatives for water diversion from Mono Lake. Which alternative would you prefer to see enacted? (Circle choice.)

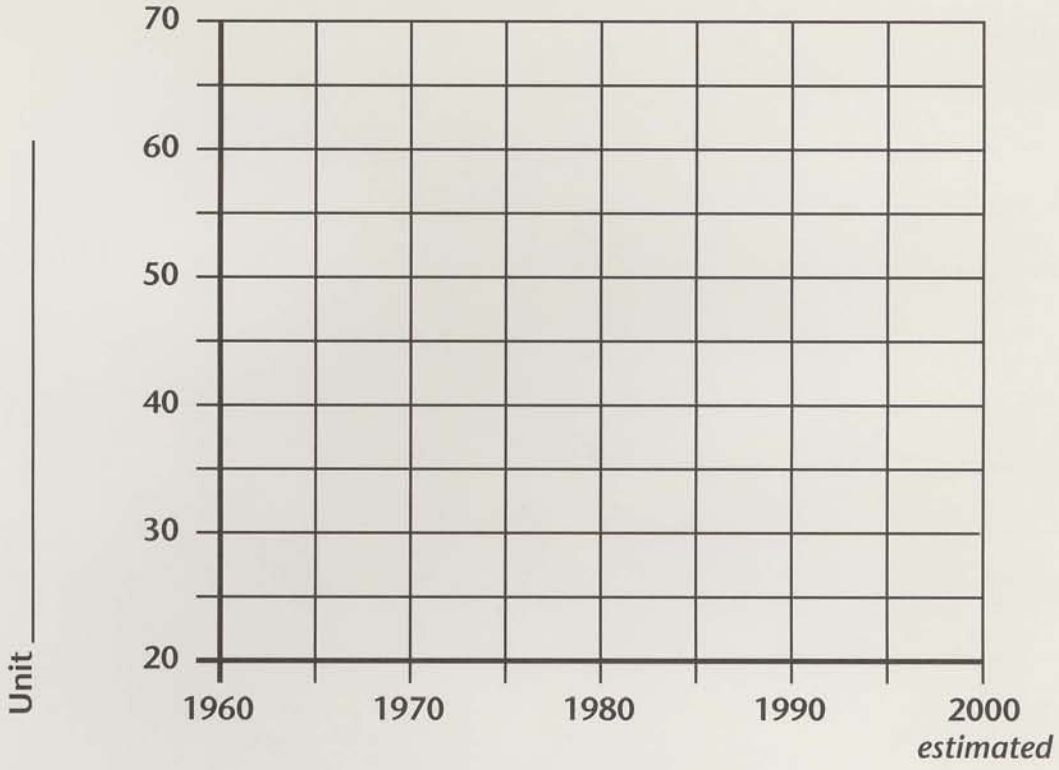
   Alternative 1 Alternative 2 Alternative 3

Source: Loomis 1987

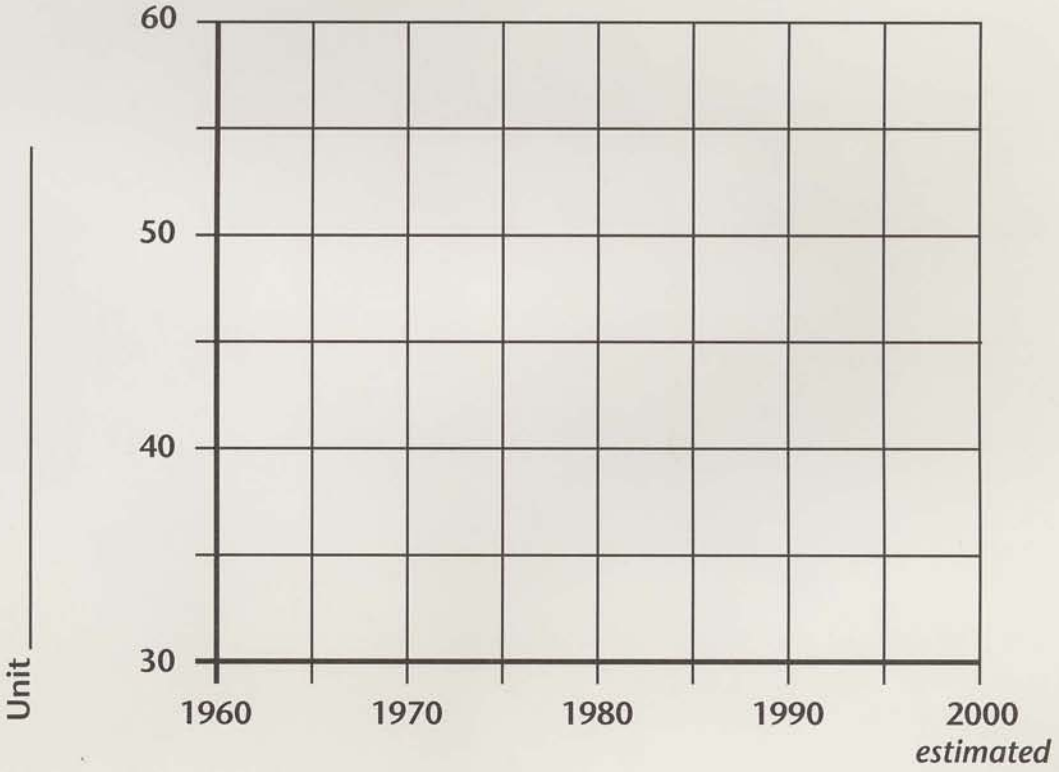
Name _____

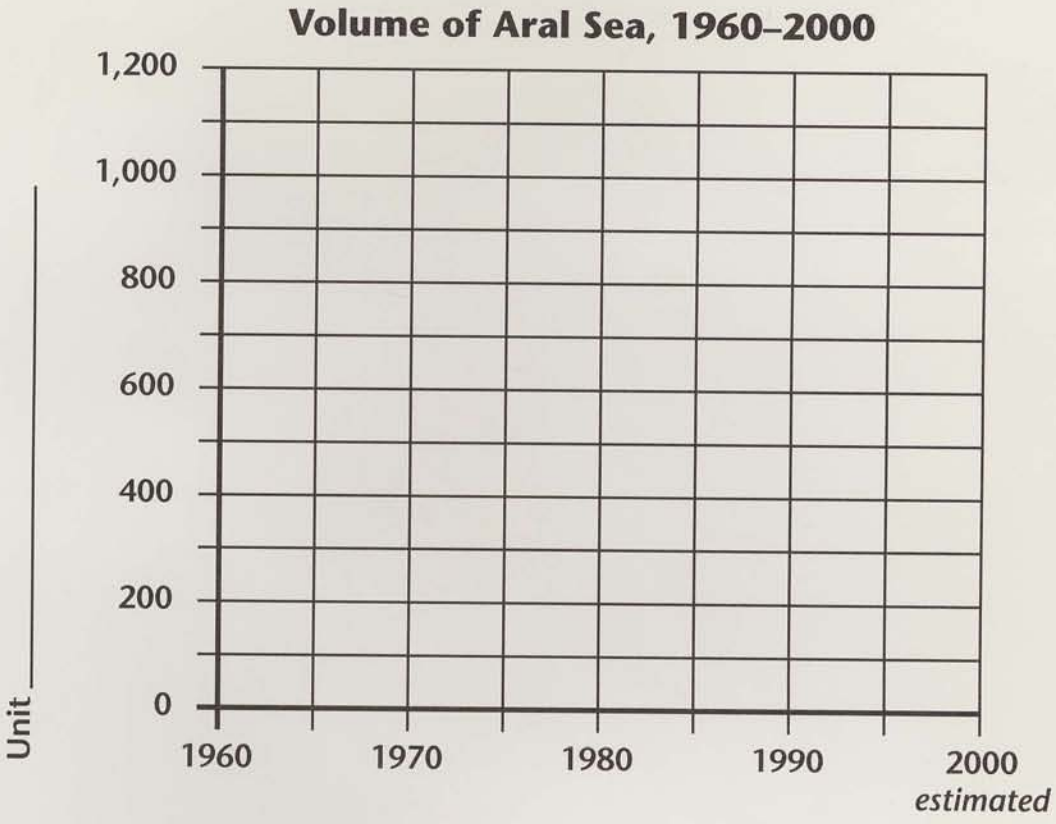
Graphing the Aral Sea

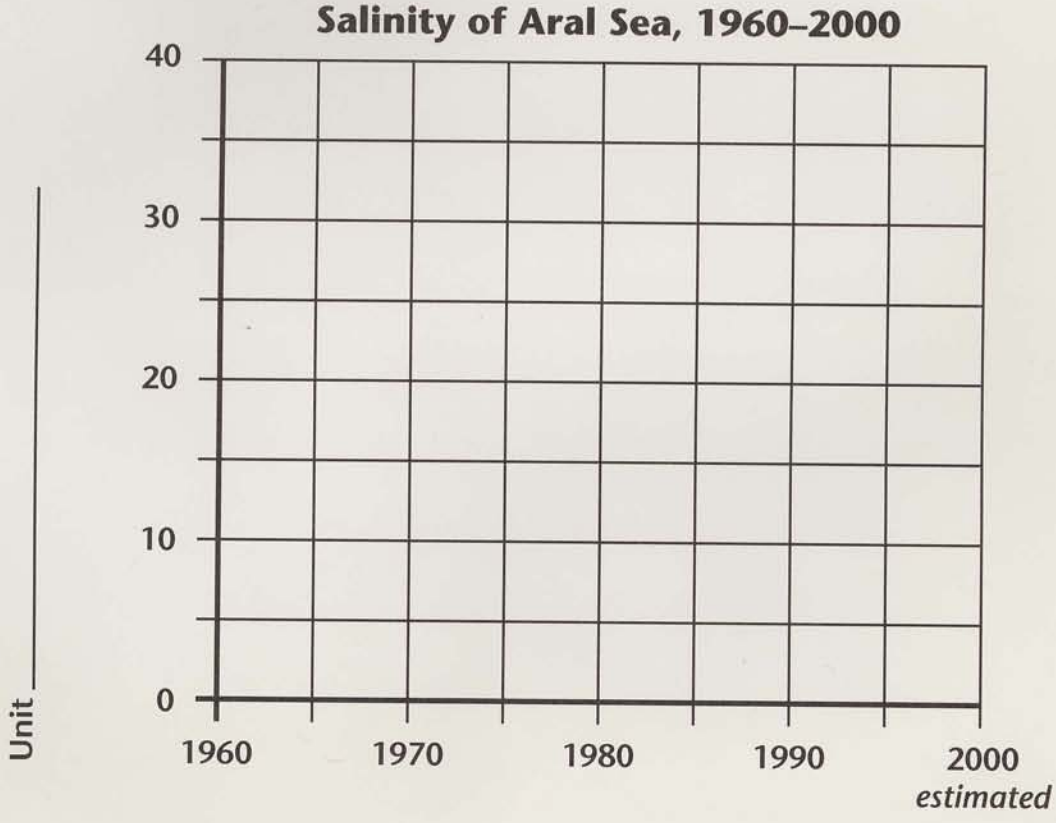
Area of Aral Sea, 1960–2000



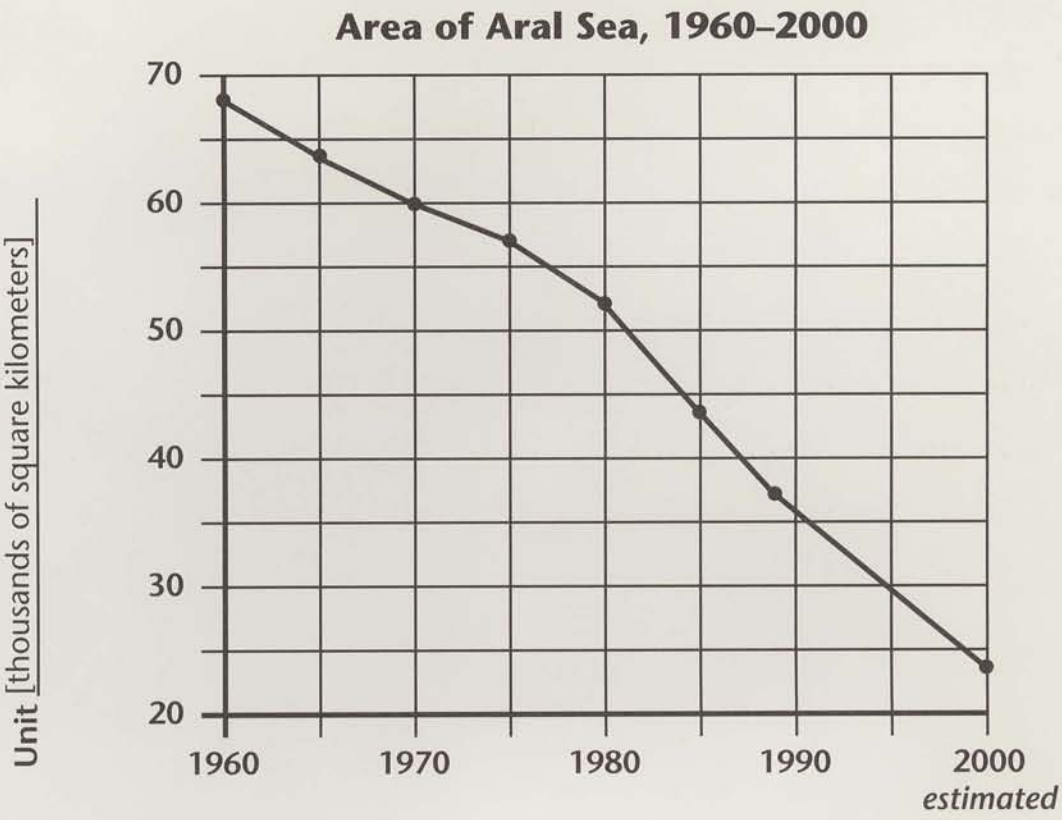
Level of Aral Sea, 1960–2000

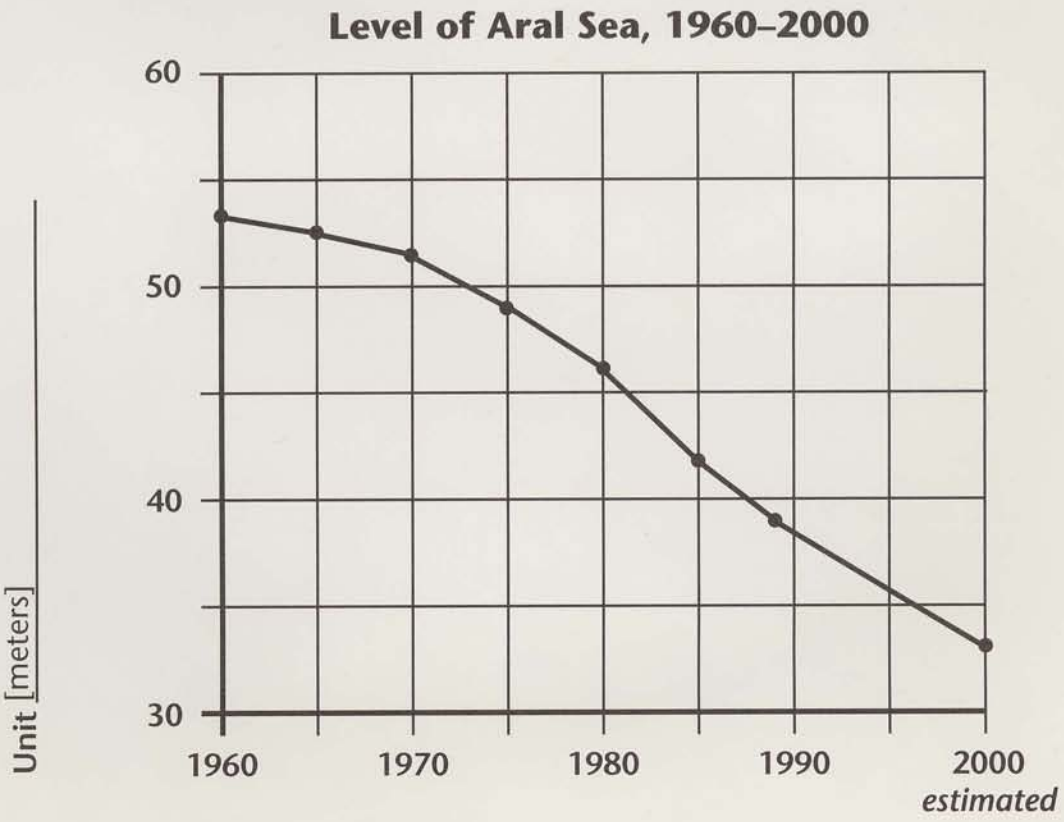


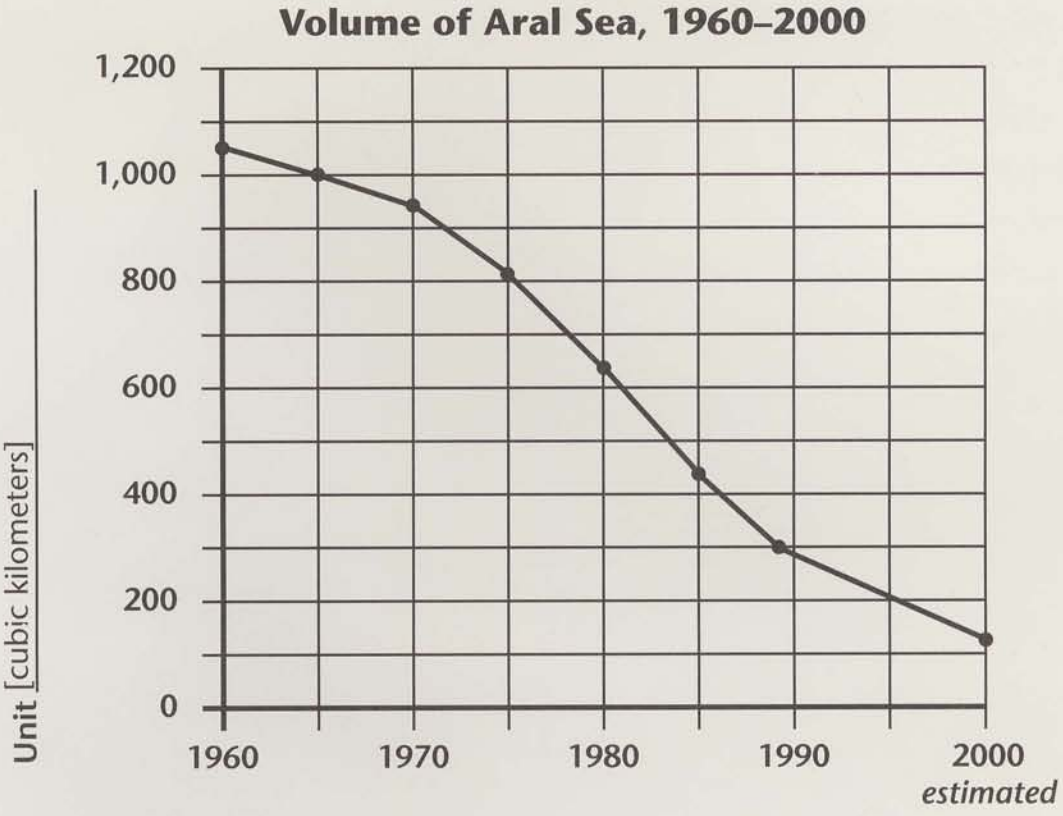

Volume of Aral Sea, 1960–2000
1,200
1,000
800
600
400
200
0
Unit
1960
1970
1980
1990
2000
estimated

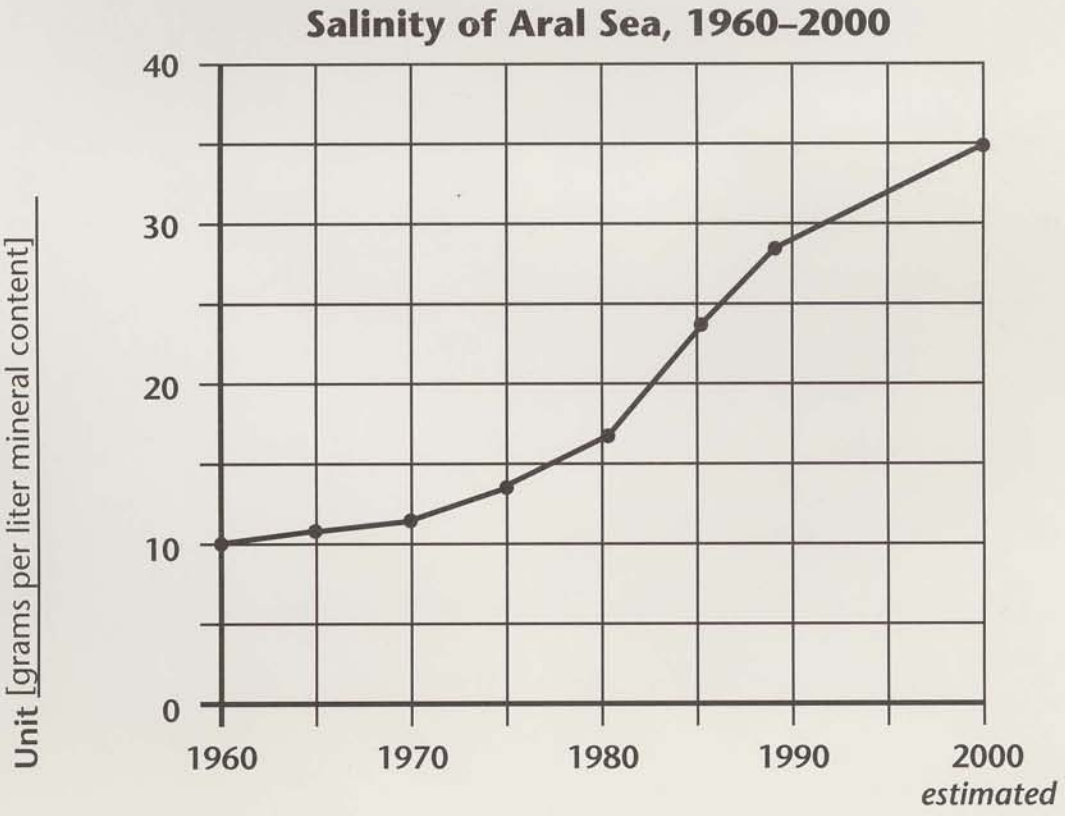

Salinity of Aral Sea, 1960–2000
40
30
20
10
0
Unit
1960
1970
1980
1990
2000
estimated

Graphing the Aral Sea






Volume of Aral Sea, 1960–2000
Unit [cubic kilometers]
1,200
1,000
800
600
400
200
0
1960
1970
1980
1990
2000
estimated


Salinity of Aral Sea, 1960–2000
Unit [grams per liter mineral content]
40
30
20
10
0
1960
1970
1980
1990
2000
estimated

Name _____

The Shifting Cultivation Cycle

Below are the 10 steps—*scrambled up*—of a 15-year cycle of shifting cultivation. Arrange the steps in the proper sequence, showing the order in which they take place.

Steps of a 15-year Shifting Cultivation Cycle (scrambled!)

The crop is planted.

The land is left fallow for 15 years.

Ash enriches the soil.

The field is abandoned.

The vegetation on the land is cut and left to dry.

The crop is harvested.

The vegetation takes about 15 years to regrow.

The dried vegetation is burned.

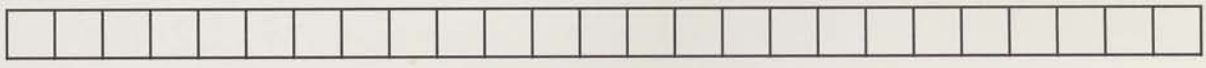
After two or three years the soil loses its fertility.

The crop is tended by the farmer.

1. Put these 10 steps into a diagram to illustrate this cycle. Label all steps.
2. The time line below illustrates the 15-year shifting cultivation cycle over a 25-year period. The shaded years show the time land is left fallow. On the blank time line, shade in the fallow years *if the fallow periods last only three years*. How many more cultivation cycles occur in the 3-year cycle during a 25-year period?

15-year cycle (shaded = fallow; blank = cultivated)

Years: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

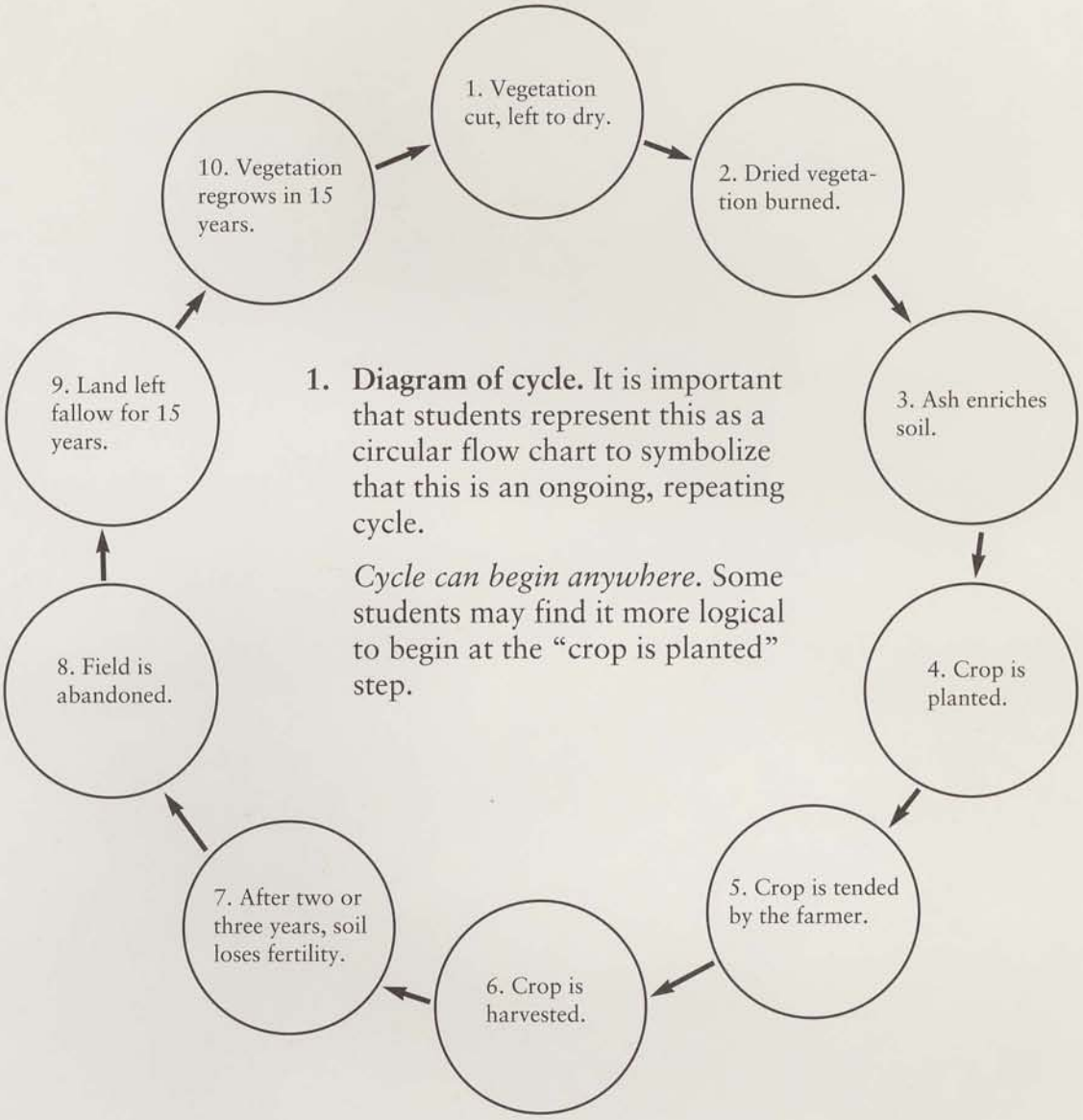


3-year cycle (shaded = fallow, blank = cultivated)

3. What are the advantages and disadvantages of shifting cultivation?

4. How is the cycle changed if land cleared for farming is later used for something else (for example, to build cities)?

The Shifting Cultivation Cycle



1. **Diagram of cycle.** It is important that students represent this as a circular flow chart to symbolize that this is an ongoing, repeating cycle.

   Cycle can begin anywhere. Some students may find it more logical to begin at the "crop is planted" step.

2. Time line, 3-year cycle

Years: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Cultivated is blank; fallow is shaded. Total of four planting periods in 25 years, compared to only two in the 15-year cycle.

3. Advantages: low technology and inexpensive, so poor countries can rely on it. Also uses natural, not chemical fertilizers. Disadvantages: produces only enough food for subsistence, not enough to produce surplus for sale. Also leads to erosion and deforestation if cycle is too short.
4. If cleared land is used for cities or other uses, then new forest land has to be cleared to support agriculture. This increases pace of deforestation.

BRITANNICA GLOBAL GEOGRAPHY SYSTEM

GIGI

Geographic Inquiry into Global Issues

Environmental Pollution

Program Developers
A. David Hill, James M. Dunn, and Phil Klein

Regional Case Study
Former Soviet Union

Britannica
ENCYCLOPAEDIA BRITANNICA EDUCATIONAL CORPORATION
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Senior Buyer: Hazel Janke
Logo and Package Design: Richard Laurent

ISBN 0-7826-1022-6

Acknowledgments
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Contents

GIGI National Field Trial Locations

Anchorage, AK
Juneau, AK
Birmingham, AL
Grove Hill, AL
Ventura, CA
Arvada, CO
Boulder, CO
Colorado Springs, CO
Lakewood, CO
Westminster, CO
Wilmington, DE
Nokomis, FL
Lithonia, GA
Marietta, GA
Beckemeyer, IL
Red Bud, IL
Lafayette, IN
La Porte, IN
Merrillville, IN
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Morgantown, KY
Lowell, MA
South Hamilton, MA
Westborough, MA
Annapolis, MD
Baltimore, MD
Pasadena, MD
Detroit, MI
Mt. Pleasant, MI
Rochester Hills, MI
South Haven, MI
St. Joseph, MI
Jefferson City, MO
Raymondville, MO
St. Louis, MO
McComb, MS
Boone, NC
Charlotte, NC
Oxford, NE
Franklin Lakes, NJ
Lakewood, NJ
Salem, OH
Pawnee, OK
Milwaukie, OR
Portland, OR
Armagh, PA
Mercersburg, PA
Spring Mills, PA
State College, PA
Swiftwater, PA
Easley, SC
Alamo, TN
Evansville, TN
Madison, TN
El Paso, TX
Gonzales, TX
Houston, TX
Kingwood, TX
San Antonio, TX
Tyler, TX
Centerville, UT
Pleasant Grove, UT
Salt Lake City, UT
Monroe, WI
Racine, WI
Cheyenne, WY
Worland, WY

Memo to the Student from the GIGI Staff

GIGI stands for *Geographic Inquiry into Global Issues,* which is the name of a series of modules. Each module inquires into a different world issue. We wrote this memo to explain that GIGI is different from most textbooks you have used.

With GIGI, you can have fun learning if you think like a scientist or detective. The main business of both scientists and detectives is puzzle-solving. They use information ("data" to the scientist and "evidence" to the detective) to test their solutions to puzzles. This is what you do with GIGI. GIGI poses many puzzles about important global issues: Each module centers around a major question, each lesson title is a question, and there are many other questions within each lesson. GIGI gives you real data about the world to use in solving these puzzles.

To enjoy and learn from GIGI, you have to take chances by posing questions and answers. Just as scientists and detectives cannot always be sure they have the right answers, you will sometimes be uncertain with GIGI. But that's OK! What's important is that you try hard to come up with answers, even when you're not sure. Many of GIGI's questions don't have clear-cut, correct answers. Instead, they ask for your interpretations or opinions. (Scientists and detectives are expected to do this, too.) You also need to ask your own questions. If you ask a good question in class, that can sometimes be more helpful to you and your classmates than giving an answer.

The data you will examine come in many forms: maps, graphs, tables, photos, cartoons, and written text (including quotations). Many of these come from other sources. Unlike most textbooks, but typical of articles in scientific journals, GIGI gives its sources of data with in-text references and full reference lists. Where an idea or piece of information appears in GIGI, its author and year of publication are given in parentheses, for example: (Gregory 1990). If the material used is quoted directly, page numbers are also included, for example: (Gregory 1990, pages 3–5). At the end of the module you'll find a list of references, alphabetized by authors' last names, with complete publication information for the sources used.

To help you understand the problems, GIGI uses "case studies." These are examples of the global issue that are found in real places. "Major case studies" detail the issue in a selected world region. You will also find one or two shorter case studies that show variations of the issue in other regions.

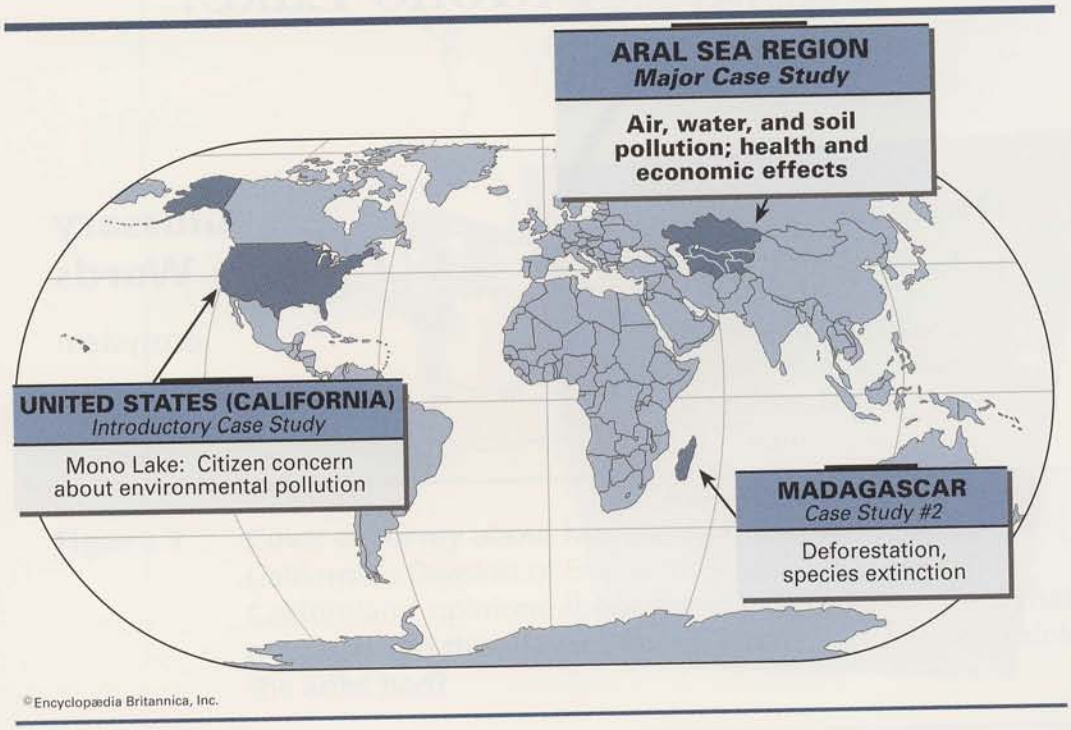
We hope your geographic inquiries are fun and worthwhile!

Environmental Pollution

What are the effects of severe environmental pollution?

- What forms of pollution are a problem in your community?
- Why does environmental pollution happen?
- What can happen when pollution problems become severe?
- How can people prevent severe environmental pollution?

In this module, you will examine case studies from three places—Mono Lake in California, the Aral Sea Region in Central Asia (formerly the Soviet Union or USSR), and the island of Madagascar. Each case illustrates how human activities have polluted the place's environment. Using a geographer's point of view, you will examine and evaluate information from a variety of sources. You will also study how activities that were planned to use Earth's resources in a beneficial way have sometimes had unplanned, and even disastrous, results.



Questions You Will Consider in This Module

- How can land uses change a place's physical characteristics?
- How do geographers measure the changes in the physical environment?
- What are the consequences of human changes to physical environments?
- How is the quality of human life linked to the quality of the environment?
- How can people show their environmental opinions in order to enact political change?

How have people influenced the fate of Mono Lake?

Objectives

In this lesson, you will

- Recognize that people understand the importance of places according to their own values.
- Be aware that land-use choices can be influenced by popular opinion.

Glossary Words

ecosystem

environment

What is the issue at Mono Lake?

Often, people must decide how an environmental resource should be used. Sometimes, possible land uses conflict because one choice would pollute the resource so much that the ecosystem is damaged. Suppose a chemical industry wants to build a plant next to a river. Some people might object because that river is used for their town's water supply or is their favorite fishing spot. They might be concerned that chemical pollution would destroy these other uses. On the other hand, people might support the industry's plan because it would provide better jobs for the town. In your own community, there may be similar debates about how to use a hill, a lake, or a river.

Figure 1 Cover of survey about Mono Lake. The University of California's Division of Environmental Studies surveyed Californians' opinions about the value of Mono Lake. What messages did this drawing send? What values do you think the artist had?

Source: Loomis 1987.

How can people choose among competing land uses? How can decision makers know what value people place on a resource? One way is to survey peoples' opinions about the resource. By learning how important people believe a resource is, land-use planners can decide how to use it.

In this lesson, you will see how Californians learned what people felt about one environmental resource, Mono Lake (Figure 2 on page 6). At issue was a choice about how to use the rivers that feed the lake. The Los Angeles Department of Water and Power wanted to divert more water from these rivers to supply the city of Los Angeles. Doing so would have lowered the lake's level. Many Californians opposed this plan. They wanted to keep the lake's water supply high enough to preserve the ecosystem. The following "Description of Mono Lake" was the introduction to a survey about Mono Lake. The cover of the published survey is shown in Figure 1.

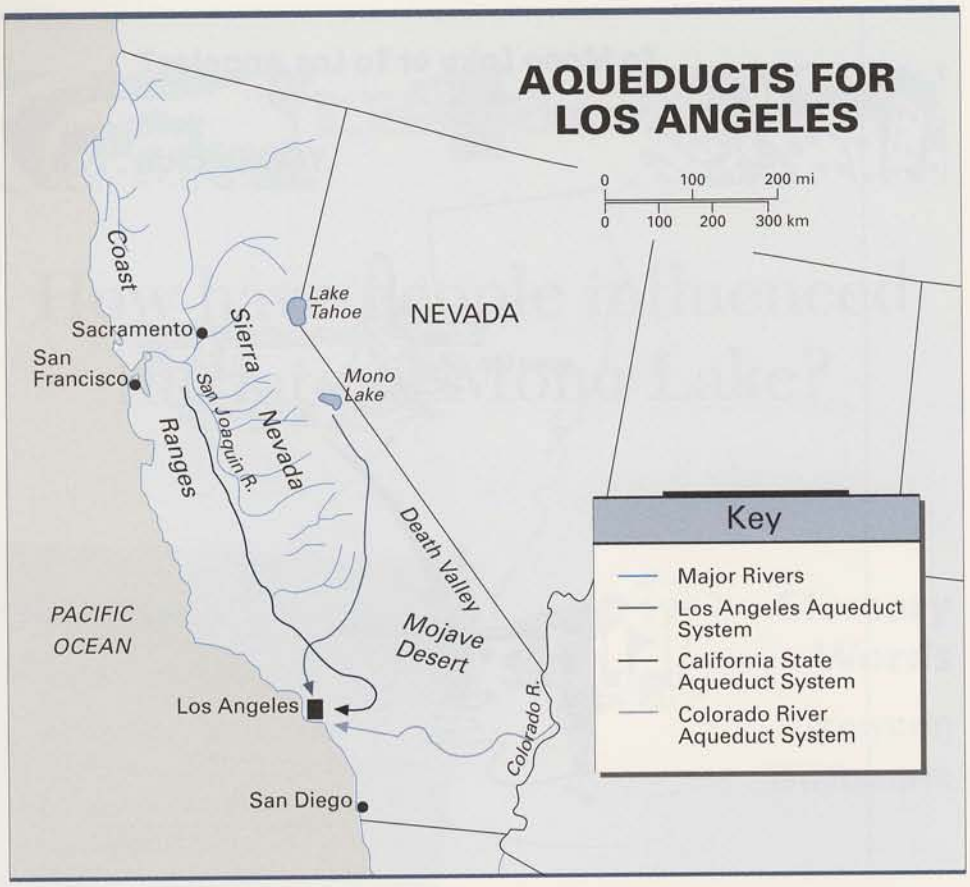


Figure 2 Location of Mono Lake and the three major water diversion systems supplying Los Angeles. How many miles is water transferred from Mono Lake to Los Angeles? Why does Los Angeles need to import its water?

Description of Mono Lake

Mono Lake is one of the largest lakes in California. Mono Lake is located just east of the Sierra Nevada mountains and about 100 miles south of Lake Tahoe [Figure 2 above]. A unique and productive ecosystem developed at Mono Lake in response to the natural saltiness of the Lake's waters. For example, the Lake provides habitat for hundreds of thousands of birds including 80 percent of the State's nesting population of California (sea)gulls. It supports a major part of the world's population of Eared Grebes and Wilson's Phalaropes [Figure 3 on page 7]. Several species of shorebirds and waterfowl use Mono Lake each year as a critical resting stop on their annual migrations. Another unique feature of Mono Lake is its tufa towers. These towers, which range in size up to 30 feet, are formed underwater where freshwater springs mix with the minerals in the lake water. Mono Lake's scenery with the Sierra Nevada mountains in the background and the tufa towers reflecting in the Lake

attracts thousands of visitors each year [Figure 3 below].

Currently the City of Los Angeles diverts 100,000 acre-feet of water that would normally flow into Mono Lake. The water is diverted to eastern Sierra Nevada reservoirs and generates hydroelectric power before it reaches Los Angeles. These water diversions provide 17 percent of the water the City of Los Angeles uses each year for industry, homes, and outdoor purposes. However, this rate of water diversion is causing Mono Lake to shrink in size and potentially become too salty to sustain the birds' food supply.

One question we all face is balancing low-cost urban water supplies with maintaining natural environments such as Mono Lake. This balancing requires information on the costs and benefits of alternative water sources. While information exists on the costs of alternative water sources and replacement electricity, no information exists on the benefits of water in Mono Lake. The University of California's Division of Environmental Studies is performing this survey to determine the benefits (if any) you derive from the resources of Mono Lake. This information on benefits will be compared to cost of alternative water sources to assist State officials in balancing the State's competing demands for water (Loomis 1987, page 116).

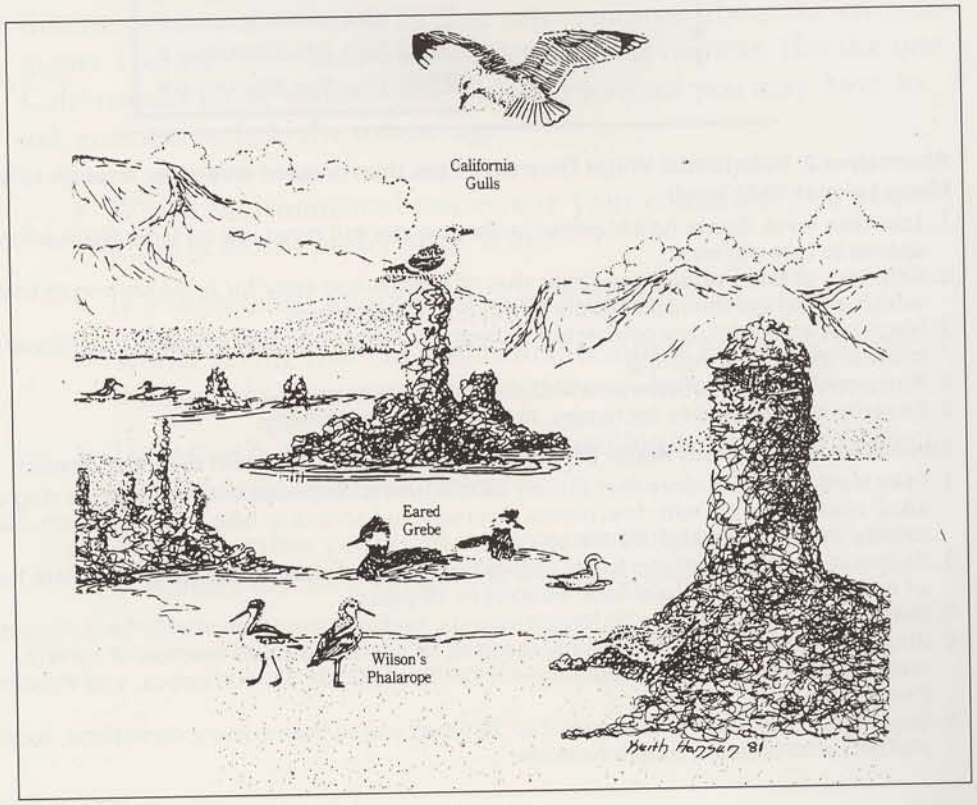
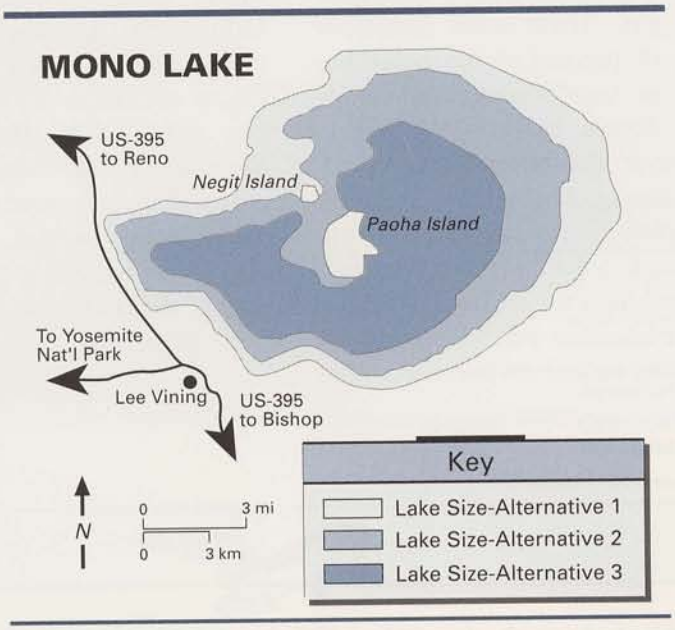


Figure 3 Sketch of Mono Lake. View is looking west, showing tufa towers and some nesting birds who feed on the lake's brine shrimp.

Source: Loomis 1987.

Alternative 1: Minimal Water Diversion (to restore Mono Lake level to pre-1982 level)

1. Within five years, lake level would be 15 feet higher than in 1982. Most visible tufa towers would rise from their reflections in the water. Good access to lake for recreation.
2. Saltiness of lake water twice that of the ocean—slightly above lake's natural level but still tolerable for brine shrimp, which are a key food source for birds.
3. Negit is an island where gull nesting is safe from predators.
4. About 1 million birds use the lake and nearly 100 species of birds stop at the lake during migration.
5. The occasional dust storms do not severely affect scenic visibility or air quality.



Alternative 2: Substantial Water Diversion (less than present diversion; enough to keep Mono Lake at 1982 level)

1. Low lake level. Some tufa towers rise from water but most are on land. Recreational access to lake difficult.
2. Saltiness of lake water three times that of ocean—too salty for brine shrimp to tolerate, which would cut the food supply of the bird populations.
3. Negit not an island, but connected to land. Coyotes and other predators can invade and prevent gulls from nesting.
4. Bird populations decrease and bird diversity is reduced.
5. Severity of dust storms increases, reducing scenic visibility.

Alternative 3: Maximum Water Diversion (continuation of present diversion levels)

1. Lake level drops 30 more feet during next 30 years. Exposed shore is a white ring of alkali mud and dust with few plants. Recreational access to lake is very difficult. No tufa towers rise out of water; all are on land.
2. Saltiness of lake water increases to five times that of ocean—almost a complete loss of brine shrimp (the birds' food supply) in 15 years.
3. Both Paoha and Negit are no longer islands, making them unavailable for gull nesting.
4. Bird populations at Mono Lake decrease in 15 years to a small fraction of current number, reducing world populations of California Gulls, Eared Grebes, and Wilson's Phalaropes.
5. Severity of dust storms becomes 2 to 10 times worse than current conditions, reducing visibility and creating health hazards.

Figure 4 Three alternative water diversion plans for Mono Lake. The environmental impacts of each diversion level are listed. Which alternative do you like best?

Source: Loomis 1987.

Mono Lake's ecosystem was threatened by the plan to divert more water to Los Angeles. The survey asked people to think about the uniqueness of the lake. It asked people to choose which of the three alternatives shown in Figure 4 on page 8 they preferred. The survey asked how much money people would spend or if they were willing to be inconvenienced to save Mono Lake. The results of this and other surveys helped decision makers determine the value of this environmental resource. Because so many people expressed a preference to keep the lake level high enough to maintain the ecosystem, the increased water diversions have not yet taken place.

In fact, a 1993 report for the California Water Resources Control Board recommended that Los Angeles receive less water deliveries from the Mono Lake basin so that the lake level can rise 8 1/2 feet in order to protect the lake's scenic and environmental values (Murphy 1993). In addition, the U.S. Environmental Protection Agency (EPA) intended to declare the Mono Lake basin in violation of federal air-quality standards because dangerous alkali dust storms rise from the dried-up parts of the lake bed. This could force California to allow the lake to rise even more toward its natural size (Bad Air Is Good News 1993).

What if an environmental resource in *your* community was threatened by pollution? What are your opinions about the environment? You may face land-use conflicts in your lifetime, like the one Californians faced about Mono Lake. Questions you may have to ask yourself include the following:

- Which environmental resource in your community do you think is worth preserving? Why?
- Is it threatened by some form of pollution?
- Would saving that environmental resource be worth it, even if it meant that some people could lose jobs?
- How much money would you be willing to spend to protect this resource from pollution?
- What do other people in your community think about this resource? Do they value it as much as you do?

How is the Aral Sea changing?

Objectives

In this lesson, you will

- Use maps and remote-sensing images to analyze geographic information.
- Recognize that each place has its own distinct physical characteristics.

Glossary Words

environment
exotic river
interior drainage
remote sensing
salinization
watershed

What is the Aral Sea environmental disaster?

Maps, graphs, and satellite images are some of the tools geographers use to study changes on the surface of Earth. Photographs of Earth taken from satellites are examples of a technique called remote sensing. Images taken from space show things that cannot be seen from the ground. An example of this is the weather map shown on the nightly television news. Because the images of the atmosphere are taken from space, meteorologists can identify weather systems long before they reach your region. This helps them predict when large storms, such as hurricanes, will strike.

Remote-sensing images are also helpful in spotting patterns useful for explaining environmental changes. Figures 5 and 6 on pages 12 and 13 are satellite photographs of the Aral Sea region in Central

Aerial view of the Aral Sea photographed by NASA's *Spacelab 2* mission, August 1985.

Asia taken during the springs of 1977 and 1987. Both figures are composites of 12 separate images taken from a satellite called Landsat. The figures show exactly the same area—that is, the scale of the two figures is the same. Look carefully at these figures.

1. What differences between these two images can you spot?
2. Has the Aral Sea gotten larger or smaller in these 10 years? Could the change be important? Why do you think so?
3. What was the distance across the Aral Sea (from east to west and from north to south) in 1977? In 1987?

Figure 5 Aral Sea, Republic of Uzbekistan, Spring 1977.

Source: Earth Observation Satellite Company 1977; Landsat MultiSpectral Scanner data, 12-scene photomosaic; single-band, near-infrared data; 80-meter spatial resolution. Landsat image reproduced with permission of Earth Observation Satellite Co., Lanham, MD, USA.

Figure 6 Aral Sea, Republic of Uzbekistan, Spring 1987.

Source: Earth Observation Satellite Company 1987; Landsat MultiSpectral Scanner data, 12-scene photomosaic; single-band, near-infrared data; 80-meter spatial resolution. Landsat image reproduced with permission of Earth Observation Satellite Co., Lanham, MD, USA.

Would you have guessed that the Aral Sea situation is as bad as this writer describes?

> Soviet Central Asia faces an ecological disaster of unparalleled proportions—and its most dramatic feature is the steady shrinking of the Aral Sea. . . . Once the Aral supported a thriving fishing industry, mixed agriculture, and numerous species of plant and animal life. Now nearly half [of its area has] been reduced to a saline desert—the source of dust storms which, 15 times a year, drop up to 75 metric tons of salt and dust, contaminated with pesticides and other chemicals, onto surrounding areas (Perera 1989, page 124).

What is the Aral Sea region like?

Central Asia is the driest region of the former Soviet Union. It has vast expanses of deserts and steppes, or plains, surrounded by extremely tall, rugged mountains. Glaciers in these mountains are the source of the few rivers that flow through the drier parts of the area. One of the major physical features of this region is the Aral Sea. Although it is called a "sea," the Aral is, in fact, a large saltwater lake. It has no outflow into the ocean.

Geographers frequently define regions around lakes in terms of the watershed. A lake's watershed is the total land area from which runoff feeds the streams that supply the lake. The Aral Sea's region consists of the independent republics of Kyrgyzstan (pronounced keer-geez-STAHN), Tajikistan (ta-JEEK-uh-stan), Turkmenistan, and Uzbekistan (ooz-BEK-uh-stan), as well as the southern part of Kazakhstan (KAZ-uk-stan). Within Uzbekistan, right next to the Aral Sea, is a province called Karakalpakia (Figure 7 on page 15). The total population of the region is nearly 40 million. This represents about 14 percent of the former Soviet Union's total population (Micklin 1988).

In 1960 the Aral Sea was the fourth largest lake in the world, covering over 26,000 square miles. But by 1991, the water level had dropped over 47 feet. Now, the lake's surface area, at 14,000 square miles, is about 40 percent less than it was in 1960 (Micklin 1990; Kotlyakov 1991). Today the Aral Sea is only the world's sixth largest lake.

To understand why this is a problem, you need to understand the physical geography of the Aral Sea. The Aral Sea's watershed collects water, but it does not release water (except through evaporation), because this region has an interior drainage system similar to that of Mono Lake. This means that the water from rivers that drain into the Aral Sea goes no further. There is no outflow from the Aral Sea to other rivers or to the ocean (Armstrong and Hunkins 1989).

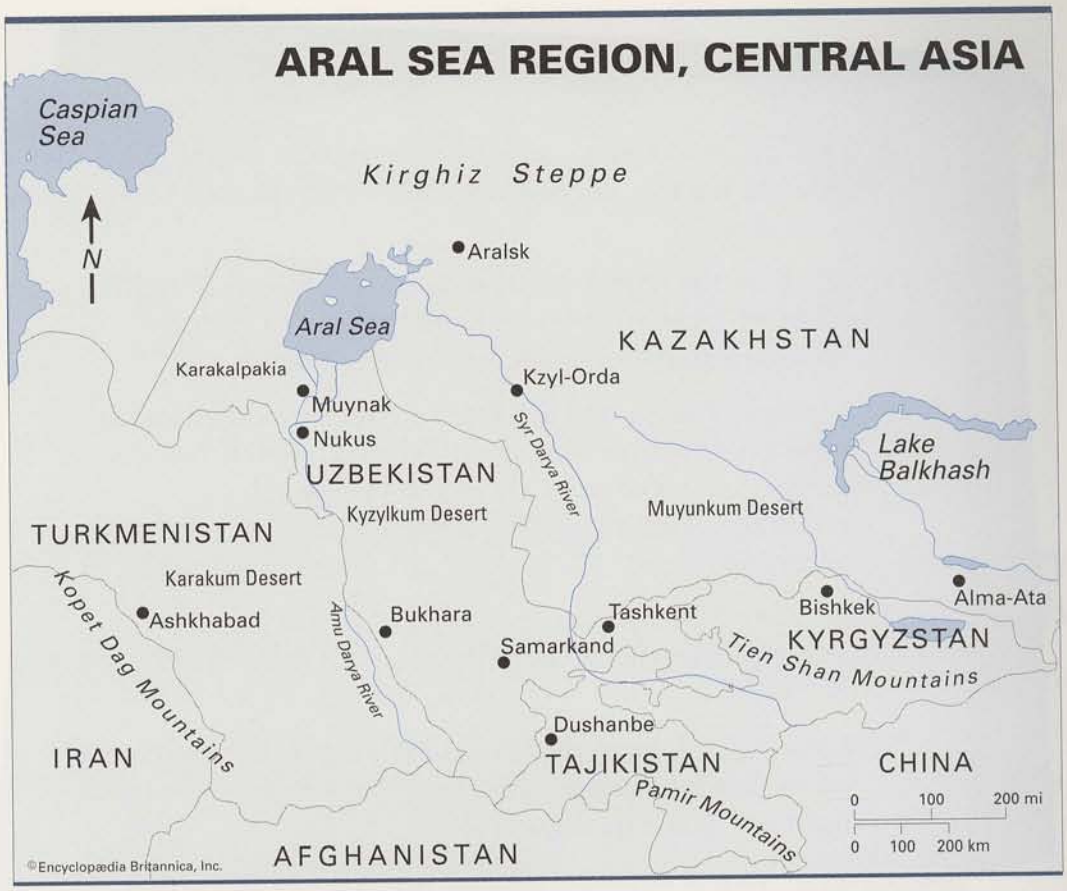


Figure 7 Aral Sea region in Central Asia.

Interior drainage systems are not uncommon—the Great Basin of the United States (covering parts of six states in the West, mainly Nevada and Utah) also has interior drainage.

Historically, about 90 percent of the water going into the Aral Sea came from two rivers: the Amu Dar'ya and the Syr Dar'ya (Figure 7). The remainder came directly from the atmosphere as precipitation (Kotlyakov 1991). In the lake's natural state, water lost through evaporation equaled the amount of water contributed by precipitation and by the two rivers (Micklin 1988). The Aral Sea's water level was maintained by this balance.

However, recent human activities have upset this balance, leading to environmental pollution. The Aral Sea is vital to the environmental and economic stability of the region. For example, the Aral Sea was once known for its commercial fishing industry. But since 1960 the fishing industry has been destroyed by the falling water level and chemical pollution from agricultural runoff. The water quality of the Aral has declined so much that it can no longer support most forms of life (Brown 1991).

4. The Aral Sea region covers about 626,000 square miles. Describe an area of the United States that is about this same size.
5. What are the names of the mountain ranges that are the sources for the Amu Dar'ya and Syr Dar'ya rivers? Approximately how high are these mountains?
6. The Amu Dar'ya and Syr Dar'ya rivers are called exotic rivers because they flow mainly through desert regions but their water sources are in snowfields in high mountains. Find two other major rivers in the world that are exotic rivers.
7. How are the exotic rivers you identified in Question 6 different from the rivers of the Aral Sea region? How are they similar?
8. What major lake in the United States is similar to the Aral Sea in that it has no outflow and is in a region of interior drainage? Is it a freshwater lake?
9. What human activities do you suspect are causing the Aral Sea to shrink? Why do you think so?

Why is the Aral Sea shrinking?

Objectives

In this lesson, you will

- Recognize that human use of the environment is based on cultural, economic, and political perspectives.
- Explain the relationships among agricultural production, irrigation, and water loss in the Aral Sea.

Glossary Words

central government

environment

salinization

> By the end of 1989, the Aral Sea had receded into two separate parts. . . . The trend is clear. Without drastic measures, the Aral Sea is destined to become a small brine lake of [under 2,000 square miles] (Kotlyakov 1991, page 6).

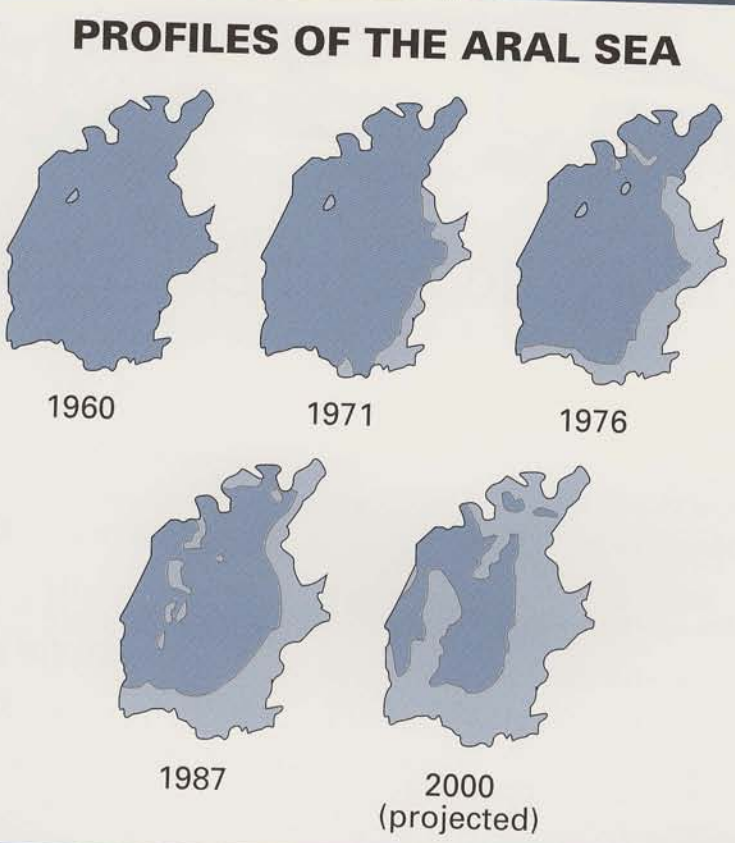


Figure 8 The changing profile of the Aral Sea, 1960–2000. Shaded areas show the actual size of the Aral Sea compared to the outline of the lake as it was in 1960.

Source: Micklin 1988.

There is little doubt that the Aral Sea is vanishing (Figure 8 above). How can this loss of water be explained? The answer can be summed up in two words—*irrigation* and *cotton*. Irrigation systems were built in the Aral region (Figure 9 on page 19) to support production of cotton and other crops.

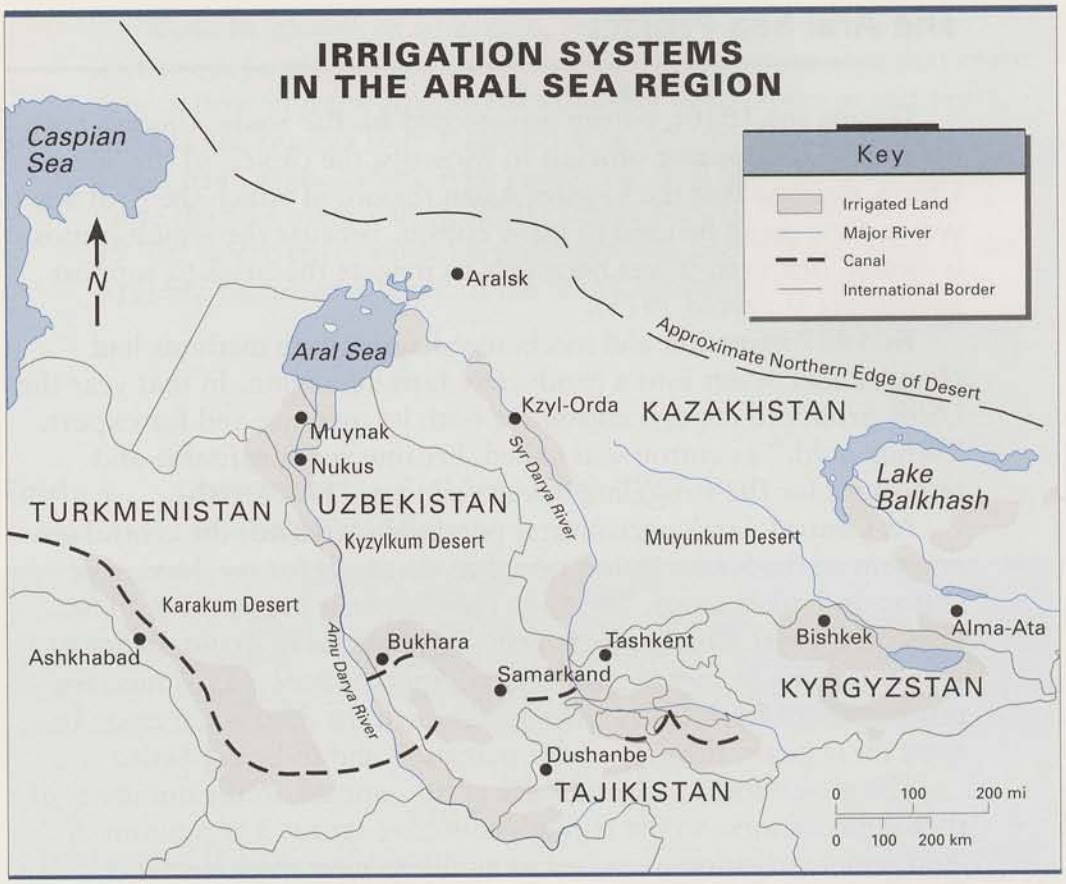


Figure 9 Irrigation systems in the Aral Sea region.

Source: Kotlyakov 1991.

1. Why is irrigation necessary to support agriculture in the Aral Sea region?
2. What benefits would irrigation bring to the Aral region?
3. Why have the irrigation systems shown in Figure 9 caused the Aral Sea to shrink?

The Aral Sea Project

During the 1930s, cotton was needed for the Soviet Union's textile mills. Government officials in Moscow, the capital of the Soviet Union, decided that the Central Asian region, of which the Aral Sea was a part, could be used to grow cotton. Because the region is mostly desert, however, it was necessary to irrigate the fields to support agriculture (Legvold 1971).

By 1937 irrigation and mechanized agriculture methods had changed this desert into a productive farming region. In that year the USSR produced enough cotton for both its own use and for export. "White gold," as cotton was called, became very profitable and important for the struggling Soviet economy (Ellis 1990).

As Central Asia's agricultural potential increased, the central government of the Soviet Union raised its demands for production of cotton and other crops. The Soviet government began the Aral Sea Project in 1960. This project's primary goal was to maintain Soviet self-sufficiency in cotton production. Another goal was to increase production of fresh fruits and vegetables in the Aral Sea region. To meet these goals, the area under irrigation had to be expanded.

The government assigned huge cotton quotas, in the hundreds of thousands of tons, to the region's collective farms. The amount of land under irrigation increased annually to meet these demands (Brown 1991). By 1992, 47 percent of Uzbekistan's land was planted in cotton. As a result, Uzbekistan became the world's third largest cotton producer (Lee 1992).

Water withdrawals from the region's rivers

In the 1950s, before the largest irrigation projects began, the Aral Sea's water level was steady. Each year about 60 cubic kilometers of the Aral Sea evaporated away. But the water level was maintained by the annual inflow of 56 cubic kilometers from the Amu Dar'ya and Syr Dar'ya rivers. Precipitation supplied an additional 5 cubic kilometers of water each year. The water system was in balance (Kotlyakov 1991).

In the 1960s, rapid development of irrigated agriculture began, and water withdrawals from the region's rivers greatly increased. Today, over 17 million acres in the five Central Asian republics are irrigated. About 105 cubic kilometers are withdrawn from the Amu Dar'ya and Syr Dar'ya rivers each year to supply water for these irrigation systems (Kotlyakov 1991). This means much more water is now withdrawn from the rivers than flows into the Aral Sea.

With the growth of irrigation, the Aral's water balance was destroyed. So much water is removed from the rivers now that there is no inflow into the Aral Sea at all in dry years. Even in wet years, there is not enough river water flowing into the Aral to replace the losses from evaporation. As a result, the Aral Sea's level has dropped more than 14 meters since 1960 (Tables 1 and 2 below). By the 1970s, severe environmental pollution was becoming evident in the Aral Sea region as a result of the lake's shrinkage (Brown 1991).

Table 1 Changes in the Aral Sea, 1960–1989, with estimates to 2000

Year	Sea level (meters)	Sea area (thousands of square kilometers)	Sea volume (cubic kilometers)	Salinity (salt content, grams per liter)
1960	53.3	67.9	1,090	10.0
1965	52.5	63.9	1,030	10.5
1970	51.6	60.4	970	11.1
1975	49.4	57.2	840	13.7
1980	46.2	52.4	670	16.5
1985	42.0	44.4	470	23.5
1989	39.0	37.0	340	28.0
2000 (est.)	33.0	23.4	162	35.0

Sources: Kotlyakov 1991; Micklin 1988.

Table 2 Annual decline in Aral Sea water level

Decade	Average annual decline (meters per year)
1961–70	0.21
1971–80	0.58
1981–90	1.09

Source: Kotlyakov 1991.

4. Why did the Soviet government want to increase agricultural production in the Aral Sea region?
5. How has irrigation caused the Aral Sea to shrink?
6. How does the fact that the Aral Sea is a lake with no outflow in a desert region that is fed by exotic rivers contribute to this problem?
7. About how many meters has the Aral Sea's level already dropped? How many more meters of lowering are expected by 2000?
8. Did the *rate* of lowering in the Aral Sea's area increase or decrease during the 1980s? What do you think is the connection between this changed rate and what was happening in the region then?
9. Why is the salinity of the Aral Sea increasing?
10. Why might increasing salinity be a problem?

Up to the end of the 1950s, the environmental stability of the Aral Sea region was not threatened. The Aral Sea Project pushed the environment out of balance. By some important measures, however, the Aral Sea Project has been *very* successful. The Aral region now produces 90 percent of the former Soviet Union's cotton, 33 percent of its rice, and 25 percent of its fresh produce (Brown 1991). What do you think some environmental and social effects of this project have been? What kinds of information would a geographer—or you—need in order to find out?

What are the effects of the Aral Sea environmental disaster?

Objectives

In this lesson, you will

- Describe and explain the ecological and social effects of severe environmental pollution in the Aral Sea region.
- Evaluate the connection between the quality of human life and the quality of the physical environment.

Glossary Words

defoliant
ecosystem
environment
interior drainage
salinization
solonchak
transboundary pollution

The data in Figure 10 on page 24 provide clues to some important effects of the Aral Sea irrigation project. Notice the trends in the two graphs up to 1980, and then notice what happens in 1985. What questions occur to you?

Woman harvests cotton near the Aral Sea.

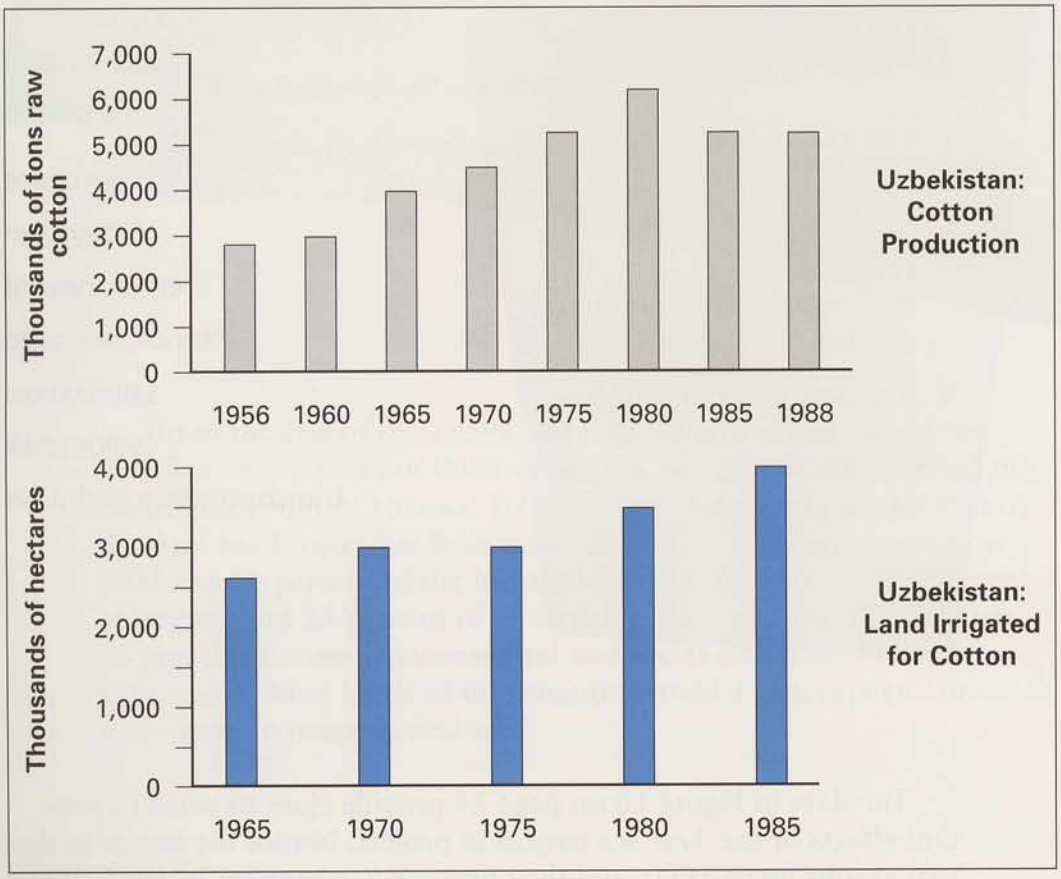


Figure 10 Amount of irrigated land and cotton production in Uzbekistan since the Aral Sea Project. Other republics (Kyrgyzstan, Tajikistan, and Turkmenistan) show similar trends.

Source: Gleason 1990.

What are the ecological effects of the shrinking Aral Sea?

Salt-dust storms

As the Aral Sea shrinks, the minerals that were once dissolved in the water have been left as deposits on the newly exposed shorelines. As a result, large areas of salt badlands, called solonchaks, have begun to emerge. These salt deposits are picked up by strong winds. In 1985 the crew of the space shuttle *Challenger* photographed huge white clouds of salt-dust being swept up from the shores of the Aral Sea. These dust clouds are up to 300 kilometers in size (Kotlyakov 1991).

It has been estimated that in some areas 1,000 pounds per acre of salt-dust are deposited annually on cropland. Closely linked with the salt-dust storms is salt-laden precipitation (Brown 1991). Rain and dew with high amounts of salt seriously damage soils and plants many miles from the Aral Sea. Mixed with this salt-dust are residues from defoliants and from officially banned—yet still used—pesticides such as DDT (Ellis 1990). These chemicals, which have been used to increase agricultural production, are toxic to many animals and plants.

Degraded water quality

Growing cotton commercially requires fertilizers, pesticides to control the boll weevil, and defoliants that remove leaves (to make harvesting easier). But these chemicals contaminate the soil, and they get washed through the soil into the groundwater. Polluted, toxic groundwater flows into the Aral Sea or is drawn up by wells for use on farms. The Amu Dar'ya and the Syr Dar'ya rivers have become heavily polluted by contaminated runoff from cotton and produce fields. Because irrigation has severely cut the rivers' flow into the Aral Sea, what little water does reach the Aral is a concentrated trickle of chemicals and salts (Brown 1991).

The lowering sea level, increasingly high salt and chemical contents, and airborne pollutants have all seriously degraded the water quality. The Aral is now a lake without aquatic life. By the early 1980s, 20 of the 24 native fish species had disappeared. Levels of pesticides are so high in the remaining fish that commercial fishing in the Aral Sea was halted in 1987 (Micklin 1988).

Habitat destruction

On land, native plant and animal communities have been hard hit by the declining water levels and deteriorating water quality. Prior to 1960, the river deltas were important both ecologically and economically. The deltas provided food for livestock, spawning grounds for commercial fish, and opportunities for hunting and trapping.

Tugay forests, which are dense stands of tall grasses and shrubs, play a major role in the ecosystems around the Aral Sea. But over the last 30 years, the area of the tugay forests has been cut by half. As this habitat has declined, the animals that depend on it have suffered. Once there were 173 different species of animals in the Aral region—mainly living around the river deltas. These animals included "muskrat, wild boar, deer, jackal, many kinds of birds, and even a few tigers" (Micklin 1988, page 1173). Now only 38 species remain. Highly mineralized water places stress on endangered species such as the Asiatic wild ass and the steppe antelope, which also live in the area (Micklin 1990).

Soil salinization

Irrigation provides water to allow more agriculture in the Aral Sea basin, but in the dry climate irrigation also causes a process called salinization. This occurs when salt accumulates in soil that has been heavily irrigated. Over time, the salt deposits get concentrated, becoming toxic to plants (Salter and Kovacik 1989). Because of the salts in the solonchaks, vegetation cannot grow. Without vegetation to anchor the soil, the winds continue to blow the salts (Micklin 1988). Much of the Aral Sea basin is now a wasteland of salt-poisoned soil.

Why does salinization occur? Irrigation water is full of chemicals and salts, because of the pesticides and fertilizers added by farmers. But in hot deserts, evaporation rates are very high and this dries out the soil surface. Water within deeper layers of the soil is forced upward toward the drier surface. This occurs for the same reason that moisture spreads toward the drier parts of a paper towel. As the soil water is drawn up to the surface, so are the salts and other minerals that are dissolved in it. As the water evaporates, the salts are left behind as a deposit on the soil (Kupchella and Hyland 1989).

Climate changes

Like all bodies of water, the Aral Sea helped moderate the climate of the surrounding region. This is because the water stored great amounts of heat. In a zone 100–200 kilometers from the Aral Sea, summers were cooler and winters warmer than the regions farther from the lake.

But as the Aral Sea has shrunk, its influence on the regional climate has also been reduced. The climate has become more like that of the continental interior. Precipitation has decreased and the temperature now fluctuates more. Summers are warmer and winters cooler than they used to be. With more extreme temperatures, the occurrence of killing frosts has increased. This has shortened the growing season. In the Amu Dar'ya delta, the frost-free season has been reduced to as few as 170 days. This is much less than the 200 frost-free days needed to grow cotton (Kotlyakov 1991). Some cotton plantations have had to switch and grow other crops (Micklin 1988).

1. In what ways has the environment of the Aral Sea region changed? Give an example from each of the previous five short readings on environmental effects.
2. Recall that the Aral Sea is part of an interior drainage system. How does this fact contribute to the salt and chemical pollution problems of the region?
3. Give two different reasons for the decline in cotton production in the late 1980s (Figure 10 on page 24).
4. Given the decline in cotton production, do you think that the Aral Sea Project has been successful? Why or why not?
5. Why have fish, bird, and mammal populations declined in the Aral region?
6. How do you think the human population might be affected?

How has the pollution of the Aral environment affected people?

Figure 11 "High and dry." What effect on people does this photograph show?

Source: Kotlyakov 1991.

What effects on people does the following quotation describe?

Effects on the Aral region economy

When Grigory Reznichenko, executive director of [the Soviet magazine] *Novy Mir,* visited the shoreside fishing town of Aralsk in the late 1950s, he was impressed by the variety of fish, fruit, and vegetables on sale at the local markets. When he returned in 1988 at the head of an expedition of 33 scientists and writers, he found a dead city. The sea had retreated about 60 km, leaving the hulks of abandoned boats aground in a desert [Figure 11].

More than 15,000 fisherfolk had left the town, and of the 10,000 people who remained, half were jobless. Many were sick with typhoid or hepatitis, and infant mortality was 10 percent—four times the national average. Other Aral ports, such as Muynak [Figure 7 on page 15], had suffered a similar fate.

> Recalling his distress as the expedition flew over the area, Reznichenko said: "Once human beings have reduced their environment to a state where they themselves can't live in it, then the human race itself faces the end of life on Earth" (Perera 1989, page 124).

Between 1960 and 1985, 20 of the 24 fish species native to the Aral Sea disappeared (Lee 1992). As the fish died, so did the once-prosperous commercial fishing industry. Muynak, once on the sea's southern coast, employed over 10,000 people in fishing or fishing-related jobs during the 1950s. At that time 100 million pounds of fish were taken annually from the sea. Most of it was processed in Muynak (Brown 1991).

Today Muynak is more than 30 miles from the sea (Figure 7 on page 15). Thousands of people who depended on the Aral for their livelihood have been forced either to find new employment or to retire early (Ellis 1990). Now that the Aral's commercial fishing industry no longer exists, there is a threat of political unrest among those who are unemployed. To keep canneries in the area open and avoid political unrest, the government of the former Soviet Union devised the following plan. Fish from the Atlantic, Pacific, and Arctic oceans are taken off ships in ports on the Baltic Sea and transported for processing to the Aral. For example, frozen fish are shipped to Muynak by rail for 1,750 miles, and then by truck for another 60 miles before being processed (Ellis 1990; Brown 1991).

Livestock raising in the Aral region has also been reduced. Salinization of soils kills grasses that livestock eat. Pastures and hayfields in the Amu Dar'ya delta have declined by 81 percent.

Estimates of total economic losses from the Aral Sea environmental disaster vary. One estimate, made in 1983, placed the *annual* damages at about $140 million—and this was only for the area around the Amu Dar'ya delta (Table 3 below).

Table 3 Estimates of annual economic losses in the Amu Dar'ya River delta

Economic sector	Annual losses (millions $)
Agriculture and livestock raising	62.2
Fishing and fish processing	45.9
Hunting and trapping	19.3
River and sea transportation	11.9
Total	139.9

Source: Micklin 1988.

7. Describe why each economic sector in Table 3 on page 29 is experiencing major annual losses.
8. Do you agree or disagree with the measures that the government took to reduce possible political unrest (e.g., bringing in fish from long distances for processing)? Why?
9. What kinds of possible economic activities are *not* listed in Table 3? Could any of these types of activities be encouraged to replace the region's lost economies? Why or why not?
10. Who should be responsible for repairing the economy of the Aral Sea region? Should the Commonwealth of Independent States (former Soviet Union) reduce the economic impact of this environmental disaster? Or should this be the responsibility only of the countries in the Aral Sea region? Why do you think as you do?

Effects on the health of the Aral's people

Human health problems related to air and water pollution are numerous and severe. The situations described in Table 4, which follows, are believed to be caused by salt and chemical contamination of the water and air.

Table 4 Disease in the Aral Sea region compared to the whole area of the former Soviet Union

Typhoid fever cases	30 times the national average
Hepatitis	7 times the national average
Kidney disease, gallstones, chronic gastritis, and liver diseases	Above average increases
Esophageal cancer	7 times the national average
Birth deformities	Far above the national average
Cancers of many other kinds	On the increase

Sources: French 1989; Brown 1991; Kotlyakov 1991.

Air polluted by salt, chemical fertilizers, and pesticides has led to respiratory illnesses. Lung diseases were the third leading cause of death in Uzbekistan in 1988, after heart disease and cancer. Nearly half the people in Karakalpakia, next to the Aral Sea, suffer from respiratory troubles (Lee 1992).

Water has been contaminated by agricultural chemicals. About 90 percent of the people in the Aral region depend on wells and rivers for their drinking water (Perera 1989). These water supplies have become toxic. The declining quality of drinking water is probably the main reason for the increasing intestinal illnesses (particularly among children) and increasing cancer rates. The problem is worst in the heavily populated delta areas of the Amu Dar'ya and Syr Dar'ya rivers.

Nukus, capital of the region of Karakalpakia and a city of 152,000, has no choice but to use the toxic well-water (Figure 7 on page 15). A 125-mile-long pipeline to bring in water from clean reservoirs is being built. Until it is completed, there is little hope of reducing the high infant mortality and cancer rates of Karakalpakia (Ellis 1990).

Children have been most affected by the severe pollution of the Aral region. Women participating in a symposium on the Aral Sea issued this declaration:

> We, the women participants in the first international symposium, "The Aral Crisis: Origins and Solution"—specialists in the areas of ecology, medicine, geography, sociology, and demography—have concluded from analysis of data gathered from field observations that the Aral Sea region is one of ecological catastrophe that is especially hazardous to children.
>
> The mortality rate of children in Karakalpakia is one of the highest in the world and is growing each year. The maternal death rate in Karakalpakia has tripled in the last five years. More than 80 percent of women suffer from anemia, and every third pregnant woman gives birth prematurely. . . . Almost 70 percent of the children in Karakalpakia . . . are practically sick. The number of children suffering from nervous and psychological disorders has tripled in the last two years (cited in Kotlyakov 1991, page 36).

Children in the Aral Sea region are the most affected by its pollution.

11. What has caused the well-water supplies to become toxic?
12. Why would the people of Karakalpakia be the most severely affected by these health problems?
13. Do you think building new pipelines to bring in safe water solves the problem? Why or why not?
14. Why do you think infants and small children are especially at risk?
15. How are the health problems listed in Table 4 on page 30 related to the five environmental effects described earlier in this lesson?

How has the Aral Sea disaster affected other regions?

Following a visit to the Aral region, the geographer Philip Micklin wrote:

> The former eastern shore of the Aral is a barren wasteland with sand and solonchak stretching as far as the eye can see. A thick haze caused by blowing salt and dust obscured our view toward the remnant Aral Sea. The eastern shore of the Aral has retreated over 100 km in some places. The largest dust/salt storms arise from here, lifting particles 4 km [in the air], which are deposited up to 500 km downwind and . . . perhaps much farther (Micklin 1991, page 95).

Winds carrying Aral salt-dust can be strong and persistent. Scientists have found traces of salts as far away as the Arctic coast of Russia (Ellis 1990). Most salt from the exposed former lake bed of the Aral, however, gets blown toward the southwest by the prevailing winds (Figure 12 on page 34).

If Aral Sea salts have been found in areas hundreds of miles away, then transboundary pollution has occurred. Transboundary pollution is pollution that crosses a boundary. Political, physical, or regional boundaries are some types of boundaries that can be crossed. The problem of transboundary pollution is a concern for many countries, including the United States and Canada.

Pollution knows no boundaries.

16. Which areas of the Aral Sea are sources for salt-dust storms?
17. What neighboring countries could be affected by salt pollution originating in the Aral Sea basin?
18. How do you think governments in other countries should respond to pollution originating across a political boundary?
19. What would you do if you lived in a place polluted by salt from the Aral?
20. What are some examples of pollution across state boundaries that could occur within the United States? How about across international boundaries between the United States and its neighbors?
21. Is your community affected by pollution originating in neighboring communities? How do you feel about that? What do you think should be done about it? What might be the consequences?

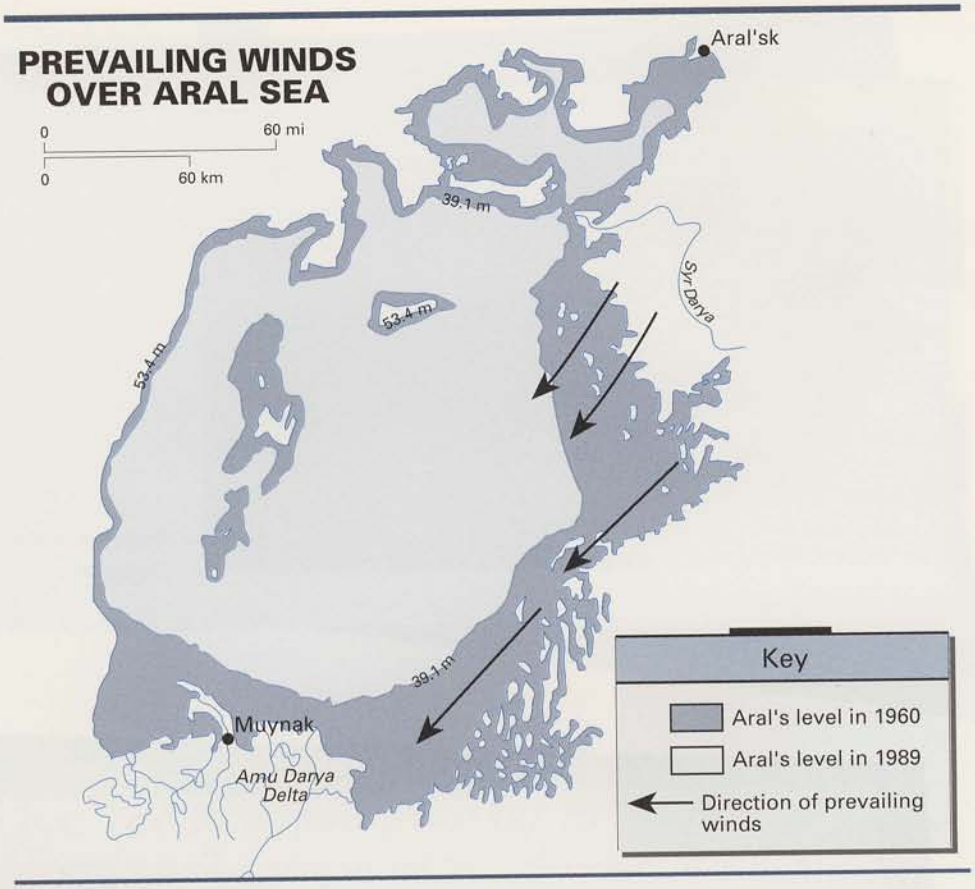


Figure 12 Source areas of salt-dust storms from the Aral Sea. The predominant direction of the storms is shown by the black arrows.

Source: Micklin 1991. Used with permission of P. Micklin.

Lesson summary

This lesson has described the ecological changes in the Aral Sea region and the economic and social problems associated with them. Consider this:

What is the connection between the quality of human life and the quality of the physical environment?

Think of some examples of this connection you can find within your own community.

How can the Aral Sea be saved?

Objectives

In this lesson, you will

- Recognize why the Aral Sea environmental disaster was unforeseen.
- Evaluate some proposals to solve the Aral Sea crisis.

Glossary Words

defoliant
desiccation
environment
hydrological

How could an environmental disaster such as the Aral Sea occur?

During planning for a major expansion of irrigation in the Aral Sea basin, conducted in the 1950s and 1960s, it was predicted that this would reduce inflow to the sea and substantially reduce its size. At the time, a number of experts saw this as a worthwhile tradeoff: A cubic meter of river water used for irrigation would bring far more value than the same cubic meter delivered to the Aral Sea. They based this calculation on a simple comparison of economic gains from irrigated agriculture against tangible economic benefits from the sea. Indeed, the ultimate shrinkage of the Aral to a residual brine lake as all its inflow was devoted to agriculture and other economic needs was viewed as both desirable and inevitable.

> These experts largely dismissed the possibility of significant adverse environmental consequences accompanying recession [of the water in the Aral Sea]. . . . Although a small number of scientists warned of serious negative effects from the sea's desiccation, they were not heeded (Micklin 1988, pages 1171–1172).

The former Soviet Union's government wished to increase agricultural output from the Central Asian region. This led to the decision to divert water from the rivers feeding the Aral Sea. In the Soviet Union, the development of crops was treated in the same way as the development of other industrial products, such as steel. Production targets or quotas were set by the government in the national capital, Moscow. Planners developed production quotas for each region in the vast USSR to contribute to the national economy.

Soviet agriculture had three kinds of farms. State farms, collective farms, and plots privately owned by farm employees all contributed to the Soviet agricultural economy. State and collective farms were controlled by the government, and local leaders were responsible for meeting the quotas set for the farms by government planners.

Two-thirds of Soviet farmland belonged to state farms. The average state farm had about 42,000 acres and 600 paid employees (Armstrong and Hunkins 1989; Resnick 1984). Collective farms averaged about 16,000 acres (Armstrong and Hunkins 1989). These farms were operated under the direction of a committee, led by a chair. The chair managed all aspects of the farming, such as machinery, livestock, farm buildings, and the employees' village. About 460 families made up the work force on these farms. Employees of state and collective farms were paid according to the amount of work done each month (Resnick 1984).

The third kind of farm was the privately owned plots, which were not under government control. These plots were given to state and collective farm employees for their own use. Produce and livestock from these plots were sold on the free market, and all of the profits were kept by the farmers. Soviet citizens came to depend on the private farmers for about one-third of their produce. People preferred produce from the private plots over the poorer-quality products sold by the government.

Cotton farming in the former Soviet Union.

Employees of the state and collective farms were encouraged to meet or

exceed their production goals. These farms needed to meet the government's crop production quotas. Higher production meant that farmers could share in the profits.

In Central Asia, cotton quotas kept increasing as the amount of irrigated land was increased. Farming techniques to increase cotton production were successful until the early 1980s. But in time these practices were unable to maintain increased cotton production. These farming techniques helped create the environmental crisis of the Aral Sea region.

Farming practices in the Soviet Union

Here are some general statements about agricultural techniques in the Soviet Union. How might these practices have contributed to or prevented the Aral Sea environmental disaster?

- Farmers used chemical pesticides and defoliants to increase the yield of the cotton crop. They knew it was hazardous to them and their families to use these, but they had to meet their collective's quota.
- As employees of state farms, farmers were given private plots for gardens. In these gardens, fruits and vegetables prospered. The farmers owned and took care of these plots and they produced well.
- On a collective farm, the land, farm machinery, tools, farm buildings, fertilizers, pesticides, and anything else that is part of farming was owned by the collective.
- Farmers' wages were paid every month. The more a person worked, the more that person was paid. The money came from what was left after the collective's expenses were paid.
- The government told farmers how much cotton they had to produce, and the farmers were expected to do their part in achieving the country's goal.
- The land is so dry farmers had to irrigate the crops. Even if the river went dry for part of the year, water-demanding crops such as cotton and rice had to be irrigated.
- Government policies forced farmers to use practices that were wrong for the land, wrong for the climate, or wrong for the water available. But farmers were considered to be employees of the state who couldn't question these policies.

1. How did the fact that agricultural plans were made by government officials in Moscow contribute to the environmental crisis in Central Asia?
2. Do you think this level of environmental pollution would have occurred had local farmers been in control of agricultural planning? Why or why not?
3. Who do you think should decide how the environment is used? Why?

How can the Aral Sea crisis be solved?

What can be done to repair the Aral Sea environment? It isn't as simple as stopping all irrigation. Irrigation is the economic backbone of the region; over 90 percent of the harvest comes from irrigated lands (Micklin 1988). There are national campaigns to make irrigation more efficient, ban pesticides, and clean up polluted waters (Micklin 1988; Kotlyakov 1991). But even these acts won't return the Aral environment to its former state. Some people say the Aral is beyond saving, but local inhabitants have not accepted this bleak judgment. Following are two very different plans to solve the Aral Sea crisis.

Plan I. Diverting water from Siberia to Central Asia

One proposal is to divert water from Siberian rivers, which flow north into the Arctic Ocean, and transfer it via pipelines to the Aral Sea basin (Figure 13 on page 39). Such water diversion projects have been discussed for many years. Plans for Figure 13's Project V had progressed to the engineering stage in 1985, but the Soviet government later shelved the project (Micklin 1988). During the final years of the Soviet Union, the country was troubled by major economic problems, and government planners thought that the enormous Project V would prove too costly.

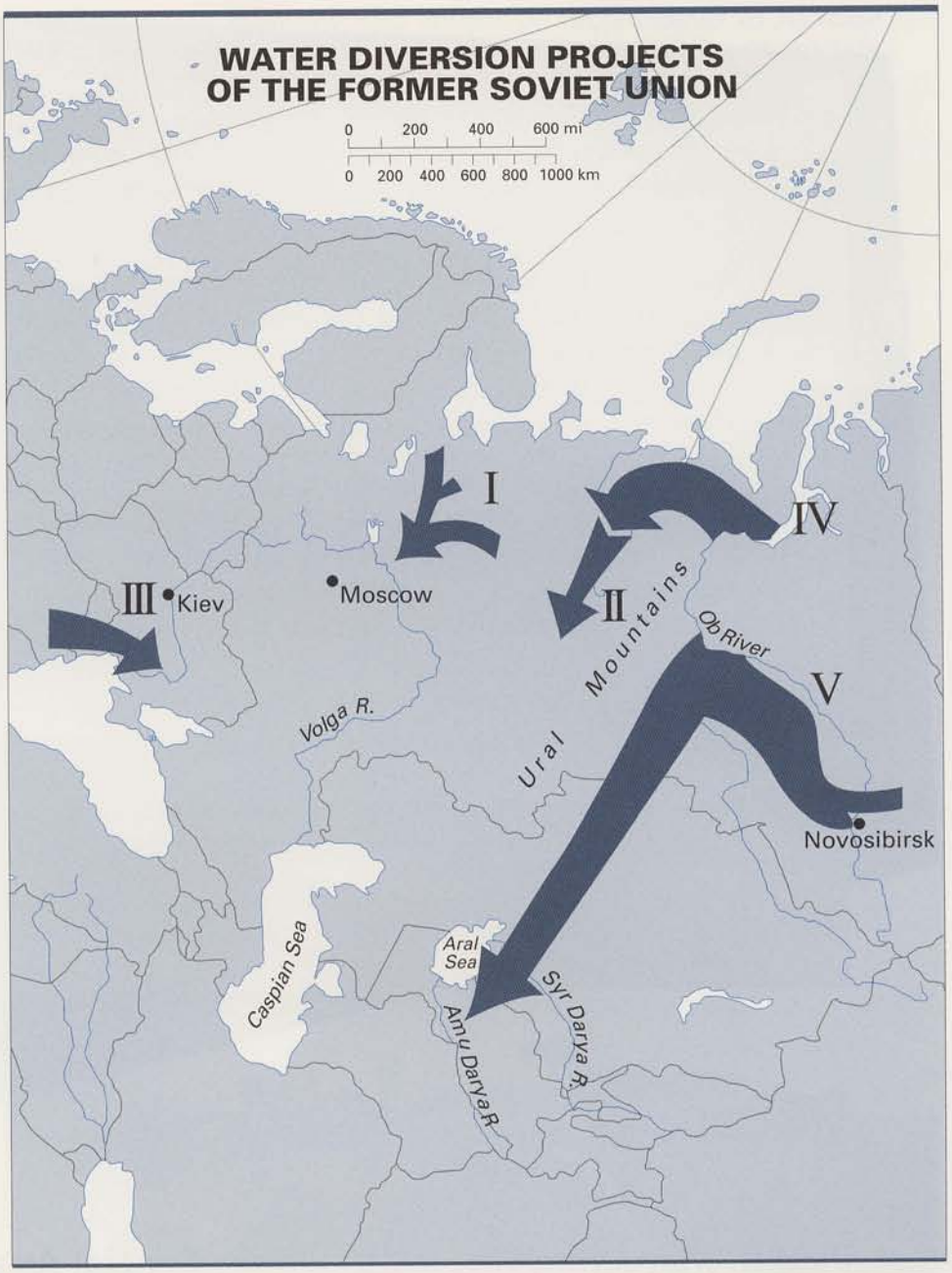


Figure 13 Five proposed water diversion projects in the former Soviet Union. The width of the arrows indicates the volume of water that was proposed to be transferred for each project. The proposal for Project V was to transfer water from the Ob River basin of western Siberia to the Aral Sea basin.

Source: Boehm and Swanson 1989.

4. Approximately how many miles would water have to be moved to divert the flow of the Ob River to the Aral Sea, according to the plans for Project V?
5. What does Figure 13 indicate about the size of Project V, in terms of the volume of water diverted, as compared to the other projects? What conclusions can you draw about the relative importance of this water diversion project to Moscow (that is, to the central Soviet government)?
6. With the USSR dismantled, Project V now would be an *international* water diversion—from Russia through Kazakhstan to Uzbekistan, which are now all separate nations. How does this change affect the likelihood of Project V being built? Who do you think should pay for Project V if it is built?
7. What would be the *economic* advantages and disadvantages of diverting water to save the Aral Sea?
8. What would be the *environmental* advantages and disadvantages of diverting water to save the Aral Sea?
9. In general, do you support the idea of a water diversion project to save the Aral Sea? Why or why not?

Plan II. Managing water use within Central Asia

Would diverting water from one country to another really solve the Aral Sea problem? V. M. Kotlyakov, director of the Institute of Geography in the Academy of Sciences in Moscow, has suggested that solving the Aral Sea environmental disaster needs a different strategy. He believes the management of Central Asia's water resource must be improved.

> The current practice of adjusting water use to meet the demands of agricultural production development must change. On the contrary, the problems of water use should be the deciding factor in agricultural production plans. The role of cotton in

the country's economy also should be reconsidered to increase the production of foodstuffs and to introduce more salt-resistant and less water-intensive crops.

The water resources of Central Asia must be inventoried. Special attention should be given to increasing the efficiency of water-[saving] systems, decreasing irrigation quotas by 15 to 20 percent, optimizing drainage systems to reduce water consumption, and improving regulation of runoff. The water freed in this way should be used primarily for resolving ecological imbalances to reinstate the normal conditions of life and health for local populations.

Saving the Aral region and resolving its tangle of ecological, hydrological, and socioeconomic problems will require a new attitude and an entirely new approach to economic activity throughout Central Asia. Agriculture and other branches of the economy should be allowed to return to their traditional forms, which have been destroyed over the past decades, and attitudes toward water use should be changed (Kotlyakov 1991, pages 36–38).

At a 1990 conference in Nukus, the capital of the Uzbekistan province of Karakalpakia, over 200 scientists met to develop a plan to save the Aral Sea. These scientists included specialists in water management, ecology, and medicine. People attended from all countries in the Aral Sea basin as well as from Russia, the United States, and over 25 other countries.

Girls and cattle at a water hole in the Aral Sea region.

These scientists *unanimously* agreed that the water level of the Aral Sea must be stabilized to restore the ecological health of the region. They argued that the region's economy would be restored if the environmental problems were repaired. People's health would improve and social tensions would be reduced. They recommended that these four steps be taken to manage the region's water resource and stabilize the Aral Sea (Kotlyakov 1991):

- Strictly limit use of water by countries in the region and introduce water-saving technology in all areas of the economy;
- Prohibit expansion of the land area under irrigation to free river flow for preserving the Aral Sea;
- Limit rice and cotton agriculture and remove unproductive land from irrigation. Develop instead orchards, vineyards, and alfalfa crops;
- Remove systems that drain polluted agricultural runoff from irrigated land to the Aral Sea.

10. Kotlyakov emphasized that water use should dictate agricultural planning and not the other way around. Why? Do you agree? Why or why not?
11. What does Kotlyakov mean when he says that saving the Aral Sea "will require a new attitude"? How do you think this could be achieved?
12. How would each of the four recommended steps stabilize the Aral Sea and maintain the region's environmental quality?
13. Which of the two proposed solutions to save the Aral—water diversion or water management—do you think is better? Why? Why do you think other people would disagree?
14. Which plan would be more difficult to undertake? Why?

Lesson 6

How has the pollution of the Aral Sea affected people's perspectives?

Objectives

In this lesson, you will

- Understand that environmental perspectives can be expressed in a political way.
- Illustrate a political view based on acquired geographic information.

Glossary Word

environment

Figure 14 Graffiti written on a rock. The graffiti translates as: "Come back, Aral. Forgive us."

Source: Kotlyakov 1991.

As early as the 1960s, people living in the Aral Sea region became aware of the environmental problems discussed in this module. At that time, when the region's environmental problems were just beginning, the Soviet government was not concerned with environmental pollution. The primary focus was on economic development based on plans and production quotas. Cotton production had priority over all else (Ellis 1990).

The people of the Aral Sea area alerted their government to the changes to the environment. Fishermen could see the decreases in their catches. People felt the summer temperatures increase and the winter temperatures decrease. The water in the sea, in the rivers, and in the ground became scarcer and saltier. Children and adults had more health problems. Social unrest increased in the region as more and more people lost their livelihoods and fell sick. Residents of the Aral Sea region remembered when the winds were not full of salt-dust.

Now, after more than 30 years of environmental pollution, the entire economic and environmental structure of the Aral region has been overturned. The Russian geographer Kotlyakov (1991) said that in order to save the region, new perspectives were needed on the relationship between the economy and the environment.

Political art is a powerful way for communicating ideas to try to change people's perspectives. The person who wrote the message on the rock (Figure 14 on page 43) has a particular point of view about these changes. Political cartoons, comic strips, and bumper stickers also express opinions. These statements may be humorous, satirical, sarcastic, or serious, but they are typically short, poignant, and thought provoking.

How do you feel about the Aral Sea crisis?

How would you design a short, clever, and thoughtful way to express your thoughts about the environmental pollution of the Aral Sea region? Here are some possibilities:

- Comic strips
- T-shirts or hats
- Bumper stickers
- Billboards
- Pins or buttons
- Political cartoons
- Posters
- License plates

How has Madagascar's environment been degraded?

Objectives

In this lesson, you will

- Identify two reasons for the high diversity of plant and animal species on Madagascar.
- Explain how population growth can lead to agricultural practices that alter the physical characteristics of places.
- Compare the environmental pollution on Madagascar to that of the Aral Sea.

Glossary Words

biodiversity
ecosystem
environment
hectare
shifting cultivation
subsistence farming

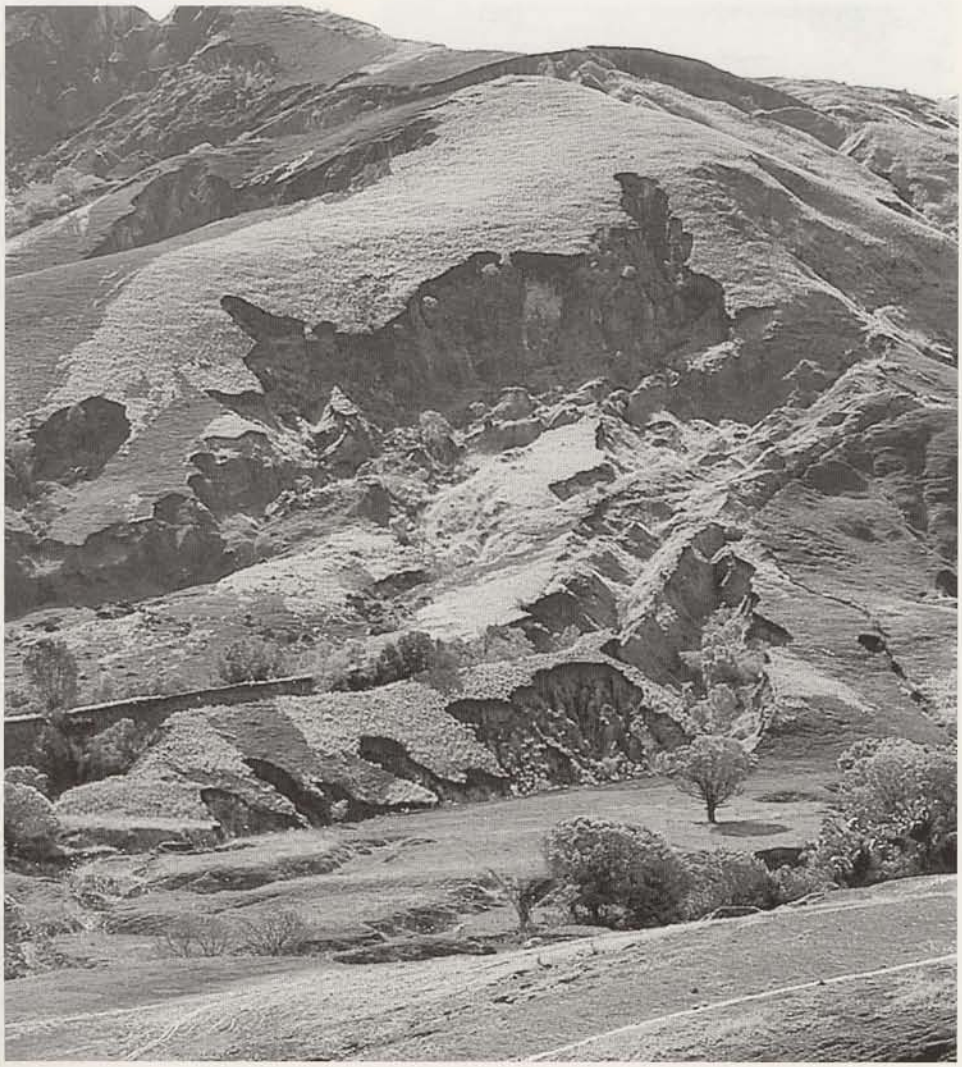
What is the issue on Madagascar?

To continue our look at how environments can be changed by humans, we now turn to the island of Madagascar (Figure 15 on page 47). As with the Aral Sea, human activities have caused major environmental change. But though the Aral's problems developed within the time span of one generation, Madagascar's environmental problems have developed over many generations.

Before humans arrived on Madagascar, its biodiversity was probably higher than anyplace of similar size on Earth (Durrell 1986).

This huge island, the world's fourth largest, has a broad range of environments: mountains and river valleys, deserts and forests. Combined with its wide range of climate, this diversity leads to many vegetation types (Figure 15 on page 47). Many different kinds of animals and plants can thrive in the countless variety of habitats (Durrell 1986).

Another reason for Madagascar's biological richness is that the island has been isolated from other continents for millions of years. Originally a part of Africa, the island broke away about 165 million years ago (Jolly 1987). Long isolation from other species allowed the island's plants and animals to evolve into unique varieties. Eighty-five percent of Madagascar's plant and animal species are unique to the



Serious gullying results from deforestation of steep slopes in Madagascar.

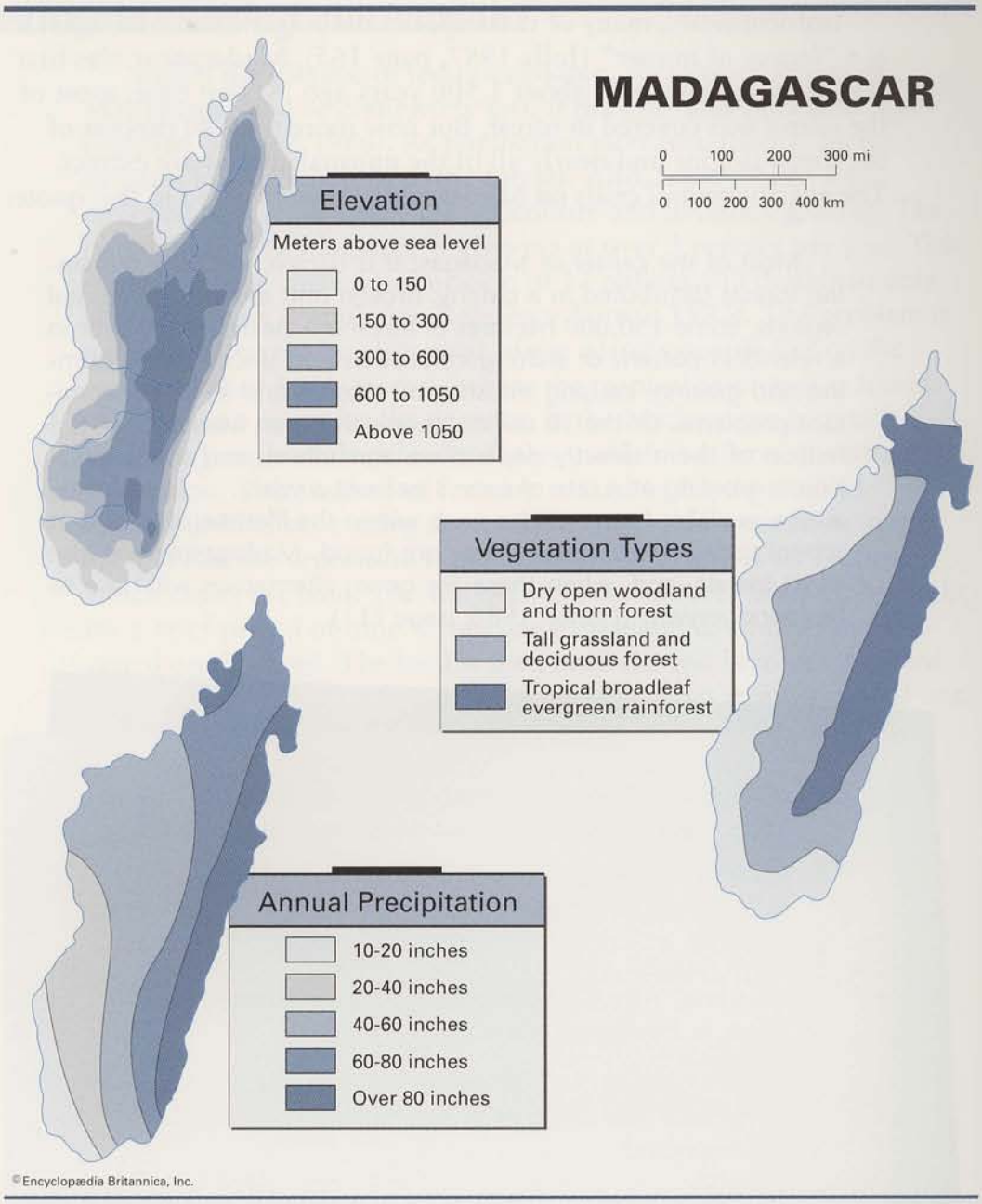


Figure 15 Madagascar: relief map, annual precipitation, and vegetation types.

Source: Goode's World Atlas, 18th edition, 1990.

island (Fowler 1989). Animals were totally different from those on mainland Africa—or from anywhere else, for that matter. Some examples: three kinds of giant flightless birds, two giant tortoises, and 11 species of giant lemurs (Durrell 1986).

Unfortunately, many of these species no longer exist. Madagascar is a "legacy of misuse" (Jolly 1987, page 165). Madagascar was first settled by humans only about 1,500 years ago. At that time, most of the island was covered in forest. But now more than 80 percent of the forest is gone and nearly all of the unusual species are extinct. The environmental crisis on Madagascar is summarized in this quote:

> Most of the center of Madagascar is barren, with the remaining forests distributed in a patchy, broken ring around the coastal regions. Some 150,000 hectares of forest are cleared every year in a relentless pattern of shifting cultivation and uncontrolled burning and grazing, causing massive soil erosion and all its concomitant problems. Of the 10 million people living on Madagascar, 8.5 million of them directly depend on agriculture, and the population is growing at a rate of over 3 percent a year. . . . At this rate, all the available forest will be gone within the lifetime of a child at school today. Unless alternatives are found, Madagascar will lose all its forests, and, when these are gone, alternatives will have to be found anyway (Durrell 1986, page 111).

1. What two reasons are given for the high number of unique plant and animal species found on Madagascar?
2. How do these two factors help explain Madagascar's high biodiversity?
3. At its closest, about how many miles is Madagascar from mainland Africa? Approximately how large, in square miles, is Madagascar?
4. Looking at the three maps on Figure 15 (page 47), how many different kinds of environments can you identify on Madagascar?
5. Would you expect the number of unique plant and animal species on the Comoros Islands to be more or less than on Madagascar? Why?
6. Do you think diversity of plant and animal species is important? Why?
7. Why is an increasing population leading to destruction of forests on Madagascar?
8. What do you think the author (Durrell) meant in the last sentence of the quote?

What is *shifting cultivation*?

Within the lifetime of today's children, the diverse forests of Madagascar will be completely lost, if present rates of destruction continue (Durrell 1986). As population increases, there is higher demand for fuelwood from the forests. Also, more forests are removed to provide space for agriculture and livestock grazing. The population of Madagascar is growing at over 3 percent per year. This means that the current population of 12 million will double in only about 22 years (Population Reference Bureau 1992). The problem is made more severe because most of the island's people live on the eastern side of Madagascar—where the tropical rainforest is found.

The main cause for the decrease in the Madagascar forests is what the people of the island call *tavy*, which is a form of shifting cultivation. This method of farming is used widely in tropical regions. It involves cutting down all the trees and vegetation in an area. When the vegetation is dry enough to burn, it is set on fire, which clears the land. The soil becomes enriched by the ash, but only for a brief period of time. Crops are then planted, tended, and harvested on this land. The land is used until the soil becomes depleted of nutrients, which can happen in just a few years in a warm and wet climate. Farmers then abandon the plots to let the vegetation reestablish itself and let the soil recuperate. The farmers move on to another area of land and repeat the process. In this manner crop rotation takes place over a period of years.

While this may seem environmentally destructive, it is an ancient method of farming (Salter and Kovacik 1989). Tavy farming in Madagascar has been productive for centuries. However, since 1950, over 80 percent of the island's forests have been destroyed. Why has the situation changed?

Why has shifting cultivation become a problem?

Shifting cultivation [is] one of the major agricultural systems of the world. Widespread though it has been, shifting cultivation has not generally resulted in long-term elimination of forests. For example, Southeast Asia has featured shifting cultivation for at least 2,000 years, which indicates that the system is an essentially sound mode of utilizing

Results of shifting cultivation in Madagascar.

> forest environments within traditional patterns. Farmers would follow a locally migratory way of life by . . . felling and burning a patch of forest, raising crops for two or three years until the soil lost its fertility or until weeds encroached, then moving on to repeat the process in another patch of forest, eventually returning to the original location. This [system] allowed the cultivator to make sustainable use of the forest environment. As long as there were only a few cultivators per square kilometer, generally five or less (depending on local circumstances), and provided the patch of farmed forestland could be left fallow for at least 10 years in order to renew itself, the system worked. . . . Now, however, in many areas, the numbers of shifting cultivators have increased to a point where there are often three or more times as many people per square kilometer as formerly, with the result that they have less space for local migration. The upshot is that they [allow] local ecosystems insufficient time to recover. Soils then rapidly become exhausted, and especially in wetter areas, weeds encroach. After as few as two cycles, the cultivator is obliged to abandon the area altogether, and move on to start afresh in a new patch of primary forest, hence progressively disrupting undisturbed [tropical forests] (Myers 1980, pages 23–24).

In Madagascar, as in many other parts of the world where shifting cultivation occurs, the people who are engaged in this method of agriculture are subsistence farmers. This means that their crops supply food or products only for small groups of people, perhaps for a family. However, since 1950 the population of the island has doubled. This increase in population has led to some drastic changes in the farming cycle. In the past a piece of land was cleared and replanted about every 15 years. But because there are now more people who need to grow food from the same land, the cycle has been shortened to three years (Knox 1989). Shorter cycles of shifting cultivation do not permit enough forest regrowth to restore the soil's fertility. This means that the farm productivity must decline (National Research Council 1982).

Another consideration related to a rapidly growing population is where the people live. Shifting cultivation formerly did not cause a permanent clearing of land. The land would be cleared, farmed, and abandoned—allowing the forest to regrow. But as the population grows rapidly, land used for crops may afterward become a town or be developed for another use, instead of being allowed to return to forest. If forests are not allowed to regrow, new forest areas must be cleared to provide land for farming. In this way the traditional rotation of shifting cultivation is broken, and increasing amounts of forested lands are removed for farming (Salter and Kovacik 1989).

How can we prevent future environmental disasters?

Objective

In this lesson, you will

- Create a statement that guarantees rights to the environment, in order to prevent future environmental disasters.

Glossary Words

ecosystem

environment

transboundary pollution

Excerpts from the U.S. Bill of Rights (ratified in 1791)

I. Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances.

IV. The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated . . .

V. No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a Grand Jury, . . . nor shall any person be compelled in

any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law. . . .

IX. The enumeration in this Constitution of certain rights shall not be construed to deny or disparage others retained by the people.

Should there be an Environmental Bill of Rights?

A scientist from Moscow State University, Ruben A. Mnatsakanyan, has suggested that the international problems of environmental pollution cannot be ignored. He argues that there is a need for international law to prevent transboundary pollution. He believes that decisions made by individual countries that affect other countries' environmental well-being should only be made according to established criteria. Such criteria would establish a global basis for future interaction between humans and the environment.

To achieve this, Dr. Mnatsakanyan has proposed that a Bill of Rights be drafted for the environment. He suggests that it be modeled after the U.S. Bill of Rights, which guarantees the rights of individual people in the United States. His point is that all of Earth's individual ecosystems need similar protection (Richman 1990).

- How would you write an Environmental Bill of Rights to guarantee the protection of Earth's environment?
- What principles would be important to ensure that environmental pollution does not continue?
- How are the rights of U.S. citizens protected and enforced? How could the environment's rights be enforced?

Glossary

Biodiversity Short for biological diversity, meaning the variety of plants and animals found in an area. Higher biodiversity means that there are more species present.

Central government A political system in which the power for making policies and decisions affecting every place in the country is held by one body, unlike decentralized government, where policies and decisions for places are made by many different bodies, both national and local.

Defoliant A chemical sprayed or dusted on plants to cause the leaves to fall off.

Desiccation Drying of soil and land surfaces, for example, by seasoned climate change, or by human action such as the removal of forests.

Ecosystem The interactions among groups of living organisms, together with the interactions between the living organisms and the nonliving elements of their physical environment.

Environment The surroundings of a plant or animal, including other plants and animals, climate, and physical location.

Exotic river A stream that flows across a region of dry climate but gets its water from adjacent mountains where there is a surplus of water.

Hectare A measure of land in the metric system; 1 hectare equals 2.471 acres.

Hydrological Refers to water and water-related processes on Earth, such as precipitation and evaporation.

Interior drainage A system in which rivers flow into lakes or basins within a region rather than flowing to other rivers or oceans outside the region.

Remote sensing The use of aerial photography, satellite images, and radar for gathering information about Earth from a distant vantage point.

Salinization The process by which salts accumulate in the soil, sometimes to levels toxic to plants, after the evaporation of large quantities of irrigation water.

Shifting cultivation A method of farming in which plots of land are cultivated for several successive years and then abandoned for a time so that they can recover their fertility before being cultivated again. Farmers shift to cultivate another plot of land while the first plot recovers. Usually the plant cover is cut or burned prior to cultivation. In Madagascar, this system is called *tavy*.

Solonchak A Russian word for a salt badland near a body of saltwater, caused by receding water levels.

Subsistence farming Cultivation that produces only enough food to feed the cultivator and his or her family.

Transboundary pollution Any form of pollution that crosses a boundary of any kind, such as a political, physical, or regional one.

Watershed All the land area that contributes runoff to a particular body of water. Also referred to as a basin or drainage basin.

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Britannica Global Geography System

A Note on Assessment

Enclosed is an achievement exam for one module of the Britannica Global Geography System (BGGS). It is one of the many tools for you to use in assessing your students' work on Geographic Inquiry into Global Issues (GIGI). The multimedia, inquiry approach of BGGS lends itself to a variety of evaluation options.

This achievement exam includes objective matching, multiple choice, and true–false questions, as well as more subjective data analysis and short-answer questions. Tests emphasize four major areas of student comprehension of the GIGI material. First, students must be able to recognize and define important glossary terms. Second, they must demonstrate a grasp of the principal geographic concepts introduced in the study of each global issue. Third, they must manipulate examples of data they used in the module to prove their facility with geographic skills. Finally, students are challenged to think critically about analyzing issues and data. Keys provide objective answers and guidelines for evaluating students' written responses.

With the inquiry-based program of GIGI, various techniques of assessment can contribute to your overall program of evaluation. Questions posed in the module are often intended to stimulate open-ended inquiry, speculation, and discussion. As a comprehensive exercise, assign a longer essay, giving your students an opportunity to summarize their understanding of the issues. Essays can be based on each module's leading question (the title of the Student DataBook *Overview*), which incorporates the geographic theme explored in the module. Have students defend a position, citing data supplied in either the module or in their independent inquiries.

The BGGS package has many resources for assessment. See the *Assessing Learning* section of the *Memo to the Teacher* section of the Teacher's Guide for suggestions. More ideas for assessment are provided in the *For Further Inquiry* sections of many lessons and in the *Extension Activities and Resources* section at the end of each Teacher's Guide.

Consider having students maintain a Module Portfolio or Student Journal throughout the course of their inquiry. A portfolio can include students' definitions of glossary terms, answers to questions, completed activity sheets, and their individual or group investigations. Students may also create and present their own inquiry lessons using the BGGS videodiscs and CD-ROM. They can gather information and design a visual display about countries and world issues using Geopedia™.

The possibilities for assessment are limitless. Blend strategies to see if your students have attained the three main goals of BGGS and GIGI—to promote (1) responsible citizenship; (2) geographic knowledge, skills, and perspectives; and (3) critical and reflective thinking.

The GIGI Staff

Name _____

GIGI
Environmental Pollution • • •

Assessment

1. Matching:

___ desiccation	a. interactions among groups of living organisms and between the living organisms and the nonliving elements of their physical environment
___ ecosystem	b. variety of plants and animals found in an area
___ salinization	c. land area that contributes runoff of a body of water or drainage basin
___ watershed	d. process by which salt accumulates in soil after evaporation of large quantities of irrigation water
___ solonchak	e. drying of soil and land surfaces
___ biodiversity	f. salt badlands caused by receding water levels

2. What is an *exotic* river?

3. The two major rivers flowing into the Aral Sea are:

_____ and _____

These rivers flow from which two mountain ranges?

a. Himalayas and Urals

b. Andes and Rockies

c. Pamirs and Tien Shan

d. Alps and Caucasus

4. Remote sensing images are:

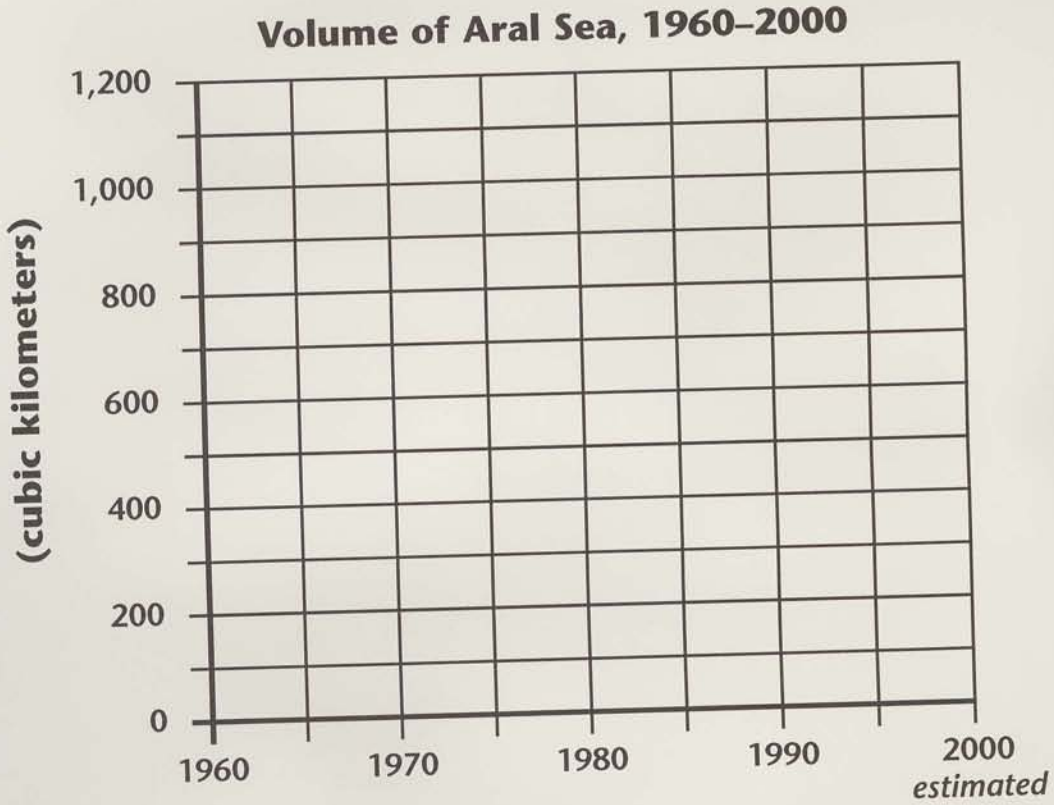
a. rarely used because they're taken from very far away

b. helpful in spotting patterns of environmental changes

c. tools often used by medical doctors to perform surgery

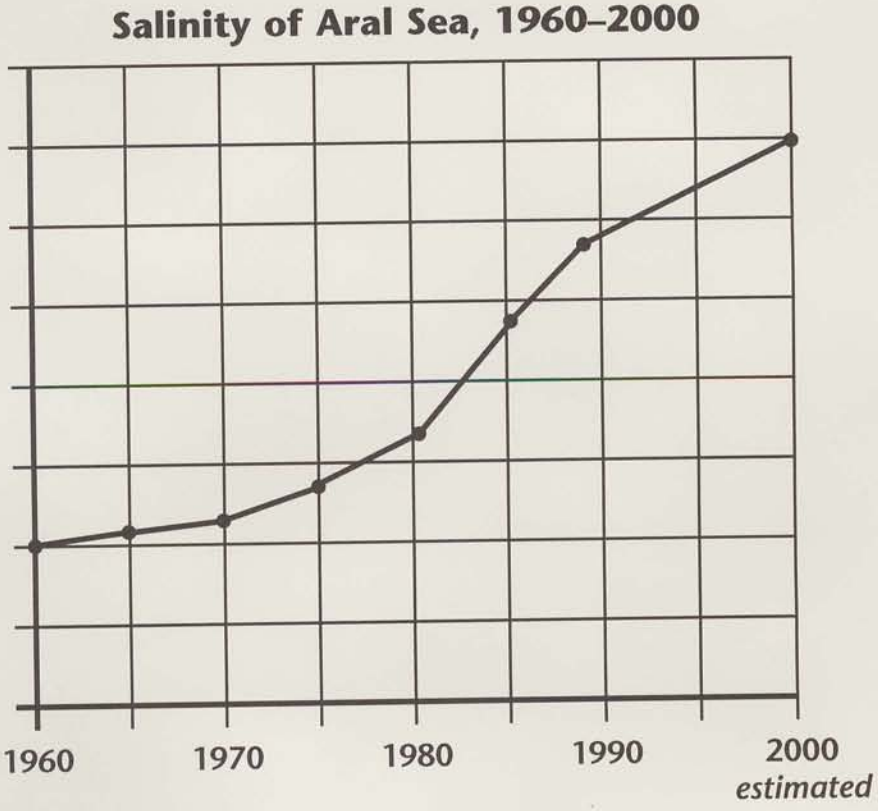
d. a small black box that changes the channels on your TV

5. a. On the following graph, draw a line that shows what has happened to the volume of the Aral Sea.



b. Why did that change occur?

6. **a.** What does this graph illustrate?



b. Why has this change occurred in the Aral Sea region?

7. Before 1960, the Aral Sea provided economic importance to the people of the region through all of the following except:

a. commercial fishing

b. subsistence farming

c. food for livestock

d. hunting and trapping

Name _____

8. When irrigation was introduced in Central Asia, which physical change occurred to the environment?

a. The quality of well–water improved.

b. Dust storms became less frequent.

c. The habitats in the river deltas improved.

d. Seasonal differences in temperature became more intense.

9. Currently, the rate of evaporation is _____ the amount of water flowing into the Aral Sea?

a. greater than

b. less than

c. equal to

10. True or false?

a. Transboundary pollution can effect people hundreds of miles away from the original source.

b. The Soviet government did not predict the environmental problems that the Aral Sea Project would create.

c. Subsistence farming is a method of farming used to grow crops for export.

d. Madagascar once had a very high biodiversity because it has a wide range of climate and environments.

Name _____

11. Both the Mono Lake and Aral Sea regions share a common type of watershed system that collects water but does not release it except through evaporation. This type of system is a/an:

_____

12. Commercial fishing was halted in the Aral Sea region in 1980 because:

a. All the people started farming.

b. There wasn't a market for fish.

c. The fish were contaminated by water pollution.

d. People in the region didn't eat fish.

13. a. List three ecological effects caused by the shrinking of the Aral Sea.

_____

_____

_____

b. Explain how the each of these affects both the human and physical environment of the Aral Sea region.

Name _____

14. What group from the Aral Sea region is MOST at risk of health problems because of the pollution? Explain.

15. Human health problems have increased significantly since the Aral Sea Project began. Why?

16. Describe two ways in which the Aral Sea crisis can be solved. What are the advantages and disadvantages in each of the two plans discussed?

Name _____

17. Below are six steps of a 15–year cycle of shifting cultivation. Arrange the steps in the proper sequence, showing the order in which they take place.

a. Land left fallow for 15 years.

b. After two or three years, soil loses fertility.

c. Vegetation regrows in 15 years.

d. The crop is harvested.

e. Field is abandoned.

f. The crop is planted.

1. ___ **2.** ___ **3.** ___ **4.** ___ **5.** ___ **6.** ___

18. Since 1950, over 80% of Madagascar's forests have been destroyed. All of the following are reasons for this destruction except:

a. The increase in population caused shorter cycles of shifting cultivation.

b. Uncontrolled burning and grazing of the land caused massive soil erosion.

c. Because of population increases, more towns were built where the land used to be abandoned for restoration.

d. People cut down the trees to sell timber to other countries.

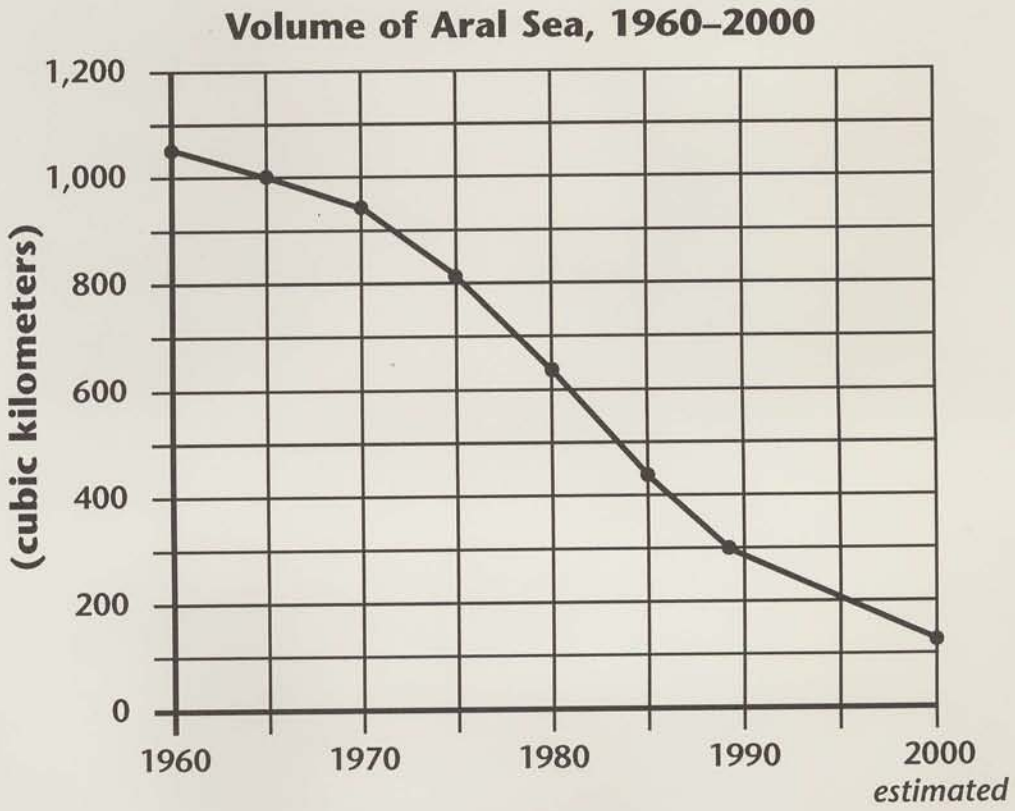
1. e, a, d, c, f, b

2. An exotic river is a stream that flows across a region of dry climate but gets its water from adjacent mountains where there is a surplus of water.

3. Amu Darya and Syr Darya; c

4. b

5. **a.** The graph should show volume decreasing over time.



b. The size of the Aral Sea decreased because of direct results of the Aral Sea Project in which water was diverted from the rivers before it reached the Sea.

6. **a.** Salinity has increased over time.
b. As the volume of water decreases, the salinity increases.

7. b

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Assessment

8. d

9. a

10. a. True
b. True
c. False
d. True

11. Interior drainage

12. c

13. a. Ecological effects described include:
salt-dust storms degraded water quality
habitat destruction soil salinization
climate changes

b. Salt-dust storms cause health problems both in the Aral Sea region and through transboundary pollution as wind carries the salt-dust in the air and gets into people's lungs, covers crops, and ends up back in water.

Water is contaminated by chemical fertilizers getting into the groundwater, well-water, and eventually back into the Sea.

Declining water levels and deteriorating water quality affected the food supply for livestock, spawning grounds for commercial fish, and opportunities for hunting and trapping. It also eliminated several species and endangered others.

Soil salinization is soil that is contaminated by salt, severely reducing the nutrients available to plants.

Water stores heat, so as the Sea was shrinking, its influence on the region's climate was reduced.

14. Infants and children

15. Air polluted by salt, chemical fertilizers, and pesticides has led to respiratory illnesses. Well-water and river water used for drinking has been contaminated by agricultural chemicals leading to intestinal diseases and increasing cancer rates.

16. Plan 1. Diverting water from Siberia to Central Asia.

Disadvantage – too costly, might not ultimately solve the problem and might create problems in Siberian rivers.

Plan 2. Managing water use within Central Asia.

Advantages – People's health would improve; social tensions would be reduced.

17. f, d, b, e, a, c

18. d