Author Name: Jack Ashton	**Content Areas:** Environmental Science
Lesson Plan Title: AP Environmental Science Labs	**State: NC**
Lab Time Frames: Environmental Lab Skills 1-2 periods Wild Populations: Using Field Data 1-3 periods Environmental Lab Skills 1-2 periods You Decide the Fate of the Country 1-4 periods	**Expedition Title:** Carnivores of Madagascar
Student Level: High School AP Environmental Science	

Lesson Plan Introduction

In Advanced Placement Environmental Science, students need to incorporate real world examples with the content from their book. To this end, I have applied what I have done in Madagascar into my course. Attached are four labs that have been added into the student's lab manual starting in the 2005-2006 school year. Additionally, I will include information from my work into lectures on portions of the North Carolina standard course of study (at the end of this page). These changes will be made permanent in the lab manual and course outline.

Competency Goal 2: The learner will build an understanding of the interdependence of Earth's systems.

2.02 Investigate the cycling of matter.
- Water.

2.03 Investigate the solid Earth.
- Earth history and the geologic time scale.
- Influences of plate tectonics on evolution and biodiversity.

2.05 Investigate the biosphere.
- Organisms: adaptations to their environment.
- Populations and communities: exponential growth and carrying capacity.
- Ecosystems and change: biomass, energy transfer, succession.
- Evolution of life: natural selection, extinction.
- Biomes: global distribution

Competency Goal 3: The learner will build an understanding of human population dynamics.

3.01 Analyze human population history and global distribution.
- Demographics.
- Age structure diagrams.
- Survivorship curves.
- Patterns of resource distribution.

3.02 Investigate local, regional and global carrying capacities.
- Limiting factors.
- Density-dependent and density-independent factors.

3.03 Analyze cultural and economic influences on population
- Pronatalist factors.
- Antinatalist factors.
- Demographic transition.

Competency Goal 4: The learner will build an understanding of the distribution, ownership, use and degradation of renewable and nonrenewable resources.

4.01 Analyze sources and uses of freshwater and oceans.
- Agricultural, industrial and domestic water uses.
- Fisheries and aquaculture.
- Water management and conservation.

4.03 Analyze local, regional and global soil aspects.

- Erosion and conservation .

4.04 Analyze biological resources.

- Benefits of biodiversity.
- Threats to biodiversity.
- Endangered species management.
- Nutrition and food supplies.

4.06 Analyze land types and uses.

- Residential and commercial, land use planning.
- Agricultural and forestry.
- Recreational and wilderness.
- Ecotourism, Parks and preserves.

Competency Goal 5: The learner will build an understanding of air, water and soil quality.

5.04 Analyze and investigate local, regional and global issues concerning solid waste.

- Types, sources and amounts.
- Disposal methods and environmental effects.
- Decreasing waste: Reduce, reuse, recycle.

5.05 Analyze impacts on human health.

- Infectious disease.
- Chemical agents.
- Risk assessment.

Competency Goal 6: The learner will build an understanding of global changes and their consequences.

6.02 Investigate effects and consequences on the oceans.

- Sea level changes.
- Surface temperatures and currents.

6.03 Investigate effects and consequences on biota:

- Habitat fragmentation and destruction.
- Introduced species.
- Overharvesting.

Lesson Title	Environmental Lab Skills
Grade Level	High School
Content Area	Environmental Science
Time Allotment	1-2 class periods
Academic Standards Addressed	North Carolina Standard Course of Study – AP Environmental Science 1.02 Design and conduct scientific investigations to answer questions related to earth and environmental science. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.
Abstract	Students work on introductory skills at the beginning of the course by tying them into real life examples from the field. I use this at beginning of the year to re-enforce lab skills that may have been lost over the summer break.
Performance Indicators	By the end of this lesson students should be comfortable using metric measurements, graphing data, and making analytical measurements.
Contact Information	Jack Ashton ashtonj@guilford.k12.nc.us
Other	Information from the pre-lab is from the following website: http:www.nicholas.duke.edu/news/screeningroom/ students/madagascar2005/

Environmental Lab Skills

Objectives

After this lab you should be able to do the following:

- Work with metric units.
- Understand the purpose of lab work and general lab methods.
- Create and analysis graphs from collected data.

Materials

Materials for this lab are:

Ruler

Triple beam balance

Measuring Tape

Sand

Beaker

Introduction

In the summer of 2005, Mr. Ashton participated in a field research team studying endemic carnivores of Madagascar. This lab will work to help you understand some of the basic skills involved in environmental research and this class. The following are excerpts from the briefing about this field work.

Project Background

Despite the unique ecology and enigmatic evolutionary history of Malagasy carnivores, members of this family have been the subject of few in-depth field studies. The carnivores of Madagascar, like many other members of the island's biota, display a particularly high degree of endemism (endemic – Native only to a certain region) among modern taxa (taxonomy – classification of living organisms). Seven of the eight species of carnivore found on Madagascar have no extant representatives anywhere else in the world. No felid, hyaenid, and canid representatives are commonly recognized within Madagascar's endemic mammalian predator guild. As in most biodiversity hotspots, non-endemic species encroach upon the natural habitats of Madagascar's top endemic predator. Investigating and identifying how both endemic and invasive predators divide their resources and otherwise affect one another provides significant information to increase our understanding of both ecological and conservation issues in Madagascar and abroad.

The current conservation status of the Malagasy carnivores, noted by the International Union for the Conservation of Nature and Natural Resources, ranges from "vulnerable" to "unknown," and many of these species are targeted for persecution by indigenous human populations and continue to decline in numbers. Carnivore populations have been identified in more than twenty protected areas throughout Madagascar (Kohncke and Leonhart 1986), but most of these populations have not been monitored for almost thirty years.

The focal site for this proposed project is the Ampijoroa Research Station and its surrounding area in Ankarafantsika National Park, Madagascar. This project consists of trapping surveys of carnivore populations to estimate their current distributions and relative abundances. Our study focuses on an in-depth examination of the natural history and behavioral ecology of Madagascar's largest carnivore, the puma-like Cryptoprocta ferox, commonly known as the fossa. Only three species of Malagasy carnivore are thought to occur at Ampijoroa. These are Cryptoprocta, a recently discovered (yet taxonomically unidentified) species of Wild Cat, and the smaller, non-endemic Viverricula indica. We are particularly interested in how invasive, competing species affect the behavioral ecology of the large, endemic Cryptoprocta.

The trapping portion of the research project, in which volunteers most actively assist, is merely a portion of the research and conservation activities that are included in this project's priorities. Research pursuits associated with this project range from natural history to veterinary to genetic studies. In addition, the presence of our well-established field team also lends assistance to and promotes the development of other biodiversity studies in the region. The conservation aspect of this work ranges from direct wildlife based educational activities and community outreach to the development of multiple sustainable alternatives to traditional activities that previously contributed to Madagascar's current biodiversity crisis.

Our conservation and research efforts are in close collaboration with ANGAP, the Department of Water and Forests of Madagascar, the Institute for the Conservation of Tropical Environments, Conservation International, the World Wildlife Fund, and the University of Antananarivo, among other entities currently active throughout the region.

Our research provides baseline assessments of current carnivore populations including data on their behavior, abundance and distributions in Ankarafantsika National Park in addition to an established monitoring program on the overall biodiversity of Ankarafantsika. This has established and facilitates long-term monitoring of these populations. In this way, we are developing important scientific results and also help ensure the conservation and maintenance of the endangered species and habitat of Ankarafantiksa and the surrounding Mahajunga basin.

Methods

With the assistance of Earthwatch volunteers, the lead PI, Luke Dollar, conducted his first field season at the Ampijoroa Research Station in 1999 to investigate the research site and lay the groundwork for this ongoing project. The PI led a trapping and radiotelemetry study in the Lac Tsimaloto region of Ankarafantsika (22 km east of the Ampijoroa Research Station) the year before, in 1998. At the Lac Tsimaloto site, six different Cryptoprocta were trapped in 12 trapping events during 400 trap-days. More than 300 hours of radiotelemetry data were also collected during this 3.5 week survey. While the biomass of predators found in the Lac Tsimaloto (1998 and 2001 surveys) and Ampijoroa (1999-present) regions of Ankarafantsika National Park was relatively constant, the composition of Ampijoroa's top trophic level was completely unexpected.

<u>Primary Objectives and Their Methods</u>

1) Conduct trapping surveys to further locate and identify the carnivore populations and trends in the Ampijoroa Research Station area of Ankarafantsika National Park, Madagascar, collect anatomical data on each species of carnivore at this site, and to collect carnivore scat samples for analysis of diet composition/contents; and

2) Establish baseline indices or indicative measures of relative abundance of Cryptoprocta ferox and additional carnivore populations in the dry, deciduous forests of Ankarafantsika;

<u>Animal handling, processing, and measurement</u>

Captured Viverricula will be released from the trap into a handling bag. Drug is administered via intramuscular injection with the animal still in the handling bag. Captured Cryptoprocta and Wildcats are tranquilized while still in the trap using the Pneu-dart drug delivery system. Using the Pneu-dart system, a trained staff member blowpipes the trapped larger carnivores using procedures outlined by Glander, et al.

(1992). Anesthesia is delivered via dart in the hindquarters and only if the animal is facing away from the shooter so as to reduce the risk of damage resulting from shots in the face, abdomen, shoulder, or neck.

Once the animal appears to be adequately tranquilized, the darter and an assistant remove the tranquilized animal from the trap or handling bag. Anatomical measurements are taken prior to affixing and activation of the radiocollar device to captured fossa. Anatomical measurements collected include weight, total body length, tail length, hind limb length, hind foot length, hind limb girth, forelimb length, forefoot length, forelimb girth, chest girth, neck circumference, height at shoulder, ear length, canine anterior-posterior and lateral diameter, carnassial molar lengths, and genital measurements. All anatomical data are collected by the lead PI so as to avoid bias in interobserver measurement techniques.

The morphometrics (Measurements of the form and structure of an organism) selected represent a conglomeration of anatomical measurements used in several different realms of mammal ecology. Definitions for most of these measures are derived from Dayan & Simberloff (1994) and Eason Smith & Pelton (1996). Body length is measured from the tip of the nose to the base of the tail. Tail length is measured from the base of the tail to the tip of the most distal bony tail segment (tip of the last tailbone). Hind limb and forelimb length is measured from the medial fold of the limb to the tip of the longest portion of the foot pad. Hind foot and forefoot length is measured from the most proximal to the most distal portion of the foot pad (from the maximum points on the foot). Forelimb girth is measured around the widest portion of the brachium. Hind limb girth is measured around the widest portion of the thigh region. Chest girth is measured just inferior to the forelimbs. Neck circumference is measured at its widest point. Collection of this information fulfills objective 1.

After anatomical measurements, ear-tagging, blood and tissue collection (for population genetic analysis - objective 9 – and for epidemiological study – objective 13), and attachment of a unique color-coded radiocollar are complete, the study animal is returned to the traps at the location of capture, monitored until free from drug effects, and released.

Pre-lab Questions

1. What is the primary purpose of the research described in the pre-lab?

2. Theorize what use may be made of the analytical data collected about individual organisms.

3. What does the pre-lab say is done to make sure the data collected in a precise (conforming to a strictly proper form) manner?

4. Explain how you would take the following measurements on a person

   A. Height
   B. Wrist Circumference
   C. Neck Circumference
   D. Total Length from right hand to left hand (including fingers)
   E. Volume of cupped hand

5. On a separate page create a data table with 6 columns and enough rows for all class members. The first two rows are below:

Name	M or F	Height	Wrist	Neck	Hand to hand	Volume cupped hand
Each person's name here						

Procedure

Preparation

1. In your lab notebook write your height in inches and multiply by 2.54 to convert into cm.
2. Use a measuring tape to measure the circumference of your own wrist and neck.
3. Choose a partner who you will make measurement on and who will make measurements on you.

Data Collection

4. With your partner, take the first 4 measurements and record them on into your lab notebook. DO NOT TAKE WITH YOUR PARTNER ABOUT THE NUMBERS DURING THIS TIME. You should not let your partner know the numbers you have recorded about them.
5. With your partner calculate the volume of your cupped hand. First find the mass of a beaker using the triple beam balance. You should record a measurement with 2 decimal places.
6. Cup your hand and lift out sand from the container. Allow excess sand to flow back into the container. Once you have a stable amount of sand, have your partner place the beaker under your hand so that you may pour ALL the sand into the beaker.
7. Mass the beaker and calculate the volume of sand you can hold (repeat for your partner)
8. Once you have recorded all the information about your partner into your data table, put that information on the board.
9. Copy all the information about all the people into your data table

Data Analysis

1. Create a scatter plot of height (x-axis) vs. hand to hand distance (y-axis). Include scales, labels, and a best fit line.

2. Create bar graphs of the entire class's neck circumference. (What is x-axis, what is y-axis?)

3. On one graph create two bar graphs of wrist circumference. Separate the data by male and female.

4. Find the percent difference between your height, wrist and neck measurements and your partner's measurements of your height, wrist and neck.

Lab Questions

1. Using the first graph, what relationship can be shown between height and hand to hand distance?

2. Using the second graph, what is the medium neck circumference of the class? What range does most of the class fit into?

3. From the third graph describe the difference between the medium wrist circumference of males and females. Judging from the chart would you able to identify if a wrist is male or female from the size?

4. If your measurements and your partner's measurement of your height, wrist and neck were difference explain some possible reasons for the difference. Why would the differences be important to keep in mind when talking about the data we have collected today (this should be a long answer).

Point break down

Title, and objectives – 5 points
Pre-lab Questions – 16 points (4 points each)
Data from Procedure – 15 points
Graphs and Data Analysis – 32 points (8 points each)
Lab Questions – 32 points (8 points each)

<table>
<tr><td>Lesson Title</td><td>Wild Populations: Using Field Data</td></tr>
<tr><td>Grade Level</td><td>High School</td></tr>
<tr><td>Content Area</td><td>Environmental Science</td></tr>
<tr><td>Time Allotment</td><td>1 class period or extended to up to three</td></tr>
<tr><td>Academic Standards Addressed</td><td>North Carolina Standard Course of Study – AP Environmental Science
1.02 Design and conduct scientific investigations to answer questions related to earth and environmental science.

• Select and use appropriate measurement tools.
• Collect and record data.
• Organize data into charts and graphs.
• Analyze and interpret data.
• Communicate findings.

2.05 Investigate the biosphere.

• Organisms: adaptations to their environment.
• Populations and communities: exponential growth and carrying capacity.</td></tr>
<tr><td>Abstract</td><td>To help students understand how levels of biodiversity are actually calculated, students will use different methods to estimate an unknown population. Students will also learn about other methods (radio tracking) to learn about organism.</td></tr>
<tr><td>Performance Indicators</td><td>By the end of this lesson students should understand different methods of estimating population including pros and cons of each. Students should understand how radio tracking is used my researchers to learn more about an animal.</td></tr>
<tr><td>Contact Information</td><td>Jack Ashton
ashtonj@guilford.k12.nc.us</td></tr>
<tr><td>Other</td><td>Information from the pre-lab is from the following website:
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http://www.pbs.org/wgbh/nova/ madagascar/expedition/fossa_rt.html</td></tr>
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Wild Populations: Using Field Data

Objectives

After this lab you should be able to do the following:

- Explain how sampling can be used to calculate populations.
- Understand why estimating the number of wild populations is difficult.
- Calculate estimated populations from sample data.

Materials

Materials for this lab are:

Ruler

Compass

Bag of beans

3 Colors of Markers

Introduction

When studying and tracking animals in the wild, scientist need to be able to us incomplete data to figure out the complete data for an entire group. This can occur for multiple reasons, but usually scientists are unable to count or track every individual. For example, if you wanted to find the number of plants in a large field you may not have the time to count every animal. In Mr. Ashton's summer fieldwork, he tracked fossa which must be trapped to be counted, so any animal not trapped would not be counted.

We will discuss three methods of estimating populations and a method of finding data about an animals range. The three methods of estimating population are estimating from a small sample, transect survey and the mark and capture technique. Each has advantages and disadvantages. Each is explained below.

The simplest method of finding a population is to count all the organisms in a small area and expand that into a larger area. This method works will for species that have an even distribution and can be easily counted. Plants are very useful for this technique. If a scientist knows that a species of plant is spread evenly through a 200 acres forest, they could figure out the average number of plants per acre and multiply out to find the number of the forest. This method is usually used with other methods to find distributions of species though an entire ecosystem. This method alone does not work well for species (like large mammals) which can run away or be difficult to count.

Another method is a transect survey. A transect is a line that runs through an ecosystem. In a line-transect all the organisms on the line or seen from the line are counted and recorded. A formula is used to change the sample data into an estimate for the entire area. This method is better since it takes into account differences within a sample area. For a forest you could start from one end and see both the edge and the dense center. Mr. Ashton used this method in Madagascar to find population of species which could be food for the fossa.

A third method used to estimate population size is the "mark and capture" technique, in which scientists capture some animals from the population, mark them, and release them. At a later time, the scientists again capture animals from the same population and observe how many of them are marked. Scientists can use the percentage of recapture to calculate the number of organisms in the sampling area. The largest weakness for this method is that a large number of organisms may need to be captured.

While the three methods above are useful in estimating a population of a species, some species like the fossa, may move. If a species has members that move into and out of a sampling area, they can affect the population numbers (usually raising them). To understand how to interpret the population data, a scientist may need to understand how the individual organisms are moving. One useful method is radio-tracking.

Radio tracking can be a very useful tool to help scientists study animals in the wild. Among other things, radio tracking can help researchers determine a species' home range, population density, and key habitat elements essential for survival, such as places to live.

Just about anything can be tracked, and transmitters are made for animals as small as beetles. Biologists have tracked many animals using this method, including wolves, elephants, moose, deer, bats, foxes, rattlesnakes, turtles, raccoons, fish, badgers, seals, and owls, among others.

Scientists try to tag and track as many individuals of a given species as they can when learning about a population. When they capture an animal, they document information about its size, weight, and other physical characteristics. When tracking, they record such variables as the time of day, habitat information, and how they located an animal.

Scientists usually use a frequency in the very-high-frequency (VHF) band -- which comprises the wavelengths between about one yard and 11 yards -- to track animals. That's because animals don't naturally emit sounds in any frequencies in that band, and it allows researchers to use a relatively small, hand-held antenna.

Radio tracking is not without its problems. It is difficult to tell the exact location of an animal tracked by radio; whenever possible, users make a visual sighting to confirm the quarry's position. Also, many systems will only track for a couple of miles or fail to track at all if the creature slips into a ravine or behind a ridge. In addition, the animal may move after its tracker has determined its initial position.

The data received from all these methods can be used to study organisms, help support conservation efforts or show the effects of human’s work. The work with fossa has show that previous ideas were wrong. Fossa hunt during the day and night (originally there were though to be nocturnal), they hunt alone, have large ranges, and endangered.

“Dollar's trapping and tracking work, helped along by volunteers from the Earthwatch Institute, has shown that fossa density in Ampijoroa is surprisingly low. In three weeks in 1998, in the neighboring forest of Tsimaloto, he caught three fossa in live traps and documented another three with motion-sensitive cameras. Given the similar terrain and lemur life here, he expected to trap 10 to 20 in three months. By project's end, he would catch only two.

Dollar's conclusion is sobering: Although fossa live in every kind of woodland on the island--from montane rain forest to dry deciduous forest--they may not always be able to put down roots. "As soon as there's any habitat disturbance, fossa fall out," he says.”

Pre-lab Questions

1. The formula for the mark and capture method requires two samplings and a count of the number of recaptures. It uses the formula below

$$N = \frac{Mn}{R} = \frac{(First\ Sample)*(Second\ Sample)}{Number\ Recaptured} = Population$$

If a fisher catches 40 fish, marks them all, and releases them; then catches 40 fish with 10 already caught the data would be as follows

$$\frac{40*40}{10}=\frac{1600}{10}=160\ organisms$$

Use this method to calculate the estimated number of each population

a. First sample: 50 Second Sample: 50 Recapture: 40

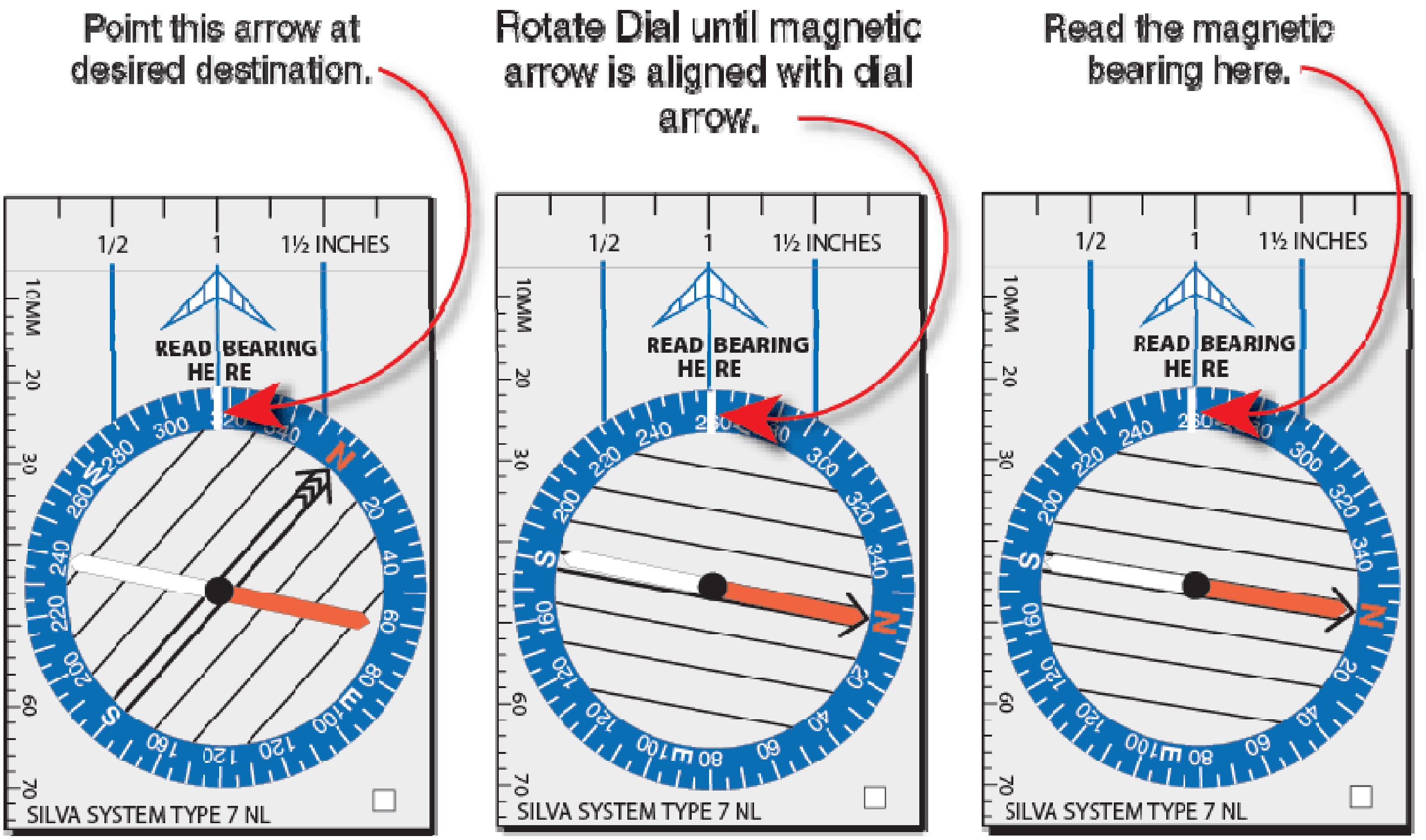
b. First sample: 50 Second Sample: 50 Recapture: 10

c. First sample: 10 Second Sample: 50 Recapture: 5

d. First sample: 5 Second Sample: 5 Recapture: 0

2. From the data you calculated in the first questions. Decide rules for deciding the size of your samples.

3. If the radio tracking model of this lab you will need to be able to take a bearing with a compass. Use this example. If you have questions make sure you are prepared to ask Mr. Ashton.



Procedure

Estimating Population with Simple sampling.

1. In the sampling area, stake out a 1 ft by 1 ft square in the grass.

2. With your partners, count the number of individual plants in your sample.

3. Using the large tape, estimate the total area of the entire sample, and multiply out to figure out the number of individuals in the entire area.

Estimating by Mark Capture method

4. Collect a bag of beans and three markers.

5. In using one marker, take a sample of 20 beans and mark them all the same way.

6. Place your marked beans back into the bag, and shake. Collect another 20 and count the number of recaptures. Record this data in your lab notebook.

7. Use the formula from the pre-lab to estimate the number of beans in the bag.

8. Repeat this process using another color and taking samples of 50 beans.

9. Repeat the process using your third color and taking samples sizes of your choice.

10. Once you have all three estimates, count the actual number of beans in the bag.

Using Radio Tracking.

11. Mr. Ashton will take you outside and you will set up a grid. In the grid we will place flags representing possible locations of animals.

12. Each group will be given instruction on which area your animal is, and what they are doing. The group will need to decide on which flags to use as your markers.

13. Using a compass, take the reading of 10 flags from two locations (see handout). Record the compass bearing into a chart.

14. You will trade off the chart with another group and try to figure out the range or activity of the organism.

15. Record the location of each measurement using the data from the other group.

Data Analysis

1. Compare the value your group calculated for the population of grass. How does you number compare with those of other groups.

2. Calculate the percent error of your mark capture estimate of bean population for each try compared to the actual number of beans.

3. On the grid, shade in the section you believe to be the range of your animal.

Questions

1. Were all the estimates of the grass population similar? What might be done to produce a better estimate for this lab?

2. What rules can you make about how to make the best estimate for the mark capture measurement?

3. What might make using the mark capture method difficult in the field? What factors must be taken into account in using this method?

4. What uses might radio tracking have to an environmental scientist?

Point break down

Title, and objectives – 10 points
Pre-lab Questions – 16 points (8 points each)
Data from Procedure – 35 points
Data Analysis – 15 points
Lab Questions – 24 points (6 points each)

Lesson Title	Environmental Lab Skills
Grade Level	High School
Content Area	Environmental Science
Time Allotment	1-2 class periods
Academic Standards Addressed	North Carolina Standard Course of Study – AP Environmental Science 4.04 Analyze biological resources. • Benefits of biodiversity. • Threats to biodiversity. • Endangered species management.
Abstract	Students work independently or in pairs to research different biological hotspots. They will then present this information to the class so that the class knows information about all major biological hotspots
Performance Indicators	By the end of this lesson students should be able to discuss biological hotspots and threats.
Contact Information	Jack Ashton ashtonj@guilford.k12.nc.us
Other	Information from the pre-lab is from the following website: http://www.biodiversityhotspots.org/xp/Hotspots/madagascar/

Biological Hotspots: Reasons and Threats

Objectives After this lab you should be able to do the following:

- Explain why certain locations are considered biological hotspots.
- Understand the importance of protecting these areas.
- Identify threats to different hotspots.

Materials Materials for this lab are: Research materials

Introduction A Biodiversity hotspot is a biogeographic region that is both a significant reservoir of biodiversity and is threatened with destruction. The Biodiversity hotspots were identified by Conservation International (CI), and identify the 25 biologically rich areas around the world that are the focus of Conservation International's conservation activities. According to CI, the remaining natural habitat in these biodiversity hotspots amounts to just 1.4 percent of the land surface of the planet, yet supports nearly 60 percent of the world's plant, bird, mammal, reptile, and amphibian species. Today the list has grown to34 regions worldwide where 75 percent of the planet’s most threatened mammals, birds, and amphibians survive within habitat covering just 2.3 percent of the Earth’s surface. An estimated 50 percent of all vascular plants and 42 percent of terrestrial vertebrates exist only in these hotspots. This includes 75 percent of the planet’s most threatened mammals, birds, and amphibians.

Madagascar

A series of islands scattered in the western Indian Ocean off the southeast coast of Africa forms the Madagascar and the Indian Ocean Islands hotspot. Dominated by the nation of Madagascar, the fourth largest island on Earth, the hotspot also includes the independent nations of Seychelles (including Aldabra), the Comoros, Mauritius (including Rodrigues), and the French overseas departments of Réunion, Mayotte (one of the Comoros) and the Iles Esparses around Madagascar.

Because Madagascar and the continental Seychelles broke off from the Gondwanaland supercontinent more than 160 million years ago, the hotspot is a living example of species evolution in isolation. Despite close proximity to Africa, the islands do not share any of the typical animal groups of nearby Africa. Instead, they have evolved an exquisitely unique assemblage of species, with high levels of genus- and family-level endemism, in only 1.9 percent of the land area of continental Africa.

The natural vegetation of this hotspot is quite diverse. On Madagascar, tropical rainforests along the eastern escarpment and in the eastern lowlands give way to western dry deciduous forests along the western coast. A unique spiny desert covers the extreme south. The island is also host to several high mountain ecosystems such as Tsaratanana and Andringitra massifs, which are characterized by forest with moss and lichens. The Sambirano region, a northern transition zone between the western dry forest and the eastern rainforest that has many of its own endemic species.

The Indian Ocean islands are composed of a range of relatively recent volcanic islands (the Mascarenes and the Comoros), fragments of continental material (the main group of the Seychelles), and the coral cays of the Amirantes and the atolls of the Farquhar, Cosmoledo, and Aldabra groups, as well as the five Iles Eparses. The volcanic islands have high peaks that in the recent past were covered by dense forest; indeed, the Comoros and the Mascarenes are sometimes subjected to very high levels of rainfall (up to 6,000 millimeters per year on Réunion). The highest peak in the Indian Ocean is the Piton des Neiges on Réunion (3,069 meters), which received the heaviest downpour on record (4.9 meters of rain in one week in 1980). By contrast, the continental Seychelles are relatively dry with a relatively low altitude reaching only 914 meters at its highest in Mourne Seychellois National Park.

The hallmark of the flora and fauna of Madagascar and the Indian Ocean islands is not necessarily their diversity (though this is high in some groups of organisms, particularly given the islands' size), but their remarkable endemism. The high level of species unique to Madagascar and its surrounding islands resulted from tens of millions of years of isolation from the African mainland and from people, who didn't arrive until 2,000 years ago. Endemism is marked not only at the species level, but also at higher taxonomic levels: the islands have an astounding eight plant families, five bird families, and five primate families that live nowhere else on Earth.

Plants

Vascular plants total at least 13,000 species (and possibly as many as 16,000), of which about 90 percent are found nowhere else in the world. Incredibly, eight of at least 160 plant families found here are endemic, a level unmatched by any other hotspot: seven are confined to Madagascar and an eighth is found on the Seychelles (the Medusagynaceae). The hotspot also has at least 310 endemic genera of plants. Local endemism is high as well; some individual mountaintops have 150-200 plants found nowhere else on the island.

The case of the baobab, or bottle tree, illustrates the spectacular diversity and endemism of plants in this hotspot. Worldwide there are eight baobab species in the genus Adansonia, one from continental Africa, one from northwest Australia, and the remaining six from Madagascar. Grandidier's baobab (Adansonia grandidieri), the largest baobab species on the island, is pollinated by nocturnal lemurs; other Malagasy species are pollinated by fruit-eating bats. Found in the drier regions of the west and south, baobabs are well adapted to desert like conditions. Large reserves of water are stored in their characteristic bottle shaped trunks.

Madagascar recently made headlines in the botanical world with the rediscovery of Takhtajania perrieri, the only Afro-Malagasy member of the primitive family Winteraceae, in the northeast of the country. It is fitting that Madagascar's signature endemic plant, the traveler's tree (Ravenala madagascariensis), is pollinated by the island's flagship vertebrate species, the lemurs.

Vertebrates

Birds

The avifauna of Madagascar and the surrounding islands is characterized by low diversity but spectacular endemism. More than 300 bird species are regularly found in the hotspot; nearly 60 percent of which are found nowhere else on the planet; additionally, 42 genera and four families are endemic. The bird fauna includes some extraordinarily relict bird species on Madagascar, such as the ground-rollers, cuckoo-rollers, and mesites.

The region's birds are also seriously threatened. Over 55 endemic species are currently threatened, and 32 have already gone extinct. The wet forests of eastern Madagascar have the highest number of threatened birds, including the Madagascar serpent-eagle and the Madagascar red owl Birds endemic to the island's wetlands, which have undergone extensive conversion for rice cultivation, are faced with imminent extinction. In the east, the Madagascar pochard has only been recorded three times since 1960; the Alaotra grebe has not been confirmed in the last decade. The flightless elephant bird, extinct more than five hundred years ago, was the heaviest bird ever to have lived at roughly 200 pounds.

Mammals

As with birds, the diversity of the hotspot's mammals is relatively low, but the level of endemism is exceptional. About 90 percent of the more than 150 mammal species that live on the islands are endemic. And new species are being discovered in Madagascar at a rapid rate; for example, in the last 15 years, 22 new mammal species and subspecies have been described.

The most intriguing mammals of Madagascar are the lemurs, represented by five families of primates unique to this island. Madagascar is home to 72 kinds of lemurs, making the Madagascar and Indian Ocean Islands Hotspot the world leader in primate endemism and the single highest priority for the conservation of primates. The lemurs of Madagascar vary widely, from the tiny Madame Berthe's mouse lemur, which, at only 30 grams, is the world's smallest primate, to the indri, which leaps from tree to tree similar to the airborne kangaroo. One of the most unusual lemur species is the aye-aye, which has huge ears, shaggy fur, continuously growing incisors (like a rodent), and a very thin middle finger on each hand, that together with its large ears are used for catching woodboring insect larvae or excavating coconuts.

Madagascar is also home to more than 15 endemic bat species, including the Madagascar flying fox, and numerous endemic rodents, like the unusual giant jumping rat, and carnivores, including the fossa, which resembles a cross between a dog and a cat. An agile hunter on the ground and in the canopy, it is the primary predator of lemurs. The endemic tenrecs, a unique family of insect-eating mammals, occupy the ecological niche that shrews and moles occupy elsewhere.

Reptiles

Although the hotspot has only one endemic reptile family, it boasts high species diversity and endemism; 96 percent of nearly 400 reptile species are found nowhere else on earth. The area is a major center for chameleon diversity, and it has recently been proposed that all the worlds' chameleons originated in this hotspot.

Amphibians

There are two endemic families of amphibians: the Sooglossidae, found in the Seychelles, and the Mantellidae, endemic to Madagascar and Mayotte. Endemism is the most marked in amphibians, with only a single species of the 230 present not endemic to the hotspot.

Among the flagship amphibians are the beautiful frogs of the genera Mantella and Scaphiophryne. However, the most striking amphibian in the hotspot may be the tomato frog, a bright red, bullfrog-sized animal found only in a small corner of northeastern Madagascar.

Invertebrates

Most of the invertebrate fauna on Madagascar is poorly known. However, some of the non-marine invertebrate groups that are reasonably well known include: terrestrial snails (651 species, all endemic); scorpions (40 species, all endemic); spiders (459 species, 390 endemics); dragonflies and damselflies (181 species, 132 endemics); lacewings (163 species, 119 endemics); tiger beetles (211 species, 209 endemics); scarab beetles

(148 species, all endemic); true butterflies (300 species, 211 endemics); freshwater crayfish (six species, all endemic); and freshwater shrimp of the family Atyidae (26 species, 20 endemics). Overall, total species richness for macroinvertebrate groups covered in a recent review of the natural history of Madagascar is slightly more than 5,800 species, of which 86 percent are endemic to the island.

Pre-lab Questions

1. Explain the reasoning behind the classification of biological hotspots.

2. What reasons are there for classifying Madagascar and the Indian Ocean Islands as biological hotspots?

3. Choose five examples from the passage and explain why each would be of interest to conservationists.

(You do not need to do this in your lab notebook. All this should be your own work, do not copy)

Procedure

In this lab, your group will be asked to choose one biological hotspot and prepare a presentation about your hotspot. Your presentation will need to include the following things:

Oral presentation

Poster

Species Fact sheet (discussing some of the species that need to be protected in this area, choose many different types of organisms)

Map

Notes or handout (short and summarized from your information)

List of Biological Hotspots

North and Central America

California Floristic Province

Caribbean Islands

Madrean Pine-Oak Woodlands

Mesoamerica

South America

Atlantic Forest

Cerrado

Chilean Winter Rainfall-Valdivian Forests Tumbes-Chocó-Magdalena

Tropical Andes Europe and Central Asia

Caucasus

Irano-Anatolian

Mediterranean Basin

Mountains of Central Asia

Africa

Cape Floristic Region

Coastal Forests of Eastern Africa

Eastern Afromontane

Guinean Forests of West Africa

Horn of Africa

Madagascar and the Indian Ocean Islands

Maputaland-Pondoland-Albany

Succulent Karoo

Asia-Pacific

East Melanesian Islands

Himalaya

Indo-Burma
Japan
Mountains of Southwest China
New Caledonia
New Zealand
Philippines
Polynesia-Micronesia
Southwest Australia
Sundaland
Wallacea
Western Ghats and Sri Lanka

Point break down

Pre-lab Questions – 30 points (10 points each)
Presentation – 15 points
Poster – 15 points
Species Fact Sheet – 15 points
Map – 10 points
Notes/Handout – 15 points

Lesson Title	You Decide the Fate of the Country
Grade Level	High School
Content Area	Environmental Science
Time Allotment	1-4 class periods depending on depth of coverage
Academic Standards Addressed	North Carolina Standard Course of Study – AP Environmental Science 3.01 Analyze human population history and global distribution. 3.02 Investigate local, regional and global carrying capacities. 3.03 Analyze cultural and economic influences on population 4.01 Analyze sources and uses of freshwater and oceans. 4.02 Analyze local, regional and global mineral resources. 4.03 Analyze local, regional and global soil aspects. 4.04 Analyze biological resources. 4.05 Analyze and compare conventional and alternative energy sources. 4.06 Analyze land types and uses. 5.01 Analyze the sources of major pollutants. 5.02 Investigate the effects of pollutants on: 5.03 Analyze and investigate pollution reduction, remediation and control measures. 5.04 Analyze and investigate local, regional and global issues concerning solid waste. 5.05 Analyze impacts on human health. 6.01 Investigate human effects and consequences on the atmosphere.
Abstract	As a final lab activity as part of the final review for the AP exam, my students will use this activity to incorporate everything they have learned in the class. By sharing the information at the end students will receive review in causes and effects of all major environmental problems discussed in class.
Performance Indicators	By the end of this lesson students should be competent in all topics of environmental science.
Contact Information	Jack Ashton ashtonj@guilford.k12.nc.us
Other	Information from the pre-lab is from the following website: http://www.sustainer.org/dhm_archive/search.php?display_article=vn575ipated

You decide the fate of a country

Objectives

After this lab you should be able to do the following:

- Explain the environmental problems of first and third world countries.
- Apply what you have learned in class to solve these problems.
- Discuss the root causes of environmental problems.

Introduction

Understanding the reasons for environmental problems are some of the most difficult concepts to apply. Many people have many views on the subject. At the beginning of the course we were introduced to a view IPAT. “IPAT” is shorthand for a formula, first proposed in the 1970s by Commoner, Ehrlich and Holdren, that has long been used in discussing environmental impacts of human action:

$$\text{Impact} = \text{Population} \times \text{Affluence} \times \text{Technology}$$

In the IPAT formula, the population sets the scale of the overall impact, modified by changing patterns of affluence and technology. In this view small polluting countries have the same effect as larger less polluting countries.

The following is an essay written by Donella Meadows, a professor of Environmental Studies at Dartmouth College

Who Causes Environmental Problems?

To a small but influential bunch of global thinkers the abbreviation "IPAT" (pronounced "eye-pat") says volumes. It summarizes all the causes of our environmental problems.

IPAT comes from a formula originally put forth by ecologist Paul Ehrlich and physicist John Holdren:

Impact equals Population times Affluence times Technology.

Which is to say, the damage we do to the earth can be figured as the number of people there are, multiplied by the amount of stuff each person uses, multiplied by the amount of pollution or waste involved in making and using each piece of stuff.

A car emits more pollution than a bicycle, and so the 10 percent of the world's people rich enough to have cars cause more environmental impact in their transport than do the much more numerous bicycling poor. But a car with a catalytic converter is less polluting than a car without one, and a solar car even less. So technology can counter some of the impact of affluence.

The IPAT formula has great appeal in international debates, because it spreads environmental responsibility around. The poor account for 90 percent of global population increase -- so they'd better get to work on P. Rich consumers need to control their hedonistic A. The former Soviets with their polluting factories, cars, and buildings obviously should concentrate on T.

I didn't realize how politically correct this formula had become, until a few months ago when I watched a panel of five women challenge it and enrage an auditorium full of environmentalists, including me.

IPAT is a bloodless, misleading, cop-out explanation for the world's ills, they said. It points the finger of blame at all the wrong places. It leads one to hold poor women responsible for population growth without asking who is putting what pressures on those women to cause them to have so many babies. It lays a guilt trip on Western consumers, while ignoring the forces that whip up their desire for ever more consumption. It implies that the people of the East, who were oppressed by totalitarian leaders for generations, now somehow have to clean up those leaders' messes.

As I listened to this argument, I got mad. IPAT was the lens through which I saw the environmental situation. It's neat and simple. I didn't want to see any other way.

IPAT is just what you would expect from physical scientists said one of the critics, Patricia Hynes of the Institute on Women and Technology in North Amherst, Massachusetts. It counts what is countable. It makes rational sense. But it ignores the manipulation, the oppression, the profits. It ignores a factor that scientists have a hard time quantifying and therefore don't like to talk about: economic and political POWER. IPAT may be physically indisputable. But it is politically naive.

I was shifting uneasily in my seat.

There are no AGENTS in the IPAT equation, said Patricia Hynes, no identifiable ACTORS, no genders, colors, motivations. Population growth and consumption and technology don't just happen. Particular people make them happen, people who shape and respond to rewards and punishments, people who may be acting out of desperation or love or greed or ambition or fear.

Unfortunately, I said to myself, I agree with this.

Suppose we wrote the environmental impact equation a different way, said the annoying panel at the front of the auditorium. Suppose, for example, we put in a term for the military sector, which, though its Population is not high, commands a lot of Affluence and Technology. Military reactors generate 97 percent of the high-level nuclear waste of the U.S. Global military operations are estimated to cause 20 percent of all environmental degradation. The Worldwatch Institute says that "the world's armed forces are quite likely the single largest polluter on earth."

Suppose we added another term for the 200 largest corporations, which employ only 0.5 percent of all workers but generate 25 percent of the Gross World Product -- and something like 25 percent of the pollution. Perhaps, if we had the statistics, we would find that small businesses, where most of the jobs are, produce far less than their share of environmental impact.

Suppose we separate government consumption from household consumption, and distinguish between household consumption for subsistence and for luxury, for show, for making us feel better about ourselves. If we had reliable numbers, which we don't, we might be able to calculate how much of the damage we do to the earth comes from necessity, and how much from vanity.

An equation was beginning to form in my head:

Impact equals Military plus Large Business plus Small Business plus Government plus Luxury Consumption plus Subsistence Consumption

Each of those term has its own P and A and T. Very messy. Probably some double counting and some terms left out. But no more right or wrong, really, than IPAT.

Use a different lens and you see different things, you ask different questions, you find different answers. What you see through any lens is in fact there, though it is never all that is there. It's important to remember, whatever lens you use, that it lets you see some things, but it prevents you from seeing others.

My purpose in having you read this is to remind you that there are no simple answers to environmental problems. Keep that in mind as you do the following activity.

Activity

We have discussed many environmental problems in this class. I would like to focus on the differences between first world (developed) countries and third world (developing) countries. Your group will need to analyze the problems of a first world (USA) and a third world (Madagascar). First here is break down of each country's environmental problems.

Problem	USA	Madagascar
Air Pollution	America has made strides to combat air pollution, but the amount of coal, gas, and oil burned contribute to the USA as one of the leading most polluting countries. Since everyone expects to have a car and unlimited electricity, many pollution controls are offset by the amount of pollution	Madagascar does not produce as much air pollution, but it may be more harmful. Some gas in Madagascar still contains lead, while few cars have pollution controls. Was it not for the fact that few people have electricity or cars, Madagascar may be a major polluter.
Biodiversity – Aquatic	America has over fished many natural fisheries and depleted many species. There is no sign that this will change.	Aquatic biodiversity may be threatened, but since there is less technology, fewer fish are caught. Also farmed fish may help depleted stocks
Biodiversity – Terrestrial	America has had problems keeping terrestrial biodiversity, but is making efforts to protect the biodiversity that remains.	Terrestrial biodiversity is severely threatened in Madagascar. Due to reasons such as loss of forests, Madagascar has over 10,000 endangered species. Remember new species are still being discovered)
Climate Change	America is the number one producer of green house gasses and produces more than twice the number two Russia.	Since few people have cars or electricity, climate change is less of an issue at present.

Energy	America is the number one user of electricity on earth. Using almost three times the number two China	Madagascar uses 0.02% as much energy as the USA. (1/5000th)
Natural Resources – Forests	Forests have been destroyed, but efforts are being made to protect existing forests and promote the creation of new forests.	The most recent estimate states that only about 10% of Madagascar's original forest remains. Slash and burn agriculture along with poor sandy soil has lead to most of the deforestation.
Natural Resources – Land	Presently ~19.5% of land is used for growing crops. USA is a net exporter of food (it produces more food than it needs)	Presently ~6.1% of the land is used for growing crops. Madagascar is a net importer of food (it must buy food from other countries)
Natural Resources – Water	Americans use almost 445,000 gallons of water per person per year. The USA is a more water rich nation, but has less water available per person than Madagascar.	Malagasy use almost 250,000 gallons of water per person per year. Madagascar is more water poor than the USA but has more freshwater per person.
Population	The USA has a growth rate of 0.6% meaning at present rates, the population will double every 116 years	Madagascar has a growth rate of 3% meaning at present rates, the population will double every 23 years
Waste	The USA produces a large volume of solid waste, most of which ends up in sanitary landfills	Madagascar produces less waste per person, but most does not end up in sanitary landfills
Water Pollution	Water concerns in the USA tend to focus on chemical and industrial waste.	Water concerns in Madagascar tend to focus on organic waste and pathogens.

1. Decide among your group what environmental problems face each country in the near term and long term.
2. Create two sheets one for each country. For each country, define the problems. Explain why you have chosen each problem and possible negative results of the problems.
3. Next brainstorm solutions. Make sure each problem has immediate actions (things that can be done today), short term actions (things that should be done for controlling present problems) and long term actions (things that should be done to stop present problems or prevent future problems)
4. You will need to create a brief (an overview) for the leader of each country. Keep in mind social, economic, and technological concerns (for example 50% of

Malagasy live below their poverty level, you can not make everyone buy a water filter, or install a toilet unless you pay for it). Your budget can not be limitless, keep in mind the results you expect in the near term when planning for the long term. Make sure to apply information you have learned in class

5. Using memo format type out each brief, one per group.

Point break down

Analysis of problems – 30 points
Immediate and short term solutions – 20 points
Long term solutions – 30 points
Reality of solutions – 20 points