ArcAtlas in the Classroom: Pattern Identification, Description, and Explanation

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ABSTRACT

The use of geographic information systems (GIS) in the classroom provides a robust and effective method of teaching the primary spatial skills of identification, description, and explanation of spatial pattern. A major handicap for the development of GIS-based learning experiences, especially for non-GIS specialist educators, is the availability of spatial datasets that are not only inexpensive and easy-to-use, but incorporate a large array of topical and regional themes. ArcAtlas Our Earth is a possible solution to these dual problems. This article describes the composition and structure of this database that is designed for academic and educational applications. It also provides a workable example, links the exercise to Bloom's Taxonomy, and the National Geography Standards, includes a suggested grading rubric, and provides suggestions for additional exercises.

Key Words: *geographic inquiry, ArcAtlas, GIS, zoogeography, spatial analysis*

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Among the most important outcomes of a successful geographic education is an ability to recognize, describe, explain, and, finally, to predict spatial patterns. These abilities are valuable real-world skills. A common tool for implementing spatial decision making, the geographic information system (GIS) is beginning to make inroads into K–12 educational systems as a means for teaching these skills. While some have issued a cautionary note about the integration of GIS into the K–12 curriculum (Meyers *et al*. 1999), others speak to its potential as a tool that is well-adapted to the exercise and strengthening of spatial skills (Audet and Abegg 1996; Baker 2005; DeMers 1999). While the debate continues, efforts to improve the successful integration of GIS into the educational system attempt to address one of the primary limitations of such integration, that is, data. Without appropriate inexpensive data the educator's ability to employ GIS technology in the classroom is severely compromised.

ArcAtlas: Our Earth is a comprehensive, although now somewhat dated, collection of digital thematic maps in ArcView Shapefile, ArcInfo Coverage, and GIF (graphics interchange format) formats that was explicitly designed to be used as a library resource of spatial data. The maps include both human and physical themes including atmospheric, hydrological, societal, economic, land use, land cover, soils, geological, vegetative, and zoological phenomena. Its database of over forty maps at scales of 1:10,000,000 (Europe), 1:20,000,000 (The Americas) and 1:25,000,000 (Asia and Australia) also includes one hundred space images for visual comparison with the map data.

With access to adequate spatial data, educators at all levels are very creative in their abilities to produce meaningful learning activities. At $250, ESRI's ArcAtlas is one readily available, reasonably-priced resource that fills this void. This article provides a brief description of the database and a lesson plan example that, although targeting a particular group of students, is adaptable to many educational levels. The lesson plan is aimed at high school students (grades 10–12), community college students, and freshman and sophomore level undergraduate university students in non-GIS courses. It contains explicit learning objectives, estimates of Blooms Learning Level for each objective, a complete grading rubric, and explicit links to the objectives to the National Geography Standards (Downs and de Souza 1994; Hill 1994). The article concludes by suggesting additional exercises to inspire educators to experiment with the variety of problem-based learning activities that could be developed.

The lesson plan is implemented within ESRI's ArcGIS 9.x (ArcView) product because of its availability to both K–12 and higher education. While the steps are specific to that software, the lesson plan is easily modified to adapt to other software that is capable of importing the file types present in the database.

THE TEACHER'S PERSPECTIVE

From the teacher's perspective, one engaging approach to teaching is through inquiry. This requires the student to pursue a particular path of investigation, the end product of which is the ability of the student to discover spatial insights and make deductions from their explorations of the lesson rather than being provided with answers by the instructor. The teacher provides the problem or scenario, directs the inquiry process, and often supplies the necessary data to obtain the desired outcome. By using ArcAtlas as the data source, the student is able to view continent scale distributions, to compare distributions at these scales, and to examine questions related to the nature, causes, and possible consequences of these distributional patterns.

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Teachers, especially in the K–12 environment, frequently lack the luxury of time to develop large spatial databases necessary for class exercise development. Moreover, creating such databases requires software, hardware, and skills that are not always readily available to busy educators. ArcAtlas brings together a wide array of good data for use in class exercise construction. However, because of the sheer size of the database, the complexity of the text legends, and the multiple necessary base maps, bringing these together in a coherent whole for a given exercise seems, at the outset, to be an overwhelming task.

Fortunately an alternative approach is available. When ArcMap is opened, it provides three options: a new empty map, template, and an existing map. The template provides ready-to-use layouts and basemaps for various geographic regions. Although the template coordinate system is not identical to that used for ArcAtlas, the databases are easily incorporated within the template's coordinate system. This not only simplifies the development of exercise-specific databases, it also provides a quality map output with legend, north arrow, scale bar, grid, and other cartographic design elements. The themes available within ArcAtlas can be added individually as needed. Once accomplished, the students can perform simple polygon display and/or overlay operations to observe pattern co-occurances. An example of this would be to show the vegetation that falls within the range of the American bison or soils that fall within the densely populated areas to show settlement patterns.

The Student Perspective

For this exercise example we envision a high school science student—perhaps in a general science, biology, or other natural science class, or possibly a college freshman or sophomore in a non-GIS course. While some students may have had access to GIS technology, the vast majority will probably not have had much experience with either GIS or ArcAtlas. Fortunately, today's high school and college students are often very comfortable with computers and are therefore amenable to experimentation with software, especially if it is visually appealing and intellectually stimulating. In fact, it is becoming apparent that these tech-savvy students are part of a new generation of students whose learning styles are more amenable to immersion in technology than ever (Dede 2005).

There are two primary goals in this exercise. The first is to keep the graphical user interface (GUI) simple, uncluttered, and intuitive. Menu selections should allow the student to focus on the exercise and its lesson rather than on manipulating the software and the ArcAtlas database. This requires that the teacher spend some preparatory time taking the students through the operation of the software and its GUI prior to actually assigning the exercise. It is often a good idea to begin with a demonstration and then allow the students to replicate what you did. Also useful is to record both screen captures of the steps and/or to make movies with screen capture software. A handout with properly sequenced screenshots makes a handy tutorial prior to lab assignment. Development of point-and-click functionality is more a function of the ArcGIS software than ArcAtlas but both will need to be configured to enhance the quality of the student experience.

The second goal is to have the exercises placed at the appropriate ArcAtlas view. To prepare for this lesson, copy all the ArcAtlas files to the machine being used for the exercise and place it where the students will have easy access. The exercise should clearly indicate which continental view the student is going to be using. The first steps in the exercise will involve the student opening ArcMap, then choosing the template option, and from that selecting the appropriate template (e.g., North America or South America).

At this point the student will be required to use the "add data" button to add the appropriate data. It is useful to include only the target data first (e.g., the distributions for which you are seeking an explanation), then ask the students to think about what types of other data might indicate factors controlling or at least influencing the distribution. This is the part of the exercise that allows the student to experiment. As the student makes suggestions they are actively engaged in the learning process in an appropriate inquiry mode. When learners suggest possible related factors one might always ask why they think these factors are related. Even if they are unable to identify appropriate mechanisms of interaction, and often "because" they cannot, one should allow them to go ahead and pull in and examine their suggested data. Becoming aware of nonspatially related factors is just as important to the discovery method as recognizing those that are.

Example Exercise

The first example is an exotic environment (the African continent) rather than one that is more familiar to the student. This encourages discovery rather than reliance on areas with which the students might be more likely to be more familiar. The approach is to move from Bloom's Learning Level One (Knowledge) to at least Level Four (Analysis). When the student is too familiar with the material they are merely reciting known relationships rather than logically analyzing patterns to arrive at conclusions.

At the same time that we select our study area it is important to examine something that will engage students in inquiry. We chose to examine both the current and the historical distributions of lions. While many students may know that lions are in Africa, they often lack knowledge of where within Africa they might occur. Additionally, because students are familiar with lions, the exercise is of interest. The following is a skeleton view of the exercise that can be modified to accommodate the individual

Table 1. Suggested lab-based learning rubric (100 points).

Score %	Content (40 pts)	Conventions (30 pts)	Organization (20 pts)	Presentation (10 pts)
100%	• GIS analytics well thought out and support conclusions • Reflects substantial critical spatial thinking • Provides at least 4 specific spatial explanatory factors for distributions.(Maps) • Suggests processes for each factor. • Suggests an additional comparative example not given in exercise	• Uses proper map formatting (e.g. neat line, north arrow, scale bar, etc.) • High level use of GIS analytics evident • Description of analytic operations in standard format • Flowchart (if present) demonstrates operation sequences	• References highly relevant and supportive of conclusions • Well organized maps portray conclusions extremely well • Report organizations leads reader to the correct conclusions • Result of GIS analytical operations obvious • Excellent flowchart	• Excellent integration of text, maps, and flowcharts • Report organization enhances conclusions • Report neatness and graphical design enhances reader interpretation
75%	• Is well thought out and supports solution to challenge or question • Some critical thinking is apparent • GIS analytics partly related to problem • References several relevant citations • Is accurate	• Maps present but with minor errors • Only minor reference errors— no missing information • Correct use of GIS analytics • Flowchart has some errors	• References support conclusions • Maps support conclusions • Maps reasonably easy to interpret • Flowchart reasonably well constructed	• Good integration of text, maps, and flowcharts • Report organization does not detract from conclusions • Report neatness and graphical design does not detract from reader interpretation
50%	• Supports the solution • Demonstrates apparent critical thinking • Has no clear goal • One or no supporting references • Has some factual errors or inconsistencies	• Maps present but of poor quality • Report somewhat disorganized • Some references poorly formatted or lacking information • GIS analytics show some errors • Poor flowchart	• References only tangentially support conclusions • Some maps support conclusions or maps only partially support conclusions • Maps hard to interpret • Some evidence of GIS analytic results	• Passable integration of text, maps, and flowcharts • Report organization doesn't suit content. • Lack of report neatness and graphical design detracts from reader interpretation
25%	• Provides inconsistent information for solution • Has no apparent evidence of critical thinking • Has no clear goal • No references • Has significant factual errors, misinterpretations	• No map output • Report very disorganized • Poor or incorrect use of analytics • No flowchart	• Lack of maps makes interpretation difficult • Lack Information does not support the solution to the challenge or question • Lack of analytics confuses reader • Lack of flowchart confuses reader	• Integration of text, maps, and flowcharts lacking or sloppy • Report organization detracts from content • Sloppy report makes reading difficult or impossible

instructor and classroom circumstance. Be sure to have the students review the grading rubric (Table 1) before to beginning the assignment.

Spatial Inquiry Exercise: The Lions of Africa

Problem Introduction: The African lion has undergone extreme pressure on its habitat, resulting in a reduction in the size of its range. Although we have a pretty good idea of where lions used to live (their historical range), as well as where they live now (their present range), it is important to determine what factors might explain these distributions. If, for example, we can determine what factors contribute to their historical distributions, we can hypothesize what factors might have changed to account for their loss of habitat. Moreover, if we can determine appropriate explanations we might be able to predict

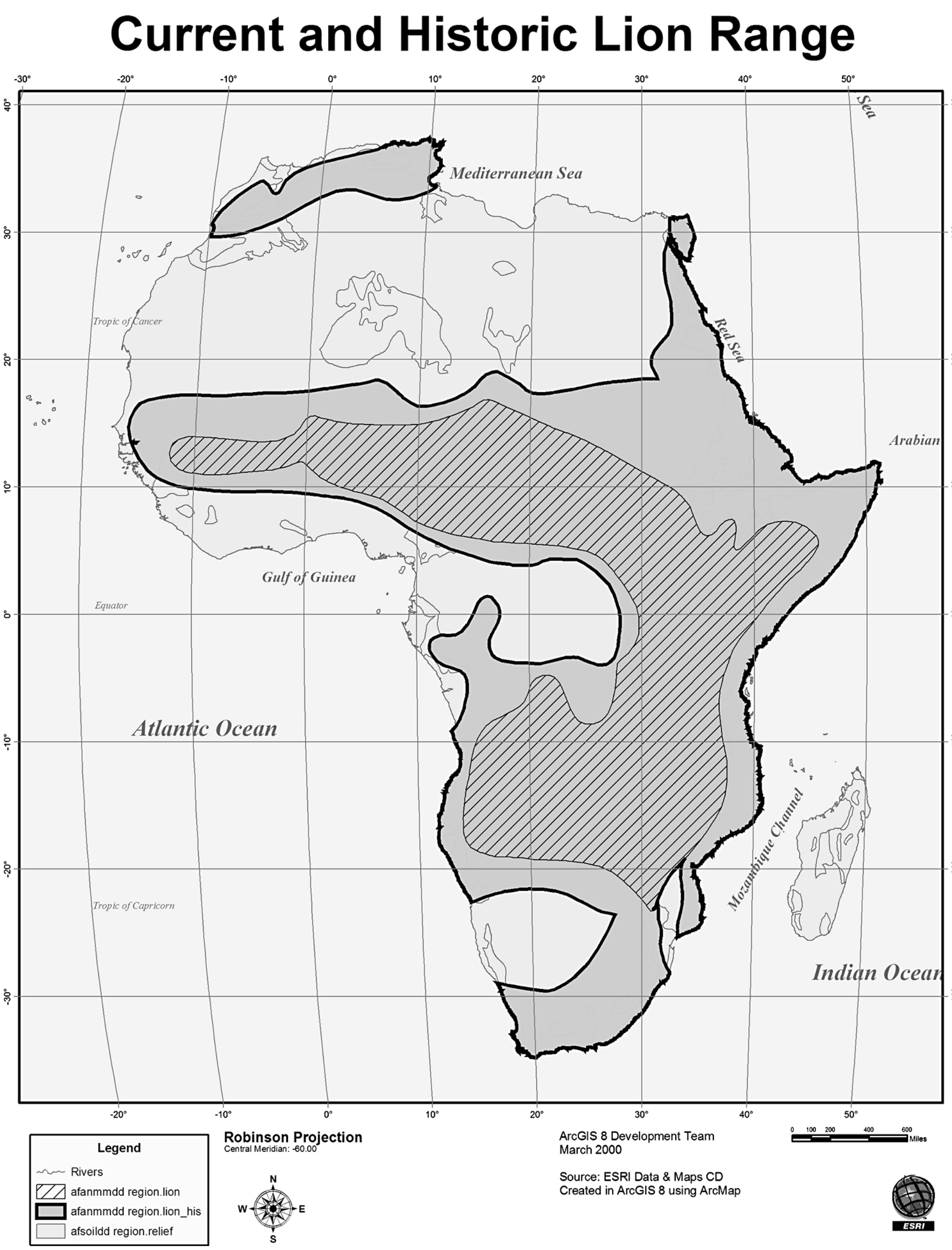

Figure 1. Display of the present and historical lion range using ArcGIS.

future distributions and/or plan for the preservation of these animals.

Scenario: Imagine that you are a researcher working for an international wildlife conservation society. Your mission is to determine what can be done to conserve lions in the African continent. Your first task, and the goal of this exercise, is to explain past and present lion distributional patterns, and to suggest what is likely to occur in the absence of any mitigating action. With what you are able to glean from this project you should make suggestions for action to preserve the species. These suggestions will become a basis for discussion. [*Teacher's note: this allows for the movement to Bloom's Level Six,Eevaluation*.]

Procedures: [*Teacher's note: these are in brief and require each instructor to elaborate*.]

1. Open ArcMap.
2. When the menu opens it asks you to "Start ArcMap using . . . ," select option two (a template).
3. When a list of templates appears, select "Africa.mxt" from the world templates tab.

4. When a small version of the Africa map appears, click "OK."
5. Click the "Add Data" button and migrate to the WORLD data and then the RESOURCE folder.
6. From the list of RESOURCE folders, select WILDLIFE.
7. Within WILDLIFE there is a folder named "afanmmdd," which stands for African animals (mammals).
8. Scroll to the right and find two folders: "region.lion" and "region.lion_his, " which stand for current and historical distributions of lions, respectively.
9. Select one (highlight it), then hold the shift key and select the second one. Hit enter. A warning about incompatible reference system appears. Do not worry, ArcMap is pretty smart. Select "OK to all." Both distributions will appear (Fig. 1).

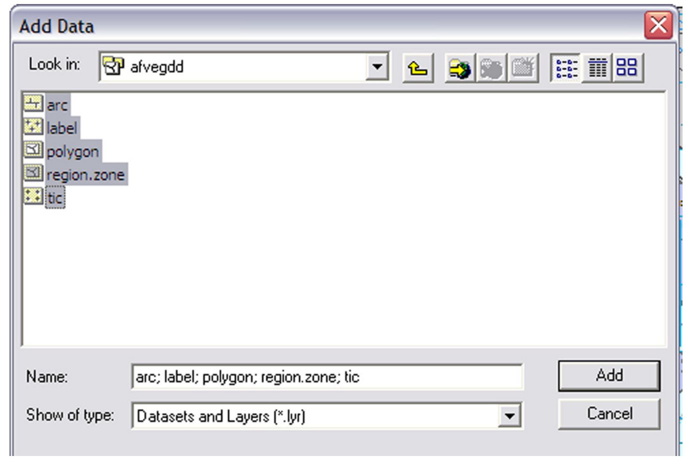

Figure 2. Highlighting and adding the files needed for the vegetation data layer.

Modify the Appearance: When you see the distributions in your Africa map one will appear over the other (the order of appearance can be modified by moving the layers up or down on the legend at left). If the historical layer is placed above the current distribution, the smaller will be hidden. You can modify the appearance so that the order does not matter by double-clicking on the small color square in the legend. A menu pops up that allows you to select the fill color (you can select "no color" as an option), the line width (make it bigger so you can see it), and the line color (you decide). You are now ready to start examining your distributions. Another approach might be to show the students how to set transparency to eliminate administrative boundaries, thus both speeding up the redraw and simplifying the map.

Preparation for Analysis: Before importing more layers, lead students in a discussion of the following questions:

1. What do lions need to survive? [*Teacher's note: entice students to think about the three basics of food, drink, and shelter.*]
2. What habitat characteristics are necessary to provide these needs?
3. What layers are available to explain these conditions for the historical lion distribution?
4. What do you think has changed in these conditions to account for the smaller current distribution?
5. What are the possible causes of these changes?
6. Which available layers do we have to make these comparisons?

Comparing Layers: [*Teachers note: this is one example. Each factor the students select will involve a separate set of steps and a separate subsequent discussion.*]

1. For the historical distribution it was determined that vegetation was responsible for the prey base from which the lion gets its food. Load the vegetation data available within the RESOURCE folder under VEG. The file folder "afvegdd" contains the vegetation for Africa. Click on that folder and, using the shift key and left mouse button to highlight all the elements listed (arc, label, polygon, region.zone, and tic), click the add button (Fig. 2).
2. As before, the reference system warning will appear on screen. Accept all, if you did not turn off this warning earlier.
3. Move the lion distribution map (one or both) above the two vegetation layers (afvegdd, afvegdd region.zone).
4. Compare the lion distribution (either one) to the large scale vegetation zones by turning off the afvegdd layer (clicking on the check mark).
5. Notice that although the vegetation layer is visible, it has no distinctive shading patterns. That is because the default is to assign a single color to all polygons. Go to the afvegdd region.zone layer and right click on its title. When the popup appears click on "properties" (Fig. 3).
6. On the resulting menu make sure you are in the "symbology" tab. Select categories and proceed to select "ZONE" from the values field, decide on a color ramp selection, and then be sure to click "add

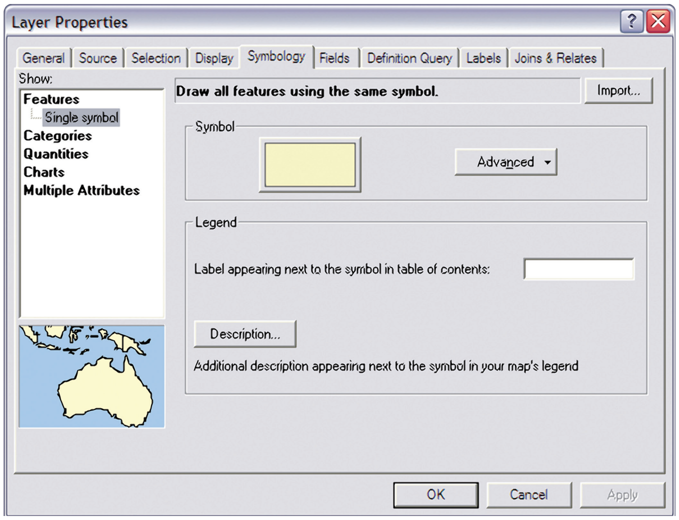

Figure 3. Changing the vegetation layer properties for different categories.

all values." Finally click the "apply" button and view the results (Fig. 4).

7. Check the vegetation codes against the list of vegetation types in the CODES folder of ArcAtlas using the "vegzone.txt" file. [*Teacher's note: to save time you might want to find these and reclassify the database beforehand.*]
8. Save the project to work on subsequent layers later on.
9. Answer the following questions.

Questions Relating Vegetation and Historical Lion Distribution:

1. Describe any pattern correspondences you observe.
2. What vegetation types are most commonly found in the historical lion range?
3. Which vegetation types are only partly found, particularly on the edge of the historical lion range?
4. Why is the correspondence not perfect? [*Teacher's note: refer to the ideas of classification, mapping scale, and multiple related factors.*]
5. What other factors could we examine to make our relationships better correlate?
6. Given what you have concluded from Question 5, continue to add layers and evaluate the spatial correspondences between the current and past

Table 2. Comparison of exercise with National Geography Standards.

National Standard	Exercise
How to Use Maps and Other Geographic Representations, Tools, and Technologies to Acquire, Process, and Report Information From a Spatial Perspective	The exercise relies explicitly on the use of maps and geographic data and forces the students to perform all these tasks as a final product.
How to Use Mental Maps to Organize Information About People, Places, and Environments in a Spatial Context	This is weakly addressed at first, but the results form strong mental maps after analysis.
How to Analyze the Spatial Organization of People, Places, and Environments on Earth's Surface	The use of visual display and correspondence of maps for analysis explicitly addresses this standard.
The Physical and Human Characteristics of Places	All characteristics of the region are necessary to do the exercise.
That People Create Regions to Interpret Earth's Complexity	A part of the discussion involves the relationship of classification to analysis.
How Culture and Experience Influence People's Perceptions of Places and Regions	This is addressed implicitly, but not explicitly. The choice of an unfamiliar region modifies our perceptions.
The Physical Processes That Shape the Patterns of Earth's Surface	This is explicitly addressed in the correlation of distributions.
The Characteristics and Spatial Distribution of Ecosystems on Earth's Surface	Because we are working with lions this is an integral part of the analysis.
The Characteristics, Distribution, and Migration of Human Population on Earth's Surface	Not explicitly included except for predicting future distributions and other labs related to human distributions.
How Human Actions Modify the Physical Environment	Explicitly addressed by examining the change in lion range.
The Changes That Occur in the Meaning, Use, Distribution, and Importance of Resources	Implicitly addressed in the final report and discussions.
How to Apply Geography to Interpret the Past	Explicitly addressed by examining the historical lion range
How to Apply Geography to Interpret the Present and Plan for the Future	Explicitly addressed in the final report and purpose of the exercise.

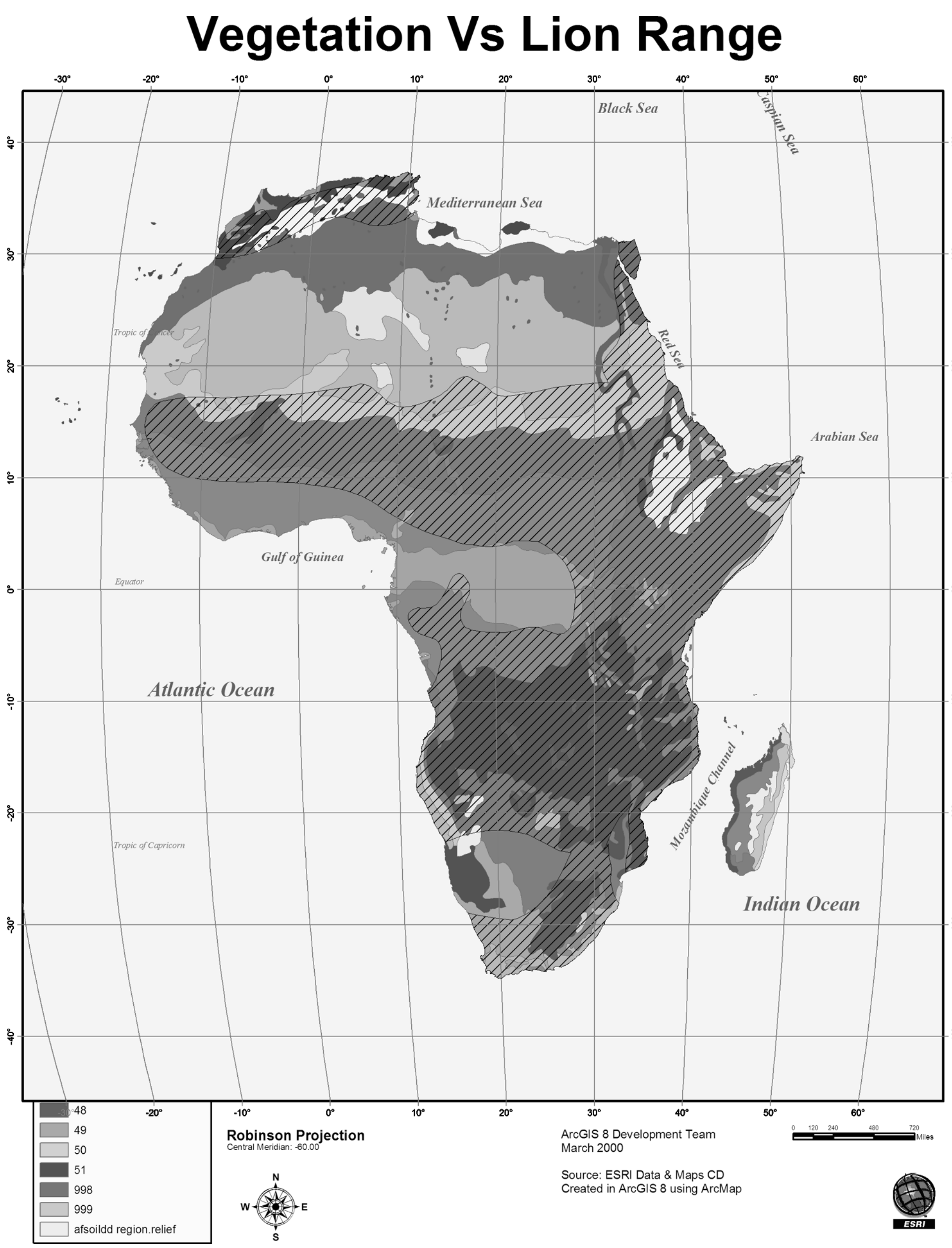

Figure 4. The output map of vegetation zones related to historical lion range.

distributional patterns of lions and physical, and your selected socioeconomic factors that you have selected.

Final Report: Provide a final report including the maps created that includes the following.

1. Explanations of the relationships between the historical lion range with appropriate factors (e.g., vegetation, soil, other animals, etc.). [*Teacher's note: depending on the class level, it might be important to remind the students about the spatial association between, for example, prey animals and their vegetation.*]
2. Explanations of the relationships between the smaller current distribution of lions and other spatial factors (especially related to nonphysical factors that might have altered the availability of habitat).
3. Description of what you anticipate the range of the species will look like in the future given no change in current trends (e.g., population, land use, desertification, etc.).

4. A final recommendation for what might be appropriate means of ensuring the survival of the species. [*Teacher's note: this is a great way to have students weigh the habitat needs of a wildlife species against the needs of the human population.*]

Some Suggested Additions

There are many additional exercises that can be linked explicitly to this brief exercise. Among the more interesting, include an examination of socioeconomic factors related to the lion distributions, especially to the change in distribution. For more advanced students, the before and after maps of lion distributions could be compared using an intersection overlay, thus indicating only the area that is no longer occupied by the lion. This would allow the student to examine a host of possible related layers, both physical and human. An interesting approach might be to have the student examine the land use layer relative to the change in lion range. The examination of the lion's range might also encourage students in the biology class to examine what other wildlife distributions correspond to the lion's range to evaluate what they eat. This is an excellent discovery method that could then be confirmed by a relatively cursory review of literature or Internet resources. With the robust dataset available with ArcAtlas, the list of potential exercises is enormous and is limited only by the quality of the data, the ingenuity of the instructor, and the nature of the class in which it is being developed.

Relationship To The National Geogrpaphy Standards

In K–12 environments this exercise, and the possible derivative exercises that could result from it, has the distinct advantage of addressing many of the existing National Geography Standards (Geography Education Standards Project 1994). Table 2 reviews which standards are addressed and how this is accomplished. Keep in mind that while some of these standards are not addressed, there is ample potential for their application within the ArcAtlas database.

References

Audet, R. H., and G. L. Abegg. 1996. Geographic information systems: Implications for problem solving. *Journal of Research in Science Teaching* 33(1): 21–45.

Baker, T. R. 2005. Internet-based GIS mapping in support of K–12 education. *The Professional Geographer* 57(1): 44–50.

Dede, C. 2005. Planning for neomillenial learning styles. *Educause Quarterly* 1(3): 7–12.

DeMers, M. N. 1999, Integrating GIS into the K–12 curriculum. *Education West* 3(2): 24–25.

Downs, R. M., and A. R. de Souza. 1994. *Geography for Life: The National Geography Standards*. Washington, DC: National Geographic Society Committee on Research and Exploration.

Geography Education Standards Project. 1994. *Geography for Life: The National Geography Standards*. Washington D.C.: National Geographic Society Committee on Research and Exploration.

Hill, D. A. 1994. Geography instructional materials for standards-based education. *Journal of Geography* 93(1): 14–20.

Meyer, J. W., J. Butterick, M. Olkin, and G. Zack. 1999. GIS in the K–12 curriculum: A cautionary note. *The Professional Geographer* 51(4): 571.