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Smithsonian Biodiversity Outreach Program in Gabon

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Dr. Alfonso Alonso, Director of Conservation
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Washington, D.C 20013-7012

Dear Dr. Alonso, Dr. Henderson, and Ms. Sevin,

Enclosed is our report, entitled Smithsonian Biodiversity Outreach Program in Gabon. This report was developed at the Smithsonian Institution Monitoring and Assessment of Biodiversity Program offices during the period starting October 22 and ending December 13, 2007. Seven weeks of preliminary research and work were completed at Worcester Polytechnic Institute in Worcester, MA prior to our arrival in Washington, D.C. Copies of this report are also being submitted to Professors Holly Ault and James Hanlan. After faculty review, the entirety of this report (which includes the three lesson plans we developed) will be catalogued in the Gordon Library at WPI. We appreciate the time that you have devoted to us and thank you for your continual input, advice, and feedback

Sincerely,

James Brodeur

Peter Eliopoulos

Smithsonian Biodiversity Outreach Program in Gabon

An Interactive Qualifying Project Report
For the Washington D.C. Project Site

Submitted to the Faculty of the

WORCESTER POLYTECHNIC INSTITUTE

In Partial Fulfillment of the Requirements for the
Degree of Bachelor of Science

By

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Smithsonian Institution Monitoring and Assessment of Biodiversity

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Abstract

This report was prepared for the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program (MAB). Our project created lesson plans regarding ecological problems in Gabon and the research of the Smithsonian to mitigate these problems. The report describes the methods used in creating the lesson plans, and an analysis of the structure, content, activities developed, and recommendations for future lesson plans. The implementation of these lesson plans will provide the Gabonese youth awareness of the ecological issues of their country as well as knowledge of Smithsonian Institution research.

Executive Summary

The goal of this project was to develop a series of lesson plans that would serve as models for a more extensive series of lessons. The overall goal was to develop at least three lesson plans, centered on recent and ongoing studies conducted by the Smithsonian Institution's Monitoring and Assessment of Biodiversity (MAB) Program. These lessons will be utilized by Smithsonian employees in Gabon, at both the private school in Yenzi as well as at the local Smithsonian laboratory.

After over fourteen weeks of background research and analysis combined with carefully reviewed written and graphic work, and a total of three lesson were completed. A large number of Smithsonian staff were available for rapid consultation and material review. Feedback was collected from interns, program directors, conservation biologists, and education specialists and was used to guide the development process and provide the background needed to make informed decisions about content and style.

These plans have all been formatted in such a way as to be useful in the expected setting as well as being easily transferable to other settings. Appropriate instructional material for the instructors is provided within the lesson plan itself, making it more user-friendly and leaving each plan as a stand-alone lesson that does not require previous use of any other lesson in the series. In this way, these lesson plans would not be artificially limited in usefulness. The tone of each lesson is designed to not be overly accusatory of any groups, which is important due to the active industrial operations on Gabon—industry that students' parents may work for.

By providing these easy-to-use lessons to the MAB, the MAB will have an easier time integrating these lessons and concepts into existing biodiversity/conservation related educational settings in Gabon. The hour-long format will make these lessons ideal for use at the lab in Gabon

as an activity for visiting children, but should also mesh well into the Yenzi school's activities. Components of these lesson plans will be useful as repeatable, flexibly-structured activities that can be included in the nature club in Gamba.

Each lesson plan was designed to present information in such a way that a 12 year old would be able to understand it. Background information was chosen to give context to each learning objective in as full a form as was practical. In order to facilitate learning, each lesson plan was developed to incorporate the three primary learning styles that have been identified (auditory, kinesthetic, and visual).

Complex topics were described in simpler terms. In cases where complicated terminology was required in order to adequately present meaning, factual data, or preserve context, words that students may be unfamiliar with were defined in glossary sections. Links to additional, useful online resources were also made available for teachers to reference.

The lesson plans all encourage discussion between the students and the teacher presenting the material. The exact manner in which to handle this is left to the discretion of the teacher; however, "discussion prompt" questions are included with each lesson, and students are expected to write down their answers to these, even if they do not get a chance to talk about them out loud. The interactive nature of the lessons was intended to hold student attention and promote retention.

Each lesson plan contained a primary activity with instructions on how to use the activity for a class of around twenty students. However, these activities generally will scale to larger or smaller groups. Alternative methods and activities were also suggested to adjust to the nature of the group. The team made efforts to ensure these activities would appeal to the various learning

styles where possible. Also, time for discussion and student collaboration was planned into each activity to allow for working in pairs or groups.

In addition to these in-class activities, an opportunity for the use of take-home activities is presented in each lesson plan. These additional activities are created to be extensions of the in-class material, not as stand-alone components, and as such they might rely on material contained in the in-class activity. The take-home activities are also designed to be suitable for pairs or small groups, and may be used as homework assignments.

The Smithsonian MAB program aims to promote the appreciation and conservation of biodiversity, while the Smithsonian at large is interested in the general dissemination of information. The Smithsonian scientific operations exist to engage in "research and discovery" along with understanding the origin and evolution of "life's biological diversity and human cultures," in order to "inform and inspire a diverse public" (Kress, 2005). The lesson plans developed as part of this project are intended to assist with exactly that—spreading information about biological diversity and how it interacts with humanity, and to inspire the students.

According to early discussions with MAB staff, students in Gamba may not realize the rich biodiversity that surrounds them, and therefore cannot fully appreciate it. Nor do they necessarily understand what Smithsonian staff are doing there, looking at elephants and watching the trees with binoculars with the help of locally-based veteran field assistants. A component of each lesson will help students understand what the Smithsonian is doing in Gabon and why. This naturally also supports the Smithsonian Science vision of "inspiring the public to understand how scientists learn about the world" (Kress, 2005).

While SI/MAB has had good support from the local population, only continued interest and support will make their continuing work possible. By educating students about Smithsonian

activities, they can better appreciate what this outside organization is doing to support their natural heritage and will be supportive of these efforts. The MAB's efforts will gain more exposure with the use of these lessons, as a sizable portion of each lesson focuses on a particular researcher's project(s) in Gabon. The take-home activities are designed to spark the interest of adults who see the students working on them, or when they bring them home. One activity in particular, from the second lesson plan, actually encourages a discussion between the students and their elders about the changing local biodiversity.

Each lesson plan promoted additional thought into possible extensions, "sequel" topics, and possible future changes. These have been discussed in the results section of this report. Along with the established framework provided by the developed proof-of-concept lesson plans, this will allow the Smithsonian Institution to produce a large library of lesson plans of a similar style, without the need to do as much planning as it would otherwise take. Questions and surveys included with the lesson plans will allow MAB employees to evaluate each plan's usefulness and identify areas for improvement or identify patterns and methods that worked well, contributing further to future development. The format is obviously not limited just to use in Gabon, and certain activities could be adapted with relative ease to fit into the context of another locale.

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Acknowledgements

We would like to thank all of the people that have helped us throughout the duration of our project. First we would like to thank our Smithsonian liaisons, Alfonso Alonso, Ann Henderson, and Jennifer Sevin, for all of their assistance, suggestions, and guidance with all of our lesson plans. As well as Olivier Pauwels, Annabelle Honorez, and Marc Dethier for providing us knowledge about Gabon and the biodiversity of the area, and for deciding to use the lesson we have developed. We would also like to thank Johanna Choo, Ph. D, Amy Dunham, Ph. D, and Jason Munshi-South, Ph. D, for the documents and information they provided for us to use in our lesson plans. Additionally, we'd like to thank Ricki Ashcraft for reviewing our lesson plans and giving us feedback for improvements. We would also like to thank all of the MAB staff who provided a friendly environment and an enjoyable experience, and for always being available to review and discuss matters pertinent to our project. Furthermore, we thank Nick Gilligan for his contributions to the preliminary research done in Worcester, MA. Finally, we would like to thank Professors Holly Ault and James Hanlan for all the assistance and recommendations made for this project.

1.0 Introduction

In recent years, the concept of biodiversity has come to be an important and popular topic for study by both scientists and policymakers. While the Earth is inherently biologically diverse, only within recent decades have larger groups, including organizations as large as the United Nations, become interested and involved in this field. Biodiversity, as best defined, is "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (United Nations, 1997). A loss at any level has the potential to affect diversity at other levels both directly and indirectly, with co-extinctions a reality and the loss of an animal species capable of dramatically altering the landscape over time (Whitty p 3, 2007). As a result of human activities, extinction rates have increased over the natural rate by a factor of 1,000; every year, anywhere from 18,000 to 55,000 species become extinct (Djoghlaf, 2007).

According to estimations from the international Convention on Biological Diversity, the rich forests of Africa alone stand to lose up to 40% of their unique species in the next 80 years. In vital forested areas such as the Gamba Complex in Gabon, Africa, humans can threaten the strong native biodiversity through habitat alteration and disruption such as over-hunting, participating in uncontrolled fishing and logging and resource collection by foreign companies subject to very little regulation (WWF, 2005). Efforts to adopt modern agricultural methods generally forsake native crops in favor of a few "international" species (The International Plant Genetic Resources Institute, 2006). The trend towards such monoculture and lowered genetic diversity only increases susceptibility to disease or accidents wiping out staple crops and livestock—harming dependent populations, both wild and human.

Worldwide, biodiversity loss is a “serious threat to sustainable development and the quality of life of future generations” (Maillard & Gonzalez, 2006). Beyond novelty interests such as tourism, humans rely on biodiversity for pest management, sources of medicine, bioremediation, and improved crop productivity (Lovejoy, 1994). The economic success of a nation may be tied solely to products of its local biodiversity (Donald, 2004). Even our fresh air is dependent on biodiversity, with regard to photosynthesizing plant life. Wealthy, city-bound populations often react more slowly to biodiversity loss as their technology and economic power together serve as a buffer to feeling its effects, other than rising product and research costs (King pg 7, 2005), and their local biodiversity is often limited. However, it is these populations that also may have the resources necessary to help promote the preservation of biodiversity where it still is strong.

To address the leading cause of biodiversity loss (habitat disruption), we can identify ways of changing the attitudes and behavior of rural people, especially those who reside in biodiversity-rich areas (McNeely, 2006). In Gabon, Africa, for example, the government has been issuing an increasing number of temporary logging permits, despite already having trouble monitoring the existing operations. While large international oil companies including Shell have substantial operations in the region, they operate under strict regulations that are ignored by smaller local operators who may not see the need for such rules. There is also a fear that enterprising Gabonese residents, searching for economic opportunity, will use biodiversity-rich lands for crop development—possibly in restricted/protected lands. Educated rural people will be able to make informed decisions regarding important issues that affect their native biodiversity, which can also help prevent damage caused by foreign operators that are allowed to conduct business there. They can also realize the benefits of supporting and protecting the park systems.

If biodiversity continues to decline, the traditional way of life may become impossible for the Gabonese people.

Many large organizations have recognized the necessity and challenges of protecting biodiversity, and have developed programs and task forces to confront the issue. One of the many branches of the Smithsonian Institution is the National Zoo which is famous for being home to many endangered species of animals from around the world. The National Zoo also makes efforts to protect endangered species in their natural habitats in the wild, and in doing so directly promotes biodiversity. The division of the National Zoo dedicated to biodiversity outreach efforts is known as the Monitoring and Assessment of Biodiversity (MAB) Program. The MAB Program works towards preserving and restoring biodiversity worldwide by educating the public about what major issues exist. Target audiences for these outreach efforts in the past have been policy makers, business people, scientists, and others in positions of power. The MAB hopes to spread knowledge to a more diverse range of people and hopefully to improve the quality and quantity of biodiversity awareness and preservation efforts throughout the world.

Currently, the MAB is working with the Shell oil company in a major new effort "to increase understanding of biodiversity and energy resource development in Gabon" (Smithsonian Monitoring & Assessment of Biodiversity, 2007). The MAB hopes to research and assess the biodiversity situation in Gabon, inform the population of their findings, establish links and goals for preservation and sustainable development among people in science, industry, and politics, and to establish protocols to help maintain people's capability to continue biodiversity efforts. The MAB and Shell hope their efforts in Gabon will help to preserve a biodiversity-rich part of the world, while helping to sustain the local way of life in the future.

MAB's next area of focus will be middle school aged students in Africa who live in

places with extremely rich biodiversity. Students in developing countries, such as Gabon, do not always have computers, internet access, and textbooks. This will need to be considered in developing the curricula. They will, however, have the ability to partake in field activities that utilize the natural biodiversity for an educational purpose.

The goal of this project is to create five mini-curricula on biodiversity conservation to present to the Smithsonian Institution. Additionally, we will attempt to define broad themes around which future curricula can be developed, and generalized outlines that will form a framework for future curricula. Smithsonian staff will travel to local schools in Gabon (or have Gabonese students visit the Smithsonian lab there) and present each curriculum through the various planned activities. Currently there are educational activities being conducted but these are done on a rather informal basis rather than as a structured, repeatable lesson.

The purpose of our curricula is to increase awareness about the increasing threat to biodiversity worldwide, the local biodiversity, and the best methods to conserve biodiversity to the students that will be participating in our outreach. Students will also be provided with take-home materials they can show to their parents and friends to further spread awareness and generate interest. These mini-curricula will assist the Smithsonian Institution in trying to educate the youth of Gabon, who will be growing up in a biodiversity rich area, in biodiversity conservation. Those we develop will be only the first of many to be made.

2.0 Literature Review

Conservation groups agree that it is necessary to preserve and restore biodiversity throughout the world. A sparsely populated area rich in biodiversity, such as Gabon, is a good setting to begin implementing reform in the direction of human efforts towards restoration and coexistence with existing biodiversity. Our efforts in spreading awareness of this issue is intended to cause people to take action to preserve biodiversity and prevent the catastrophic effects of not doing so. The mini-curricula we develop should give Gabon a head start by educating the youth upon whom the future of their biodiversity relies, and by drawing the interest of their parents towards the activities in which the Smithsonian participates.

In undertaking a project of this type, many aspects of the nature of the subject, the background of the audience, and the methods of implementation (in this case, outreach curricula) must be taken into consideration. This literature review attempts to address these issues to set the stage for the project at hand.

2.1 Biodiversity Defined

The concept of “biodiversity,” considered to have originated as recently as 1985, has already taken on a broad scope of meaning. It can often be found intertwined with the more limited concept of generic plant and animal “conservation,” which reflects the source and purpose of the word: a simple contraction of “biological diversity” to be used when discussing environmental topics that indeed included conservation. A Natural Resources Defense Council (NRDC) definition follows this, defining biodiversity as “a large number and wide range of species of animals, plants, fungi, and microorganisms” (NRDC), but it also takes into account some micro-scale biodiversity. “Biodiversity” has actually evolved to become a whole-subject

term, ranging in use from macro-scale ecosystem analysis, to applications in determining variation between organisms right down to their genetic code; and it represents the shift towards grouping together these related fields of study and understanding how they are connected (Wilson, 1988).

It is natural that individual organizations may have selected more narrow uses of the term, either for ease of understanding or for policy-related purposes. For example, the Massachusetts Community Preservation Initiative considers biodiversity to be “the tendency in ecosystems, when undisturbed, to have a great variety of species forming a complex web of interactions” (Massachusetts Executive Office of Energy and Environmental Affairs, 2007). This is an understandable definition in the context of the organization, which focuses on community land preservation. In a similar manner, genetics research groups may define biodiversity more specifically as referring to DNA differences within species, ecologists may be focused more on diversity between ecosystems themselves, and so on.

As a result of the varying scopes of “biodiversity,” the current worldwide consensus (and that accepted by the Smithsonian Institution) is a multi-level definition accounting for these varying viewpoints. In its simplest wording, “biodiversity consists of three different levels of diversity: genetics, species and ecosystem” (Alonso p 4-7, 2001). Many organizations have adopted this definition, albeit with varying wording.

This three-tiered conceptualization of the definition of biodiversity actually stems from the 1992 United Nations Conference on Environment and Development, held in Rio de Janiero and better known as the Earth Summit (United Nations 1997). This UN Earth Summit found that biodiversity is “the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are

part: this includes diversity within species, between species and of ecosystems." Because this definition is supported by the United Nations, this is an "official" definition often found when worldwide agencies (both governmental and non-governmental) adopt phraseology to describe biodiversity.[1] The Smithsonian IQP team has therefore adopted this definition for our own use, along with the shorter summation when a succinct explanation is required.

2.2 Necessity of Biodiversity Preservation

Biodiversity, or rather the robust presence or lack thereof, has been tied directly to overall ecosystem health (Culotta, 1996). It has been shown that low levels of local biodiversity can invite tremendous problems for the native species as foreign flora and fauna invade, and that even the smallest components of biodiversity—those organisms unseen to the naked eye—can have a huge impact. Look no further than the Irish potato blight, where the agricultural monoculture (the focus on the potato instead of a diverse series of crops) caused a catastrophe when the crops died off. Ecosystems are complex systems of varying degrees of stable organism diversity and density, but *any* ecosystem could be disrupted and thrown into disarray by a loss of species or even a decline in genetic variety within a species.

It might be tempting to critics of biodiversity conservation to cite instances where relatively low biodiversity actually has managed to maintain stability over time that appears to rival that of areas with high biodiversity including, for example, desert regions or some standing waters. However, this can make it easy for disease or the sudden appearance of foreign species

[1] A simple online search query of that exact string will confirm its presence in glossary/definition pages on American, Australian, Belgian, Bulgarian, Canadian, Czech, French, German, Hong Kong, Irish, Namibian, Polish, South African, UK, and New Zealand governmentally backed web sites—all of those along with non-governmentally-backed, "international," and "EU" organization websites within the first 80 of 38,000+ results using Google, the 73rd of which is from a Smithsonian Institution page. (as of late September 2007). However, the source for the definition appears rather infrequently.

(perhaps even simple algae) to damage local populations (Ping), much as the arrival of insects or disease can quickly damage certain low-biodiversity agricultural operations. A 12-year study in the Chihuahuan Desert showed the impact of the removal of just a select few species of rat; the conversion from desert scrublands to grasslands, which could not actually support the previous number of annual plants, and then ultimately a decline in the bird population (Heske, 1994).

One important facet of biodiversity loss is the insidious phenomenon of co-extinction (Brown, 2005), or a drop in numbers of one population when another species is on the decline. The loss of even a single species can potentially cause an extinction cascade for all affiliated species; the army ant alone, for example, has over one hundred affiliate species that would be impacted by its removal from the ecosystem. While these kinds of ripple effects are not as obvious in regions with low biodiversity and interrelated species, they can be profound in areas of high biodiversity. This is one reason for the emphasis on targeting these areas for conservation efforts over developed regions that have already entered a status of lower biodiversity.

It is clear that "the amount of unexploited lands and waters will decrease with increasing human population … Ergo, biodiversity decreases with increasing human population" (Morowitz, 1991). There are many reasons this is true, and the evidence is certainly there—extinction rates due to human influence are currently 1,000 times the background rate (Djoghlaf, 2007). Part of this reason is purely expansion related: humans expand civilization by encroaching upon wild lands, and as such the leading cause of biodiversity loss is this habitat disruption (McNeely, 2006). Conservationist groups realize that human expansion is not halting, and that efforts must be taken to curb the loss of biodiversity that will otherwise result.

Complex models have been used to analyze extinction rate trends in recent times, allowing scientists to predict what the future could hold. Figure 1 below makes it obvious that

extinction rates have already risen compared to the past; but the important thing to note is that projected figures indicate that in the near future, extinction rates could begin to approach 10,000 times the original background rate. While it is true that some extinctions are part of the "natural process," circumstances in recent times have clearly pushed the rate far higher than what could be considered natural (extinctions of the sort that are evidenced in the fossil record).

Another cause of biodiversity loss is human tendencies towards efficiency, specialization and monoculture especially in agriculture; rather than growing a variety of crops, it is often more efficient to pick just a few varieties of grains or, as in the opening paragraph of this section, a crop such as potatoes. This highlights another key biodiversity concept: strong biodiversity *within* a species can afford protection against such cataclysm, be it disease or weather or some other disaster; and humans are intimately connected towards its decline, according to some sources. Projected figures, such as those in **Figure 1** below, indeed show alarming trends: in only the recent past, extinction rates are much higher than the natural background rate that would occur without human interference, and future extinction rates are predicted to be even higher than that.

In previous decades there was uncertainty regarding the causation of climate and biodiversity changes, with some belief that the causes were natural; however, the conclusion of the Convention on Biological Diversity (CBD) in modern times is that *human actions* are the cause of the sharp decline in biodiversity in recent years. The sharp decline in Africa's unique species (possible 40% loss by 2085 (Djoghlaf, 2007)), for example, is directly attributed to human activities. The CBD also points out biodiversity change between and within species can spur on ecological/climate change and the deterioration of other natural habitats, and this can effectively form a feedback loop that exacerbates the original change.

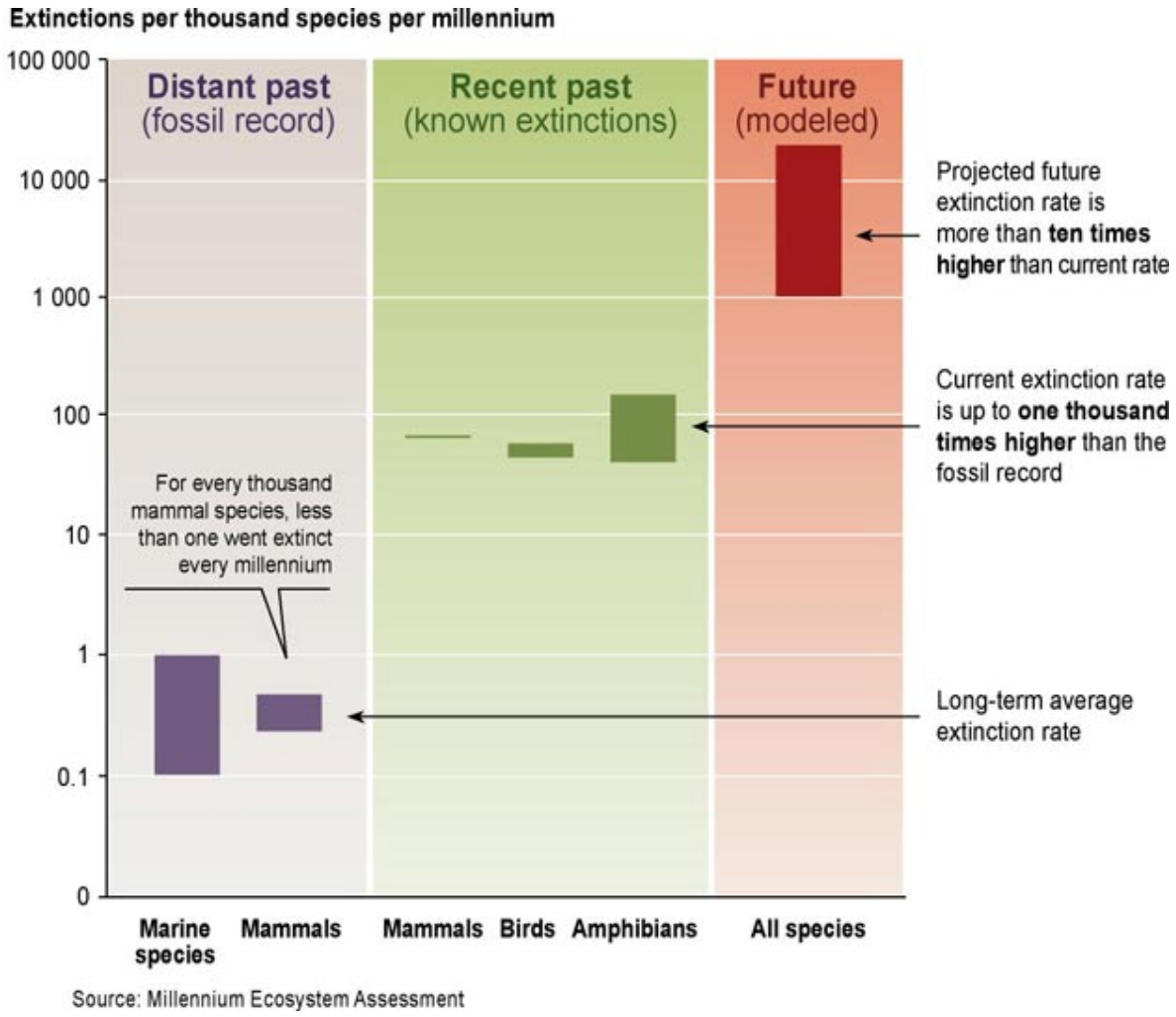

Figure 1. Extinction Rates

(Millennium Ecosystems Assessment pg. 44, 2005)

Worldwide, this biodiversity loss is a "serious threat to sustainable development and the quality of life of future generations" (Maillard & Gonzalez, 2006). "People are dependent on living, healthy ecosystems and the services they provide. This dependence is often more apparent in rural communities, whose lives are directly affected by the availability of common property resources such as food, water, medicinal plants and firewood" (King pg 7, 2005). One irony is

that the biodiversity reductions associated with agricultural activities may actually be a cause for lowered crop output. Efforts to adopt modern agricultural methods generally forsake native crops in favor of a few "international" species (The International Plant Genetic Resources Institute, 2006) which may not be as sustainable in the reworked environment.

High biodiversity leads to other benefits for humans. Healthy animals and crops gain value from high biodiversity by way of improved health and desirable characteristics; conversely there are fears about the lack of crosspollination due to the loss of strong biodiversity in and among crops. Diverse species and unique biological processes tied to them present opportunities for medical and chemical research. In terms of economic stability, high biodiversity can be tied to maintaining a rich variety of exportable natural resources, as well as tourism profits (Donald, 2004). Also, due to the nature of disease, there are health benefits to be had that come along with high biodiversity including increased resistance and forcing diseases to specialize and thereby losing efficacy and epidemic potential (Society for Conservation Biology, 2000).

2.3 Necessity of Education

The implications of unchecked biodiversity loss is felt by humans in the short term through rising prices, combined with (and caused by) long-term resource scarcity (DeBano 1999). The quality of food and lumber products can suffer, which raises the price of the better stock. This sort of realization has caused international efforts with amazing amounts of effort involved (such as the Millennium Seed Bank project) to produce biodiversity "stockpiles" as a contingency plan in the face of the danger of losing significant numbers of species through what would probably be accidental causes such as warfare[2] or natural disasters, but an obvious pro-

[2] Generally speaking, precautions are taken to avoid mutually destructive situations during combat. Some warfare methodology, however, intentionally targets enemy biodiversity—salting fields to prevent growth, torching forests,

active plan would be to minimize biodiversity loss caused by current practices humans employ and the general lack of understanding of biodiversity that leads to damaging actions.

Hotspots of biodiversity are primarily locations that have faced limited human impact, including places like Gabon. Due to the strong ripple effects of biodiversity loss in these hotspots, it is important to focus biodiversity preservation efforts on these locations, where it can have a greater impact than "modernized" areas which have already seen biodiversity loss. Biodiversity education is often sadly lacking in these regions, however, and this is why the Smithsonian Institution has sought to develop outreach programs for these areas, which can draw from on-site research and promote biodiversity friendly human populations where it seems to matter most.

Educational programs can help adjust human understanding and attitudes to bring about behavioral change. Human behavior has been shown to damage biodiversity; but with proper education there is hope of turning this around and promoting biodiversity-friendly behavior to halt and even turn around the damage caused by humans (Hamu, 2003) and in turn avoid the potentially disastrous consequences of plummeting biodiversity. The goal of the 2007 WPI project in conjunction with the Smithsonian Institution, therefore, is to produce educational materials that target the youth in Gabon, a biodiversity-rich location where the Smithsonian already conducts biodiversity research, in an effort to promote biodiversity-aware/friendly attitudes and behavior in the next generation.

Current potential threats to the rich Gabonese biodiversity include logging and oil drilling. Naturally there are risks associated with both of these activities, and it is important that that native community understands the importance of not exploiting the natural biodiversity in favor

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and spreading disease. An accidental or intentional nuclear detonation will damage the surrounding biodiversity on all three levels of our definition, on the other hand. Western nations frown upon these biodiversity-damaging methods and have agreements limiting their use.

of profit (although Shell, which operates many of the oil wells both on land and at sea, operates under strict guidelines[3]). Unfortunately, smaller oil operations do not adhere to these regulations and oil periodically covers portions of the coastal waters and washes up on the shores or is spilled on land.

There is also currently poor monitoring or understanding of the illegal logging that goes on. The statistics that are known, however, demonstrate a need for responsible timber harvesting practices including replanting efforts and minimized habitat destruction. As early as 1995, the Global Forest Watch estimated that Gabon had lost between twenty and thirty-one percent of its original forest cover. The GFW also points out that there is little oversight of logging companies, with a large increase in the number of temporary logging permits given every year to unproven companies that likely do not operate in an environmentally friendly manner. It is clear below in Figure 2 that despite a plummeting area of forest cover, the number of logging and clearing permits is on the rise in Gabon. It may seem surprising, but Smithsonian research has shown that this forest cover decline has impacted even the fish: the decline in killifish populations in Gabon has mirrored the disappearance of the forest (Mamonekene et al. pg 290, 2006).

[3] A large amount of information is available online for browsing and is periodically updated by Shell.
http://www.shell.com/home/Framework?siteId=envirosoc-en&FC2=&FC3=/envirosoc-en/html/iwgen/environment/biodiversity/dir_biodiversity_000407.html - Biodiversity information
http://www.shell.com/home/Framework?siteId=envirosoc-en&FC2=/envirosoc-en/html/iwgen/leftnavs/zzz_lhn5_0_0.html&FC3=/envirosoc-en/html/iwgen/environment/dir_environment_16042007.html -Environmental information
http://www.shell.com/home/content/envirosoc-en/making_it_happen/our_commitments_and_standards/health_safety_and_environment/dir_health_safety_environment_24042007.html -Health Safety and Environment protection information

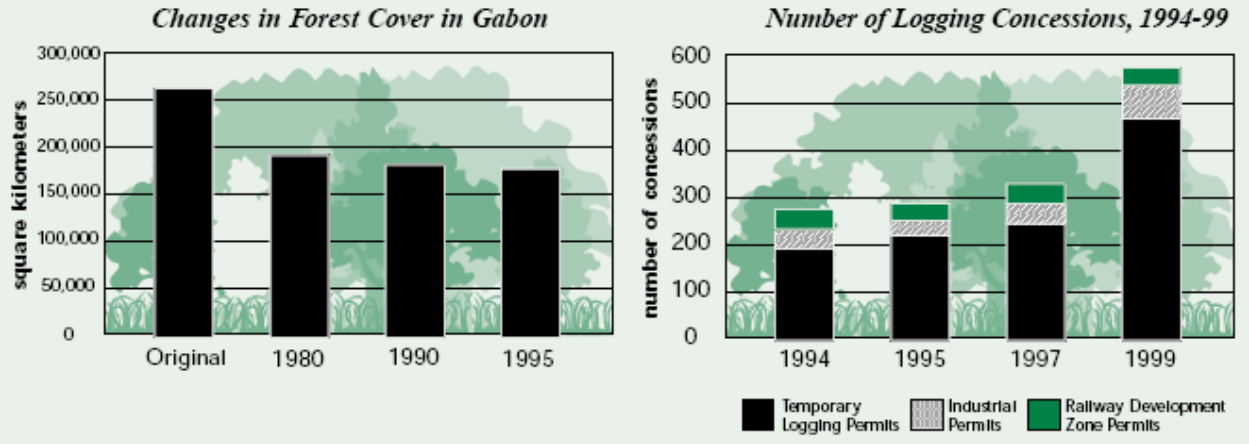

Figure 2. Changes in Forest Cover and Number of Logging Concessions (1994-1999)

Adapted from *A First Look at Logging in Gabon* fig. 6, 7

(Global Forest Watch, 2000)

Other threats identified by conservation organizations include over-hunting by both locals and visitors to the country. Modern technologies make traditional hunting's impact pale in comparison, as hunters armed with high power weapons and rugged vehicles are able to locate, kill, and haul off a far greater number of wild species and even the process of driving around through the forest can cause damage (World Wildlife Fund, 2005). The damages and harm caused by the modern version of traditionally practiced hunting, fishing, and farming may not be immediately obvious without proper education, leading to biodiversity losses caused by mistake.

In addition to free-roaming hunters that have limited access due to thick vegetation in many areas, the Smithsonian Institution and other organizations are concerned over the use of developed and dirt roads by organized hunting groups to get at animals for the bush-meat market (usually in violation of hunting restrictions) and then quickly bring the product to market. This is feared to be promoting the spread of Ebola fever, which has already killed many primates in Gabon and can infect humans (Lumpkin 2003). Despite Shell's restrictions on hunting and possession of bush meat, in some areas, it is still an ongoing problem.

Another significant fear is that the population may use its resources to compete in over-fishing and over-farming. Using prohibited methods such as offshore trawling has posed a significant threat to the marine biodiversity off the coast of Gabon, and unregulated semi-industrialized fishing inshore may even lead to human conflict between the native population and foreign commercial fishermen (World Wildlife Fund 2005). Lack of other acceptable economic opportunity may lead to natives conducting unsustainable agricultural activities in the protected Gamba Complex as well, with the farmers having little understanding of the impact upon the ecosystem that modern farming methods can have. Misunderstandings about acceptable land use and inappropriate activities may lead to clashes between park management authorities and the farmers, which could be avoided with proper education and understanding of alternative options.

2.4 Basic Historic and Cultural Background of Gabon

According to the United States Central Intelligence Agency World Factbook (a full set of reports on world countries, governments, and geographic regions), Gabon is a country of 1.45 million people situated on the west coast of central Africa (see **Figure 3** at the end of this section), a figure that has grown this large in recent years due to Shell operations in the area. Gabon was formerly a French colony with a much lower population; it received its independence on August 17th 1960. Since the death of the first president of Gabon, Leon M'ba (in 1967), there has only been one other president in power in Gabon, a man named Omar Bongo. Bongo is one of the world's longest serving rulers, serving for almost forty years (CIA, 2007).

Initially Gabon's economy relied primarily on the export of timber and manganese, until the early 1970s when offshore oil was discovered. Currently, oil is responsible for over fifty percent of Gabon's Gross Domestic Product and eighty percent of Gabon's exports. Because of

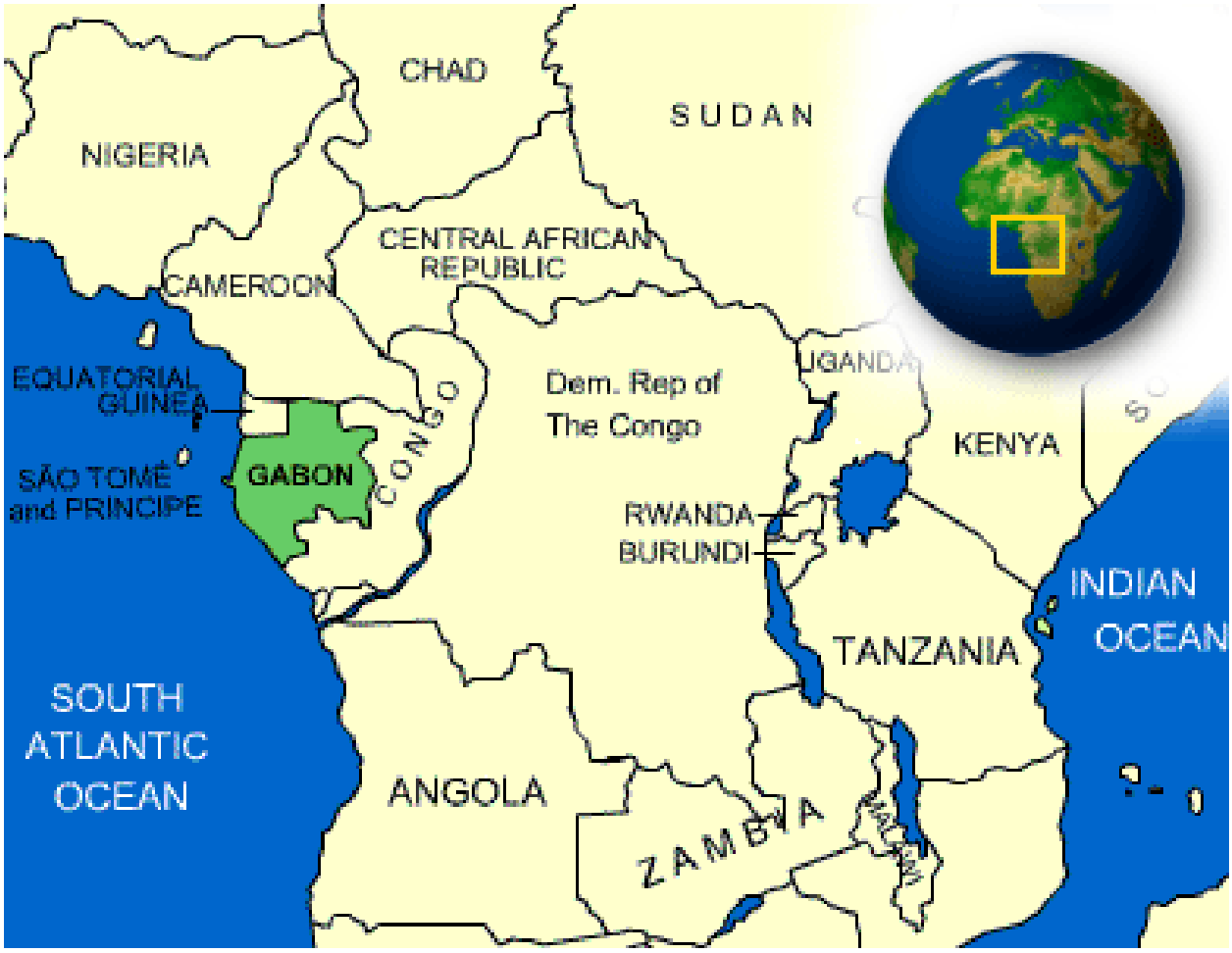

Figure 3. Location of Gabon

CountryReports.org (2007), *Gabon*

its oil industry, Gabon's per capita income is more than four times higher than that of any other sub-Saharan country. This high per capita income suggests that the country has a higher standard of living than most sub-Saharan African countries, but the country's wealth is not equally distributed. Therefore only a minority of the population has the wealth and a large majority of the population remains comparatively poor by US standards. However, its large average wealth has made protecting its rich biodiversity possible (CIA, 2007).

Gabon is well known for its large national park system that was established in September, 2002, by President Omar Bongo (Smithsonian Monitoring & Assessment of Biodiversity, 2007). There are currently thirteen national parks in the country, possibly the largest park network in the world. The Gamba Complex (see **Figure 4** at the end of this section) covers 11,320 square kilometers; this is about 1.5 times the size of Yellowstone National Park in the United States (WWF, 2006). Two of these parks, Loango National Park and Moukalaba-Doudou National Park, are contained within the protected Gamba Complex. Despite the large land area contained within its bounds, there are fewer than 10,000 humans within the Complex; most live in the town of Gamba itself, a coastal town in southwestern Gabon. Only 2,000 live outside the town, in small villages (Smithsonian Monitoring & Assessment of Biodiversity, 2007). The area is known for its strong biodiversity, which has been maintained in part due to the limited human disruption of the environment, a consequence of the low population. It is due to this high biodiversity that the Smithsonian Institution National Zoo's MAB program has an interest in the region; the Gamba Complex alone has 80% of the country's amphibian biodiversity, justifying its conservation value (Lee pg 235, 2006).

Similar to many developing countries, the majority of the wealth is distributed in the hands of only a few people while the rest of the country remains in poverty. Poverty is actually

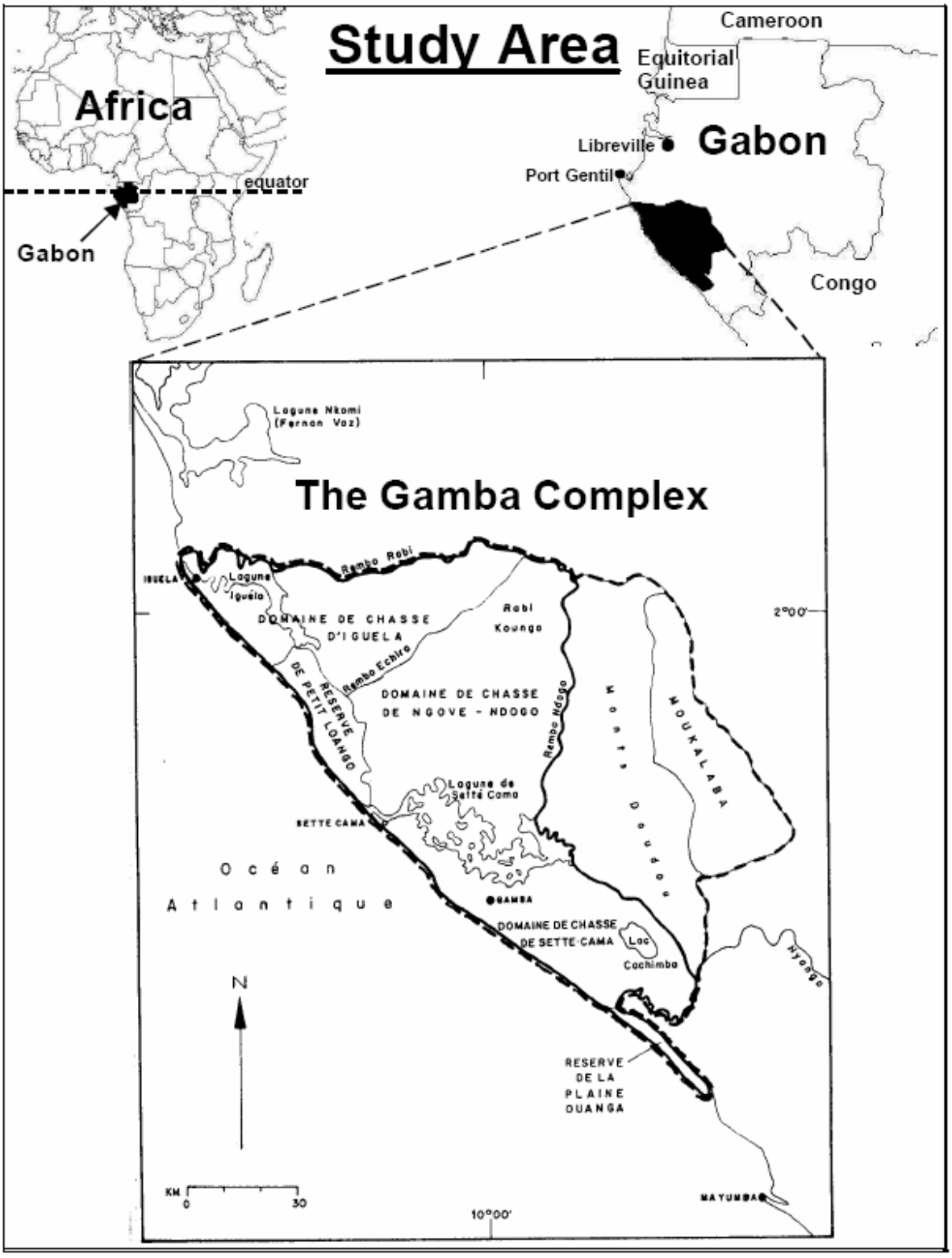

Figure 4. Map of the Gamba Complex

(Smithsonian Institution Monitoring and Assessment of Biodiversity)

the state of one who lacks a usual or socially acceptable amount of money or material possessions (Merriam-Webster, 2007), but does not necessarily indicate unhappiness or a failure to make a living. Poverty is predominately seen in the cities of Gabon because the majority of the urban population lacks a "socially acceptable" amount of money. Because the wealthy live in the cities, financial disparities among the population are more readily seen than in the villages. Poverty is therefore not as visible in the villages, because in these places the socially acceptable amount of money is substantially less than that of the cities; thus the majority of the rural population is on an equal economic level. Lack of economic resources is less evident, especially in Gabon, due to the vast amount of natural resources people have at their disposal in rural areas.

2.5 Educational System in Gabon

Children in Gabon can receive primary education starting at the age of five and that schooling lasts for six years. The International Association of Universities (IAU) is an international educational cooperation coordinator and states that, for a Gabonese child to receive secondary education, he or she must pass an entrance examination (International Association of Universities, 2006). Secondary education covers seven years of schooling. This secondary education is broken down into two cycles, a lower cycle that lasts four years and an upper cycle that lasts three years. While in the upper cycle students can begin to specialize in Mathematics, Natural Sciences or Humanities, Economics and Science and Technology (International Association of Universities, 2003).

School systems in Gabon are much different than those in the United States. Approximately sixty-three percent of men and women over the age of fifteen in Gabon are literate (CIA World Factbook, 2007), this is a relatively high literacy rate for a developing

country which indicates that the educational system in Gabon is slightly more developed than those in other developing countries. The average student/teacher ratio in Gabonese public schools in 2002 was about thirty-six students per teacher (Britannica Encyclopedia). This number is high in comparison to public schools in the United States, where the student-teacher ratio is roughly sixteen students per teacher (National Center for Education Statistics, 2001), while it is also much less than some other developing countries like Bangladesh, with more than sixty students per teacher (Association for the Development of Education in Africa, 2001).

Another problem that most public schools in developing countries face is the lack of educational resources such as textbooks and computers. In countries such as Uganda the target number of textbooks for a classroom is one book for every three students (Association for the Development of Education in Africa pg 10, 2006). This lack of educational resources often hinders intellectual growth. When developing the mini-curricula that will be implemented in Gabon, any lack of educational resources could play a major role.

While the public schools may not have as many resources as a first-world school would, the private school in Gamba is another matter. If the lessons are to be used in a private school, such as the Yenzi school where a large number of Shell employees' children go, a significantly greater number of resources are then available, including accessible high-speed internet access as Gabon is one of the few African nations with high-speed submarine fiber optic communications cables. In addition, notebooks and writing materials would be available to the students, as well as the ability to use consumable worksheets.

2.6 Effective Teaching Methods

In education there is one issue that has always been, and will always be, a problem no matter where children are raised, and that is keeping students' attention when they would rather be socializing or enjoying various forms of entertainment (Harmin pg 11, 1994). In order to keep the students' attention the teacher must keep them active. Active learning is a style of learning devoted to keeping students active throughout the entirety of the lesson. This type of learning allows students to interact and ask questions in an active, overt manner – not passively (Lancaster pg 55, 1974). When students feel comfortable in open discussion with educators and peers, they are more likely to be actively involved in the learning process.

Teachers need to keep students' attention and "the first responsibility of the teacher is to stimulate the students' imagination and second, to develop the capacity for extraordinary effort" (Lancaster pg 179, 1974). Our activities need to grab the students' interest enough for them to stay focused on the subject, and they also need to be informative enough for the students to comprehend and fully understand what the lesson plans are trying to convey.

One of the greatest methods of active learning is cooperative work. Students are faced with a common goal or objective to achieve and, by working together, the students are actively learning (Gray, Papia, and Vallieres pg 16, 2005). Working in cooperative groups encourages the students to combine talking and listening, reading, writing, and reflecting (Meyers & Jones p 98, 1993). Every student has his or her own individual strengths and while working in a group each student can use those strengths to the fullest. A student may feel inadequate in a certain aspect of learning, maybe the student does not write well, but while in a group the student does not need to be good at everything because each individual student has different strengths and abilities to bring to the table.

2.7 Learning Styles

Beginning in the 1970s, research began to be done on student learning styles. During preliminary project literature review focused on education and outreach, the exploration of three or four main learning styles was noted. The three primary models used to describe these methods are kinesthetic learning, auditory learning, and visual learning (Spence, 2006). A fourth learning style that is often seen as a component of the others is read/write learning. While there has been skepticism about utilizing these various learning/teaching styles and the supporting experiments (Curry, 1990), these models are generally accepted as at the very least being non-inhibitive to learning.

According to the theory behind these models, students all learn in different ways and various individual children may respond better to some methods as opposed to others. Incorporating a student's (perhaps unconsciously) preferred model should both increase retention and reduce the stress of learning new material. In order to make the project's lesson plans as useful as possible as a learning tool, each lesson will incorporate a wide spectrum of these learning models.

2.7.1 Kinesthetic Learning

Kinesthetic learning may be termed "hands-on" learning by some sources without losing meaning. In this model, learning is often achieved using physical activity as opposed to, for example, listening to a lecture. This method of learning is a "learn-by-doing" style. According to some sources, up to 45% of the population may benefit from this learning style (Spence, 2006). A kinesthetic learner is a person who will benefit just from the act of writing something down. This model may match up well in some cases with the notion of inquiry-based learning.

Examples of kinesthetic learning are role-playing and the construction of physical representations of models. Some kinesthetic learning methods may require additional materials for building activities, or suitable settings for movement and acting.

2.7.2 Auditory Learning

Auditory learning is “learning-by-hearing” in its simplest description. Traditional classroom teaching methods are largely auditory. Students who are auditory learners would benefit the most from a lecture-based course. In-class discussions are another teaching method that would benefit auditory learners. Auditory learning can also be accomplished by asking students to present aloud, from a selection of text. By doing so, students may also be gaining additional understanding from the act of reading itself and then vocalizing the information. The aural information does not need to be limited to speech, and can include music and other sounds. Recorded samples can be used to create reproducible and transportable lesson components. According to some sources, up to 25% of the population may be attuned to auditory learning (Spence, 2006).

2.7.3 Visual Learning

Visual learning is “learning-by-seeing” and it has become a highly popular way to present information in the modern age due to the practicality and ease of presenting information in a multimedia format. Due to the ability of diagrams, video, and still images to convey a vast amount of information in a short amount of time and without the need for lengthy written description, the use of visual presentations of all sorts has become popular. At least 30% of the

population can achieve the most benefit from the visual presentation model (Spence, 2006). Visual learning methodology allows students to store information in specialized visual memory.

One study for Inspiration Software, Inc. by The Institute for the Advancement of Research in Education (2003) has shown that, for almost all users, visual learning improves information retention, critical thinking capacity and analyzing relationships between data, the comprehension of new ideas, and assists in the organization of large amounts of concurrent data. Additionally, visual learning models allow students to capitalize on the human brain's well-developed pattern recognition abilities as part of learning. The advantages in presentation that visual information can provide have long been understood and are the reasons underlying the popular proverb, "a picture is worth 1000 words."

2.8 Designing Effective Outreach Activities

There are numerous concepts in designing outreach activities and curricula to educate students about topics in a short period of time. Methods of implementation range from informational websites with downloadable quizzes, pamphlets, and activities to entire detailed lesson plans to be used by an instructor with his or her class. All of these methods have their merits, but it is crucial to be aware of the specific needs of the target audience in choosing a specific outreach medium.

Many organizations, including The Smithsonian Institution, The National Science Resource Center, The World Wildlife Foundation, and others have prepared numerous outreach curricula sets on various topics, designed for learners of all ages[4]. The style and format of these

[4] Of most interest to us were (National Science Resources Center, 2002) NSRC/NSF prepared materials on ecosystems; (Martin, 2001) material for BirdLife Seychelles; and (U.S. Department of the Interior National Park Service, 2003) on invasive species. Other materials reviewed include (National Museum of Natural History) undated

curricula vary, but the key concepts and goals seem to be consistent. Each method involves some sort of informational document which can be used in a lecture or reading assignment. This is necessary to provide some background information to students who may know nothing about the subject.

Once a familiarity with the topic has been established, activities to engage students in active thinking about the subject are available. These activities include but are not limited to individual research assignments, open discussion among a group, open-ended essay questions, and quizzes (Smithsonian Education 2007). They are designed to enhance the level of thought one puts into a topic. After reviewing numerous curricula sets, it appears that the general consensus is that in order to maximize the effectiveness of an outreach program, it must require the students to develop their own thoughts on the material, which will ensure they have a thorough understanding. Providing additional take-home materials beyond the main lesson itself can help with this as well.

2.9 Development and Integration of Curricula

Many environmental outreach programs involve hands-on study of local plants and animals (Fullard p 3, 2006). Many of the curricula sets requested students to explore their local environment in order to locate signs of wildlife. The key emphasis here was to establish the proximity of "wild animals'" habitats to our own. By limiting the outreach focus to flora and fauna indigenous to the region where the curriculum is instituted, students are more likely to be interested in the topics at hand, and are able to experience and put to use what they have learned at home long after the educational program has ended.

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material on insects, (Fernbank Science Center) undated material on birds, (Illinois Natural History Survey, 2003), and (Townsend) undated material.

While it is important to make the material directly relevant to students' every day lives, great care must be taken to focus their studies in the appropriate places. It may seem necessary to provide extensive background information on the macroscopic issues at hand; however, young students will have more difficulty in digesting highly detailed information that does not pertain to their home environment. In a report on education reform in rural parts of Africa, various methods of improving education quality were discussed. Included in the seminars were representatives from many countries such as Burkina Faso, Ethiopia, Guinea, Kenya, Madagascar, Mozambique, Niger, Senegal, South Africa, Uganda, and the United Republic of Tanzania; however the issues at hand were relevant to all rural regions in Africa. "Experience suggests that the curriculum should combine the core national content with local content, taking into account context, customs, livelihoods and rural development activities. On the contrary, the curriculum of many of the participant countries has tended to be too academic, theoretical and examination oriented" (Shibeshi p 32-33, 2006). A balance must be found to ensure basic understanding of the core issues, and to provide most of the raw data from the local ecosystem.

2.10 Monitoring Effectiveness of Outreach Programs

A major issue in implementing an outreach program is determining its effectiveness. Before investigating how to monitor effectiveness, it must first be defined. The Smithsonian Institution Monitoring and Assessment of Biodiversity (MAB) Program established the following goals during a workshop in 2000:

- Increase knowledge of biodiversity within Gabon through biodiversity research, assessment and monitoring;
- Promote links among stakeholders in Gabon, researchers, conservation scientists and resource developers;
- Increase in-country capacity for continued biodiversity work through technical training in established protocol;.

- Disseminate the scientific information generated from the biodiversity assessments to a wide range of audiences;
- Advance the model of conservation and sustainable development through successful partnerships among local stakeholders, scientists and industry. (Campbell p 5, 2003)

These are large scale goals which the MAB Program hopes to achieve through massive outreach and intervention projects. Our curricula will not encompass the entirety of these goals, but our project will be a step towards assisting the MAB Program in attaining its objectives. The outreach curricula should initiate interest in the subject among the local youth so that future generations will be more active in pursuing this initiative.

As stated above, there are many factors to consider in selecting what type of outreach should be used, all of which bring up questions which lack a single concrete answer. The only way to be certain that the outreach is effective is to monitor the students' grasps of the material before, during and after the program's initiation. A popular method which has been used frequently in monitoring the effectiveness of outreach is conducting surveys with outreach administrators, and distributing quizzes, or question sheets to assess the learning that has taken place. These data must be compiled over time to provide an accurate picture of how much difference the outreach has made, if any. Once these data have been analyzed, specific aspects of the outreach attempts which seem to have failed can be removed, while recurring, successful sections can be refined and reused. This review of previous outreach material is necessary because "although [various outreach] program data are available, relatively little evaluation of [these] outreach activities has been published in the literature. In fact, many programs … are collecting data, but the key is to use data routinely and effectively to monitor and improve progress [in developing these materials]" (Summer p 4, 1999).

As stated earlier, biodiversity impacts everything in an ecosystem and if one species starts to decline in number, it could prove to be catastrophic to many other species in the same

ecosystem. Educating students at a young age could be beneficial because they will be the people in the future who will have a say in the conservation of biodiversity in their locale. In addition to this, students should be made aware of ongoing efforts that various organizations, in particular the Smithsonian Institution, have made towards conserving and monitoring biodiversity in the world and in their region. By emphasizing the importance of biodiversity and its preservation, progress will be made towards long term preservation-oriented attitudes and a more conservation-friendly atmosphere, while fostering an appreciation for our "natural heritage[5]".

[5] This old phrase was used more commonly before the development of the term "biodiversity."

3.0 Methodology

The goal of this project was to develop up to five lesson plans/mini-curricula on biodiversity conservation and the impact human activities have on the ecosystem. These lesson plans will be used in an outreach program in Gabon, Africa, more specifically, in Gamba at the Yenzi private school. The lesson plans were made to last an hour long, and were geared towards twelve year olds. These lesson plans can also be used as activities for school groups visiting the Smithsonian research laboratory at the Gamba Complex. In fulfilling our goal of developing these lesson plans, the following tasks were accomplished:

- Identify a structure for the lesson plans
- Identify a stand-alone topic for each lesson plan based on previously done or current Smithsonian projects
- Define objectives for each lesson plan
- Develop the lesson plans
- Submit the lesson plans for review and make any necessary revisions.

Further explanation on the specific means of achieving these goals will be explained in this methodology.

3.1 Filling Research Gaps

After initially getting to Washington, D.C. it was important to gather site-specific information that was not available to us at WPI. There was a great deal of information that we needed to acquire once we arrived at the Smithsonian because of the availability of information and resources in Washington. It was important that we were able to quickly acquire this information so that we could produce suitable curricula in the timeframe we had.

Research gaps included information about the local biodiversity in Gabon and the threats to it, the details of the educational system in Gabon, specific Smithsonian Institution projects in the area, and the culture of students in Gabon which would undoubtedly have an effect on the curricula we would develop. Once these gaps had been filled, work towards our primary goal of curricula topic selection and content development could begin.

3.1.1 Interviews to Fill Research Gaps

One principal method we chose to fill our research gaps was to conduct interviews with MAB researchers who have worked or are currently working on projects in Gabon. In addition, we also spoke to outreach developers and consultants who had experience in biodiversity outreach as part of another branch of the National Zoo, or who were not actually Smithsonian employees. These interviews were conducted as semi-structured interviews. The strategy was to ask open ended questions. Open ended questions allowed the interviewee a chance to give us more information than the questions had entailed. We wanted to also be able to ask targeted questions that would give us the answers that we needed, but not miss any important details. Interviewees were identified based on consultation with our Smithsonian liaisons and then we scheduled appointments to speak with them.

We were able to obtain a wealth of background information during our first meetings with on-site staff. A meeting with Alfonso Alonso, Ph. D (SI CCES[1] Director of Conservation) and Jennifer Sevin (SI CCES Education and Training Coordinator) served to refine our goals and give more detailed information about Gabon.

[1] CCES (Center of Conservation Education and Sustainability) is a new branch of the National Zoo; the MAB group is now located under this branch, rather than directly under the National Zoo. At the time of writing, it is a transition period for the organization to adopt this new structure.

Ann Henderson, Ph. D (SI CCES Conservation Biologist) and--via teleconference-- the three directors of the Gamba Complex research center, Olivier Pauwels, Annabelle Honorez, and Marc Dethier helped us to identify our target audience and the five Smithsonian projects on which we should base our lesson plans. They explained to us that the primary goal when implementing these lesson plans is to teach the students about what the Smithsonian Institution is doing in Gabon to protect and maintain biodiversity, in addition to increasing awareness and appreciation of biodiversity. After this interview, we composed a list of the MAB researchers who completed the projects on which we were going to base our lesson plans. These scientists would be our primary resources for each project.

Meeting face-to-face for interviews was not always possible. For Smithsonian staff in Washington it was very practical to sit down and talk, although this was not the case for scientists who worked farther away. Phone calls and teleconferences were ideal, along with email, for getting in touch with these hard-to-reach contacts. Many contacts did not mind informal discussion and told us to not hesitate if we had a question and wanted to place a quick call; scheduling a time to talk could take more time and effort than placing the quick call.

The purpose of interviewing these MAB scientists was primarily to inquire about the projects they had done in Gabon. Some of the questions that we asked the MAB staff can be found in Appendix B. The information we obtained from the interviews was incorporated into the background section of our lesson plans. Not only did we receive background information through the interviews, we also received advice and ideas on activities to include in our lesson plans. Smithsonian scientists were eager to help us and offered to give us unpublished documents and proposals of the projects that proved to be a valuable resource when making the lesson plans

3.1.2 Information gathered from Smithsonian

We immediately began to collect written materials we knew would be useful background information. We anticipated the availability of a large amount of otherwise-inaccessible material, and were correct. A large number of reports were available on the Smithsonian internal network. These reports contained photographs, maps, and data related to our selected curriculum topics. We often referred to one road map of the Gamba Complex we had hanging in our workspace to allow us a deeper geographical sense of where activities were conducted, compared to where the target audience lives and where the oil industry operates, for example. In addition to this, we were also presented with a variety of proposals for future, previous, and ongoing studies in Gabon. Many of these proposals also had updated versions available, non-technical versions, and associated report summaries that made it easy to see at a glance the motivation for a project, the methods, and the expectations or results. A large number of these documents were either unpublished or just for internal reference, and thus were inaccessible prior to our arrival.

We also obtained a large, recently published book, Alonso, A; Lee, M; Campbell, P; Pauwels, O; and Dallmeier, F *Gamba, Gabon: Biodiversity of an equatorial African Rainforest*, which contained a collection of reports from Gabon that had the factual data, analysis, and statistics that we sought. These proved quite useful in understanding the Smithsonian's reason for operating in this area and providing credibility to certain arguments we made.

3.1.3 Lesson Plans

Using our resources at the Smithsonian, we obtained a large number of sample lesson plans and curricula of a diverse nature. We found many different lesson plans although many of

them were not necessarily adaptable to our needs. Although many of these lesson plans were more complex than what ours would be and the content was different, we were able to examine a variety of formats and lesson plan styles that we could use.

We began to look for comparisons between previously completed and published lesson plans. We considered mainly the lesson plans that our liaisons gave us because of their coherent format. Based on the similarities between the lesson plans, we determined what popular lesson plan formats and methods were commonly used. We, as well as our sponsors, felt that many of these popular formats and methods could be integrated into our own lesson plans.

After the format was finalized, we had to develop the main part of the lesson plan, the learning objectives and the learning activity. Transfer of information can easily be done although actually teaching students about a topic is more difficult. We wanted to develop an activity which involved the students and which was interactive. Each lesson plan was different and had its own message to give to the students. The activity's job was to support the message. We reviewed activities from these lesson plans to determine what their goals were and how they accomplished these goals. We believed that each of our activities should have an objective and the activity would need to meet that objective.

3.2 Curriculum Assessment

In order to design curricula which will have a noticeable impact on their audiences, we needed to develop a solid understanding of widely accepted methods in designing effective outreach curricula. Outreach curricula have been developed by numerous institutions covering various topics. Much of the modern curricula developed are designed for school systems with sophisticated levels of available technology. Because we couldn't always assume such is the case

in Gabon, we utilized the major concepts included in all outreach curricula, but found a method of presentation that did not require advanced technology.

Interviews were conducted with dedicated outreach developers and other educators with experience teaching in developing nations such as Gabon. Many educational specialists, outreach developers, and consultants can be found within the MAB and National Zoo. Their experience in developing curricula was highly valuable to us because improving curricula is a trial and error process where success or failure can almost never be assessed until after a period of implementation of the curricula. We contacted Mario Castellanos, the Community Service Outreach Program Director at The National Zoological Park, and asked him about education outreach in relation to Gabon. Questions that we asked him can be found in Appendix B.

The next step in our curriculum assessment was to determine the major cultural and educational system differences in Gabon and effective ways to implement our curricula. Our major sources of information on these topics were review of curricula which have been successfully implemented in the past and interviews with people who have worked on outreach programs or who have firsthand experience in Gabon's or other developing nations' educational systems.

Cultural differences which we may not have accounted for were a major topic of discussion in an interview with Alfonso Alonso. This interview was an unstructured interview. Dr. Alonso has been involved with the Gamba research site and has visited Gamba many times, so we felt that he could provide us with ample information regarding Gamba, the research site, the oil companies there, and the average daily life of children in Gamba. With this information we planned to ask Dr. Alonso and our outreach contacts to review our lesson plans to determine if they believed that what we developed would keep the interest of a student living in Gamba.

3.3 Developing the Curricula

To begin development of the lesson plans, review of previously completed lesson plans had to be accomplished. We reviewed lesson plans published by the Smithsonian and other organizations such as the World Wildlife Foundation. These lesson plans did not give us any content for our lesson plans, but made us aware of structural and formatting styles. After reviewing the different structural styles, we discussed our possible structure with Jennifer Sevin (SI CCES Education and Training Coordinator), because of her extensive experience with lesson plans. Once we had the structure for our lesson plan finalized we needed to fill it with content.

We developed objectives for each lesson plan in order to ensure that our goals for each lesson plan would be met. The information gained through interviewing MAB scientists and information gained in the papers and proposals of the projects provided content for our lesson plans. A large portion of the lesson plans was the activity section. For each lesson plan we devised several different possible activities. Throughout the development process these possible activities were, at times, fused together and sometimes even completely thrown out. We judged each activity based on what kind of characteristics it would bring to our lesson plan. Our goal was to develop the most effective activity to teach the students about the ecological problem that the lesson plan was addressing.

Throughout the entire development process everything that we did was checked and reviewed by Smithsonian researchers or directors who had extensive experience in developing lesson plans. We spent a great deal of time speaking with Jennifer Sevin and Ann Henderson on the structure, the content, our audience, the resources available to us, and many other aspects of the lesson plans.

3.4 Evaluating Curricula

During and after our curriculum development, we had to rely on some means of evaluation to analyze our lessons' effectiveness in achieving their educational objective. Unfortunately, we were informed that there currently are no set standards for the kind of mini-curricula we were tasked with developing. However, we got in touch with outreach and education professionals (including our own advisors, professors at WPI) who had experience in developing and deploying educational materials. Their judgment would be valuable in evaluating our materials.

We worked with Smithsonian MAB staff, including CRC[2] Education Program Manager Jennifer Buff and Ricki Ashcroft, an Education Specialist from Jennifer Buff's office, to determine if the curricula met expectations with regard to level of content in the background materials and the difficulty and applicability of the activities for each lesson. A number of these Smithsonian professional staff were experienced in outreach programs, having prepared their own lesson plans or having acted as consultants. Beyond that, a Smithsonian researcher checked our curricula for anything that might be culturally insensitive that we missed in our own review. Reviewers were welcome to provide suggestions on where elaboration was required or on areas that needed attention, and served to greatly help in the revision process.

We developed our curricula in series, using a procedure that allowed us to have constant feedback on our progression. Each lesson-activity pair was developed section by section. As each section was completed, it was submitted for peer review and passed on to our liaisons as well as the Smithsonian reseacher who conducted the project that our lesson plan covered. This

[2] Conservation and Research Center, a Directorate of the Smithsonian National Zoological Park. The CRC itself is located in Virginia, but CRC employees work behind the scenes at many Zoo exhibits, as well as in the field.

practice guaranteed that every component of the complete draft lesson plan was submitted for review as at least a second draft, and allowed time to discuss potential issues early before they manifested themselves as larger problems.

Once each lesson plan was in complete form (aside from any additional materials such as take-home worksheets which were not necessarily part of the core plan), its components were revised based on feedback and compiled into a basic sectional presentation format which was again submitted in whole form for review. During a weekly meeting with our advisors and Smithsonian liaisons, we were then able to discuss the lesson we had developed and receive important feedback and share concepts and ideas for future inclusion or investigation. The lessons plans were then set aside until they were ready to be placed into a final presentation format, while the next lesson was already under development.

The lesson plans that we developed are intended to be the first of what could possibly be many lesson plans. Because the material that we developed will serve as a model it was important that we evaluate and review our lesson plans extensively. In order to further promote revision, we took notes on possible future extensions or enhancements to the lessons and activities as we developed them. These suggestions for future lesson topics should prove useful for future development teams.

4.0 Development of Structure and Framework

In order to begin work on the lesson plans, a structure needed to be created. Once the outline of the structure and framework for each lesson had been developed the outline created could be filled with all the necessary content.

4.1 Determining our Audience

Before determining the structure and components to include in each lesson plan, it was necessary to determine the characteristics of the audience so that the lesson plans could address issues relevant to the audience. Previous literature review had revealed important topics and sensitive subjects for the students, and had brought forth many ideas regarding the final presentation of the materials. However, shortly after entering the planning stages of the lesson plan structure, a teleconference with Gabon-based contacts Annabelle Honorez, Olivier Pauwels, and Marc Dethier (with Ann Henderson in attendance locally) significantly changed the expectations of the project.

Information gathered from the meeting revealed that the public schools in Gabon were unwilling to use the lesson plans that would be developed since the public schools are firmly committed to their own uniform curricula. Consequently, this required retargeting the materials that were being developed towards the private school in Yenzi, Gamba and to expect possible use at the small Smithsonian lab in Gamba, as well as for local nature club use. The students would be about 12 years of age, although younger or older children could also benefit from these lessons.

Short discussion revealed that Yenzi is in a wealthier downtown area that resembles a typical American suburb, and that the private school there is largely trilingual (French, English, and Dutch). Its student body is primarily composed of Shell employees' children, which is

important to know due to the ease of inadvertently criticizing the oil industry in the discussion sections of the lesson plans. The lesson plans would be presented by the experienced Smithsonian staff in Gabon and/or the private school teachers as a roughly one-hour lesson, or by Smithsonian staff as part of an informal nature club they run in the area.

These changes introduced significantly more resources to rely on for the primary audience at the Yenzi School; this includes computers with color printers which would make it feasible to employ consumable color worksheet materials, and providing paper for taking notes would not be difficult. The Gabonese contacts and directors of the research laboratory even suggested the potential use of webcams in lesson material. While Gabonese villagers do not always have the required access for computer use, Gabon is among the few African nations to have high speed internet connectivity, with submarine fiber optic cables that round the coast and lead up to Europe. Recognizing the possibility of future expansion, and wishing to keep the resources presently required affordable, however, we chose not to focus on computer aided learning but did investigate potential uses of the technology; further discussion of this is in recommendation section**.**

4.2 Structure

Once the audience for the lessons was determined, we could begin development of the structure for each lesson plan. An outline was necessary to demonstrate how the lesson plan would be implemented. The outline would also provide direction when filling in the outline with content.

4.2.1 Developing the Outline

In order to develop an understanding of what might be common structural elements required for each lesson plan, several existing plans, fold-out informational sheets, and activity books were reviewed and analyzed. These materials were found within the Monitoring and Assessment of Biodiversity department. Developers of these exemplar materials included the National Zoological Park, the National Academy of Sciences, the National Science Foundation, the National Museum of Natural History, the National Park Services, and BirdLife Seychelles[6]. Some of these lesson plans can be found in Appendix D. Each exemplar had its own formatting style and structure, but similarities were found among the lesson plans. These similarities and differences were discussed in individual meetings and phone conversations with Smithsonian staff members including CCES/MAB professional staff and educational specialists in order to develop a format and structure for the lesson plans that would be developed. These meetings also provided insight and direction for a structure that could incorporate these components. The direction and approval of MAB educational specialists led to the decision about which sections should be included in the lesson plans.

Actual structure of existing lesson plans was the first aspect to be reviewed. This was done because new lesson plans would require a proven foundation for their structure, and this could best be developed by utilizing structural components from existing lesson plans. As these lesson plans were reviewed, certain trends were found. Components that were included most often were: the objectives listing, which provided the overall educational goals for the lesson; an introduction section that gave instructions to the teacher in terms of the presentation of the

[6] [6] Of most interest to us were (National Science Resources Center, 2002) NSRC/NSF prepared materials on ecosystems; (Martin, 2001) material for BirdLife Seychelles; and (U.S. Department of the Interior National Park Service, 2003) on invasive species. Other materials reviewed include (National Museum of Natural History) undated material on insects, (Fernbank Science Center) undated material on birds, (Illinois Natural History Survey, 2003), and (Townsend) undated material.

material and the format of the lesson plan; a background section that contained detailed factual information and gave context to the material that was to be presented; and a primary activity that makes use of the background context to reinforce certain ideas from the lesson, and includes a materials listing early in the description. Many lessons also included questions to promote further thinking and reveal whether or not the students had been absorbing the concepts of the lesson. A description of what was found in each lesson plan and the elements that were contained in each exemplar can be found in the following tables, Tables 1 and 2.

Table 1: Description of the Elements in the Exemplar Lesson Plans

Elements	Brief Description of each Element
Objectives	A section that explain teaching goals of the lesson
Skills	A list of skills developed during the lesson
Instructions	A section giving a brief description of the lesson plan. Also provides instructions for the teachers and tasks for them to do before the lesson
Background	A section that contains detailed factual information and gives context to the material that is to be presented
Glossary	A section that defines key terms to be used throughout the lesson
Activity	A section that makes use of the background context to reinforce certain ideas from the lesson through an activity
Questions	A section of questions for students to answer related to the lesson
Material	A section describing the materials needed for the lesson
Suggested Activities	A list of different activities for lesson but instructions to execute the activities are not included
Closure and Assessment	A section that reminds teacher to conclude the lesson and to have students write in their journals all of their observations and findings

Table 2: Elements in each Exemplar Lesson Plan (Exemplars found in Appendix D)

Elements within Exemplars	Ecosystems	Birds are Brilliant	Exploring Ecosystems in the Classroom	Animal Treasure Hunt
Objectives			X	X
Skills				X
Instructions		X	X	X
Background	X	X	X	X
Glossary				X
Activity	X	X	X	X
Questions	X			
Material	X	X		
Suggested Activities		X	X	X
Closure and Assessment		X	X	X

One similarity that was found was that most lesson plans had some type of introduction as well as a background information section. Some lesson plans had a list of objectives that the lesson plan was trying to accomplish while others did not. All of the lesson plans had an activity or a list of activities that could be done for the lesson. Not all of these activities had directions for the teachers or the students. Some had a list of suggested activities but did not provide instructions for the activity. Some activities also had questions for the students to answer throughout the activity; however, it was found that the lessons that did not provide directions for the activities also did not have any questions for the students. One element found in a few of the exemplars was the suggestion of providing the students with an activity to do at home or outside of class.

Through meetings with Smithsonian staff it was determined that a list of objectives would be useful in order to keep the lesson plans focus on the desired outcome. Other components chosen to be used in the lesson plans included group work along with oral presentation, combined with in class and take-home worksheets or assignments. Reasoning

behind selecting some of these components over others was that children would be more enticed to participate if they were working with their peers rather than by themselves. The reason for having discussion as well as writing short answers was to allow students different approaches to voice their opinions and to employ methods that reach out to students with varying learning styles (as discussed in our preceding Literature Review section. Some students may like to talk in class while others are shy and do not participate and would rather spend time writing in a journal or on a worksheet, this approach allows students to participate in both ways.

The structural format we settled on contains seven major sections: Objectives, Introduction/Instructions, Ecological Background, What the Smithsonian has done, Activities, a Conclusion, and a Glossary. These sections were developed to give the teacher instructions on how to present the lesson and background information on the topic. Included in the activities description sections were questions to prompt discussion to get the students to think about the ecological problem as well as to develop reasoning skills. Material and information for these sections would come from literature review and research based on trusted sources such as internal Smithsonian materials and interviews/conversation with local MAB researchers and field researchers. It was determined that this was an acceptable structure for the lesson plans since it gives the instructor the objectives that the lesson plan is trying to achieve while also providing the instructor with any background information and key terms to know for each topic. Lastly, it attempts to convey in totality the message through an activity that encourages the students to use their minds and think about the cause and effect of certain activities that happen in the ecosystem.

Under the structure, the Objectives section, to be developed early in the creation of each lesson plan, should contain a short list of the educational goals of the lesson. These are the

learning objectives for the students, which should be met through whatever discussion, group work, reading, or independent observation is involved in the lesson plan.

The Introduction/Instructions section contains information for the teacher about how the lesson plan is formatted and how to implement and present it. It briefly describes the different sections in the lesson plan and an order in which to implement the content and activity together.

The Background section contains a description of the ecological topic of the lesson. It contains the information necessary to give the teachers and students an understanding of the issue, and provide context for the Smithsonian project description that follows.

The section about the related Smithsonian/MAB research project has multiple purposes; it raises awareness of pressing ecological issues, demonstrates the MAB's dedication to conservation efforts, allows students to understand what the Smithsonian project teams they may see or hear about are actually doing in Gabon, and should spark student interest in the subject matter. Giving students and their parents an appreciation of regional conservation and Smithsonian activity is an overall objective for all lesson plans.

The Activity section presents a mentally stimulating activity related to the topic that will fulfill some of the learning objectives. There is also a take-home Activity in addition to the in-class activity, which could, as an intended bonus, serve to pique the interest of any adults or parents who observe the child working at home and raise awareness in an older audience. The Conclusion section then ties together the informative sections of the material. The Glossary of terms offers definitions of key terms used in the lesson plans.

4.2.2 Structuring Activities

A variety of concepts and techniques were combined in order to allow students who learn best from a variety of learning styles to absorb the concepts presented. A variety of different kinds of activities were developed that could be used for the lessons as well as ideas for future MAB-produced lessons. While the Yenzi school that had become the focus had significantly more resources than originally planned for, it was decided to limit the use of, for example, computer-aided lessons; stand-alone lessons were used in order to minimize the necessary set-up time and class-time resource access. Requiring a teacher to download and install software could prove cumbersome and not be easily transportable to a more rural setting. Preparing worksheets and cut-out materials would be easier.

The goal of the activities was to enable the students to work together on an activity that would teach them about their own local biodiversity, in addition to biodiversity in general. References to various animal groups, for example, would point out the local varieties. If a type of bird had to be mentioned, one that had been confirmed by field study and anecdotal evidence to be present and active in and near Gamba and Yenzi would be used so that students would feel closer ties to the presented material. The activities were created so the students could learn about the importance of certain aspects of the ecosystem and show the importance of minimizing ecosystem disturbance.

Our team brainstormed various possible activities that could relate to the material and support the learning objectives. An activity need not fulfill all the declared objectives, as the take-home worksheets or assignments along with in-class discussion will also address some of these objectives. Generally, we attempted to consider various activity archetypes that could be utilized. Some activity archetypes that would be considered for the lesson plans were: model

constructing, discussion, graphing/plotting, drawing, observation, matching, and others. For example, one activity involves plotting data points on a map and then discussing relationships between the data points and objects on the map.

The difficulty/detail level of the lesson also had to be tailored to suit the targeted age group, about 12 years old, but activities that would be adaptable to older and younger audiences had to be considered. Alternative presentations or questions that could be used to make things easier or more involved depending on student ages, and possibly adjusting the time allotted to each activity based on age and level of achievement were considered.

If sufficient background material was available to support the activity (which was not always the case), then development proceeded while staying in touch with our contacts, frequently getting their input for improvement. Some activities were deemed unusable either due to insufficient data or questionable resources; some of these ideas appear in the recommendations section of the paper and could be implemented if the data they require is available in the future, or if the resources are available.

Based on the original literature review of common educational techniques and learning styles in conjunction with conversation with educators and review of lesson exemplars, accepted aspects of an attractive lesson plan were determined. Some aspects include: the inclusion of group work, giving students a chance to share their own ideas and experiences aloud (Alfonso Alonso explained that kids in our target age group “love to talk”), having interesting images, intellectually stimulating the students by asking them to develop a product (a drawing, a chart, or the organization of some set of elements) they can reflect upon and be proud of, and having the students inspired to do continued study or be left with interest (a take-home would fulfill this). The lessons tried to incorporate as many of these details as possible. Thus, every lesson and

activity would have discussion prompts for the teacher and students, involve group work and the sharing of ideas among students, and have a take-home activity. Many activities would have an open-ended nature to promote this discussion, with many possible solutions. The object was not to discover a single correct answer, but for students to explore possibilities and arrive at a variety of possible answers.

The main activity would ideally incorporate having the students develop some idea either in discussion or in a physical, hands-on form. Students would be working in groups in order to help each other understand and complete the lesson both directly and indirectly by reducing the level of distraction that competing “activities” such as unrelated chatter could cause. The take-home activities, which largely would include observation and research-style work, would be completed independently after class although there would be no restriction on students working in small groups to do joint observations. As they were developed, activities were presented, along with the full lesson, for review by our sponsoring agency and periodically to our advisors for discussion at weekly meetings.

5.0 Development of Lesson Plans

Once the structure of the lesson plans was finalized the objectives, content, and activities for each individual lesson plan needed to be developed. Through interviews with the directors of the research facility in Gamba, Olivier Pauwels, Annabelle Honorez, and Marc Dethier, it was discovered that the main purpose of these lesson plans was not only to raise awareness of the ecological issues that Gabon faces, but also to inform the students of what the Smithsonian researchers are doing in Gabon to try to protect the natural biodiversity of the area. Because of this Olivier, Annabelle, and Marc made it clear that the lesson plans were to be developed based on previously completed and current Smithsonian research projects. These projects include a research project on bird communities and how human activity affects them, a research project that attempted to discover how forest fragmentation caused by oil well sites affects the local species on the edges, and a research projects that involved tracking elephant movement and determining their stress levels and causes of stress. Information on the projects needed to be acquired before beginning the lesson plans.

Ann Henderson provided papers and proposals on these projects written by the MAB researchers who actually did the research. These documents provided an idea of what the projects were, although many of the proposals were written for a technical audience and were difficult to understand completely so interviews with the researchers who did the projects were needed. These interviews were, at times, more beneficial than the papers and proposals because they allowed communication with the researchers and provided explanations from valuable sources. When parts of the research project were not understood the researchers were able to explain in fuller detail. This method proved to be advantageous because the lesson plans were intended for use by instructors who do not have any background in the topics being taught and

also by instructors who have extensive background in the topics. By having a simpler, more general background in the lesson plan, instructors without previous knowledge will not find themselves lost trying to teach the subject, while instructors with extensive knowledge will not need much assistance with the background information, so having the projects simplified proved to be helpful as well as necessary. Since the Smithsonian researchers had a great deal of experience on their specific topics, they were asked to provide activity ideas that would incorporate their topics. Every Smithsonian researcher interviewed gave ideas for activities that would suit their projects, and the majority of suggestions were used. Not all activities could be used but different suggestions were mixed together to develop some of the activities. With all of the information and resources we acquired we began to develop each lesson one by one using our staggered approach, which was described in the methodology.

5.1 Development of First Lesson Plan

The development of the first lesson plan was the most important aspect of the project. Once the first lesson plan was finalized it would be easier to develop all of the following lesson plans. The focus of the first lesson plan was a bird study research project conducted between October, 2006 and March, 2007 in Gabon by Johanna Choo, Ph. D., a conservation biologist at the MAB office. Its purpose was to find out the main diets of bird species living in areas with high human activity. Of the three topics, the bird community study seemed suitable to be the first lesson plan because Johanna was stationed in the MAB office so it would be easy to hold an interview with her. The first goal that was set was developing objectives for the lesson plan as well as brief instructions. The objectives were chosen to make the students think about the ecological issue that was to be addressed in the lesson plan. After objectives were created,

content, activities, and questions that met the objectives could be developed. The first lesson plan was entitled *Understanding Human Impacts on Bird Communities* and can be found in Appendix C.

5.1.1 Content Development

Through interviewing Dr. Choo, a great deal of information was received on the methods of her project and the ecological issue she was studying. Information from the interview as well as the papers and proposals was included in the content sections of the lesson plans. The first section that was developed was the background section for the instructors. This section includes all the information the instructor would need to have an understanding of how different human activities affect bird communities. This section gives information about the services birds provide to the ecosystem. It also conveys the concept that all organisms have a role in the ecosystem.

The three main human activities covered in the background section are logging, hunting, and the oil industry. Each one of these human activities is described and an explanation showing how each human activity has an impact on bird communities is given. We also described how these activities could have compound effects. For example, logging can create easy access to the forest for hunters because before the logging occurred in certain areas it was difficult to get into some areas of the forest.

An important factor for the lesson plan was to remain culturally sensitive. The message could be considered prejudice or give a negative attitude towards certain professions and may even sound arrogant or pushy if careful wording was not used. As stated previously, these lesson plans will be implemented in the Yenzi School, which is a private school where many of the

Shell employees enroll their children. It would be insensitive to tell the students that the professions of their parents' have many negative impacts on the environment. Instead the lesson plan explains that certain resources are necessary for human development but the methods for retrieving the resources should be taken into consideration. For example, timber is a resource used for many different purposes so loggers should not just completely stop cutting down trees, but rather selectively cut down trees, not just clear large areas of the forest at once. The same ideas apply to hunting and the oil industry. Food is a necessity of life so people should not stop hunting animals, but hunters should not hunt so much that they eradicate an entire species. Ms. Henderson explained that "there is no need to go to the extremes, there is a happy medium" and that is the message to be conveyed to the students.

The next section in the lesson plan describes the related Smithsonian research project in Gabon. This section includes the dates when Dr. Choo was doing her research and the methods she used to conduct her research. The majority of this information was taken from Dr. Choo's proposal. Because this project was conducted recently, many of the results have not been analyzed yet so there are no conclusions to be drawn.

To reinforce the students' understanding of the concepts and ensure their retention of the information presented in the lesson and activity, a conclusion section was included. This section was incorporated to reiterate to the students that human activity does have an impact on the bird communities and it is possible to mitigate these impacts.

5.1.2 Activity Development

The most important part of the lesson plan was the activity because information transfer is simple but getting the students to retain the information is difficult. As stated in the

methodology section, a few different activities were conceived. A wide range of options for our activity section was desirable since students learn in different ways. Different activity ideas would allow suggestions for possible future activities that could be incorporated into the lesson plans.

Many different ideas were thought up for this lesson plan. An activity that was first thought of included an exercise where the students would have to plot information on an x-y plane and graph the points. This would have been a population growth and decline graph. The students would have been given data from different years that indicated the number of birds in a species in a given year. They would have plotted the points and explained if the different species were growing or declining in numbers. After careful thought it was determined that this type of activity would not address any of the lesson objectives. Another activity that Johanna suggested was an identification activity. The students receive sheets with different birds and they would have to identify the species using the provided descriptions and silhouettes. Along with the activity, a question sheet was handed out to the students. These questions required the students to think about the different roles each type of bird plays in the ecosystem. The questions would require the students to think about different human activities and how they think the activities affect bird communities. We believed that this activity would be well suited for this lesson plan because everything needed for it would be provided in the lesson plan and the questions would challenge the students to think about a bird's role in the ecosystem.

In conjunction with the activity, a take-home activity could be incorporated after the lesson. This take-home assignment would allow the students to continue to think about the lesson that was taught and provide them with a fun assignment to fill out that would not be considered for any type of grading, unless the teacher felt it suitable. This activity was made to

be mainly observational, in the sense that many of the questions dealt with recording something that the student witnessed or heard. This activity would not be strenuous or difficult, rather it would be an attempt to keep the students interested in the bird communities around them.

5.2 Development of Second Lesson Plan

After the development of the first lesson plan, it was easier to put together our second. We decided to base our second lesson plan on a study of how forest fragmentation affected local species conducted from August, 2006 to March, 2007 in Gabon. This research project was conducted by Amy Dunham, Ph. D., a conservation biologist formerly at the MAB office, and its purpose was to find out if forest fragmentation had any effect on the local species along the edges. The edge is where the forested area meets the cleared area. Dr. Dunham no longer works with the Smithsonian and is now stationed in Texas at Rice University, so interviews needed to be conducted via phone. Like the first lesson plan, the first goal was to develop objectives for the lesson plan as well as brief instructions. Once the objectives were developed the content, activities, and questions that met the objectives could be developed. The second lesson plan was entitled *Understanding Impacts of Forest Fragmentation on Local Species* and can be found in Appendix C.

5.2.1 Content Development

Information that Dr. Dunham provided through an interview with her, as well as her proposal and other papers, was incorporated into the content sections of our second lesson plan. Similarly to the first lesson plan, the background section was intended to give the instructor an understanding of how forest fragmentation affects the many different species of the forest. This

lesson plan also focused on the food chain and how every plant and animal has its own role to play in the forest. If one plant or animal is taken away, many other organisms could be affected. The topic of the food chain and the interdependence that plants and animals have with each other is important to understand the effects of forest fragmentation. If the students know the different characteristics of certain plants and animals and the relationships between them, they would more easily understand why, when habitats become unbalanced, they begin to change or fall apart.

Forest edges can be caused by different human activities, although Dr. Dunham's project covered oil well sites in particular. The message that the lesson plan attempted to get across is not to condemn oil well sites or other human activities but to encourage restoration. It may be necessary for oil companies to cut down a large area of the forest to create sites to extract oil, but many of these sites will never be used again. Many oil companies believe in just leaving everything alone, trusting that the forest will come back naturally. Because of the changes that are happening along the edges, however, natural restoration will not occur.

The Smithsonian is conducting a great deal of research and attempting to provide recommendations to the oil companies. The section describing what the Smithsonian has done informed the students about this research. The majority of this information was taken from Dr. Dunham's proposal. Like Dr. Choo's project, the analysis of the results from Dr. Dunham's project have not been fully completed, but the Smithsonian has started to work with the oil companies to restore the oil well sites.

In order to try to ensure that the students understand the concepts and retain the information in the lesson and activity, a conclusion section was included. This section reiterates

to the students that all organisms in the ecosystem depend on another organism to survive and when one thing disappears many other organisms can be affected.

5.2.2 Activity Development

When speaking with Dr. Dunham on the phone, activities for the lesson plans were discussed and she identified a computer application. This application could be downloaded and it provided sample programs. One program that was found was a sheep, wolves, and grass program. It showed what happened over time in a habitat where the sheep ate the grass and the wolves ate the sheep. Even though there are no sheep or wolves in Gabon, this would have demonstrated the food web as well as what happens when certain aspects of a habitat are changed. This activity was not used because it required the school to have many computers, internet access, and for the teacher to download the application to all of the computers.

The computer application idea brought up another idea, which was an activity that would allow the students to create a food web. This idea was also varied to incorporate a larger group. The activity that was used in the lesson plan was an activity that involved every student making one big food web. Each student would be a plant or animal and would connect to their food source by a piece of string. Throughout the process of connecting different plants and animals to their food source, the students would describe what their plant or animal's role is in the ecosystem. After all of the students were connected, the instructor would take one student out of the web. The students would discuss how the absence of one plant or animal affects everything else. When all discussion ended the students would be handed out a question sheet and answer the questions. This sheet would show the teacher if the students were retaining any information from the activity. This activity would be well suited for this lesson plan because it requires few

materials and it challenges the students to think about how all the plants and animals affect each other.

5.3 Development of Third Lesson Plan

The third and final lesson plan focused on a study of tracking elephant movements by collecting dung piles. The project was conducted from August, 2006 to March, 2006 by Jason Munshi-South, Ph. D., a conservation biologist formerly at the MAB office, and its purpose was to determine the amount of stress in elephants caused by human activities. Stress can have negative impacts on elephants such as infertility and a repression of the immune system. Dr. Munshi-South no longer works with the Smithsonian and works in New York, so an interview had to be conducted over the phone. Similarly to the first two lesson plans, objectives needed to be developed as well as brief instructions first then the information content, activities and discussion questions could be developed. The third lesson plan was entitled *Understanding How Stress Caused by Human Activity Affects Elephants* and can be found in Appendix C.

5.3.1 Content Development

The information that was received through a phone interview with Dr. Munshi-South was included into the content sections of the lesson plan, as well as information found in his proposal and papers. The background section gave the instructor an understanding of elephant interactions with humans and the stress that human activities cause the elephants. It focused on explaining the negative impacts that chronic stress has on elephants and animals in general. The lesson was supposed to make the students realize that humans are not the only mammals that have stress and deal with stressful experiences. The lesson was supposed to allow the students to

realize that animals become stressed and when they become stressed they could act very different than usual, so interaction with the stressed animals should be kept to a minimum. If the students understand that animals become more irritable when they are stressed then they will most likely not endanger the animal or themselves in any way.

The Smithsonian is conducting a great deal of research on elephant movements. The section describing the Smithsonian project informed the students about this research. The majority of this information was taken from Dr. Munshi-South's proposal and information from an interview with him. Dr. Munshi-South is in the process of analyzing his results, but the Smithsonian has already used some of his results in attempts to further educate the public by creating a website that integrated satellite images and elephant movement in the Gamba Complex (Castriotta, J; Koethe, E; and Schorer, G, 2006).

The goal of this lesson plan was for the students to understand that elephants become stressed and for the students to retain the information in the lesson and activity, a conclusion section was included. This section reiterates to the students that all animals can become stressed by human interaction or natural occurrences in the environment.

5.3.2 Activity Development

When speaking with Dr. Munshi-South over the phone, possible activities were discussed and he gave a few suggestions for activities. One suggestion was an activity that allowed the students to examine petrified elephant dung. This activity could have demonstrated to the students how a Smithsonian researcher conducted the experiment. Although this activity may have interested the young students because they would have had a chance to play around with elephant dung, the only petrified dung at the lab in Gamba could not be used for the lesson plan.

Since Dr. Munshi-South's project was based on tracking elephant movements, it was decided that the activity should incorporate the idea of elephant movements. A map of the Gamba Complex was made into a grid, and students would have to plot data points that represented dung piles in the grid. The data points were made up, this was because real data would not have prompted the discussion that was intended. After plotting all of the data, the students would have to answer several questions that focused on elephant stress in general and questions specific to the data points. This activity would be well suited for this lesson plan because everything needed for it would be included in the lesson plan and it would allow the students to gain experience with plotting data and think about the relationship between the data and the map.

5.4 Learning Styles addressed in Final Lesson Plans

The activities attempted to address the different ways students learn. The activities have many different components and each component tries to address different students and the different ways they learn.

5.4.1 Birds of Gabon

The first lesson plan was intended to have a strong visual component. To that end, it was decided to incorporate a matching activity using various images of local Gabonese birds. Specific animals were picked that the audience would be most likely to encounter in their everyday life. Students would compare the silhouettes of birds to the full color image. The concept of merely reading information regarding each bird and then having the students make the connection between that written description and the color images was incorporated.

A take-home activity included the need to spot and write down information about birds, along with a minor listening component (related to listening to any calls a bird might make); this would blend in all three learning styles to some extent. The lesson itself involved listening to an instructor's presentation, and discussion of several questions that were included. The discussion questions should be presented in a way to have students write in the answers to contribute to retention via kinesthetic learning.

5.4.2 Fragmentation

The second lesson plan involved a heavily kinesthetic component. Its main activity involved a lot of movement and the use of a physical activity to reinforce a concept. In addition to this, students were, again, to be participating in a discussion throughout the activity. Visual symbolism of cutting and re-attaching were used as well in the main activity. Discussion prompt questions that would be answered on paper and discussed out loud were again included to promote auditory learning, along with the presented material. We included a number of visuals that could be used by the students as well.

As part of their development of a food web, the students would be able to visually see what they had created and share with other students. As part of their on-paper food webs, the students would all be creating their own diagrams that could be referenced and discussed with the teacher and each other. In this way, visual learners could more easily grasp the food web concepts.

5.4.3 Elephant Stress

The third lesson plan, like the first two, included a discussion component with discussion prompt questions that were to be written down, and then answered out loud in class (a boon to auditory learners). Students are also asked to share their own thoughts and feelings about stress out loud as part of this lesson plan, relating their own personal experiences. This provides a personal connection as well as interesting material for the auditory learners.

The main activity had a strong visual learning aspect, but the diagrams provided are "incomplete." In order to get the full data from the image, and as part of the activity, students must read and transcribe data from a textual format onto the image. This re-encoding activity will help kinesthetic learners as they synthesize the true meaning of the data physically and then record it; but visual learners will likewise be able to then analyze the final product to gain understanding.

6.0 Conclusions

The goal of this project was to develop a series of lesson plans that would serve as models for a more extensive series of lessons. The direct goal for deliverables was to develop at least three lesson plans, centered around recent and ongoing studies conducted by the Smithsonian Institution's Monitoring and Assessment of Biodiversity (MAB) Program. Our Gabon contacts were quite pleased with the results and confirmed that these lessons will be heavily utilized by Smithsonian profession staff in Gabon, at both the private school in Yenzi, for public and private students participating in the nature club there, as well as at the local Smithsonian laboratory and as a base for future materials.

After over fourteen weeks of background research and analysis combined with carefully reviewed written and graphic work, and a total of three lesson were completed. A large number of Smithsonian professional staff were available for rapid consultation and material review. Feedback was collected from interns, program directors, conservation biologists, and education specialists and was used to guide the development process and provide the background needed to make informed decisions about content and style. The pipeline-styled development approach proved very successful and allowed us to see results fast.

These plans have all been formatted in such a way as to be useful in the expected setting as well as being easily transferable to other settings. Appropriate instructional material for the instructors is provided within the lesson plan itself. By providing these easy-to-use lessons to the MAB, the MAB will have an easier time integrating these lessons and concepts into existing biodiversity/conservation related educational settings in Gabon. Components of these lesson plans will be useful as repeatable, flexibly-structured activities that can be included in the nature club in Gamba.

Each lesson plan was designed to present information in such a way that a 12 year old would be able to understand it. Background information was chosen to give context to each learning objective in as full a form as was practical. In order to facilitate learning, each lesson plan was developed to incorporate the three primary learning styles that have been identified (auditory, kinesthetic, and visual). The lesson plans all encourage discussion between the students and the teacher presenting the material. The interactive nature of the lessons was intended to hold student attention and promote retention.

The Smithsonian scientific operations exist to engage in "research and discovery" along with understanding the origin and evolution of "life's biological diversity and human cultures," in order to "inform and inspire a diverse public" (Kress, 2005). The lesson plans developed as part of this project are intended to assist with exactly that—spreading information about biological diversity and how it interacts with humanity, and to inspire the students. Aiming for flexibility and ease of use were recurring themes.

Each lesson plan promoted additional thought into possible extensions, "sequel" topics, and possible future changes. These have been discussed in detail in the results section of this report. The established framework provided by the developed proof-of-concept lesson plans will allow the Smithsonian Institution to fulfill its wishes of producing a large library of lesson plans of a similar style, without the need to do as much background planning. Questions included with the lesson plans will allow MAB staff to then evaluate each plan's usefulness and identify areas for improvement or identify patterns and methods that worked well, contributing further to future development. The format is intentionally flexible to maximize its usefulness in the Smithsonian's ongoing mission of disseminating information about our world.

7.0 Recommendations

This chapter includes recommendations intended to assist the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program when trying to implement and improve the lesson plans designed to educate the Gabonese youth. In addition to these implementation suggestions, there is a section outlining possible alternative activities, new topics for exploration, and possibilities for the use of extended technological resources for these and future lesson plans.

7.1 Implementing the Lesson Plans

Briefly, this section provides some suggestions on how to use the lesson plans in the class and after-school (and at the lab). It outlines the envisioned probable use scenario, and contains suggestions for how to implement some of the group work as well as providing information that could be useful to teachers.

7.1.1 Student-Teacher Ratio

These lesson plans were designed to be presented to groups of up to 30 to 35 students and last approximately one hour. Our team, along with the MAB directors, believes that these activities can be done with groups as large as 35 students. It is the team's recommendation that when managing a larger group, active participation and direction is necessary to keep the lesson focused. A simple way to achieve this would be to split the large group up and have a few instructors teach and direct each group. This would create less disruption, provide more availability for instructor help for individual students, and allow for an overall better experience for all of the students. Having more instructors or instructional aides for any size group would

be recommended to lower the student-teacher ratio in order to give each student a more personal experience.

7.1.2 Take-Home Activities

The take-home activities were not originally intended to be homework assignments or assignments that the students would need to finish and bring back. One recommendation would be to use the provided take-home worksheets as extra credit assignments. It would be a good method to get the students to think about the topics outside of the classroom and talk about it with their friends and families. The team would also recommend for future Smithsonian staff who may work on improving our lesson plans or developing their own, to try to develop other take-home activities to be incorporated with the lesson plans that have already been made, as well as several different take-home activities for any future lesson plans. This can keep the material fresh and provide additional educational value and options for the teacher. For example, some take home material might be suited especially towards a situation where the students will be able to return to the class, while other take-home material could be designed to favor a one-time visitor to the lab.

Our contacts in Gabon have agreed with us that it would be beneficial to collect the take-home assignments when successive sessions are possible (typically, for children attending the school and those who regularly participate in the nature club). Students can maintain a journal of their own feelings about each lesson and as an additional assignment, record what was most interesting to them in the lesson. Additionally, their notebooks can be used to record data for use in the take-home assignments in addition to or in lieu of reproduced worksheets.

7.1.3 References for Teachers

The content provided in the lesson plans gives adequate information on the ecological topic to complete the lesson and activity. A teacher who feels that he or she needs more information on certain topics can explore the web sites listed in the lesson plans. It is also simple to enter any search engine on the internet and search for more information the different topics. One way to keep the lesson plans fresh is to update their consumable reference materials based on new information as it is collected. For example, the lesson plan with birds could be supplemented with photographs that were recently taken instead of the stock imagery included with the lesson plan. Links have been provided to suggest possible sources of information. As the links provided are only in English, suitable links in French and Dutch would probably be good to find based on the English references.

7.2 Future Development of Lesson Plans

The project team recommends continued development of the existing lesson plans, and continued development of successive lesson plans within the developed framework. During the development phase, several ideas were brought to the table both in meetings and during the working period. However, for a variety of reasons (including adequate time and materials), these were shelved instead of implemented. This does not indicate that the ideas were invalid however, and many of them would be useful if developed for future lesson plans or used to extend existing lessons. This section will outline these ideas so that they can be considered for inclusion during future revision.

The currently investigated topics of the completed lesson plans are birds, forest fragmentation, and elephant stress. Additional topics that were considered included lessons

primarily on snakes, invasive species, and blacksports, or old oil spills. These could all be good topics for future development due to the existence of Smithsonian MAB research in these areas; there is supporting research that could be used in the activities as well as the obvious Smithsonian-project-focused lesson plan section.

Other topics considered may not have MAB-associated projects or may be related to a project already covered by another lesson. A sequel to the existing bird topic and lessons on turtles and fish may be two other good topics to be developed, along with work on butterflies and other insects. MAB staff members have completed a large amount of research into these areas, making them prime candidates since data on these subjects and a supporting SI/MAB program are both readily available for reference. These topics also reference animal groups that the existing three topics do not cover in great detail.

Although the availability of internet access and computers is not guaranteed, it is recommended that the use of technology be looked into to reduce the need for materials and to aid in the presentation of subject matter. Self-scoring applications/games and multimedia presentations can enrich the classroom presentation, and the internet allows for extended research beyond what is covered by each lesson plan; this can also reduce the need for copies of consumable materials. Partly for these reasons, online resources have been suggested for each of the three lesson plans that were developed, although internet access is not required for full use of the lesson plan. The use of the internet can also allow students to see other areas' biodiversity (or see areas of their own better) so they can make comparisons to their observations.

Additionally, it is recommended that survey questions focusing on student retention and responses to the material as well as the teacher's concerns regarding the material and its use (plus

extra room for miscellaneous suggestions) be provided to, and collected back from, the educators that proctor these lessons in Gabon. The results of these questions can be used to make modifications where needed to the material, and address issues where students or teachers had difficulty or expand upon areas where students showed significant interest. This feedback can be based upon the students' answers to in-class discussion questions as well, or the level of success of the take-home materials that are collected back for discussion. Identifying what works well is vital to the continued success of any program or series of materials, as is correcting problems in existing materials. In addition, the links and content of the lesson plans could and should be updated to keep the information current.

7.2.1 Reptiles/Snakes Lesson Material

The reptile topic in particular, as it was to be our fourth lesson plan, already has had some considerations made regarding its activity and areas of focus. Reptiles are common in the Gamba Complex, and are seen on an everyday basis. Some of these sighted reptiles are members of the diverse snake population in Gabon. Human interaction with snakes is a frequent occurrence, but due to generally-poor understanding of the ecological impact of snakes and the difficulty the human population has identifying snakes means that a large number are killed, or scientists are called in to identify and remove the snake. These facts make this topic an excellent learning opportunity that could have immediate effects on human-wildlife interactions. For these reasons, this lesson plan is one that should definitely be developed if this series is continued.

Snake identification was considered as a possible activity, along with identifying the parts of a snake and learning how to tell general groups of snakes apart. For example, how snakes move, the environment in which they are found, and how their heads are shaped can all

give good clues about the nature of that particular snake, and learning these would be advantageous as it is very fitting to the environment. Olivier Pauwels, our contact from Gabon, would be an important asset to this lesson plan as he is a herpetologist with ample experience in the region, including teaching local police how to identify the “good” snakes and also how to determine which snakes pose an immediate threat to nearby humans.

Additionally, there are many myths and rumors about snakes that are pervasive throughout cultures worldwide. Some of these are negative and give snakes a bad image. A possible activity and discussion opportunity would be having students address some of these myths. Of course, all myths should be provided for consideration, as not all of these rumors are decidedly negative in nature. Present the myths and rumors and have students identify if they are true or false; if they are false, students should be expected to provide a reason for why that rumor is not true, and possibly suggest why people might believe it.

7.2.2 Alternative Bird Lesson Material

The current images used in the main activity for the bird lesson are not from a Smithsonian source; these could be replaced with photographs taken on-site, both for better references and also to allow the plan to be published with 100% Smithsonian-owned content. Next, a number of alternative bird activity ideas were considered but eventually replaced by the current ones; sometimes we left the alternative activities as a suggestion or reworked them to their new form. For the Birds of Gabon activity, a possible extension or follow-up could address the beaks and feet of birds. While this was a minor component of the existing activity (the “what does it eat?” portion) it could be developed into its own activity where students have to match

the feet and beaks of birds to what they eat or the kind of bird it is; this might even go well in a more specific "Birds of Prey" lesson plan, as there are a large number of these birds in Gabon.

A section matching the beaks and talons of birds to the kind of food they prefer, without any other reference, could work well. It is important to mask the full identity of the bird, because well-known species would have their preferred food matched by previous knowledge of habit alone. For example, showing a full kingfisher immediately could lead a student to ignore the lesson's rationale (beak and head) for selecting fish as the food, in favor of merely recognizing that a kingfisher eats fish (previous knowledge of species habit). Something similar to the activity in the Fernbank Science Center example[7] might be practical for inclusion in the existing lesson plan, or in a follow-up lesson.

7.2.3 Alternative Fragmentation/Predation Lesson Material

Some activities were not introduced due to the potential unavailability of the required resources and the desire to retain flexible lesson plans with scalable activities for varied group sizes. One example of this is the lesson plan regarding predation and food webs along with changing forest structure and the predators' reactions to this.

Amy Dunham at the Department of Ecology and Evolutionary Biology (Rice University), a Smithsonian fellow, had suggested using computer modeling to represent the ecological systems. The free software toolkit "NetLogo" from Northwestern University[8] is a recommended tool for this, and comes with a variety of pre-loaded models that can be adapted to suit a number of systems, including predator-prey-producer relationships. Our group was impressed by the

[7] http://fsc.fernbank.edu/birding/bird_beaks.htm and http://fsc.fernbank.edu/birding/beakstoeats_worksheet.htm
[8] Main NetLogo page available at http://ccl.northwestern.edu/netlogo/

real-time specification adjustments possible in the sample model, allowing on-the-fly graphic and adjustment of energy consumption, birth rates, and plant growth control. The software also has relatively low system requirements.

Although the initial model demonstrates a relationship between “sheep” and “wolves” with “grass” available (**Figure 5**), the system uses very simple graphics which are easily modified to suit any particular species, or simply represent generic “predators” and “prey.” The scripting language used by this modeling software is remarkably simple compared to other software, and learning just enough to extend the existing model to support a variety of other organisms is easy for anybody with knowledge of simple programming. The software can be used to build stand-alone model applications that can easily be fit onto discs for distribution, and there is a NetLogo Educators Group designed to assist teachers and answer questions about using NetLogo in the classroom. Future use of this modeling tool is advised if resources allow for it, as it appears to be an excellent and well supported learning tool, especially for this activity.

The existing activity involving students forming their own food web/trophic model originally involved a full sheet of local Gabonese organisms. This sheet not only categorized the animals and plants and listed them as in the current lesson plan, but also contained line-art images to be cut out and laminated for each organism. This activity would not scale up well, nor is there the ability to laminate sheets of reproduced cardstock cutouts.

It is true that consumable handouts could be used for this activity, but due to the vast array of organisms that are referenced by this activity, it is difficult to locate suitable images of a similar art style for each one. This is complicated further by copyright issues. Obtaining permission from all of the various artists would not be possible. The recommendation is to

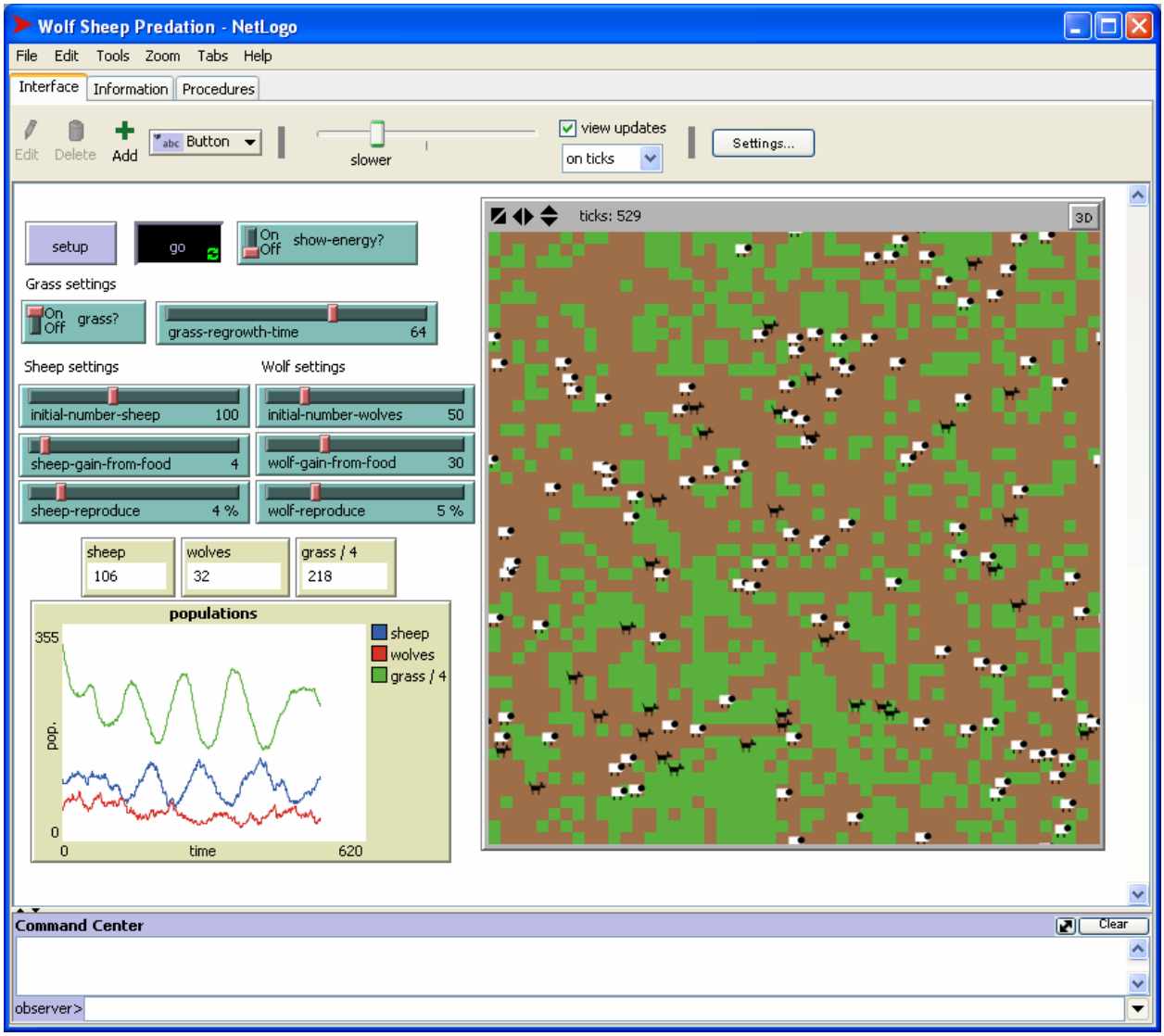


Figure 5. Net Logo: Wolf Sheep Predation Model

eventually re-introduce this part of the activity rather than always having students draw the animals and plants themselves, after having a single artist produce consistently styled images of each organism. If being able to prepare several reusable, laminated cutouts is possible, this should also be done.

7.2.4 Alternative Elephant Stress Lesson Material

The elephant stress lesson plan's activity went through several revisions before reaching its current form. The original plan called for a more interactive task than simply reading the given elephant dropping plots off a chart, although at the expense of the graphing nature of the current form. One of the earlier ideas involved using colored plastic filter material in order to mask the full nature of each elephant dropping, which would be already present on each map; essentially, students would do the reverse of what they currently do.

Due to material availability issues, this idea was not used. The general idea would be that using red/blue chromatic interference methods (Barnhart, 1995) such as those used in mystery puzzle games, data to be "analyzed" by students and recorded would be placed at pre-set locations on the map. Students would use the chromatic filter material (transparent red or blue plastic or glass) to uncover the data by viewing the map section where dung appears through the filter. The now-obvious data about the elephant DNA (a simple ID to track unique elephants) and its coordinates would then be recorded by the students and could be marked with a symbol on the map to denote each unique elephant's path. While a suitable filter material such a red plastic-wrap would be available in the United States with relative ease, this is not the case in Gabon, and the activity would be useless if no filter material was available.

Appendix A:

A Brief Description of the Smithsonian Institution

The Smithsonian Institution is named after 18th century British scientist James Smithson. In 1826, Smithson stipulated in his will that if his nephew died with no heirs, his estate should go "to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men."[9] Oddly enough, this philanthropist had never actually been to the United States; nor did he have any relations with anyone who had relocated there.

The Smithsonian continues to be funded largely (approximately 70%, or $621 million of total funding) by the US government, with additional funding from gift shop and magazine sales, and many other private benefactors that donate for scientific development. The Smithsonian also has several trust funds, which are comprised of money contributed by corporations, foundations, and individuals. Another source of funding is revenue from Smithsonian stores, restaurants, catalogs, IMAX theaters, and the like. These sources, in combination with the federal funding, give the Smithsonian a budget of around $1 billion annually, which is used to pay employees, maintain property, develop exhibits, hire security, and the like. Because of this ample funding, the Smithsonian is not forced to charge admission to any visitors, and Smithsonian museums can remain open to the public year-round.

Legally, it is an official body of the government, and more than 66% of its 6,300 current staff members are considered federal employees. Although the Smithsonian Institution is a scientific institute for research and development, it is also an educational institution that is intended to feed and foster the intellectual curiosity of members of the public. The museums and other member organizations of the Smithsonian Institution are enormously popular. For example, as presented by the Smithsonian's own website, in 2006:

- Over 23 million people visited Smithsonian Museums in DC,
- Over 2.5 million people visited the Smithsonian National Zoo,
- Over 20 million people visited other museums affiliated with Smithsonian,
- Over 4 million people visited traveling exhibitions developed by the Smithsonian; and;

[9] Smithson died in England in 1829. His nephew died without heirs in 1835.

- An astounding 150 million people visited Smithsonian websites in this single year.

The Smithsonian is a quasi-official agency of the federal government Board of Regents which includes individuals such as the Chief of Justice and the Vice President of the United States, as well as other Senators and representatives (Office of the Federal Register National Archives and Records Administration). Under the Board of Regents is the Office of management and Budget whose job includes budget calls, quarterly reports, and compiling the Budget Request to Congress each year to get funding for the Institute. The Board of Regents also appoints a Secretary of the Smithsonian who is in charge of the day-to-day operation of the Institution.

According to the US Government Manual: "To carry out Smithson's mandate, the Institution executes the following functions:

- conducts scientific and scholarly research;
- publishes the results of studies, explorations, and investigations;
- preserves for study and reference more than 136 million artifacts, works of art, and scientific specimens;
- organizes exhibits representative of the arts, the sciences, and American history and culture;
- shares Smithsonian resources and collections with communities throughout the Nation; and
- engages in educational programming and national and international cooperative research."

The Smithsonian Institution has grown since its foundation and now consists of nineteen museums, a zoo, over 156 affiliated museums, and nine research centers domestically and abroad. The most recognizable edifice (see Figure 6) of the Institution is the iconic Smithsonian Castle in Washington, DC (completed in 1855). To give another sense of scope, the Institution has over 140 million objects in its various collections, and vast collections of images and documents.

The Smithsonian Institution has several branches of operation, including the National Zoo. The Monitoring and Assessment of Biodiversity Program (formerly the Man and the Biosphere Program) operates under the National Zoo as part of the new Center for Conservation, Education, and Sustainability. The MAB works to monitor, assess, and promote biodiversity in tropical and temperate forests across North America, Latin America, Asia, and Africa. The

Smithsonian continues to work towards advancing scholarship and inspiring the public to understand how scientists learn about the world and how science affects our lives through innovative new sub-projects, study centers, and programs such as the MAB.

Figure 6. The Smithsonian Castle, courtesy Smithsonian Institution

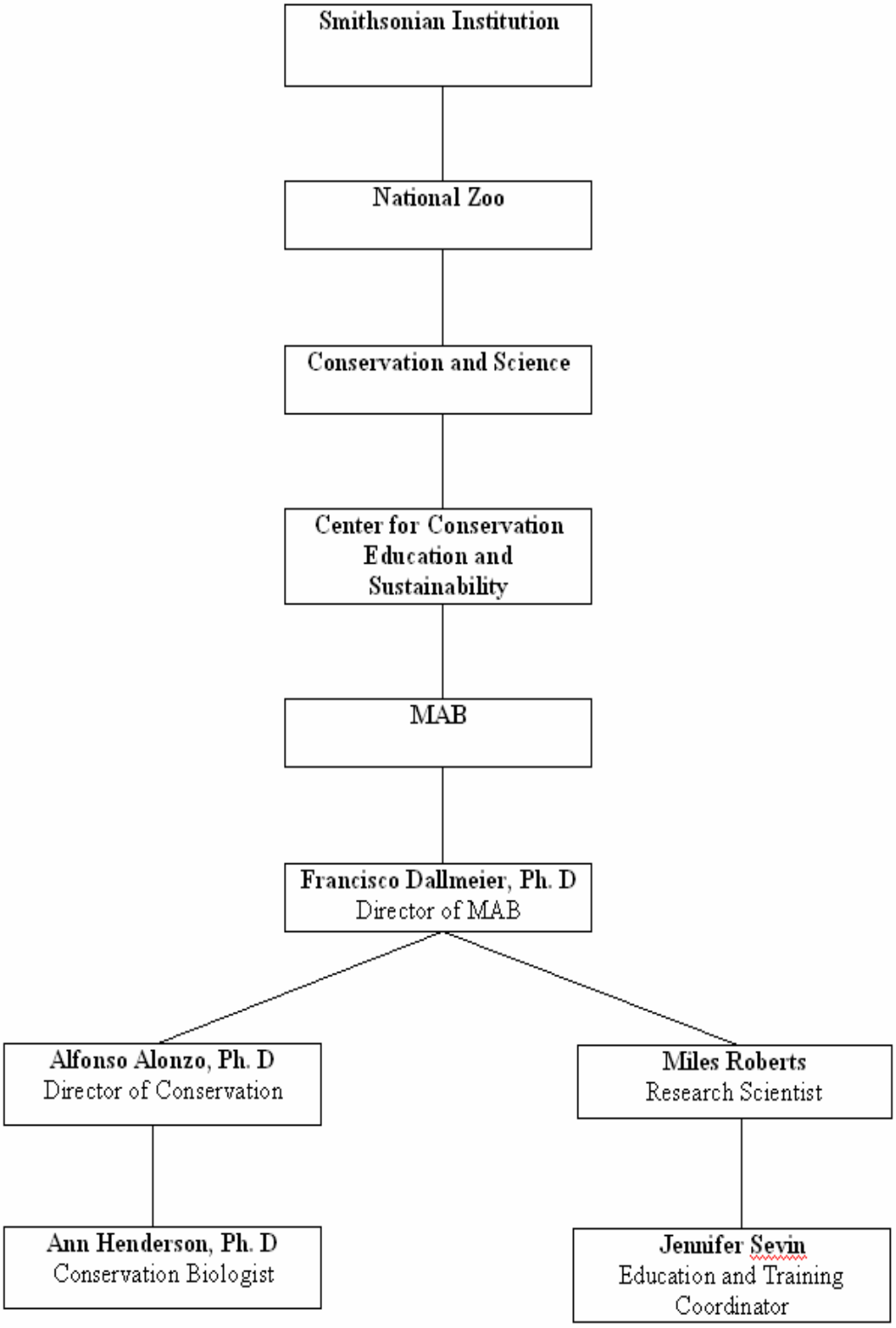


Figure 7. Organizational Structure of MAB

Appendix B:

Interview Questions to ask MAB Researchers

Start off interview by telling the researcher who we are and what our project is. Also ask for permission to use him/her as a reference.

1) What project did you work on in your time in Gabon?

2) Who was involved in your projects, who were your partners?

3) Where in Gabon did this project take place?

4) When did your project take place and how long did it last?

5) What were the methods used to carry out your project?

6) What is the ecological issue behind your project?

7) What are the implications to the biodiversity you are studying?

8) What are any implications of the community?

Appendix C: Lesson Plans

Lesson Topic: *Understanding Human Impacts on Bird Communities*

Age Level: 10-12 years old

Objectives:

1. Students will gain an understanding of the bird population's contribution to the ecosystem.
2. Students will gain an understanding of how human activities impact bird communities.
3. Students will be able to identify different birds based on their body shape and other characteristics

Introduction/Instructions:

This lesson plan is intended to teach students about how human activities can impact bird populations. The following is an explanation of the lesson plan structure.

- The following background information should be presented to the students as either a short reading assignment or as a brief discussion before the activities.
    - This background information will inform the students about the bird population and its contribution to the ecosystem, different human activities that affect the bird population, the consequences of these activities, and the research that the Smithsonian Institution has done in regards to the human impact on bird communities.
- Once the students receive the background information they can move onto the activity where they will try to identify different birds.
    - This activity will also have questions related to human impacts on birds and the role of birds in the ecosystem that the students will have to answer.
- After the students have finished the activity the conclusion section should be presented to them.
    - That section will reiterate that birds are important to the ecosystem and that they should try to protect them as best as they can. Any further questions the students have should be clarified at this time.
- Prior to leaving the class, students are to be given a copy of the bird observation handout (to be used in conjunction with the silhouette page) as a take-home activity.

- Students are to use this to record their own bird sightings, along with questions that can get them thinking deeper about bird interactions and raise their awareness of local bird life. This can be also used as a fun "homework" assignment, with observations to be shared with other students at the next class meeting (if this suits the educational setting).

- For more information, you can use an internet browser to visit the following links:
  - http://www.closertonature.com/outdoors/bird-identification.htm Learning bird identification techniques
  - http://en.wikipedia.org/wiki/List_of_birds_of_Gabon A large, freely-editable page containing a list of known Gabonese birds
  - http://fsc.fernbank.edu/birding/birdpage.htm Teacher-oriented material for teaching about birds

Background:

Today there are many different human activities that affect tropical forests globally. Some of these activities include: **logging**, **hunting**, and **deforestation** for oil exploration. Studying how these human disturbances affect tropical forests is important because the destruction of these forests can cause high levels of extinction of plant and animal species in **ecosystems** where most of the world's **biodiversity** lives. The human impact in the forests can be structural (people cut down the trees) or non-structural (the forest remains intact but people hunt animals and take fruit). Even if the human impact is only felt in a small fraction of the forest, it can still have a big effect. Forests that appear to be intact may start to have many problems, as the ecosystem becomes disturbed by human activity. We will take a look at the bird communities in the Gamba area, and how these human impacts affect the birds of these forests.

Gamba is home to 67% of Gabon's known bird species. The birds in Gamba are very diverse and are a very important part of the ecosystem because they consume things such as fruits, plants, insects, amphibians, reptiles, and mammals. The fruit eating birds, or **frugivores**, spread seeds. The nectar feeding birds, or **nectarivores**, pollinate the flowers. The insect eating birds, or **insectivores**, control the insect population. Not only do the birds help parts of forest through this behavior, they are also food for other animals such as snakes. Because of what birds

do for their communities, if they start to disappear the forest community will lose the services they provide thereby disrupting the ecosystem. Some things that can affect the bird population are logging, hunting, and the oil industry. We will look at how each one of these human activities impacts the bird community in Gabon.

Bird communities are very dependent on the forest. Many of the birds living in tropical forests feed on insects, but they also rely heavily on the fruit of the forest. Not only do the birds need fruit to eat, but the plants and trees rely on the birds to spread their seeds all over the forest to grow more fruit. If humans overlog an area and destroy some of the surrounding plants, many fruit bearing trees will disappear. The birds also need trees to make nests to live in. If the trees and plants start to disappear then there will be fewer habitats for all the birds to live in and there will be less fruit for the birds to eat, causing some birds to starve. Fewer trees also mean fewer fruits produced and hence fewer seeds, so that fruit tree regrowth declines. If the birds cannot spread the fruit seeds then the forest cannot make more fruit and there will not be an adequate supply of food for fruit-eating birds and other animals.

Another problem that the bird population faces is hunting. Hunters kill birds to eat and to sell for food, and also to sell them as pets. Although it is a necessity for humans to eat, overhunting can reduce the number of birds. All ecosystems require a balance to function properly, and when the ecosystem becomes un-balanced many different problems can begin to occur; and some of these problems can never be reversed once they happen. This imbalance can be triggered by extinction of just one species.

For example, even if only one species of insect eating birds becomes extinct, that may result in fewer insects being eaten in general and may allow the insect population to grow unchecked. It is possible that the insect population will grow so large that it takes over the entire ecosystem, despite the forest's inability to sustain such a large insect population. When the carrying capacity of the ecosystem is exceeded, these insects will run out of food and begin to die off in large numbers. This is clear evidence for the need to maintain a balance in predator-prey relationships, and thus conserve all species.

The oil industry can also affect the bird communities in the forest. The oil industry requires a lot of room for their buildings, tanks, roads, and equipment. This leads to deforestation, or cutting down a large area of trees to build structures. This can affect many animals of the forest, because now the forest is separated into fragments that may not be

connected to each other due to separation by roads or clearings. In fact some smaller animals may not cross roads causing them to be trapped on one side of the road. Some birds can fly over roads and gaps, but there are still some species of birds that will not cross non-forested areas. Other impacts that the oil industry poses is the pollution from vehicles, machinery, and oil spills, as well as the noise pollution that these produce. The oil industry brings an increase in human population by creating jobs that draw people towards these areas.

As you can see there are different types of human activities and they can all have negative impacts on the bird population and biodiversity as a whole. The effects can also be compounded by outstanding human actions. For example, in Rabi, Shell has a no firearm policy and employs guards at entrances to control access to Rabi; this industry benefits the forest by reducing illegal hunting.

Logging has a negative impact on forests because when logging companies clear large areas of trees, or open roads into remote forests they allow easy access to these remote places to hunters. Moreover, hunters usually hunt from logging camps to sell bushmeat or for self consumption. It is important to know that although some activity in the forests is necessary for humans to live, too much activity, and certain activity, can destroy the beauty and biodiversity rich areas of our world.

What the Smithsonian Has Done:

The MAB Program of the Smithsonian Institution has conducted several research projects in Gabon. One of these projects involved researching birds and the impact that logging has on them. This project involved a team consisting of one conservation biologist from the Smithsonian Institution, along with two experienced field assistants. For four months, research and observations were conducted in and near the Rabi-Ndogo Protected Area, which is part of the Shell-Gabon oil concession. Shell has placed restrictions on this protected region and built guard posts to protect it from harmful human activities that could disturb the ecosystem. The team compared three forests within Rabi and two forests outside of Rabi, but all sites were within the restricted access zones.

The group intended to determine the amount and variety of bird species in the study areas, and to learn more about the diet of fruit-eating birds. They also wanted to make a profile of the different plants they found in each location and then measure how much fruit the forest

could produce. This would help show whether or not all of the birds would have enough fruit to eat. Once this was determined, scientists could compare how the variety of birds and the amount of fruit available were related. Blood tests performed on the birds would also show the proportion of fruit versus insects in bird diets.

Before this research was done, there was not much known about fruit eating birds, except for hornbills. Scientists were also not sure how logging in the past had impacted the forest, and the team performed some tests to see if it had. The information the team collected could show that there is a need for continued forest protection in the Rabi-Ndogo area. This information could also be used to update the Shell Biodiversity Action Plan and help the Gabonese government develop a management plan for conservation.

Activity: Birds of Gabon

The students should be broken up into groups of 2 or 3 (depending on the size of the class). Each group should be given the list of 10 different birds and their brief description. For younger or less advanced students, the bird silhouette sheet that corresponds with the bird description sheet could also be given to them. Each silhouette is labeled by the bird species. After reviewing the descriptions the students will be given the sheets with 39 unlabeled birds. The students' goal is to identify what each bird's species is using the descriptions. After the students identify all of the birds they should be give the sheet of questions to answer.

One of the goals of the questions is to allow the students to use reasoning and try to determine the different sources of food for each bird type based on the shape of the bird's bill. Another goal is to encourage the students to realize that when one bird species disappears it can have a negative impact on the rest of the ecosystem that it is apart of. For example if insect eating birds became extinct a result would be that there would be more insects and those insects eat plants nut since there are so many insects the plants would not be able to grow back. The questions are meant to get the students to think about a problem and think of a possible means of solution for the problem. After all of the students have answered the questions the instructor should go over each question and allow the students to voice their ideas and opinions.

Conclusion:

As you can see from the activity, there are many different types of birds. Each species has its own role in the ecosystem, whether it is controlling the insect population, spreading seeds throughout the forest, or being a meal for another animal. It is very important that the ecosystem remains balanced; when it becomes unbalanced one species may risk extinction and that could, in turn, affect other animal species. A main cause of any ecosystem that becomes unbalanced is human activity. That is why it is important to realize the impact that someone's job, such as logging, can have a large impact to an ecosystem, and because of that it is important to try to minimize the effect of humans in the environment.

Humans are a very adaptable species and if our habitat or ecosystem changes or becomes unbalanced, we can adapt to accommodate these changes. This however, is not the same for other animal species, such as birds. If a bird species' ecosystem changes or becomes unstable it could prove to greatly impact the species, and in the worst circumstances could cause extinction of the species. When humans begin to cut trees down, or clear large areas of land for buildings and roads, or even just hunt for food, they may not realize it, but they could be endangering an entire ecosystem that will not be able to support itself in these new changes and circumstances. It is important to realize that what seems to be acceptable for humans may not be acceptable for other animals.

Glossary:

Biodiversity - The variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

Deforestation – The cutting down and removal of all or most of the trees in a forested area

Ecosystem – All the organisms in a particular region and the environment in which they live. The elements of an ecosystem interact with each other in some way, and so depend on each other either directly or indirectly

Frugivores – Animals which primarily eat fruit

Hunting – The work of finding and killing or capturing animals for food or skins

Insectivore – An organism that feeds mainly on insects

Logging – The work of cutting down trees for timber

Nectarivores – An organism that feeds mainly on nectar from flowers

Activity: Birds of Gabon

Directions:

You have probably seen many different types of birds around your homes and in your towns. In this activity you and your partner(s) will read a brief description on some birds that can be found in Gabon. Under each category in this list there will also be a specific bird that can be found around Gamba. When you and your partner(s) are ready take the two sheets with different birds on them and try to identify each bird into its species. Use the description to try to figure out what each bird is. After you and your partner identify all of the birds try and figure out what each bird eats based on the birds' bills. Once you finish this exercise you could even try to figure out what all the birds around your town are!

A bird's bill and color

You can tell a lot about a bird based on its bill, or beak. A bird with a short thin bill usually eats insects. A bird with a short thick bill usually eats seeds. Birds with a cone shaped bill use their bills to crack open seeds. A bird with a long thin bill usually probes nectar from flowers. A bird with a long pointed bill usually pecks holes in trees. Birds with short and sharp hooked bills use their bills to tear off meat from other animals. Birds with huge bills usually pick fruit from tress.

The color of birds can also tell you something about how they live. Colorful birds usually do not hunt because they can be seen very easily. Birds that hunt usually have dull colors so they can remain hidden from their prey.

Brief Description of 10 different birds found in Gabon

Quails – Quails are small and plump birds that usually remain on the ground. They make nests on the ground. Most quails can only fly short distances. Black-Rumped Buttonquails, which can be found in Gamba, have dark orange feathers and have black spots on the sides. They also have dark eyes.

Parrots – Parrots have short legs but strong feet. They are usually bright colored and have strong hooked bills. They make nests in tree holes. The Grey Parrot is grey with a maroon tail. It is tall and stands upright.

Pigeons/Doves – Pigeons and doves have compact bodies and small heads. They fly strong and fast. The Emerald-spotted wood dove has darkish bills and green wing spots.

Owls – Owls are nocturnal birds, meaning they mainly come out at night. They have rounded heads and front facing large eyes. Their eyes are fixed in their sockets and they have to turn their whole head to look from side to side. In comparison other non-predatory birds do not have to turn to see sideways but they have to tilt their head sideways to look up. Owls have trouble

seeing a few inches in front of them, but they have exceptional far vision. Owls can turn their heads and look behind their own shoulders. The Marsh owl is a plain dark brown bird.

Nightjars – Nightjars are nocturnal birds. They have long wings, a long tail, and a tiny bill. They have dark colored feathers. They can be found resting on the ground during the day, and they are active at night. The square-tailed nightjar can be found in grasslands, open woodland, and farmland.

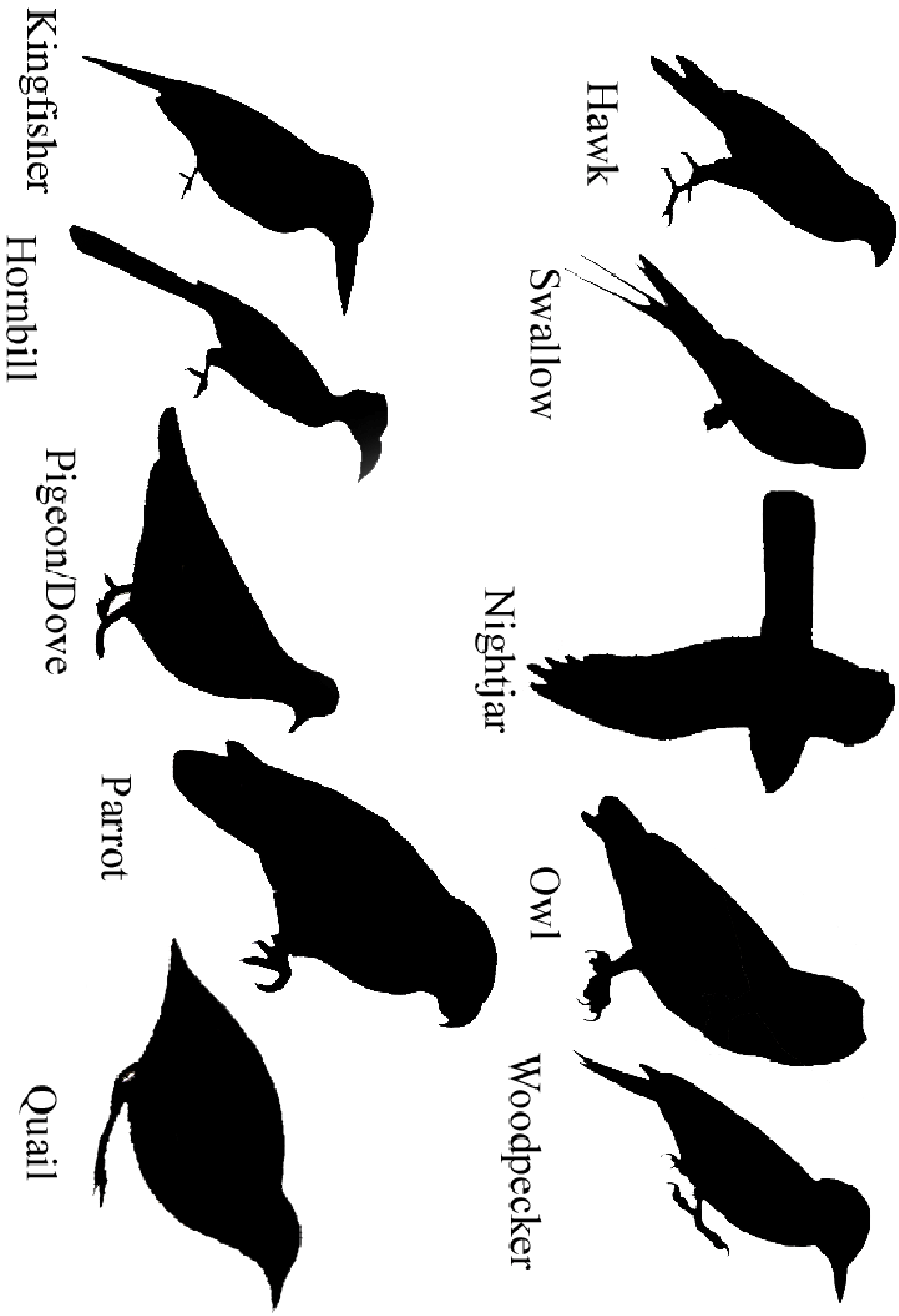
Woodpeckers – Woodpeckers have straight, pointed bills. They have strong tail feathers that support them when they are climbing a tree trunk. They also only have three toes compared to other birds which have four toes. They peck at trees looking for grubs and make their nests in tree holes they hollow out. The Green-backed woodpecker has plain green upperparts, a greenish tail, and a red forehead and crown.

Kingfishers – Kingfishers have a large head, a large dagger shaped bill, a short body and short legs. They are usually brightly colored. Like the woodpeckers they too have only three toes. The Blue breasted kingfisher has a black back, black wings, a black streak through the eye, and a blue breast.

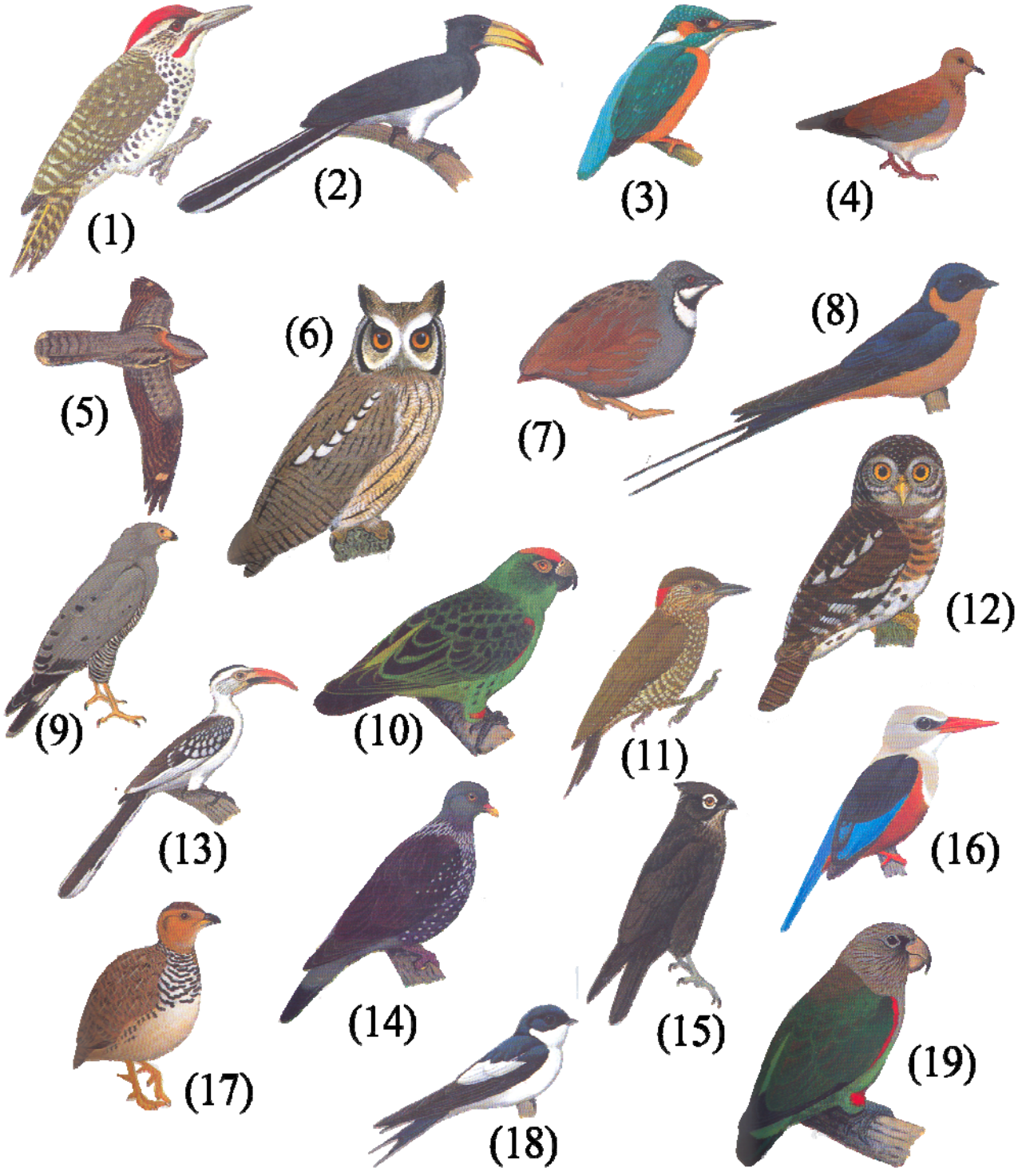
Hornbills – Hornbills are medium sized to very large. They have very large bills and a long tails. They fly with their necks outstretched and they nest in tree holes. The Red-billed dwarf hornbill is a medium sized bird with a brown upper body and a red bill.

Swallows – Swallows have a slender body, a short neck, short legs, pointed wings, and a very short bill. Their tails are forked. The Grey-rumped swallow is a small bird. They have a dark upper body and a white under body.

Hawks – Hawks have hooked bills and powerful talons. Like owls, they have front facing eyes. The African harrier hawk is large but has a small head and long legs. It is mainly grey with an orangey face.



These bird silhouettes are not to scale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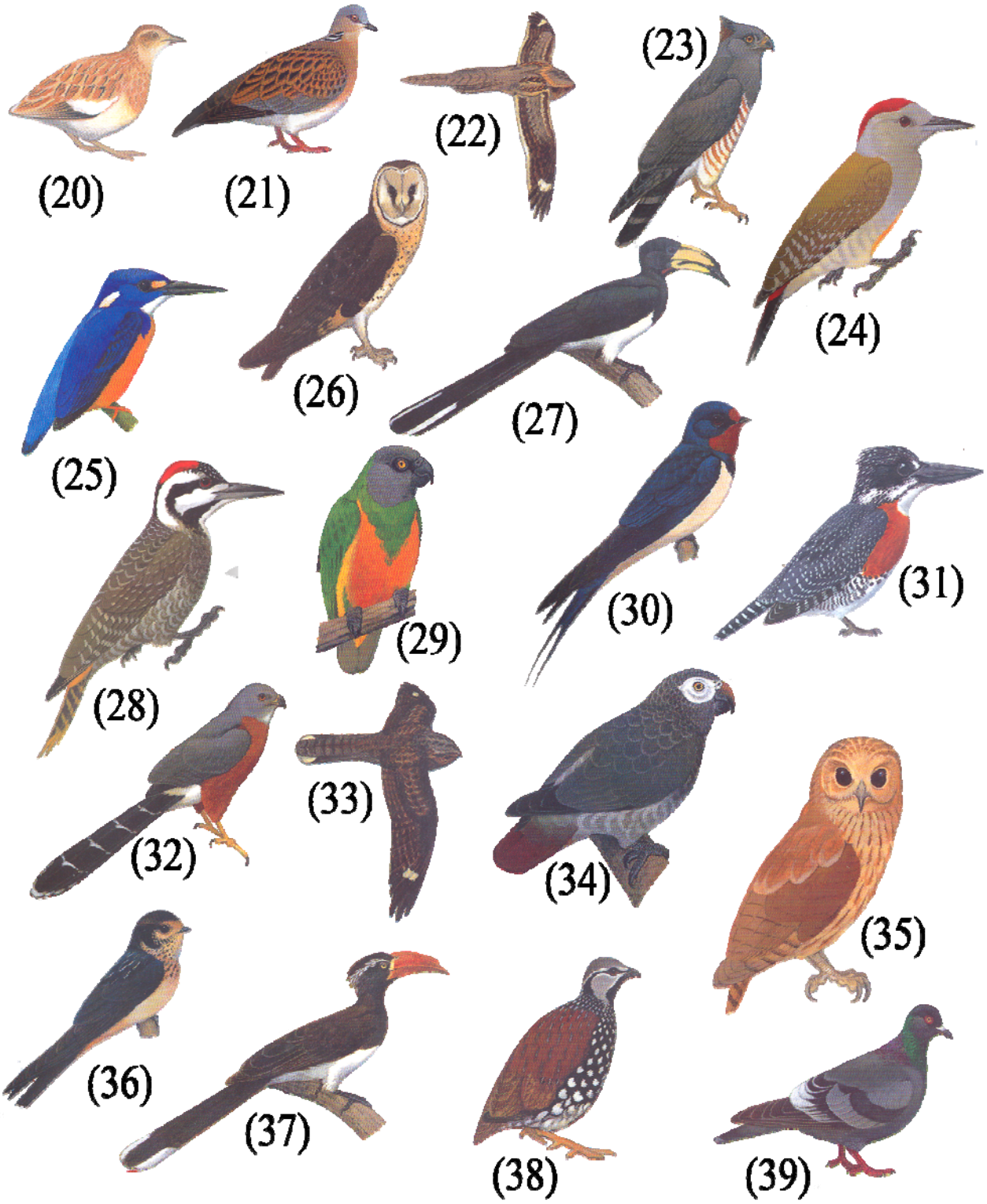
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Questions after all birds are identified.

1. Have you ever seen any of these birds? Where did you see them?

2. Have you ever seen a bird eating? What was it eating?

3. Based on the type of bill each bird has, fill the table in with the appropriate food sources for each bird.

Bird	Food Source
Quail	
Parrot	
Pigeon/Dove	
Owl	
Nightjar	
Woodpecker	
Kingfisher	
Hornbill	
Swallow	
Hawk	

4. Name at least three different human activities that impact bird communities and give a brief explanation of how each activity affects bird communities.

5. What would happen to fruit plants if hornbills, or other fruit-eating birds, became extinct?

6. What would happen to plants and flowers if insect-eating birds became extinct?

7. Is there any way for people to help keep bird communities intact?

Answer Key to Activity for Teachers:

Number	Type of Bird
1	Woodpecker
2	Hornbill
3	Kingfisher
4	Pigeon/Dove
5	Nightjar
6	Owl
7	Quail
8	Swallow
9	Hawk
10	Parrot
11	Woodpecker
12	Owl
13	Hornbill
14	Pigeon/Dove
15	Hawk
16	Kingfisher
17	Quail
18	Swallow
19	Parrot
20	Quail
21	Pigeon/Dove
22	Nightjar
23	Hawk
24	Woodpecker
25	Kingfisher
26	Owl
27	Hornbill
28	Woodpecker
29	Parrot
30	Swallow
31	Kingfisher
32	Hawk
33	Nightjar
34	Parrot
35	Owl
36	Swallow
37	Hornbill
38	Quail
39	Pigeon/Dove

Type of Bird	Food
Quails	Seeds and Insects
Parrots	Seeds and Fruit
Pigeons/Doves	Seeds and Fruit
Owls	Small Mammals, Insects, and Birds
Nightjars	Insects
Woodpeckers	Insects
Kingfishers	insects and Fish
Hornbills	Fruit, Insects, and Small Reptiles
Swallows	Insects
Hawks	Small Mammals and Birds

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The Birds of Gabon

During your free time, take this chart with you or try to remember what bird activity you saw. When you get home, you can use this chart to keep a record of your local birds. Use what you learned in class and your image sheet to decide what kind of bird you think it is, and answer the questions about each bird below the picture. See if you notice any patterns about the birds you see.

Draw the shape of the bird you that you saw						
What color was the bird you saw?						
What bird do you think this is?						
Where did you see this bird?						
Have you seen this kind here before?						
What time did you see the bird?						
What was the bird doing then?						
How many similar birds were there?						
How many different birds were there?						
Was the bird eating anything?						
What did this bird sound like?						
Did the bird also see you?						
How many people were near the bird?						

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Lesson Topic: *Understanding Impacts of Forest Fragmentation on Biodiversity*

Age Level: 10-12 years old

Objectives:

1. Students will gain an understanding of how forest fragmentation affects **biodiversity** on the edges.
2. Students will gain an understanding of the food chain.
3. Students will develop their reasoning skills.

Introduction:

This lesson plan is intended to teach students about how oil well sites can affect the different habitats that develop around the edges of the site. The following is an explanation of the lesson plan structure.

- The following background information should be presented to the students as either a short reading assignment or as a brief discussion before the activities.
    - This background information will inform the students about how the edges caused by deforestation are harmful to the habitats that previously lived in the area. It will also inform the students about how the food chain operates.
- Once the students receive the background information they can move onto the activity where they will make food webs.
    - When the activity is finished the students should be handed the question sheet to complete. This sheet is to ensure that the students retained all the information during the food web activity.
- After the students have finished the activity, the conclusion section should be presented to them.
    - That section will reiterate that every plant and animal in the ecosystem has a role and if even one plant or animal is removed it has an effect on everything else.
- Prior to leaving the class, students are to be given a copy of the take-home handout entitled Changing Biodiversity.
- For more information, you can use an internet browser to visit the following links:
    - http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/F/FoodChains.html Information about food webs

- http://www.vtaide.com/png/foodchains.htm Concise information on food chains for students
- http://earthtrends.wri.org/text/forests-grasslands-drylands/map-217.html Forest fragmentation caused by roads in Central Africa

Background:

The forest is home to many different plants and animals and many different **habitats**. Animals find homes and food in the forest, and plants find nutrition in the soil and animals to help them spread their seeds in the forest. The forest is an **ecosystem** and every organism in the forest relies on other organisms to live and prosper. This cycle is often called the **food web** or **food chain**. A food web links all of the plants and animals together with what they eat and what eats them. It demonstrates the effect that organisms have on each other and their ecosystem.

In an ecosystem, many different organisms have different roles. There are **carnivores** that eat other animals, but usually do not get eaten themselves. There are **herbivores** that eat plants, grass, vegetables, and fruit. There are **omnivores** that eat both plants and animals. Herbivores and omnivores are usually the prey for carnivores. **Scavengers** are animals that eat the remains and leftovers from other animals' meals. Grass and plants are the **producers**, giving food to herbivores and omnivores. **Decomposers**, such as bacteria and fungus, break down animal waste and dead plants and animals into **nutrients** for the soil and plants. Everything in an ecosystem has a function that it needs to carry out in order to keep the ecosystem balanced.

When the ecosystem becomes unbalanced it could potentially cause the habitats to change drastically. There are many different causes for an ecosystem to become unbalanced, but a main cause is human activity. In particular this activity will focus on human activity that causes forest fragmentation. **Forest fragmentation** occurs when large forested areas are divided into smaller areas by roads or clearings for buildings and other human development. In Gabon, much of the forest fragmentation is caused by oil well sites. Large areas of the forest are cleared for the development of these oil well sites. These sites are so large that animals once using the area do not have access to them.

Forest fragmentation may not seem to be a significant factor to the ecosystem because the forest is so large that all the animals can just move into other parts of the forest, but this is not the case for some animals. When fragmentation occurs it creates an edge around the perimeter of

the oil well site, meaning that the forest comes to an abrupt stop from highly forested to cleared grass areas. These edges pose a great problem for the habitat that once existed there. The **top predators** in the habitat that once existed do not like to be cramped on the forests' edge and they do not want to be disturbed by the human activity happening close to the edges. Naturally, they go further into the forest to not be disturbed and to hunt for their prey. This draws the smaller, herbivorous animals out from the depths of the forest close to the edges to stay away from the top predators so they do not get eaten. When the herbivorous animals are around the edges they multiply because they are not getting eaten as quickly because there are fewer predators coming to the edges to hunt them. They eat the vegetation around the edges and because there are so many animals it is difficult for the vegetation to grow back quickly because the lack of vegetation decreases the soil nutrition levels. Before the oil well sites, that area of the forest was just like the rest, although now there is a completely new habitat.

Forest fragmentation can change a forest's habitat and create problems with the ecosystem. It is not possible for an oil company to reduce the size of their wells or to make fewer sites, however they can find means of restoration. The oil that the company is drilling to get does not last forever and eventually the oil well site will remain abandoned and forgotten. Most companies have the idea that if they just leave everything alone the forest will grow back naturally, although this is not the case. Because of the reduced nutrient levels in the soil it is difficult for the vegetation to grow back to what it once was. This area just becomes an empty area in the forest that never restores itself. Although it is not the only potential fate of forest. If the oil company assists the restoration process then the forest will more likely grow back to its original habitat. Oil companies can achieve this process by replanting trees to help restore the nutrient levels in the soil and, in turn, the other vegetation will also come back to what it once was.

What the Smithsonian Has Done:

The Smithsonian Institution's Monitoring and Assessment of Biodiversity Program conducts many projects in Gabon to address the assessment and conservation of local biodiversity. As the global demand for oil, lumber for fuel and manufacturing grows, the MAB Program is carefully monitoring the impact that extraction of these resources has on local ecosystems. From August, 2006 to March, 2007, the aim of one study was to review the effects

of forest clearings on forest structure, ecosystem functioning, and species interactions near oil well sites in Rabi.

For six months, a team conducted research and observations both in and near the Rabi-Ndogo Protected Area, which is a part of the Shell-Gabon oil concession. The study had several goals, and included efforts to determine whether or not the forest "edges" resulting from clearings caused differences in soil nutrient levels, light levels, or vegetation structure. In addition, the team wanted to check if the forest edges from interior forest gaps altered the abundance and/or biodiversity of **invertebrates**.

The researchers also looked for correlations between altered abiotic conditions and the observed invertebrate biodiversity and abundance. The team also wanted to investigate how forest edges affect top predators and low-level invertebrates that play a role in nutrient control in the environment. Ten well sites (free of the **invasive species** sometimes associated with industry) were selected for all of these observations, with a study plot placed close to the forest edge and another one placed 500 meters deep into the forest for comparison purposes.

Many items were measured, including observed moisture levels, vegetation structure, the amount of canopy cover, the vegetation density, and the nutrient levels in the soil. Density and diversity of micro and macro-invertebrates were recorded, along with measurements of how successful vital nutrient-cycling invertebrates (such as springtails) were at fulfilling their role despite the impact of the forest edge. The forest edge effects on top predators and these low-level invertebrates were reviewed to analyze their impact on total invertebrate density and biodiversity.

Data collected in this manner is used to determine how old well sites and clearings should be restored, and what to do about invasive species and other factors that would inhibit forest regeneration. It has been suggested that follow-up studies should be done to compare active restoration efforts versus natural processes, so that companies such as Shell can minimize the lasting impact of their operations on the environment.

The Smithsonian conducted related experiments on the impacts of invasive species (such as fire ants) at forest clearings, and the impact of forest clearings and edges on bird populations. Birds are the vertebrate animals that fulfill the most diverse lineup of ecological roles, yet are the species probably most affected by forest fragmentation. Thus the study of forest fragmentation's

impact on birds is an obvious research topic. These studies were conducted by some of the same team members who participated in the invertebrate-centered study.

Activity: Food Web:

Activity for a smaller group:

Materials: Scissors, Tape

The students should be broken up into groups of 2 or 3 (depending on the size of the class). Each group should be given the sheet with 20 different plants and animals on it. The students should cut out each individual plant or animal. For reusable cutouts, the sheet could be laminated before cutting; then the students would have 20 cutouts that are laminated and could be collected at the end of the exercise for future use.

Explain to the students that everything in the ecosystem needs energy to live and the energy they get comes from what they eat depending on the organism. Each team should take the cutouts and construct a food web showing the energy transfer. To do this, students tape the animals to a sheet of paper and then draw arrows between them. The direction of the arrows should point in the direction of energy transfer.

For example, a hornbill eats fruit so a line should be put in between the fruit and the hornbill and the arrow should point towards the hornbill. Use tape to keep the pictures in place on a sheet of paper, and possibly tape additional paper background onto the first one if it becomes crowded. Once all the groups are done allow the groups to show off their own food web. Some food webs may be different than others, which is a good thing! Allow each group to discuss and give *reasoning* why they believe their food web is correct. Possible questions to ask each group can be found at the end of this section. Make sure that the students know that there are many different outcomes for the same plants and animals. If time permits, make one final food web allowing all the students to participate and give reasoning for their decisions.

Activity for larger group:

Materials: String, Scissors

Similar to the activity for the smaller group, this activity will involve each student and requires a rather large empty space. Each student can either pick, or be assigned, a different plant or animal. Another method of assigning parts would be to put the names of plants and

animals in a hat or bowl and allow the students to pick one without looking; this can speed up the selection and ensure a good, pre-defined set of animals that do not feature primarily carnivores (as children may want to be the powerful predatory animals).

These plants and animals can be the same ones from the cutout sheet, although if the group size is too large the instructor may need to add a few more plants and animals of their own. It is important to note that the activity should follow the **trophic pyramid,** in terms of the balance of organisms. The trophic pyramid explains that there must be *many* producers, fewer herbivores than producers, fewer small carnivores than herbivores, and fewer large carnivores than small carnivores. Once the students are assigned to a plant or animal they should figure out what category it goes into (e.g. producer, herbivore, omnivore, predator, decomposer, or scavenger).

Whoever (student or the instructor) is the sun should be the start and hold the end of the string, and that student, with help from other students, should describe what the sun does and what it gives its energy to. If the student can not answer all of the questions that the instructor asks, the rest of the students can help out and give their own answers. Once the student (or instructor) is finished, the first producer should step into the area and connect to the sun via a piece of string. The new student should discuss why he believes that he is connected to the sun and what his organism's role is. For example, if the student is a flower, the flower receives energy from the sun and the soil, it provides nectar for insects and birds, and some insects eat the leaves of the flower. Not all connections are related entirely to consumption: bees, birds, bats, and other animals play an important role in pollination and spreading plant seeds. Lead students to make this observation if they do not realize it on their own.

Again, when the student cannot think of anything else the rest of the class can be called on for their thoughts. When that student finishes the next student with a producer should follow until all the producers are in the food web connected to their energy source by strings. When the first herbivore or omnivore comes into the food web more questions can be brought up. For example, when a spider comes into the web the students should discuss what it eats and what other plant or animal it helps. If spiders eat insects that eat flowers then the spider is helping the flowers. Decomposers also bring in more discussion because not only do they eat waste from other organisms they convert that waste into nutrients for the soil.

This process should be continued until all of the students are in the food web and connected by a string and in most cases multiple strings. When all of the students are connected in the web the instructor should take out one organism by cutting the strings, preferably one with many strings attached to it. This brings up new discussion about how the removal of one organism affects the entire food web/ecosystem. Some possible questions to ask during the activity can be:

Q: What does (name of organism) provide food for?

Q: What does (name of organism) eat?

Q: How does (name of organism) *assist* other plants and animals in the ecosystem?

Q: What other roles do (name of organism) play in the ecosystem?

Q: What happens to some of the other organisms if (name of organism) is taken out of the ecosystem?

Q: Where will all of the strings that were attached to (name of organism) go if (name of organism) disappears?

Q: [Continuation of above] What happens when too many strings from consumers/predators then redirect to the *same* lower-level organism?

When all discussion has ended the instructor should pass out the question sheet. These questions are to ensure that the students retained most of the information brought forth during the activity

Conclusion:

As you can see from the activity there are many different organisms that make up an ecosystem. Each organism has its own role and provides its own service to the ecosystem. When one organism is taken out or is forced to move from its habitat, the effect can become a problem for the other organisms in the habitat. It is important to know that human activities in the forest are a reality and for the human race to develop, natural resources will be needed. Although when companies are finished taking the natural resources it is imperative that they begin to restore what they took away. When parts of the forest become disrupted by human activity, they run the risk of never being able to go back to their original state. The only way some disrupted parts of the forest can go back to their original state is with human assistance in the restoration process. If companies help by replanting trees and plants, within a few years the

forest that was cut down will re-grow to what it once was.

Glossary:

Biodiversity – The full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and encompasses ecosystem or community diversity, species diversity, and genetic diversity

Carnivore – An organism that eats meat

Decomposer – An organism that breaks down the tissue and/or structures of dead organisms

Ecology – The study of the relationship between organisms and environment

Ecosystem – All the organisms in a particular region and the environment in which they live. The elements of an ecosystem interact with each other in some way, and so depend on each other either directly or indirectly

Food chain/Food web – All the interactions of predator and prey, included along with the exchange of nutrients into and out of the soil. These interactions connect the various members of an ecosystem, and describe how energy passes from one organism to another

Forest fragmentation - occurs when large, continuous forests are divided into smaller blocks by roads, agriculture, urbanization, or other development

Habitat – The place and conditions in which an organism lives

Herbivore – An organism that eats plants

Invasive species – An organism that is introduced into a foreign ecosystem, by humans, either intentionally or unintentionally. The species tries to adapt to the environment, most of the time the species dies, but sometimes the species thrive and become pests

Invertebrate – An animal that lacks a backbone or spinal column

Nutrient - Any element or simple compound necessary for the health and survival of an organism such as air and water

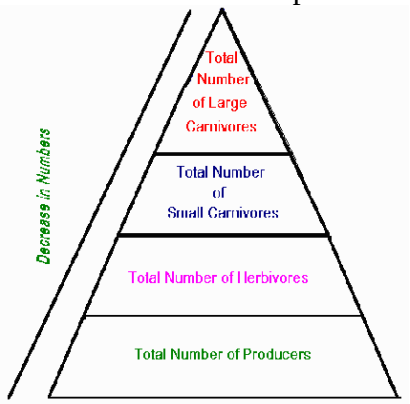
Omnivore – An organism that will eat either plants or animals

Producer – Any organism which brings energy into an ecosystem from inorganic sources

Scavenger – An organism that feeds upon dead and dying organisms

Top predator – An organism that lives by preying on other organisms but does not get eaten by other animals

Trophic pyramid – Trophic levels are the feeding position in a food chain such as primary producers, herbivore, primary carnivore, etc. Green plants form the first trophic level, the producers. Herbivores form the second, while carnivores form the third and the fourth trophic levels



Possible Organisms for Food Web Activity.

Carnivores	Herbivores/Omnivores	Producers	Decomposers/Scavengers
Mongoose	Elephant	Sun	Springtail
Hawk	Human	Flowers	Fungus
Leopard	Buffalo	Fruit	White Backed Vulture
Python	Swallow	Plants	
Crocodile	Bees	Grass	
Jackal	Fruit Bat	Trees	
Owl	Red River Hog	Mango	
Tarantula	Ants	Sarcoglotis	
Leatherback Turtle	Rats		
Barracuda	Cat Fish		
	Green turtle		
	Gorilla		
	Chimpanzee		
	Mangabey		
	Hippopotamus		

NOTE: Remember to follow the trophic pyramid; you should pick more producers and herbivores than carnivores

Questions after food web activity is completed.

1. What is the role of a producer?

2. What is the role of a decomposer?

3. What is an omnivore? Name as many different omnivores as you can.

4. What do you think would happen to a habitat that had too many predators?

5. What might cause an animal to leave its habitat that it once lived in?

6. How can birds or other animals help plants and trees?

7. Can an entire habitat be affected if one species in the habitat is removed? Explain.

Changing Biodiversity

Ask an adult that you know the following questions about how biodiversity has changed where you live. Write down their answers on the *first* line next to each question. You can also write down changes you have noticed. Then, on the *second* line, write down how you think the change might affect other plants and animals in the area.

What animals are less common now?	
What animals are more common now?	
What plants are less common now?	
What plants are more common now?	
Are there more people now? Any new buildings?	
Have any animals started to live near people?	
Have any new plants or animals appeared in this area?	
What biodiversity change stands out the most?	
What one change would you undo or keep if you could?	

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Lesson Topic: *Understanding How Stress Caused by Human Activity Affects Elephants*

Age Level: 10-12 years old

Objectives:

4. Students will gain an understanding of how human activities impact elephant communities.
5. Students will gain an understanding of how human activities can cause stress to animals and how stress can negatively animals.
6. Students will gain experience with plotting data points on a map using a grid.

Introduction/Instructions:

This lesson plan is intended to teach students about how human activity causes stress to animals, in particular elephants, and how that stress has a negative impact on the animals. The following is an explanation of the lesson plan structure.

- The following background information should be presented to the students as either a short reading assignment or as a brief discussion before the activities.
    - This background information will inform the students about what causes stress to animals, in particular elephants, and how the stress negatively impacts the animals.
    - This section will also inform the students of recent research projects completed by the Smithsonian.
- After the students have received enough background information, they should complete the activity.
    - This activity will allow the students to practice plotting data on a map. Using the data that was plotted, the students will determine relationships between elephant movements and stress levels, as well as potential causes of the elephant stress.
- After the students have finished the activity, the conclusion section should be presented to them.
    - That section will reiterate that just as humans become stressed by different factors, elephants, and all other animals, become stressed by noises and lights other human activity.

- Prior to leaving the class, students are to be given a copy of the elephant observation handout as a take-home activity.
- For more information, you can use an internet browser to visit the following links:
    - http://nationalzoo.si.edu/Animals/AfricanSavanna/fact-afelephant.cfm
      Smithsonian fact page on the African Elephant
    - http://maps.geog.umd.edu/activefire_html/checkboxes/GAMBA_checkbox.htm
      Online Gamba Elephant tracking page

Background:

At any given time in Gamba, there are around 9,000 people living in town and in nearby villages. While this sounds like a large number, there are actually 11,000 elephants sharing this area with the human population. Given this fact, it is only natural that elephants will be seen quite frequently in the area as they **forage** for food and investigate human activity. Elephants must eat a large amount of plant material each day to stay alive, and they tend to move around quite a bit in their search for food. While a large component of their diet comes from many plants that are unappealing to humans, they do enjoy fruit and will pick it off trees in and near where people live.

Elephants are rather smart animals. Because of this they may exhibit signs of curiosity towards human activities, and they may also learn to become reluctant to approaching settled areas because of an association between humans and stressful circumstances. Loud noises, bright lights, and landscape changes that are associated with human housing and industry can prove quite bothersome to elephant communities and can cause **stress**. It is not just seemingly indirect things that cause problems for elephants. Pipes and fences that border roads effectively barricade old routes the elephants once used. While many can make it over, younger elephants and the older ones often have trouble and may slip or fall, making travel more stressful. And because elephants are very social animals with close family groups, the injury or deaths of **matriarchs** or elder group members can throw the community into disarray. All of these factors can cause elephants to feel very uneasy and stressed.

Some elephants and animals, however, have always lived in very human-active areas in and around oil wells and closer to human housing. Sometimes, these elephants enjoy eating the cut grass and short, newly-grown trees, or enjoy snacking on stored fruits. With enough nearby water, they may decide to stay around closer to these areas despite the things that bother them.

These "**resident elephants**" often do not travel far from their home areas, and do not show signs of migration during wet/dry season changes. Because some animals have lived near these locations for so many years, they also act more secure and do not seem as stressed as might be expected. Living nearby to these disturbances and never wandering far means that the younger elephants are raised right there, and they become used to their surroundings. This is in contrast to migrating elephants, which may spend a significant amount of time far from humans and wander quite far. When these elephants get close to areas of great human impact, they will probably feel much more stress and hesitation about staying in the area.

The entire purpose of stress response is to encourage change or help cope with disruptive situations. It is not necessarily a bad thing; but unresolved patterns of stress over long periods of time (**chronic stress**) can have a number of negative health effects. For example, the immune system can begin to lose its effectiveness, causing the animal to get sick easier. Elephant groups that are overly stressed will even face reproductive difficulties, preventing the population from replenishing itself. Because of this, it is important to be able to understand and monitor elephant stress levels to analyze how the animals are coping with human disturbances. Understanding this will allow proper action to be taken with regards to human impact on elephant populations.

What the Smithsonian Has Done:

Due to the large number of elephants in the Gamba complex and their roaming nature, interactions between these large animals and people occur on a daily basis. The complex social structure of elephants often results in multiple individuals being spotted together. This necessitates an understanding of elephant behavior and travel patterns, as well as an analysis of how elephant communities are reacting or adapting to human disturbances in their territory. However, studying forest elephants can prove difficult, and **noninvasive** studies are required to prevent the observation itself from causing undue stress to the elephant population.

A Smithsonian Monitoring and Assessment of Biodiversity Program team took up this task from August to October in 2006. In order to minimize the impacts of the research upon the elephants, the study utilized day-old elephant dung as the direct study subject. Droppings were collected at locations both near oil well sites in Rabi as well as at less-disturbed sites in the Loango National park. By comparing samples from both industrial sites and at areas with little

human presence, scientists can spot the differences in elephant behavior and stress levels that are caused by human activity.

Fresh elephant dung contains cells from the animal's intestines, which can be collected by researches for examination. These cells contain the elephant's **DNA**, which are unique natural codes that each species also has that contain information about it. Because only twins have the same DNA, these codes can be used to identify individual elephants. This way, if the team ever finds that same DNA code again at another dung pile, they know it came from the same elephant because that elephant is probably the only one in the world with that unique code. By recording what DNA is at a particular location and when it was found, you can tell where an elephant has traveled. The Smithsonian's MAB Program has created an elephant tracking map on their website using the data they have collected from this research project. This interactive map can be found using the URL <**http://nationalzoo.si.edu/ConservationAndScience/MAB/conservation/centralafrica/gabon/MABinGabon/tracking/map.cfm**>. Other interactive satellite maps can also be found on the Smithsonian National Zoological Park's website.

The methods being used to analyze the elephant dung allow scientists to determine the composition of a group of elephants, including deciding if each sample is from a male or female. This allows them to determine if they have spotted a group with young or a small pack of male elephants. By tracking the elephant movement over time they can also determine if this is a group of "resident elephants" that choose to live in a particular area, or if they are migratory elephants that change locations throughout the season.

Elephant dung also contains a special chemical called **cortisol**, which is created in the bodies of animals (and people) when they are stressed. Scientists are able to measure the amount of cortisol in the dung to see how upset or stressed an elephant was the day before. If an elephant produces high cortisol levels, you can tell it was stressed. If an elephant only made a little bit of cortisol, you can tell that the elephant was probably content.

The MAB Program will continue to analyze elephant stresses, behavior, and movement to better understand these numerous and important animals. The results of this early study indicate that elephants that have always lived near oil sites have been able to cope with human disturbance fairly well, with stress levels similar to those found in undisturbed national park areas. Efforts to reduce human impact and reduce hunting are possibly a contributing factor, as well as the elephants being born and raised amid the commotion; many of the elephants

apparently do not migrate away from the oil sites, and live there year round. Scientists are not yet sure if migratory elephants that come into fresh contact with industrial sites will have increased stresses, but this is likely the case.

Activity: Elephant Movement

Materials: Different colored pencils, markers, or crayons

This activity can be done individually or in groups of two. Each group, or individual, should be given the blank grid map handout and the sheet with the data points and the question. Each group should spend time plotting the data in the grid on the blank map. The students should use a different color for each separate elephant's data points. If colored pencils, markers, or crayons are not available, you can use shapes, such as circles, triangles, squares, stars, etc. to differentiate between separate elephant's data points. Once the students have plotted all of the points they should answer all of the questions that follow.

One of the goals of the questions is to make the students understand that elephants can become stressed by more than just humans. Indeed there are many human activities that can cause elephants to become stressed, but there are also many natural activities that can cause an elephant to become stressed. Some examples of natural causes could be seeing a snake, encountering a large amount of other animals, encountering a female elephant, or searching for food and water. Another goal of the questions is for the students to realize the differences in stress levels of elephants when they travel to new areas that they have never been to before. They should explain that an elephant that lives around an oil field or village may not become as stressed by the human activity because they have become accustomed to it, while a migratory elephant that spends much of its time in the forest becomes more stressed when it encounters human activity because the activity is foreign to the elephant. It is also important for the students to know that even though some areas are "protected", illegal hunting can still occur and could be a cause of stress. After all of the students have answered the questions the instructor should go over each question and allow the students to voice their ideas and opinions.

Conclusion:

As you can see from the activity, humans are not the only mammals that feel stressed. Animals can feel as much stress as humans. It is possible for a person to become stressed when

it sees an unknown animal, and the same happens to animals when they encounter humans. When a person becomes stressed he or she may also become irritable and hard to interact with. The same goes for elephants, even though the majority of the time elephants are calm and do not mind human interaction, at stressful times an elephant may react quite differently to human interaction. It is important to understand when an animal is stressed and to give the animal space and allow them to become less stressed by the situation. When the animal becomes familiar with its new environment it will adapt to certain situations and become accustomed to its new surroundings.

Glossary:

Chronic Stress- A damaging condition that arises from a long-term stressful or frustrating environment that cannot be avoided; it can have strong negative health effects.

Cortisol- A chemical that is produced in the body in response to stress, and then can be found in animal droppings.

DNA- Information found inside animal cells that contains instructions for how the animal should grow.

Resident Elephants- Elephants that are particular to a certain area and return to this area regularly.

Stress- A state of mental or emotional strain or suspense that often leads to action (to remove the stress)

Forage- To search for a source of food to eat.

Matriarch- An elder ruling female in an elephant community.

Noninvasive- Noninvasive measures are those that do not interfere with the subject you are measuring.

Activity: Elephant Movement

DNA is an amazing thing. Every organism has DNA, in fact, every individual organism has its own DNA specific to the organism, and no other organism has the same DNA as another. When tracking elephants by sampling dung piles, researchers can track elephants without ever seeing the elephant. Even if a researcher finds two separate dung piles over 20 kilometers apart, the researcher will know if they are from the same elephant. This is because of the DNA found in the dung. Because each organism has its own DNA, if a researcher finds several dung piles with the same DNA they can be sure that it is from the same elephant.

Plot the dung points in the table below on the map to discover the elephants' movement over a two week period. Use a different color to mark each different elephant. If you do not have different colors then you can use different symbols to mark each different elephant such as an X, or a circle, or triangle, or star, or any other shape you like. Study the different movement patterns for each elephant and explain each movement pattern and answer the questions that follow.

	Elephant 1	**Elephant 2**	**Elephant 3**	**Elephant 4**
Dung Point 1	V-4	Q-9	I-15	V-11
Dung Point 2	U-5	R-8	K-13	U-12
Dung Point 3	S-6	R-9	J-14	U-11
Dung Point 4	T-7	R-10	I-14	V-10
Dung Point 5	S-9	Q-13	H-16	W-10
Dung Point 6	R-8	Q-17	G-17	V-12
Dung Point 7	Q-8	P-16	J-17	W-13
Dung Point 8	O-10	O-16	H-18	V-13
Dung Point 9	O-9	O-17	I-16	W-11
Dung Point 10	P-9	P-17	H-17	W-9

Questions after all points are plotted

1. What are possible causes of stress, as a result of human activity, which the elephants may experience? Give examples and explanations.

2. What are possible causes of stress, as a result of natural activities, which the elephants may experience? Give examples and explanations.

3. Researchers discovered that elephant 1 has been experiencing stress, what could be some causes of this stress? List and explain any human or natural activities that may be causing stress to elephant 1.

4. Why do you think that elephant 4 stays in the area that it was found?

5. Do you think there is a reason why elephant 2 travels to the places where it was found?

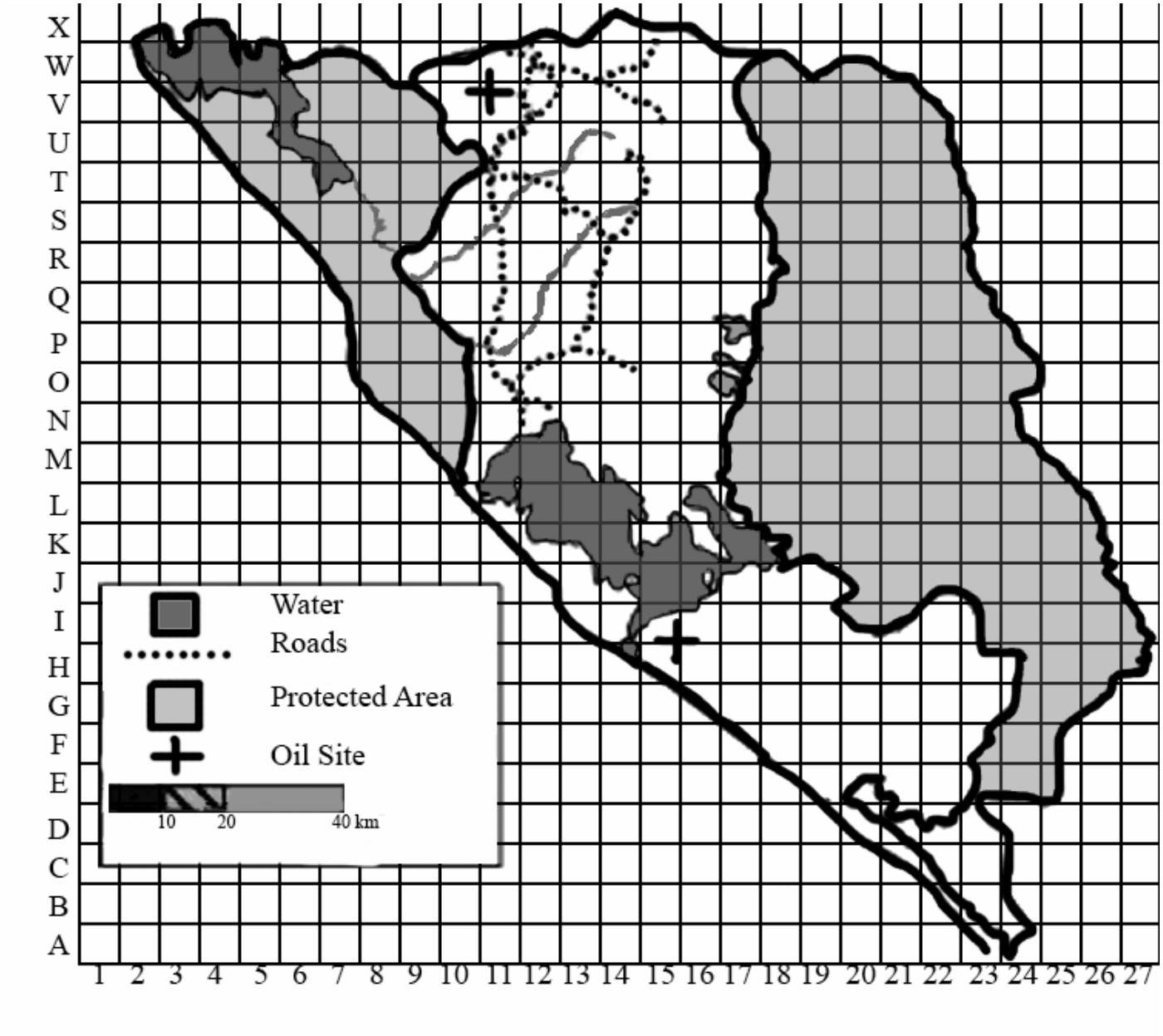
6. Just like elephants, humans also experience stress. Have you ever moved to a new place and felt stressed by the new experiences you encountered?

7. How did you deal with your stress?

8. Once you became accustomed to your new home did you feel as stresses as when you first got there, why or why not?

9. Do you think elephant 3 is more stressed than or as stressed as the other elephants?

10. How does familiarity with your environment affect stress levels? Explain.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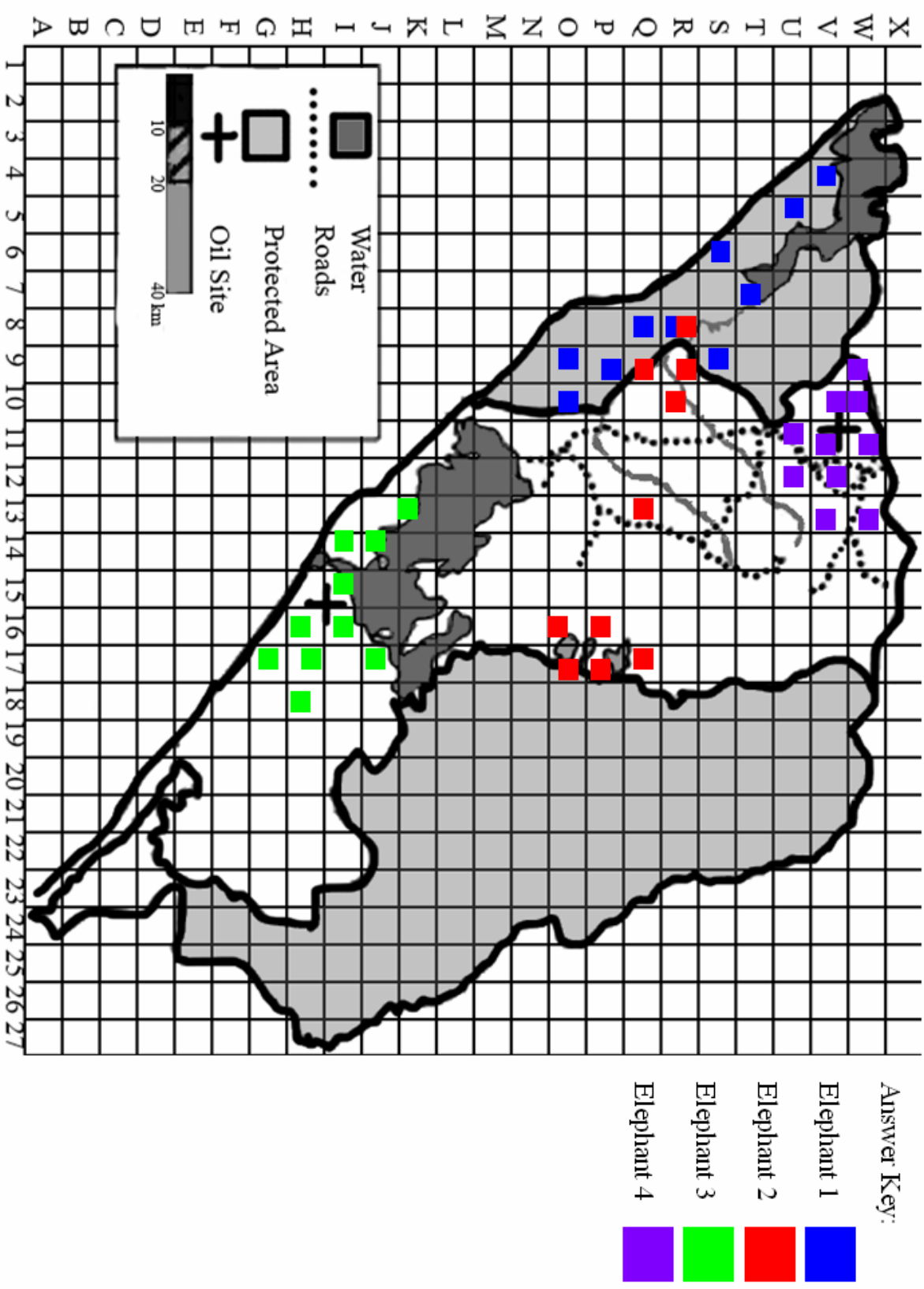
Roads
Protected Area
Oil Site
10 20 40 km

Answer Key for Teachers



Smithsonian

Elephants of Gabon

Use this sheet to keep track of any elephants you see. Be sure to observe how the elephants react to people or buildings around them, but be safe and do not get too close to the elephants or frighten them in any way. Also, write down what evidence the elephant left that it was there.

What time was it?			
Where was the elephant?			
Have you seen one there before?			
What was the elephant doing?			
How many other adult elephants were there?			
Were there any baby elephants?			
Did the elephant make any noises?			
Did the elephant see you?			
Did the elephant seem nervous?			
How many other people were nearby then?			
How many other animals were nearby?			
Was the elephant in a place people often are?			
Did the elephant leave any signs it was there?			

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Munshi-South, J. ***Proposal: Individual Movements and Stress Hormone Levels of African Forest Elephants (Loxodonta cyclotis) in response to Anthropogenic Disturbance in Gabon***. Unpublished Manuscript for Smithsonian Institution.

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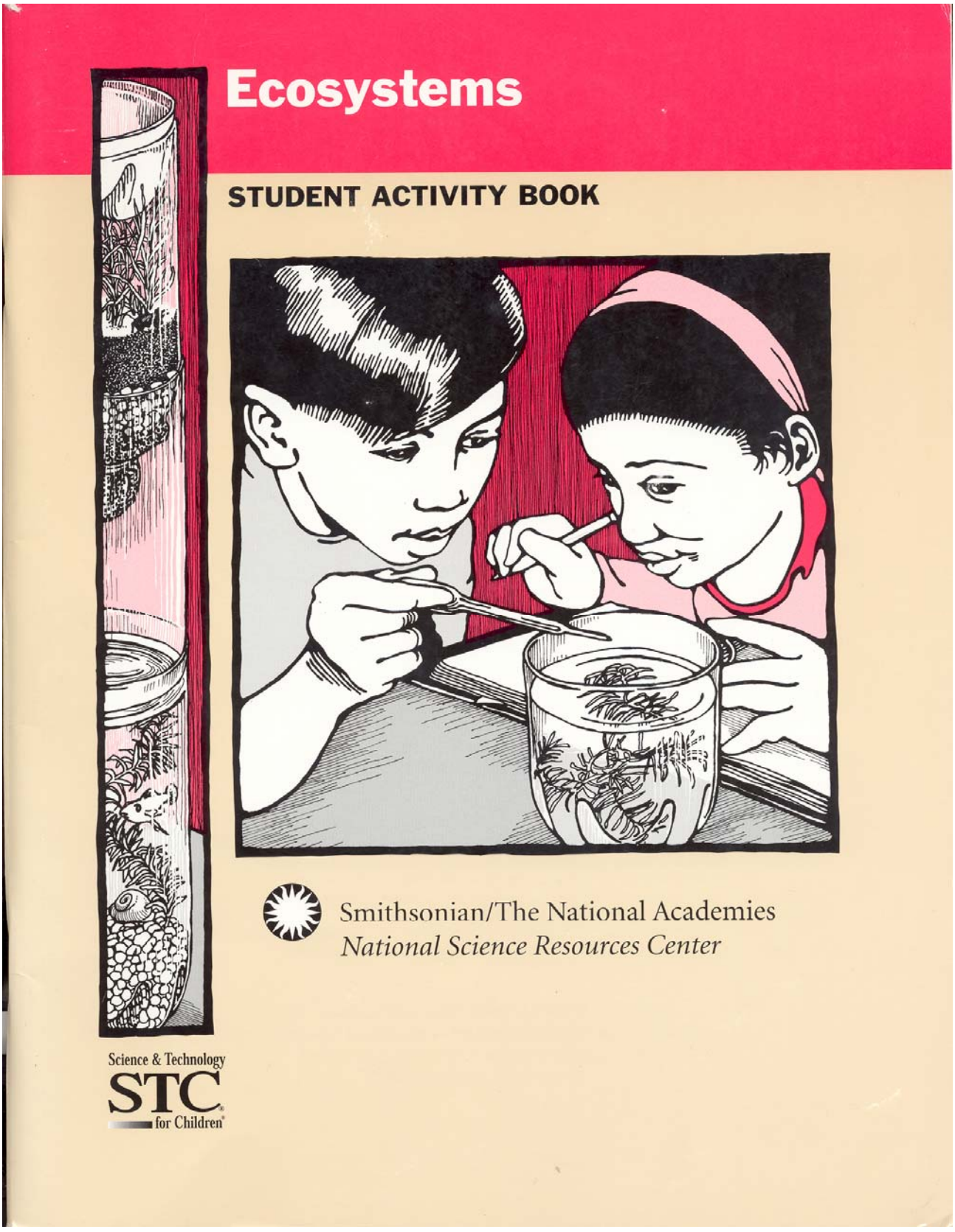
Appendix D: Exemplar Lesson Plans



Ecosystems

STUDENT ACTIVITY BOOK

SCIENCE AND TECHNOLOGY FOR CHILDREN®

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Contents

Introduction

Like every other organism on earth, you are part of a community. Your community includes living things—your family, friends, and pets. It includes nonliving things—your room, home, and street.

"Ecosystem" is another word for community. An ecosystem is made up of living and nonliving things. The living things interact with each other. They also interact with their environment. Because of these interactions, an ecosystem is always changing.

In this unit, you will build a model ecosystem, or ecocolumn. It will include a terrarium and an aquarium. You will put live organisms into each section of your ecocolumn. By studying this model, you will learn about the relationships between living and nonliving things on earth.

Your ecocolumn will be a busy place. Plants will grow. Eggs will hatch. New fish will appear.

You may see signs of trouble. Too many animals or plants may die. Or too many may be born. There might not be enough food. These events are natural. They happen in the real world, too.

An ecosystem can also be disturbed by outside factors. If not stopped, these harmful forces, or pollutants, can destroy an ecosystem. Today, many people are doing things to reduce pollutants and preserve our ecosystems.

Keep your science notebook handy during this unit. Record the changes you see in your ecocolumn. Write down information about the organisms on record sheets. You'll want to draw the organisms, too. That will help you see how they change over time.

At the end of the unit, review your notes. Then be ready to apply what you have learned to study a real ecosystem that is in danger today.

When you are done, you may even be able to find ways to help an ecosystem that is in danger in the area where you live.

LESSON 1

Thinking about Ecosystems

Think and Wonder

Many complex relationships exist in nature. Some living things depend on others for food. They may also depend on nonliving things for shelter. Look closely at an environment today. Think about some other environments around you. How many different relationships can you see?

Materials

For you

1 science notebook

For you and your partner

1 *Ecosystems* Student Activity Book

Find Out for Yourself

1. In this unit, you will study an aquarium and a terrarium. Listen as your teacher describes what you will learn.
2. Now, set up your science notebook for this unit. You will use it to record your ideas and observations. And, it will hold any record sheets your teacher gives you.
3. What do you already know about how living things depend on one another? What would you like to find out? Record your thoughts in your notebook. Then, share your thoughts with the class. Your teacher will record your ideas.
4. Look over the *Ecosystems* Student Activity Book as your teacher hands them out. What will you learn about in this unit?
5. Look at the picture of the riverbank environment on pg. 4. What different kinds of relationships can you find? Be ready to discuss these questions with your class:
   - Identify the living things in this environment. Are they plants or animals? How do the plants depend on the animals? How do the animals depend on the plants?
   - Which of these living things need others in order to survive?

Figure 1-1

Riverbank environment

- Identify the nonliving things in this environment. What part do they play in the lives of the living things?
- What might be going on that you cannot see?

6. Write today's date in your science notebook. Then write your thoughts on these topics:
   - Describe a situation in nature in which one living thing depends on another living thing.

- Look at the riverbank environment again. Imagine that a group of people begins to set up a city in this area. What will change? List as many changes as you can think of.
- What problems might occur when humans interfere with an environment? What could you do to help improve the environment or clear up the problems caused by the humans?

7. Did you ever think of the schoolyard as an environment where plants and animals live? It is. Take a look. Then, discuss these questions with your class:
   - What plants live in the schoolyard environment?
   - Is there evidence of any animal inhabitants? (Don't forget that people are animals.)
   - Are there other living things?
   - How do the animals depend on the plants for their needs? How do the plants depend on the animals?
   - What nonliving things do the plants and animals depend on?
   - How did the living things you observed get food, shelter, water, and protection?
8. Collect some materials such as dirt, rocks, and leaf matter. You can put them in the terrarium you will build in the next lesson. If you cannot take this field trip at school, explore another environment. Collect these materials for homework.

Ideas to Explore

1. Choose one relationship you see in the riverbank picture. Write a story about how each of these living things depends on the other.
2. Do some library research about the plants and animals that live in our forests, lakes, and marshes.
3. Help your class plan a field trip to a local environment: an aquarium, a pond, an arboretum, or even the local pet shop. Or, write a letter inviting a naturalist, zookeeper, fish hobbyist, or pet-shop owner to visit your class.

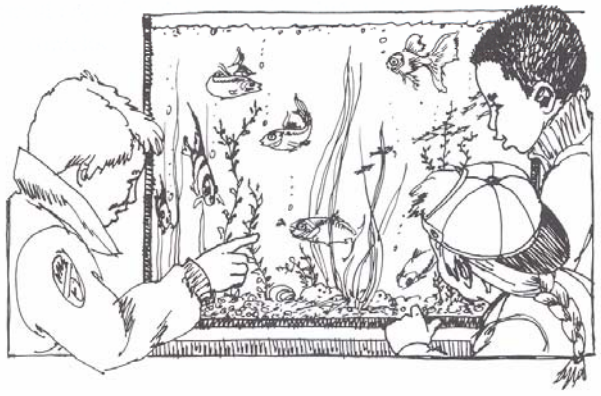
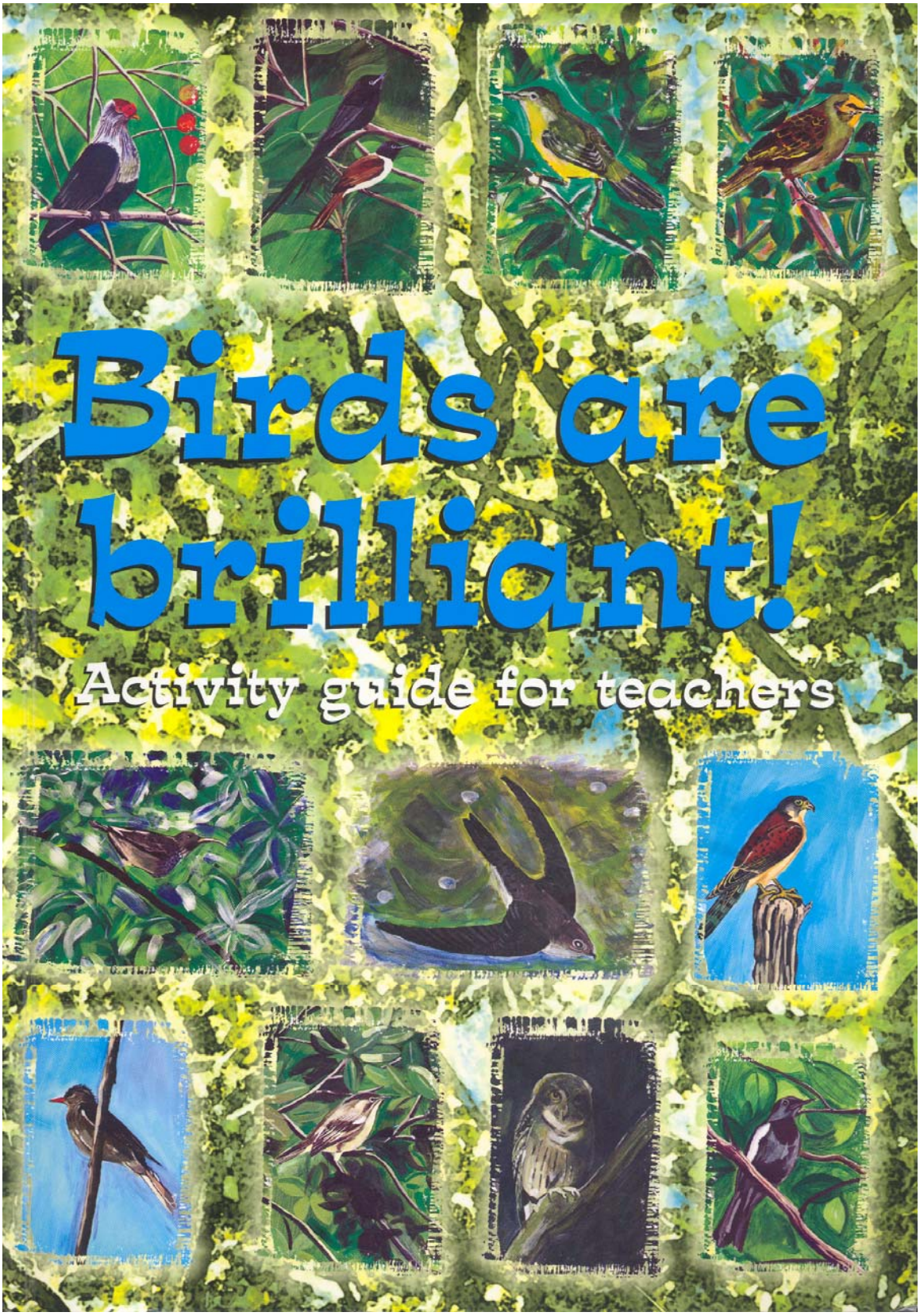


Figure 1-2

Visit an aquarium


Birds are brilliant!
Activity guide for teachers

BIRDS ARE BRILLIANT!

ACTIVITY GUIDE FOR TEACHERS

BirdLife SEYCHELLES

Compiled and written by Michèle Martin

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Layout by Michèle Martin

ISBN 99931-53-04-4

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ACTIVITY 1 – WHAT MAKES A BIRD A BIRD?

BACKGROUND INFORMATION

Birds are easily recognizable by even the youngest children. Their obvious characteristics which make them stand out from other animals are:

- They have feathers
- They have a beak
- They have two feet
- They have two wings
- They lay eggs

Also, but not as obvious, most birds fly, many make nests, they have scaled legs and feet, and clawed toes, and they have hollow bones to make them lighter for flying.

In Seychelles, we have about 70 different bird species, some of which are endemic, some are introduced, and others, like the seabirds, are native but also found in other countries. Birds can be identified with the help of a field guide, by considering their size, shape, colour, song, behaviour, and habitat.

KEY CONCEPTS: bird identification, adaptations, bird behaviour

KEY SKILLS: observing, groupwork

CURRICULUM LINKS: science, languages

SETTING: indoors and outdoors

MATERIALS: books and magazines with pictures of different animals, worksheet, field guides, binoculars (if available)

INTRODUCTION

- Look at pictures of different kinds of animals, eg. bats, lizards, birds, insects, and discuss what features make birds special.

ACTIVITY

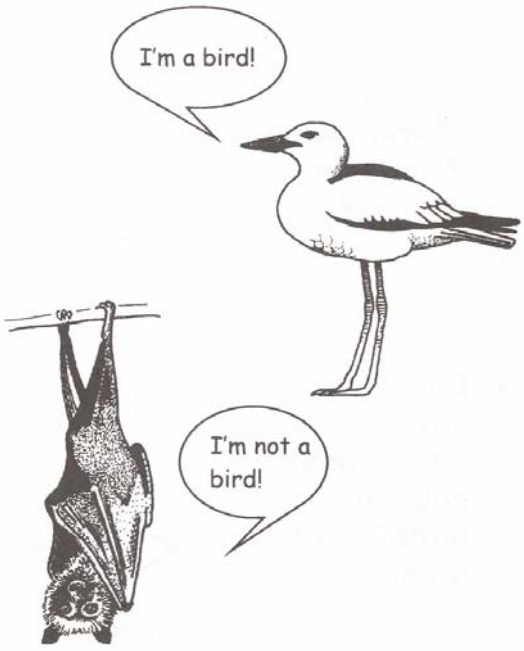
- Draw the outline of a bird on the chalkboard, and together label all of its' parts.
- Look at pictures of different kinds of birds to see how they vary in shape and size
- Go outside to observe different birds and how they behave. Have the children work in groups, and complete a worksheet (see worksheet).
- Use field guides to help you identify the birds seen.

SUMMARY

- Compare worksheet results back in class.
- Write a list of tips for successful birdwatching.

EXTENSION

- Make a key to help identify the birds around your school and community.
- Look for articles about birds in magazines, newspapers and books. Make an exhibition for you classroom.



Answers to bird puzzles on worksheet:

Puzzle 1: 1.fly, 2.sunbird, 3.beaches, 4.insects, 5.white, 6.endemic

Puzzle 2: 1.warbler, 2.hollow, 3.migrate, 4. nest, 5.seeds, 6.dive, 7.yellow, 8.neck.

Worksheet: Watching Birds

1. Tick if you see a bird doing any of the following:

2. Describe any other behaviours you have observed:

standing ☐

preening ☐

walking ☐

eating ☐

3. How many different kinds of birds did you see?

perching ☐

drinking ☐

4. Did you see any of Seychelles endemic birds? List them:

flying ☐

bathing ☐

hopping ☐

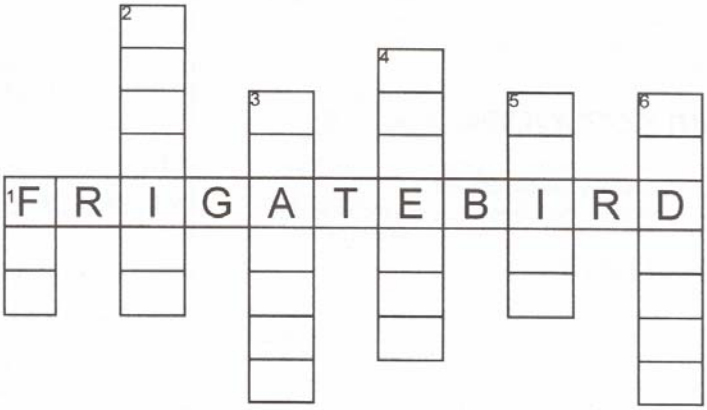
singing ☐

Illustration copied with permission from the RSPB Curriculum Guide, Early Birds, p. 18.

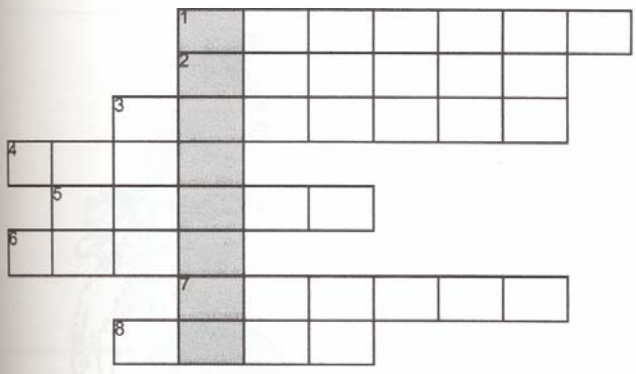
Worksheet: Bird Puzzles

1. Complete the crossword using the clues below:

1. The Aldabra rail, "tyomityo" can not do this.
2. Small nectar-feeding bird.
3. A good place to find turnstones.
4. The Seychelles warbler loves to eat these.
5. Colour of fairy terns.
6. Found only in a specific region, eg. Seychelles.



2. Find the mystery bird by filling in the missing words:



1. Small endemic insect eating bird.
2. A feature of bird bones that makes them light.
3. Birds do this to escape cold northern winters.
4. Most birds build one for their young.
5. Many birds love to eat them.
6. How many seabirds catch their food.
7. Colour of mynah birds' beak.
8. Herons have a long one.

Exploring Ecosystems in the Classroom

http://www.nps.gov/invspcurr/Alien%20Lessons/Exploring%20Ecosystems%20in%20the%20Classroom2.pdf

Subject: Life science Grade: 6-8

Lesson Topic: Ecosystems Length: 1+

Learner Objective:

Students will gain an understanding of the components of ecosystems.

Students will understand the vocabulary used to describe and define ecosystems.

Students will be able to differentiate between abiotic and biotic components of an ecosystem.

Introduction:

This collection of activity ideas is intended to supplement the regular life science ecosystem units normally taught. It provides the classroom teacher with the necessary vocabulary and concepts common to the study of ecosystems, provides a variety of activities that may stand alone or be added to the regular curriculum and can be used to transition from a broad approach of ecosystem study to one that incorporates alien weed species as the integrating context by which students study the dynamics of ecosystems in their own community.

Content:

The earth's living layer, or biosphere, is the largest ecosystem. Ecosystems may also be as small as a tiny weedy patch in the corner of a parking lot, or a puddle. Wherever you find a select group of living and non-living things interacting with each other can be considered an ecosystem.

Within each ecosystem, no matter the size, there are populations of living things (biotic), with their own particular habitat that best supports their lives. The habitat may support several populations of organisms that interact with one another and form a particular community or association. The habitat must supply the needs of the community from the non-living things (abiotic) in the form of food, water, nutrients, sunlight, and temperature. Plants are unable to move from a habitat where their needs are not met, but many have evolved mechanisms of adaptation. The plants are best adapted to particular niches within the community where the greatest number of their needs is met. Animals, on the other hand, are able to move to more suitable niches if their needs are not met. Since two or more species of plants or animals cannot occupy the same niche at the same time, it follows that competition, predation, cooperation, and symbiosis may occur, and consequentially, the plants and animals evolve strategies to deal with these processes. Therefore, each biotic population has it's own specific niche, sharing a general habitat with other populations to different degrees of cooperation and competition, and all utilizing the available abiotic resources.

The earth is also one very large biome, a place defined by particular, overlapping habitats. The most dominant biomes are deserts, tundra, grasslands, and large forested groups such as the rainforest and northern temperate forests. Many of our

National Parks of the Pacific Northwest Region are within the Great Basin Ecosystem, which encompasses a range of biomes.

Although we are often focused upon the biotic components of the world around us, it is the cycle of energy and abiotic factors that defines and determines the success of any biome, habitat, or ecosystem. The sun is the driving force behind the flow of energy in our biosphere, and all living things require energy in one form or another. The transfer of energy occurs because all living things have particular functions within the ecosystem: producers, consumers, decomposers, and scavengers. Energy within the ecosystem is transferred by these functions within the food chain.

Just as energy is cycled through the system in the give and take of nutrients, so also are other abiotic factors such as water (the water cycle), gases, and minerals. For each living thing to survive within a particular habitat there must be a system of conservation, where through a recycling of all abiotic substances maintains a supply of resources available a different moments to the living things best adapted to utilize those resources. When a resource becomes limited or disappears, living things may become endangered or extinct.

It must not be forgotten that humans too, are an abiotic partner in the earth's ecosystem, with all the same needs and functions of other living things. Since we are mobile and adaptable to a wide variety of habitats, our footprint upon the earth carries greater weight. As we shall see in later units, sometimes we alter the available resources and create an imbalance to the system of conservation that affects the ability of other living things to survive. And in some cases, by altering habitats we cause the demise of native species and invite Aliens In Our Neighborhood.

Materials and Supplies:

Materials required are dependent upon the activities, chosen from the list below.

Anticipatory Set:

Show the students a potted plant, an aquarium (or fish bowl), a glass of water, a moldy sandwich, and a clear glass of soda or tonic water. Ask them to point out which items are ecosystems and for them to explain/defend their assertions.

Activity Outline:

The above background information is intended to provide a guide to a variety of activities that may be done in the classroom to introduce students to ecosystems. There are many activities, and variations of them, of ecosystem studies that are found in a great number of life science textbooks, the Internet, and other sources. A few of the most common are listed here:

- Build a classroom aquarium, or have each student design their own using the popular Bottle Biology (Bottle Biology Project. 1993. Department of Plant Pathology, College of Agriculture and Life Sciences, University of Wisconsin-Madison. Published by Kendall-Hunt Publishing Company. ISBN 0-8403-8601-X).

- Build/design a terrarium, an ant farm, a butterfly habitat
- Create a collage of pictures depicting a particular ecosystem from pictures cut out of old magazines.

Created by Mark Goddard for Aliens In Your Neighborhood - 2003

- See also the matrix which cross-references this activity with similar activities by Project Learning Tree and Project Wild

Students can keep a journal of their daily observations. A great project is for the students to make their own Ecosystem Journal, and a good source for book binding is Written and Illustrated By: A Revolutionary Two-Brain Approach for Teaching Students How to Write and Illustrate Amazing Books by David Melton, 1985, published by Landmark Editions. ISBN: 0933849001

Closure and Assessment:

Student journals can used to assess understanding of key concepts. Their observations and reflections should utilize the above vocabulary. Journals kept over a period of time should demonstrate a movement from inference to true observation. Students may also exhibit understanding through oral presentation of the ecosystems they created.

Independent Practice and Related Activities:

Students may wish to expand their studies of classroom ecosystems by recording specific data (temperature, moisture, plant growth, mortality, pH, etc.) over time, by manipulating variables, and by developing and testing hypothesis through experimental design and process.
(These aspects of research may be used to adapt this lesson plan to upper middle school and high school classes)

Resources:

Bottle Biology. Bottle Biology Project. 1993. Department of Plant Pathology, College of Agriculture and Life Sciences, University of Wisconsin-Madison. Published by Kendall-Hunt Publishing Company. ISBN 0-8403-8601-X
Written and Illustrated By: A Revolutionary Two-Brain Approach for Teaching Students How to Write and Illustrate Amazing Books by David Melton, 1985, published by Landmark Editions. ISBN: 0933849001

Vocabulary:

Abiotic, Adaptation, Biosphere, Biotic, Community, Competition, Consumer, Cooperation, Decomposers, Endangered, Extinct, Food Chain, Habitat, Niche, Population, Predation, Producers, Recycling, Scavengers, Symbiosis

National Science Education Standards:

Science as Inquiry - CONTENT STANDARD A: As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science - CONTENT STANDARD B: As a result of their activities in grades 5-8, all students should develop an understanding of

- Transfer of energy

Life Science - CONTENT STANDARD C: As a result of their activities in grades 5-8, all students should develop understanding of

- Structure and function in living systems
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

This exemplar was not easily transferred over. Please follow the following link to find the full document

http://www.teachingkate.org/lessons/burgess.pdf

Teaching K

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TEACHING KATE
TEACHING KIDS ABOUT THE ENVIRONMENT
ANIMAL TREASURE HUNT
Grade Level: K-5 Time Required: 1-2 class periods
SC Science Standards
This lesson plan was correlated with only the grade level specified unless otherwise noted.
Grade K: Grade 1: Grade 2:
I. A. 1. a I. A. 1. a I. A. 1. a
I. A. 2. a I. A. 2. a I. A. 2. a
I. A. 4. a I. A. 4. a I. A. 4. a
I. B. 1. b I. B. 1. b I. B. 1. a, c
II. A. 1. b II. C. 1. a II. A. 2. a, b
Grade 3: Grade 4: Grade 5:
I. A. 1. a I. A. 1. a I. A. 1. a
I. A. 2. a I. A. 2. a I. A. 2. a
I. A. 4. a I. A. 4. a I. A. 4. a
I. B. 1. c I. B. 1. c I. B. 1. c
II. A. 1. b II. B. 1. b
Purpose
The students will go on an animal treasure hunt to explore a nearby habitat, the school yard, while looking for signs of animals living there.
Skills
Concluding, interpreting, observing.

Teaching K

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Concepts
Plant and animal populations exhibit interrelated cycles of growth and decline. Organisms are interdependent; they all depend on non-living components of the earth.
Materials Needed
notebooks drawing paper

markers hand lenses
sample containers

Definition of Terms

Animal Signs Evidence left which proves the presence of an animal. Signs may be scat (droppings), scrapes, rubs, tracks, feathers, hair, etc.
Habitat The place where an organism lives and grows.
Interdependent Organisms relying on each other for existence.
Organism Any living thing.

Before the Session

Consider doing this activity during the spring or fall when animals are more active during the day.
Survey the outdoor site before taking the students. Look for potential hazards and risks. Either remove potential dangers or caution students about them. For younger students, arrange to have at least one or more parents, aides or older students to help with the animal treasure hunt.
Remind students that all living things, including plants, are to be respected and not injured in any way. Follow the rule: look, learn and leave alone.
3

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Background Information

Habitat refers to the place where an organism lives and grows. Its habitat provides an organism with everything it needs to survive, including its specific needs for food, water, shelter, space and
reproduction.
Habitats vary tremendously in terms of size and appearance. For example, a field is home both to many types of grasses and to mice and rabbits that live among the grasses. A tree is the entire habitat for many tiny animals that live in its bark and among its leaves. A crack in the sidewalk is the habitat for dandelions and ants that live there.
Even in the most sterile looking environment, you can usually find some signs of animal life. In an urban school yard, for example, students can find things such as spider webs, ants underneath pieces of cement or rocks or insects buzzing around. Students need to understand that all animals,
large and small, require food, water and shelter from their environment to survive. Remind students that people are animals too. Around the school yard they will find plenty of signs indicating the presence of people.
While most students enjoy looking for animals, some may be afraid of certain organisms like spiders or worms. Be prepared for some students to act timid or scared during the activity. A brief summary, before the activity, of the kinds of animals which may be present as well as an assurance that most of the animals will be more scared than they are, may help to reassure the students. Inform the students that it is smart to be cautious and they should not touch or pick-up any plant or animal unless they are certain it is harmless.

Suggested Lesson Plan

1. Divide students into pairs. Take them outside and allow pairs 5-10 minutes to find two

animals or signs of animals. Set boundaries so that students do not roam too far.
2. Ask students to sketch animals or signs they find. Allow them to collect samples from sites.
3. The students will set up a table and record the number of each animal they find.
4. Bring the group together. Have students share their experiences and compare their findings.

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Application

The students are now aware of animals and their habitats within a given area. Allow students to collect or observe the same animals from other sites and compare the two habitats.
Students can create artificial habitats to see which animals utilize them. This is a good way to lead into a discussion on creating habitats for wildlife. In coastal areas, discarded Christmas trees are collected and used for fish habitat. Fish habitat is also created by sinking old boats and ships offshore and by the placing of specially created concrete “habitats.” Farmers and hunters are recreating hedge rows around fields, which had been removed in the interest of “clean farming,”
to restore populations of quail and rabbits.

Extension

Take students on a field trip to a wildlife management area. Arrange for a District Wildlife Biologist to give the students a tour of the area pointing out how the area is managed: for what animals, what the specific needs of these animals are and how they are met. Have them compare this area to their school yard.

Resources Available

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Prepared by: Carlos R. Burgess

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