

## Finding a Place for Panthers: Mapping Conservation Issues Related to Florida Panthers

**Author(s):** J. Stephen Gosnell, David P. Green, Laila Akallal, Chelsea Wepy, Gregory Laghiti, Muspika Akter, Noa Heller, and Nihal Ozgur

**Source:** Lessons in Conservation, Vol. 12, Issue 1, pp. 27-47

**Published by:** Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History

**Stable URL:** [ncep.amnh.org/linc](https://ncep.amnh.org/linc)

This article is featured in *Lessons in Conservation*, the official journal of the Network of Conservation Educators and Practitioners (NCEP). NCEP is a collaborative project of the American Museum of Natural History's Center for Biodiversity and Conservation (CBC) and a number of institutions and individuals around the world. *Lessons in Conservation* is designed to introduce NCEP teaching and learning resources (or "modules") to a broad audience. NCEP modules are designed for undergraduate and professional level education. These modules—and many more on a variety of conservation topics—are available for free download at our website, [ncep.amnh.org](https://ncep.amnh.org).

**Note to educators:** access presentations, teaching notes, exercise solutions, and associated files for these modules by registering as an educator, and searching for module by title.



**To learn more about NCEP, visit our website:** [ncep.amnh.org](https://ncep.amnh.org).

All reproduction or distribution must provide full citation of the original work and provide a copyright notice as follows:

"Copyright 2022, by the authors of the material and the Center for Biodiversity and Conservation of the American Museum of Natural History. All rights reserved."

Illustrations obtained from the American Museum of Natural History's library: [images.library.amnh.org/digital/](https://images.library.amnh.org/digital/)

# Finding a Place for Panthers: Mapping Conservation Issues Related to Florida Panthers

J. Stephen Gosnell<sup>i,ii</sup>, David P. Green<sup>iii</sup>, Laila Akallali<sup>i</sup>, Chelsea Wepy<sup>i</sup>, Gregory Laghitij<sup>i</sup>, Muspika Akter<sup>i</sup>, Noa Heller<sup>i</sup>, and Nihal Ozgur<sup>i</sup>

<sup>i</sup>Department of Natural Sciences, Baruch College CUNY, New York, NY, USA; <sup>ii</sup>The Graduate Center of the City University of New York, New York, NY, USA; <sup>iii</sup>National Center for Science and Civic Engagement, Washington, DC, USA

## ABSTRACT

Restoring wildlife populations requires locating, protecting, and connecting areas where species can thrive under both ecological and anthropological conditions. Addressing these spatial needs may be difficult, as required habitats may have been lost, fragmented, or altered prior to restoration. Changes in land use may also lead to increased human-animal interactions that impact restoration outcomes. In this exercise, students consider these issues in a case study of Florida panthers (*Puma concolor coryi*), a currently federally protected carnivore that has a growing population in the state of Florida, USA. Students will use Google Earth to view, manipulate, and create maps related to the growth of panther populations and related habitat needs and human interactions from the early 1990s to 2021. In doing so they will explore how stakeholders interact with each other and with panthers regarding both their hopes for species restoration and the areas they represent or occupy. Students will also consider various ways stakeholders may be engaged to provide panthers with increased protection and expanded ranges, including land acquisition, conservation easements and banking, and wildlife corridors.

## LEARNING OBJECTIVES

After completing this exercise, students will be able to:

1. Produce maps by uploading, opening, and manipulating spatial datasets in Google Earth, including adding placemarks and changing display properties.
2. Identify and define methods used to increase habitat and connectivity for endangered species, including land acquisitions, conservation easements, wildlife crossings, and conservation banking, and discuss why stakeholders use these methods.
3. Discuss how the spatial needs of species and stakeholders interact to determine ecologically and socially acceptable management strategies.

## INTRODUCTION

Although efforts to restore native populations—including reintroductions (Taylor et al. 2017) and supplementations (Seddon et al. 2014)—are becoming more prevalent, a common source of tension is determining where and how species ranges should be developed or expanded. The habitats species require to thrive may have been lost due to conversion to other uses, such as agriculture, grazing, and urban development; habitats may also have been degraded due to factors such as pollution and climate change (Kerr and Deguise 2004; Maxwell et al. 2016). Even when patches of optimal habitat still exist, they are often too small to meet species needs (Banks-Leite et al. 2020) and fragmented. Re-establishing ranges for growing populations may thus require using various conservation tools to create a patchwork of connected habitat parcels that may differ in habitat quality and protection status due to their history and land use restrictions.

Along with increases in the population size of restored species, changes in habitat availability and

efforts to connect parcels may lead to increased human-animal interactions. These interactions may have direct (via mortality or fitness) or indirect (via public or financial support) positive or negative impacts on restoration outcomes. This is especially true when the focal species are apex predators [e.g., sea otters (Pinkerton et al. 2019), tigers (Doubleday 2018)] since stakeholders<sup>1</sup> may have concerns regarding potential impacts of predator consumption on humans, pets, livestock, and large game (Lopes-Fernandes and Frazão-Moreira 2017; Niemiec et al. 2020; Sakurai et al. 2020) or associated non-consumptive effects (Laporte et al. 2010). These concerns must be balanced with the potential benefits that restoring predator populations and protecting habitats can have for ecological and human communities (Gilbert et al. 2017; Martone et al. 2020).

Attempts to restore the Florida panther (*Puma concolor coryi*) population in Florida exemplify these issues. Beyond its status as a predator, spatial considerations are especially relevant given the large habitat needs of the species. Efforts to recover the existing population through genetic introgression<sup>2</sup> and protecting habitat over the past thirty years have been successful, but now managers must decide how to handle the growing population and range needs of this large felid. In this activity you will follow changes in the panther population and habitat usage from this period and ponder future options for the continued restoration of the species. In doing so you will consider the needs of various stakeholders and learn how mapping species and stakeholder needs can provide a visual context for exploring, valuing, and comparing management options.

## EXERCISE

This exercise is a sequential activity and is designed so you can see the changes in panther protection and restoration in Florida over time. Questions are spread throughout to assess your grasp of skills and concepts. A full list of questions contained in the exercise can be found in [Appendix 1](#). Numbered responses to questions should be aggregated in a short report document for submission.

In this exercise students will use Google Earth, a free geodesign tool, to map the habitat usage and needs of Florida panthers and then relate them to the needs of various stakeholders. Maps allow the spatial aspect of data to be easily visualized and may offer insight on where restoration may be more supported given the needs of panthers and desires of human communities. Reading related media articles will supplement and provide context to GIS-based (geographic information system) activities.

Google Earth (<https://www.google.com/earth/>) is software produced by Google that offers access to satellite and aerial imagery of different parts of Earth that can be used to produce static or interactive maps. The Google Earth platform has been utilized for conservation research and outreach. For example, scientists have used Google Earth to study deforestation in Gombe National Park, Tanzania (Pusey et al. 2007), and classify different mangrove communities (Calva et al. 2019). Also, the Jane Goodall Institute has produced an interactive [Google Earth Voyager story titled Goodall, Gombe and Google](#) (Jane Goodall Institute 2017).

The below instructions focus on using the web-based version of Google Earth, given its ease of access and use across platforms. This also allows the exercise to be easily completed via in-person, remote, or hybrid learning modalities. In all modalities, students will need access to a computer with connection to the internet. Images below were formed using Google Earth version 9.176.0.1. Notes on implementing the exercise, copies of the articles used in this exercise, and information on potential extensions to this activity are available in the Instructor Notes, which can be downloaded from the NCEP module website (<https://ncep.amnh.org/>).

## Importing panther data into Google Earth

First, launch Google Earth. Visit <https://www.google.com/earth/>; the application should automatically load, resulting in an image of the earth. Once loaded, note you can move around the globe or zoom in and out for different views using your mouse and/or keyboard. Different types of data, such as names and locations of natural (e.g., lakes), political (e.g., boundaries), and man-made (e.g., roads) features can be displayed using the Map Style menu (Figure 1). **Make sure you can navigate around the globe and select different types of data to display before continuing.** Users can also create their own features (points, lines, and polygons) to overlay on top of these images using tools in the software. You will learn to create these features as part of the exercise.

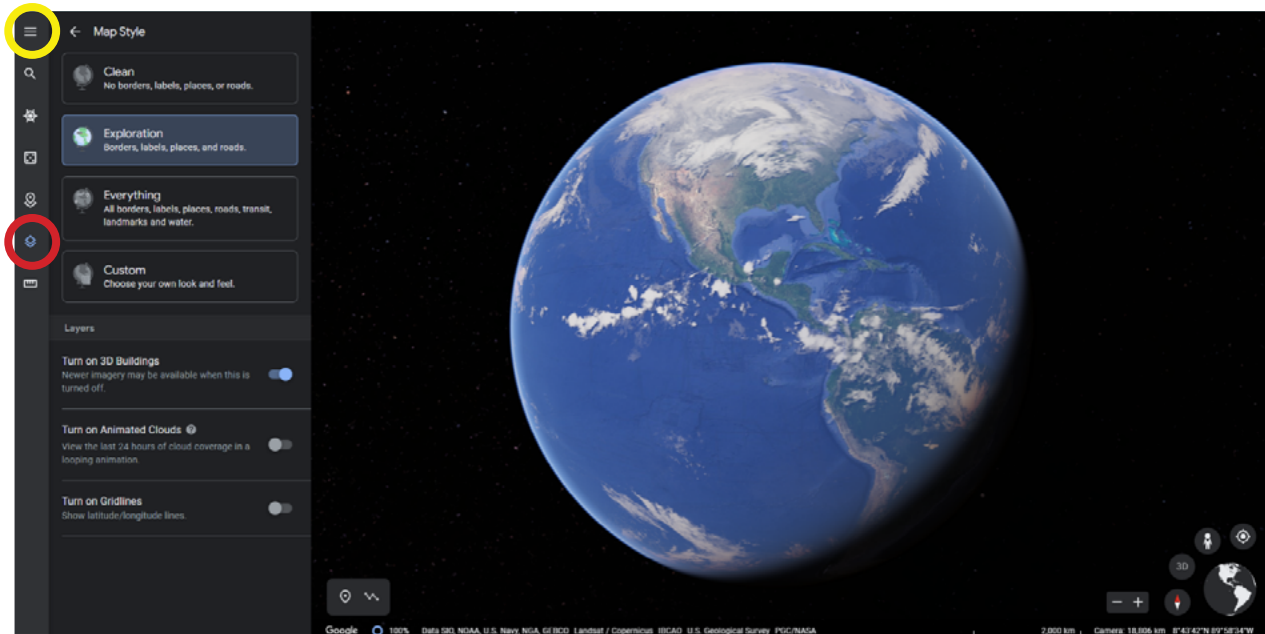


Figure 1. Users can choose the type of data displayed on Google Earth under the Map Style menu (outlined in red). Users can also change settings by selecting the Menu button (outlined in yellow) and then Settings (the gear icon) on the pop-up menu.

Next, download the exercise file (.kml or .xml file extension) that is available as a supplementary file with this module at <https://ncep.amnh.org>. Then import the file into Google Earth. For the web version of Google Earth, select the **Projects** menu (Figure 2). Then choose **Open** and choose to upload the file from your computer. Once opened, you may see a pop-up asking for permission to store the file (common on Chromebooks); please allow this so you can edit the map as required for later questions.

After you have imported the data, your Project should automatically open and look like the image shown in Figure 3. The loaded file combines data from several datasets previously published and mapped by the Florida Wildlife Commission (FWC). The combination of spatial data and information on how programs should render it are known as layers. The column on the left shows the various layers that are contained in the file.

In the web version of Google Earth, these layers cannot be expanded or collapsed, so you will also see various sub-layers contained in each layer (denoted by a folder icon). These sub-layer folders can be expanded further to show the actual features (polygons and placemarks) that can be displayed on the map (Figure 3, icon outlined in yellow). These features identify areas needed for the continued survival and restoration of Florida panther populations (Logan et al. 1993; Kautz et al. 2006) and document panther interactions with humans.



Figure 2. You can import KML or XML data into the web version of Google Earth by using the Projects menu (outlined in red).

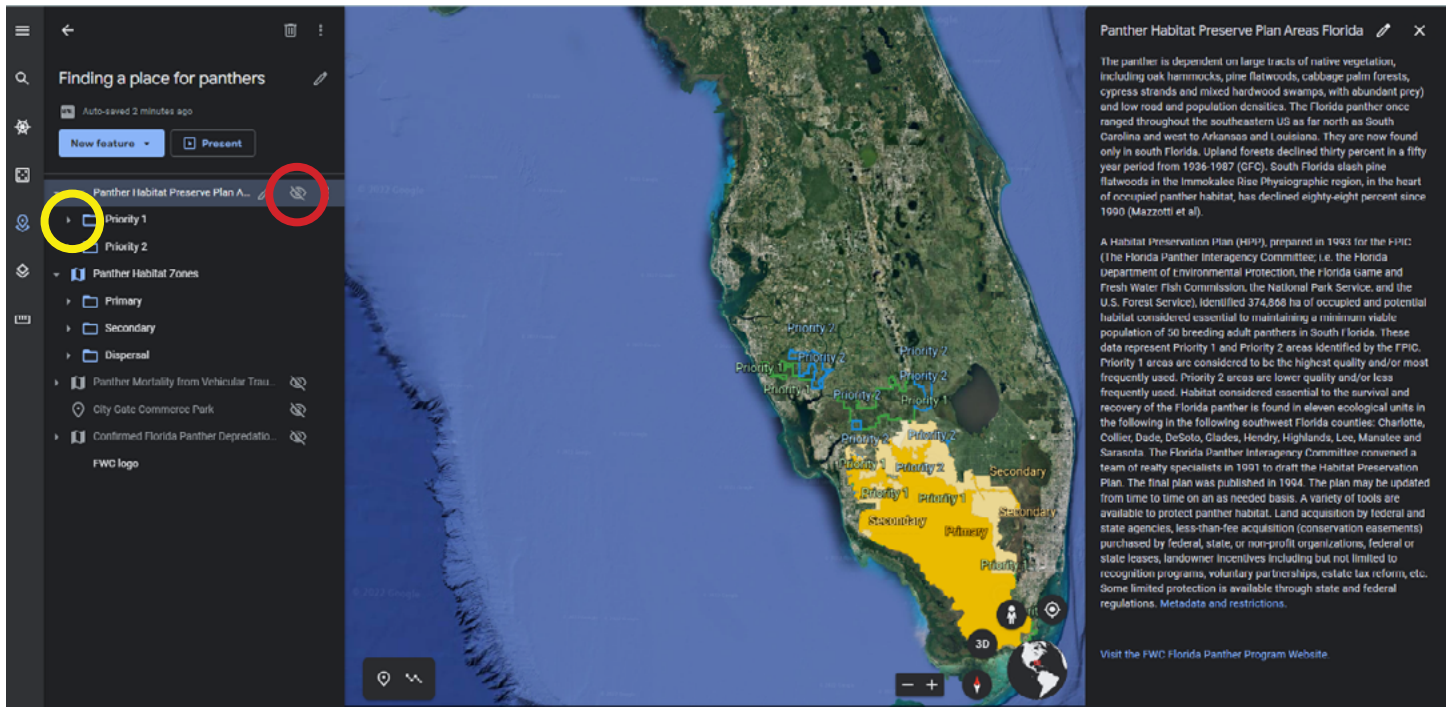


Figure 3. Overview of properly imported data in the web version of Google Earth. Selecting the layer name will open an information box. Selecting the icon outlined in red will stop displaying a layer. Selecting the icon highlighted in yellow will display the features contained in each sub-layer. Note primary layers are expanded to show information contained in sublayers.

You can hide or show layers, sub-layers, or individual features by hovering your mouse over a feature and selecting the **Show/Hide feature** (eye) that appears next to it (Figure 3, icon outlined in red). Although all icons show an eye with a line through it initially, when you hover your mouse over the icon it will continue to display this icon (and note "Hide feature") if the feature is currently displayed. For example, select the **Hide feature** (eye) icon next to the Panther Habitat Preserve Plan Areas Florida layer to see what happens.

If the feature is not currently displayed, hovering over the icon will result in the icon switching to an eye without a line through it (and note "Show feature"). By default, several layers are not displayed when you open the map. For example, re-display the Panther Habitat Preserve Plan Areas Florida layer by selecting the **Show feature** icon. **Note that if the layer or sub-layer (folder) that contains a feature is hidden, the feature or layer will not display on the map even if you select "Show feature" for that specific feature.**

Selecting any layer, sublayer, or feature listed in the Projects menu will open available information boxes. For example, selecting the Panther Habitat Preserve Plan Areas Florida layer will open the information box shown in Figure 3. By default, only data on panther habitat needs are initially displayed. Each of these layers contains multiple features (polygons or points). Double-clicking the layer will also zoom to a default view.

Selecting any of the features (outlined or highlighted regions or placemarks) on the map itself will also display additional information. For example, right-clicking on the polygons displayed by default should cause boxes to appear with information on the parent layer, size, and designation of the focal polygon (Figure 4).

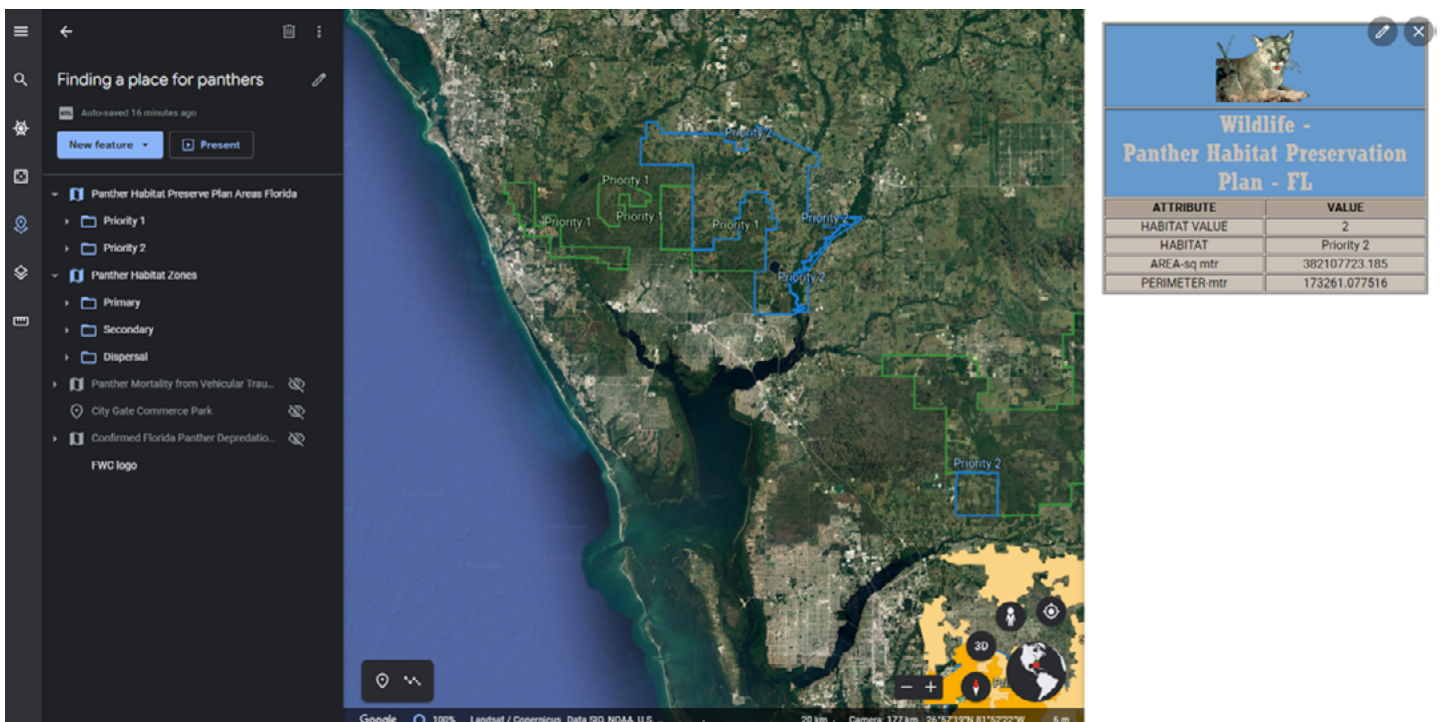


Figure 4. Information box with additional information appears when an area is selected.

## The history of panthers in Florida

Pumas (*Puma concolor*), also known as cougars, catamounts, and mountain lions, are large felid predators that were historically located throughout the Americas (Frakes et al. 2015). Populations in North America commonly interacted through the movement of adults (Culver et al. 2000; Saremi et al. 2019). However, these populations were greatly reduced, and in some cases extirpated, in the 19<sup>th</sup> and 20<sup>th</sup> centuries due to habitat loss and intentional hunting (Saremi et al. 2019). In the southeastern United States, these pressures resulted in the local species representative, known as the Florida panther (*Puma concolor coryi*) [Box 1], losing much of its historical range and being restricted to a small, isolated population in southern Florida (van de Kerk et al. 2019).

This population decline led to increasing state-level protections in Florida in the 1950s and eventual federal designation as an endangered subspecies in 1967 by the Department of the Interior. Despite these efforts, by the early 1970s the Florida panther population consisted of approximately 20 independent adult panthers (U.S. Fish and Wildlife Service 2008). The subspecies was further protected under the Endangered Species Act upon its passage in 1973. Under the Endangered Species Act, three distinct populations that each consist of at least 240 adults are required before delisting can be considered (U.S. Fish and Wildlife Service 2008).

Since their listing, groups including the U.S. Department of Fish and Wildlife Service, the Florida Fish and Wildlife Commission, and non-governmental organizations (NGOs) have worked to recover the Florida panther population (U.S. Fish and Wildlife Service 2018).

### Exploring panther habitat needs

Following their designation as a protected species, finding, protecting, and connecting habitat has been identified as a major issue in allowing panther populations to grow and eventually expand (U.S. Fish and Wildlife Service 2008). Many of the preferred habitats of panthers had seen drastic declines over the past century in Florida due to urban development, agriculture, and livestock grazing (Logan

#### Box 1: Panther Biology

Adult male panthers typically weigh 100–160 pounds and may reach up to seven feet in length (nose to tip of tail). Females are smaller, weighing 50–115 pounds and reaching six feet in length (U.S. Fish and Wildlife Service 2018). Adults typically have dark reddish-brown fur on their backs. Fur color fades to a gray or white underside, and no spots are present. Juveniles (kittens) have grayish-brown fur with darker spots and a ringed tail. These large carnivores primarily consume white-tailed deer, wild hogs, raccoons, armadillos, and other mammals (U.S. Fish and Wildlife Service 2008).



A mother with three cubs. Photo credit: U.S. Fish and Wildlife Service Southeast Region via Wikimedia Commons (public domain).

et al. 1993). Finding space for these large mammals, however, is difficult given conflicting demands for limited space on the Florida Peninsula. Adult panthers are solitary (apart from breeding), and their hunting and breeding requirements demand large, overlapping home ranges; male ranges can range from 435–978 km<sup>2</sup>, while females ranges span 193–396 km<sup>2</sup> (U.S. Fish and Wildlife Service 2008; Alfano 2013). Male ranges may include the home ranges of several females and their offspring.

To begin the exercise, you will first consider the habitat needs of Florida panthers as noted in 1993. These needs are displayed in the Panther Habitat Preserve Plan Areas Florida layer. To stop displaying features associated with the Panther Habitat Zones layer, hover over the layer and select the “Show feature” (eye) icon to hide all features associated with that layer. Click on the layer name to view information about the layer. The box also provides a link to the metadata for the layer and the Florida Fish and Wildlife Conservation Commission (FWC) website page on the Florida panther.

In 1993, the Florida Panther Interagency Committee presented maps of essential habitat that needed protection to support panther populations in South Florida (Logan et al. 1993). Areas were selected that would support at least the 50 adult panthers that population viability analysis indicated would be required for a self-sustaining population. This was done even though panthers continued to persist at low population numbers into the early 1990s, with many individual panthers suffering from reproductive and developmental issues that were likely due to inbreeding depression due to the lack of gene flow from other populations (Gross 2005; van de Kerk et al. 2019).

1. Why do you think the Committee focused on protecting habitat even when population numbers were low?

The Committee ranked focal areas as Priority 1 or 2 for protection based on current and potential future usage by panthers. As much of the identified habitat was on private lands, the Committee’s report also emphasized the importance of using both land acquisitions and strategies that encouraged private landowners to protect panther habitat (Logan et al. 1993; U.S. Fish and Wildlife Service 1999).

2. Ensure all areas are displayed (you should see Priority 1 and Priority 2 zones). Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as “Figure 1”. In the caption explain what the Panther Habitat Preservation Plan shapes identify.

To address issues related to inbreeding depression, eight females from the nearest geographical subspecies (*Puma concolor stanleyana*, native to Texas) were released in Florida in 1995 in an attempt to increase genetic diversity in the population (Gross 2005; Johnson et al. 2010; Hostetler et al. 2010). This purposeful movement of individuals to restore genetic diversity, or genetic introgression, effectively restored historic connectivity among meta-populations. Genetic restoration was successful, with admixed kittens having increased survival (Hostetler et al. 2012). Panther numbers increased over the following decade, with estimates ranging from ~100–200 adults and sub-adults by 2008 (McBride et al. 2008; Johnson et al. 2010; McClintock et al. 2015).

As the panther population grew, continuing efforts were made to monitor and understand the habitat needs of the growing population. In 2002, the Panther sub-team of the Fish and Wildlife Service’s Multi-species/Ecosystem Recovery Implementation Team (MERIT) identified regions that were both of current use to panthers and that might be used in dispersal outside of South Florida (U.S. Fish and



Wildlife Service 2008). These zones are displayed in the Panther Habitat Zones layer. Display the layer and read the provided information box.

As noted in the information box, three types of zones were used to identify areas currently inhabited by Florida panthers (in 2002) or of potential future. You will produce several maps of these zones and collect some information regarding them.

3. Produce a map that only shows the **Primary** Zone of panthers. You can do this by selecting the **Hide feature** icon for the folders that contain the features associated with the Secondary and Dispersal Zones (and for the Panther Habitat Preserve Plan Areas Florida layer). Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 2". Provide a descriptive caption for what the image shows, including the size of the area (convert to km<sup>2</sup>). You can find this information by clicking on the Primary Zone in Google Earth; this will cause an information box with information about the selected area to appear (Figure 4). Information provided includes the area's size (in squared meters), type of zone, and link to metadata.
4. Next, add all the **Secondary** and **Dispersal** Zone layers to the previous map by selecting the **Show feature** (eye) icon next to the folder containing those features. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 3". Provide a descriptive caption for what the image shows, including the size of both the Secondary and Dispersal Zones (convert to km<sup>2</sup>). Since there are multiple areas that comprise the Secondary Zone, you will need to select each individual area, note their size, and calculate the total area in the zone. Note, we recommend you expand the Secondary zone sub-layer on the left menu and click on individual polygons to display the needed information to make sure you do not miss any areas.
5. Next, produce a map of only the **Dispersal** Zone layer by hiding all other zones and zooming into this area. To see the habitat that comprises the dispersal zone, we will manipulate the transparency of the shape feature. You can select the **Edit feature** (pencil) icon (Figure 5) in the informational box that appears when you click on the dispersal zone. You can also find this icon if you hover your mouse over the Dispersal Zone shape feature (denoted by a polygon icon; Figure 5). Select this and change the fill color saturation level from 100% to 25% in the box that opens. Note you can also change the outline or fill color if you wish.

Now you should be able to see the habitat cover and shaded area of the dispersal zone simultaneously. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 4". In the caption, explain why the dispersal zone is essential to the continued success of Florida panther restoration.

6. What major landscape features do you observe in the Dispersal Zone?

The river that runs through this area is the Caloosahatchee River. It marked the northern boundary of the known breeding population following the release of panthers from Texas until 2017 (U.S. Fish and Wildlife Service 2008, 2018; Florida Fish and Wildlife Conservation Commission 2022).

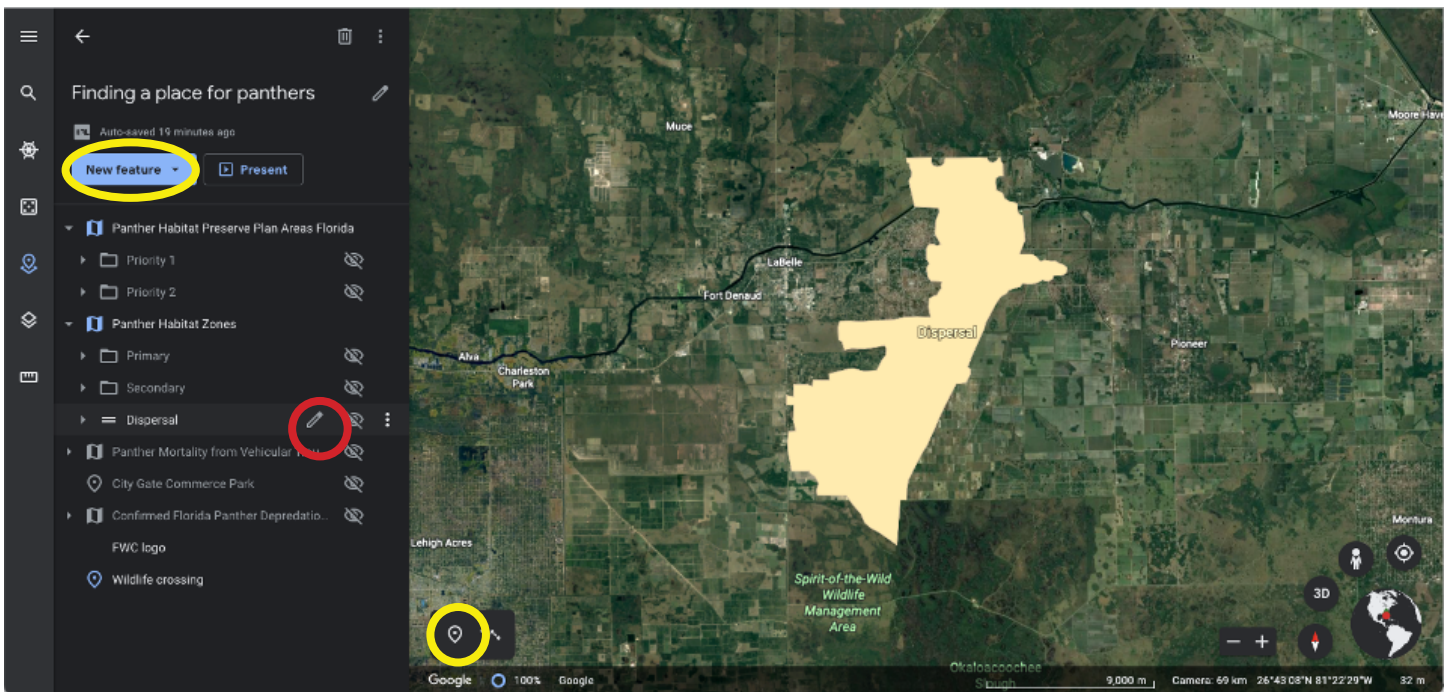


Figure 5. The Edit feature icons (outlined in red) allow you to manipulate feature properties. The Add placemark icon and New feature button (both outlined in yellow) allows you to add new features such as placemarks to your project. The coordinates of your current cursor location are also displayed in the lower right corner of the map (area outlined in blue).

- Note you can add a placemark on your own to the map by selecting the **Add placemark** icon or button under the New feature menu (Figure 5). Select this icon and add a placemark to the area where the dispersal zone intersects the Caloosahatchee River. Name the placemark *River intersection*. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 5". Note the importance of the river that runs through the dispersal zone in your caption.

You can also provide the coordinates of the *River intersection* placemark. Coordinates use a system of reference grids to specify the location of a spot on Earth. Although multiple reference grids exist, Google Earth uses a coordinate system known as the World Geodetic System (WGS-84, specifically) to identify the location of a site using latitude, longitude, and elevation. Remember, latitude measures how far north or south a point is from the equator and may be denoted as either N/S or +/- . Longitude indicates how far west or east a point is from the prime meridian and can be denoted as either W/E or -/+ . You can find coordinates in Google Earth by hovering your mouse over a point and looking in the bottom right corner of the screen, which displays coordinates in degrees, minutes, seconds format by default (Figure 5); this display can be changed in the Settings menu (Figure 1). Alternatively, if you use the **Edit feature** (pencil) icon next to a placemark you can find the coordinates in the table that appears (which displays coordinates in decimal degrees format but is the same location).

- What are the coordinates for your *River Intersection* Placemark?
- What is the benefit of being able to specify exact locations on earth to the management of natural populations? Give at least three clear examples.

One benefit of mapping software is the ability to display multiple layers simultaneously. For now, display the Panther Habitat Preserve Plan Areas Florida layer again. Note that displaying this data layer as “outlines only” allows layers to be easily stacked.

10. Using the PrintScreen function on your computer or a similar screenshot tool, capture an image of your Dispersal Zone layer (it may still be semi-transparent) and your placemark marking the *River intersection* along with the features associated with the Panther Habitat Preserve Plan Florida layer. Label it as “Figure 6”. In the caption discuss the relationship between the zones in the two layers.

Much like the Panther Habitat Preserve Plan areas, the zones identified by the MERIT sub-team included many privately held lands. For example, as of April 2001, 27% of the land in the Primary zone was privately held and the Dispersal zone was fully located on private lands. For these reasons, plan authors again discussed the importance of public-private conservation partnerships to panther conservation (Kautz et al. 2006).

For example, agricultural lands (e.g., pastures, citrus groves (see Pienaar et al. 2015) and hunting preserves (or privately-owned areas where customers pay for access to hunting sites while not targeting panthers, which may not be hunted given their protection under the Endangered Species Act) may be useful to panther recovery efforts. These are typically large areas where panther-human interactions may be limited, and they often include panther habitats such as forests and open areas. If managed appropriately, these types of properties can contribute to land protection and range expansion. One method of accomplishing this is to designate a piece of land as a conservation easement<sup>3</sup> (U.S. Fish and Wildlife Service 2019).

A conservation easement occurs when a private landowner voluntarily agrees to limit the use of their land to protect its conservation value. Importantly, landowners may be able to continue to use their land for approved low-impact activities that do not impede panther activity. These easements typically “run with the land,” meaning they are permanent and pass on to future owners. Landowners may be paid for entering into these agreements, and they may receive other benefits such as tax relief.

Compensation may be key to encouraging landowners to accept panthers and assist their range expansion, as their presence may come with costs. For example, panthers may prey on livestock and impact the targeted populations that hunting preserves are intending for human harvest. Although these effects may be minimal (for example, estimates suggest calf mortality due to panthers’ ranges from 0.5–5% annually (Jacobs and Main 2015), recognizing these potential costs and compensating landowners for providing habitat to panthers may allow for the expansion of panther range via private lands. Landowners may also be compensated for engaging in practices such as the removal of exotic plants that increase the value of habitats for panthers. These efforts may be funded by agencies such as the USDA’s National Resource Conservation Service, which administers the Environmental Quality Incentives Program (for more info, see USDA n.d.).

Market-based approaches like these can lead to added value for owners of low-use lands, further encouraging habitat conservation. Conservation easements can also offer ways to connect other protected lands, such as those in state or national parks or owned by groups for the sole purpose of habitat protection, so that organisms like panthers have a corridor to safely reach protected areas. For example, over 1500 acres of the Black Boar Ranch near Labelle, Florida, was entered into a conservation easement in 2015 to aid panthers and other species. The transaction involved payments

of 50% of the property's value (USD \$2,369,255) by the USDA's Natural Resources Conservation Service and 25% by The Nature Conservancy (NBC2 2015 p. 2). The terms of this easement means this land will remain undeveloped while still being actively used as a game preserve and cattle ranch. You can read (or listen to a podcast session) about this easement and how various stakeholders felt about panther range expansion in media produced by NPR (Allen 2015a, 2015b). Article, podcast, and transcript may be found on NPR's website (<https://www.npr.org/2015/07/03/418585657/on-the-rebound-panthers-prowl-expanding-swath-of-land-in-florida>) or downloaded by instructors from the NCEP Module collection.

11. In Google Earth, use the search tool to locate the *Black Boar Ranch* (Figure 6). On the resulting screen, select **Add to Project** to add a placemark for the ranch. Manipulate layers as needed to produce a map showing how the ranch relates to habitat and preservation zones. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 7". In the caption, explain what you displayed and the importance of the Black Boar Ranch in terms of both habitat and panther species range.

This property connects to other conservation easements to the south (Warren 2013) and to the north to better fill in the dispersal zone of the panthers and facilitate their movement across the river. You can read more about these easements in the U.S. Fish and Wildlife article by Warren (download it directly from this module's page at <https://ncep.amnh.org> or ask your instructor for the pdf version) and in an article from The Nature Conservancy (Seeger 2019). The Nature Conservancy article also has an interactive map that demonstrates connections among the protected lands and land change (visit <https://www.nature.org/en-us/magazine/magazine-articles/florida-panther-corridor> or ask your instructor for the pdf version).

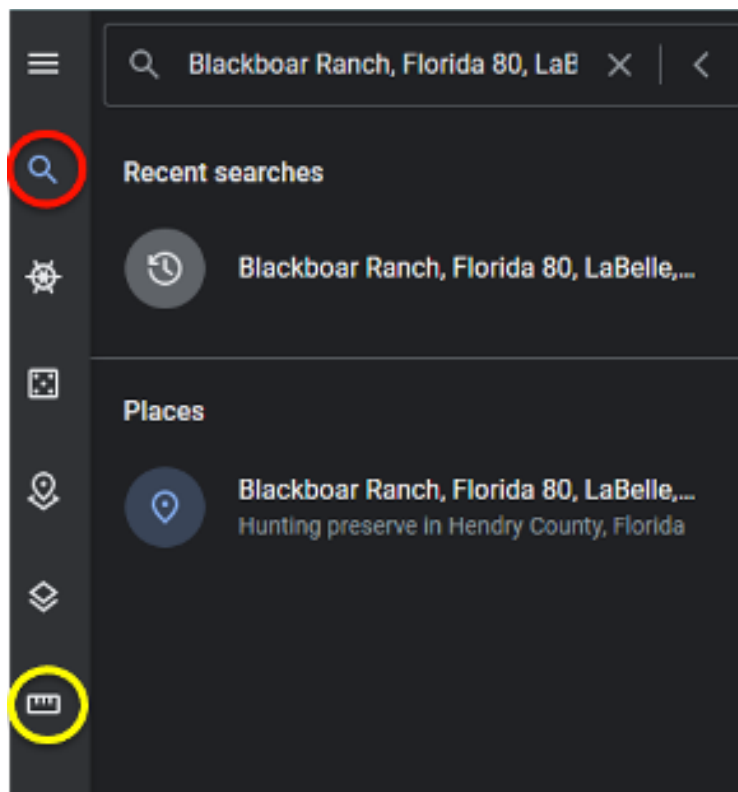


Figure 6. The Search (magnifying glass icon) tool is circled in red. The measuring tool is circled in yellow.

12. Read the articles by Warren and Seeger. Based on these and other readings completed throughout this exercise, name three reasons why choosing a conservation easement may be of value to the owner of a property. Also, name three reasons a property owner may choose not to enter a conservation easement.

These land protection efforts may have already contributed to the range expansion of the Florida panther. Recent (2022) estimates put the number of panther adults and sub-adults at 120–230 (U.S. Fish and Wildlife Service 2018), and evidence of northern range expansion has been documented. A female panther with kittens was confirmed north of the Caloosahatchee River in 2017, and additional female panthers, including a pregnant individual that unfortunately experienced mortality prior to birth, have been documented north of the river since then (U.S. Fish and Wildlife Service 2018; Kelly and Onorato 2020; Florida Fish and Wildlife Conservation Commission 2022).

### **Safety and acceptance within existing areas**

Even as panther populations expand, panther conservation still face issues. Despite a population increase, panthers still only inhabit ~5% of their ancestral territory (Frakes et al. 2015). Panthers also continue to encounter threats in established areas. Panther-vehicle collisions, for example, represent a major threat to the species, and roads may also further fragment available habitat.

13. To view the impact of vehicle collision on panther mortality, display the *Panther Mortality from Vehicular Trauma* layer. This layer shows all confirmed deaths due to vehicle collisions collected from February 13, 1972, through January 2, 2021. You can display it with (or without) other layers to make an informative image. Notice the image includes evidence of occurrence north of the Caloosahatchee River. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as “Figure 8”. In the caption note any patterns or trends you see. Are collisions distributed randomly, or do they occur more in certain areas? Where?

One option to mitigate vehicle mortalities is to create wildlife crossings that allow panthers and other species to safely navigate roadways. Understanding where panther-vehicle collisions commonly occur is necessary to optimally place these crossings, as further explored by Smith et al. (2006) and Downs et al. (2014). You can see how wildlife use these crossings in Collier County, Florida, in a YouTube video (<https://www.youtube.com/watch?v=iFJSfOsbcds&t=3s>) from the Florida Department of Transportation (Wildlife Crossing 2018).

Wildlife crossings may be constructed by state agencies. They also may be constructed as part of mitigation plans that may be required when development or other human activities would have negative impacts on protected wildlife. For example, developers of the large City Gate Commerce Park in Collier County, Florida, paid for the construction of a wildlife crossing near Immokalee, Florida (Layden 2010). This site was identified as a high priority area due to usage and panther-vehicle collisions (Swanson et al. 2005; Smith et al. 2006). You can read about this in a press release from Collier County (<https://www.colliercountyfl.gov/Home/Components/News/News/18090/18?date=20160506030200&npage=376&arch=1>) or downloaded by instructors from the NCEP Module collection (Collier County 2011). Another map of wildlife crossings and panther mortality may be viewed at <https://www.arcgis.com/apps/webappviewer/index.html?id=a105b26615f64b19b543eb9ab61fe197>.

14. Using information from the Collier County press release, attempt to find the City Gate-funded wildlife crossing. As a hint, click the “Map Style” icon on the left tool bar and choose “Everything” to see road names. Then use the search tool in Google Earth to search for Immokalee, Florida, then follow Country Road (CR) 846 (also known as Immokalee Road) east of town. You may need to make one or more layers from your currently displayed maps transparent or not visible. When you find the intersection of CR-846 and County Line Road, use the measuring tool (Figure 6) to find an area approximately 3 miles before the intersection (note, you can change the units from meters to miles by selecting the down triangle in the measuring tool dialogue box). You should be able to zoom in and locate the crossing. Place a landmark icon here and name it *Wildlife crossing*. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as “Figure 9”. In the caption explain why the crossing is essential to protecting Florida panthers.

Note that the wildlife crossing the developers paid to have built outside of Immokalee was not actually part of the developed property, which is located in Naples, Florida.

15. View the location of City Gate Commerce Park by turning on the placemark icon for the location in Google Earth. Make sure your image also shows the *Wildlife crossing* placemark. You can add any other layers you need to make an informative image or to offer insight on the placement of the crossing. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as “Figure 10”. In the caption discuss the benefits of allowing mitigation measures to take place in areas other than where the negative impacts on species actually occur. Are there any negative consequences to this approach to offsetting negative impacts on species?

Other options for mitigating negative impacts on threatened species include protecting lands that are part of a conservation bank<sup>4</sup> (Kreye and Pienaar 2015; U.S. Fish and Wildlife Service 2019). Conservation banks are lands that provide useful and protected habitat to focal species like panthers (U.S. Fish and Wildlife Service 2019). In exchange for protecting and maintaining or improving these areas, the landowners are provided with habitat or species credits that are approved by the United States Fish and Wildlife Service. These credits can be purchased by developers or other groups who need to compensate for the negative impacts (calculated using a published assessment method (U.S. Fish and Wildlife Service 2012) of their proposed activities on protected habitats or species. Conservation banking offers another market-based structure to mitigate negative environmental impacts while still allowing development to occur. Use of this practice may be more practical for developers than restoring small parcels of land and may also result in larger, more appropriate habitats being protected.

16. Read about panther habitat conservation banking in Florida in an article by Sarah Leon-Kilpatrick (download it directly from this module’s page at <https://ncep.amnh.org> or ask your instructor for the pdf version; Leon-Kilpatrick 2015). In which panther zones are the two banks discussed in the article located?

As noted in the article, conservation banks also explicitly value protecting lands for wildlife use. This value can be compared to values associated with development.

17. Do you consider establishing easements or species credits (via conservation banks) to be a payment for ecosystem services<sup>5</sup>? If so, what service are they providing, and do you think it was worth the cost?

In addition to land protection, other programs may also be used to incentivize conservation efforts and increase local support. For example, panthers may prey on pets in addition to domestic livestock (Jacobs and Main 2015), although these are generally rare events. You can view depredation on domesticated species using the *Confirmed Florida Panther Depredations of Domestic Animals* layer in Google Earth (data current through 12/3/2018). To address this issue, programs like the Florida Panther Compensation Program, which is run by the Conservancy of Southwest Florida, may compensate ranchers for free-range livestock lost to panthers or pay for pet and livestock pens. Read about these programs at the Florida FWCC page (<https://myfwc.com/wildlifehabitats/wildlife/panther/depredations/>) or downloaded by instructors from the NCEP Module collection (Florida Fish and Wildlife Conservation Commission 2022; “Depredations” n.d.).

18. Given that attacks on pets and livestock are rare, why do you think such programs are valued by conservation groups and other stakeholders? List at least three reasons.

### Support beyond a species range

Citizens living outside of the current range of the panther (in Florida and beyond) may also have feelings about panther restoration for various cultural or economic reasons. For instance, the panther plays a key role in the creation stories of the Seminole tribe of Florida, and the panther is one of eight non-human entities that represent a specific Seminole clan. The panther is also the state mammal of Florida and mascot for the state’s National Hockey League team, which hosts Conservation Nights and supports conservation efforts financially. Most of the state of Florida’s panther research is funded through the voluntary purchase of panther vehicle license plates, indicating a high level of public support (Florida Fish and Wildlife Conservation Commission 2022).

19. What do you think is the value of engaging stakeholders who may not be directly tied to the land used by panthers? Give at least three reasons engaging these stakeholders may be useful to conservation efforts.

20. How do you balance the desires of these stakeholders versus those who are directly impacted by panther restoration (like ranchers and pet owners)?

## CONCLUSION

Although panthers are still restricted to ~5% of their ancestral territory and dispersal opportunities remain an issue, the species shows promise for continued recovery beyond south Florida (Frakes et al. 2015; Frakes and Knight 2021). Areas in the north and Gulf coast portions of the state have been identified that may contain suitable habitat (Frakes and Knight 2021). Continuing to consider the different perspectives and needs of stakeholders, and where they are focused, will be critical to the success of this and other restoration programs, especially given the continued mixture of public and private lands panther populations are likely to need to grow (Pienaar et al. 2015).

## EXTENSIONS: CONSIDERING CHANGES IN PANTHER HABITAT OVER TIME

While we considered changes in habitat needs over time by viewing maps developed throughout the panther restoration program, Timelapse, an extension of Google Earth, allows you to consider temporal issues directly. For example, we can consider how available space has changed over time. You can open Timelapse in a separate tab at <https://earthengine.google.com/timelapse/>.

Given the importance of the dispersal zone to allowing panther populations to grow, we will focus on how this area has changed as an example of Timelapse. First, we need to enter coordinates into the Google Timelapse application. You can enter the coordinates you obtained from your *River intersection* placemark. You will need to enter coordinates in decimal format. If you select the **Edit feature** (pencil) icon next to the River Intersection placemark, you can find the coordinates in decimal degrees format in the table that appears (Figure 5). Alternatively, you can use the search tool to locate Black Boar Ranch again, given its proximity to the Caloosahatchee River (Figure 6).

21. Once the map is focused on the area corresponding to the dispersal zone, use the scroll bar at the bottom to select the year **1984** (or earlier if possible). Press the **Play** (triangle) icon to begin a slideshow of images showing views of the area over time. Note the slideshow may automatically repeat. For easier comparison, pause the show and select the earliest year possible. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Next use the scroll bar to select the most recent year. Capture this image as well and paste it into your report document. In the caption make sure you note the year that corresponds to each image (and their relative location). Using image marking tools in your document or screenshot tool, mark at least three areas regarding Panther habitat which have changed over time; you can do this by adding shapes over relevant areas.
22. What are the main differences between the two images? What are some possible causes of this?
23. Given the changes that have taken place in the dispersal zone over the past 25 years, what do you predict will happen in the next decade? How does this impact the need to preserve habitat for panthers?

## ACKNOWLEDGMENTS

Spatial data were originally provided by the FWC-FWRI (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute). Any alterations in the organization or display of the material is the responsibility of the authors. We appreciate the help each organization (The Nature Conservancy, National Public Radio, Florida Fish and Wildlife Conservation Commission, United States Fish and Wildlife Service) provided us in discussing optimal ways to share their work and their willingness to provide copies of the media noted in this article for off-line use by instructors (available in provided links or in Teaching materials via the NCEP collection; <https://ncep.amnh.org>). We also appreciate input students from Baruch College and reviewers provided on drafts of this activity.

## REFERENCES

- Alfano, J. 2013. Gaps in the Endangered Species Act: the plight of the Florida panther. *Boston College Environmental Affairs Law Review* 40:335–348.
- Allen, G. 2015a. On the rebound, panthers prowl expanding swath of land in Florida: transcript. Available from <https://www.npr.org/transcripts/418585657> (accessed December 2, 2022).
- Allen, G. 2015b, July 3. On the rebound, panthers prowl expanding swath of land in Florida. Available from <https://www.npr.org/2015/07/03/418585657/on-the-rebound-panthers-prowl-expanding-swath-of-land-in-florida> (accessed March 16, 2021).
- Banks-Leite, C., R.M. Ewers, H. Folkard-Tapp, and A. Fraser. 2020. Countering the effects of habitat loss, fragmentation, and degradation through habitat restoration. *One Earth* 3:672–676.
- Calva, L.G., J. Golubov, M. del C. Mandujano, A.L. Lara-Domínguez, and J. López-Portillo. 2019. Assessing Google Earth Pro images for detailed conservation diagnostics of mangrove communities. *Journal of Coastal Research* 92:33–43.
- Collier County. 2011, November 10. City Gate Wildlife Crossing accepted by Collier County. Available from <https://www>.



- [colliercountyfl.gov/Home/Components/News/News/18090/18?date=20160506030200&npage=376&arch=1](http://colliercountyfl.gov/Home/Components/News/News/18090/18?date=20160506030200&npage=376&arch=1) (accessed March 17, 2021).
- Culver, M., W. Johnson, J. Pecon-Slattey, and S. O'Brien. 2000. Genomic ancestry of the American puma (*Puma concolor*). *Journal of Heredity* 91:186–197.
- Depredations: Protecting Pets and Livestock. (n.d.). Available from <http://myfwc.com/wildlifehabitats/wildlife/panther/depredations/> (accessed March 15, 2021).
- Doubleday, K.F. 2018. Human-tiger (re)negotiations: a case study from Sariska Tiger Reserve, India. *Society & Animals* 26:148–170.
- Downs, J., M. Horner, R. Loraamm, J. Anderson, H. Kim, and D. Onorato. 2014. Strategically locating wildlife crossing structures for Florida panthers using maximal covering approaches. *Transactions in GIS* 18:46–65.
- Florida Fish and Wildlife Conservation Commission. 2022. Annual Report on the Research and Management of Florida Panthers: 2021-2022. Fish and Wildlife Research Institute & Division of Habitat and Species Conservation, Naples, FL, USA. Available from <https://myfwc.com/media/30334/pantherannualreport2022.pdf> (accessed December 2, 2022).
- Frakes, R.A., R.C. Belden, B.E. Wood, and F.E. James. 2015. Landscape analysis of adult Florida panther habitat. *PLoS One* 10:e0133044.
- Frakes, R.A., and M.L. Knight. 2021. Location and extent of unoccupied panther (*Puma concolor coryi*) habitat in Florida: opportunities for recovery. *Global Ecology and Conservation* 26:e01516.
- Gilbert, S.L., K.J. Sivy, C.B. Pozzanghera, A. DuBour, K. Overduijn, M.M. Smith, J. Zhou, J.M. Little, and L.R. Prugh. 2017. Socioeconomic benefits of large carnivore recolonization through reduced wildlife-vehicle collisions. *Conservation Letters* 10:431–439.
- Gross, L. 2005. Why not the best? How science failed the florida panther. *PLoS Biology* 3:e333. Public Library of Science.
- Hostetler, J.A., D.P. Onorato, D. Jansen, and M.K. Oli. 2012. A cat's tale: The impact of genetic restoration on Florida panther population dynamics and persistence. *Journal of Animal Ecology* 82:608–620.
- Hostetler, J.A., D.P. Onorato, J.D. Nichols, W.E. Johnson, M.E. Roelke, S.J. O'Brien, D. Jansen, and M.K. Oli. 2010. Genetic introgression and the survival of Florida panther kittens. *Biological Conservation* 143:2789–2796.
- Jacobs, C.E., and M.B. Main. 2015. A conservation-based approach to compensation for livestock depredation: the Florida panther case study. *PLoS One* 10:e0139203.
- Jane Goodall Institute. 2017. Goodall, Gombe and Google. Available from <https://earth.google.com/web/search/goodall/@-4.66243556,29.62914035,897.70794841a,1000d,30y,0h,0t,0r/ata=Ci4SNBIgMTA2NTQ0Mzg0ZWVmMTFIN-mI2MTYxOWZkN2FmNGM1ZTAiEGVmZWVxX2pnaV90b3VyXzAiJgokCOAAAAAAAAAAAAEQAAAAAAAAAAGQA-AAAAAAAAAIQAAAAAAAAA> (accessed June 23, 2020).
- Johnson, W.E. et al. 2010. Genetic restoration of the Florida panther. *Science* 329:1641–1645.
- Kautz, R., et al. 2006. How much is enough? Landscape-scale conservation for the Florida panther. *Biological Conservation* 130:118–133.
- Kelly, B., and D.P. Onorato. 2020. Central Florida panther study interim report. Fish & Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission. Available from <https://myfwc.com/media/24605/central-fl-panther-report.pdf> (accessed December 2, 2022).
- Kerr, J.T., and I. Deguise. 2004. Habitat loss and the limits to endangered species recovery. *Ecology Letters* 7:1163–1169.
- Kreye, M.M., and E.F. Pienaar. 2015. A critical review of efforts to protect Florida panther habitat on private lands. *Land Use Policy* 48:428–436.
- Laporte, I., T.B. Muhly, J.A. Pitt, M. Alexander, and M. Musiani. 2010. Effects of wolves on elk and cattle behaviors: implications for livestock production and wolf conservation. *PLoS One* 5:e11954.
- Layden, L. 2010, December 12. Developer building wildlife crossing in east Collier to protect panthers. *Naples Daily New*. Available from <http://www.naplesnews.com/community/developer-building-wildlife-crossing-in-east-collier-to-protect-panthers-ep-393097583-332204062.html> (accessed March 15, 2021).
- Leon-Kilpatrick, S. 2015. Florida panther conservation bank: providing a path toward panther recovery. *Endangered Species Technical Bulletin*. Available from <https://www.thefreelibrary.com/Florida+panther+conservation+bank%3a+providing+a+path+toward+panther...-a0438627351> (accessed December 2, 2022).
- Logan, T., A.C. Eller, Jr., R. Morrell, D. Ruffer, and J. Sewll. 1993. Florida panther habitat preservation plan South Florida population. Prepared for the Florida Panther Interagency Committee, Tallahassee, FL, USA.
- Lopes-Fernandes, M., and A. Frazão-Moreira. 2017. Relating to the wild: key actors' values and concerns about lynx reintroduction. *Land Use Policy* 66:278–287.
- Martone, R.G., R. Naidoo, T. Coyle, B. Stelzer, and K.M.A. Chan. 2020. Characterizing tourism benefits associated with top-predator conservation in coastal British Columbia. *Aquatic Conservation: Marine and Freshwater Ecosystems* 30:1208–1219.
- Maxwell, S.L., R.A. Fuller, T.M. Brooks, and J.E.M. Watson. 2016. Biodiversity: the ravages of guns, nets and bulldozers.

- Nature 536:143–145.
- McBride, R.T., R.M. McBride, and C.E. McBride. 2008. Counting pumas by categorizing physical evidence. *Southeastern Naturalist* 7:381–400.
- McClintock, B.T., D.P. Onorato, and J. Martin. 2015. Endangered Florida panther population size determined from public reports of motor vehicle collision mortalities. *Journal of Applied Ecology* 52:893–901.
- Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Wetlands and Water Synthesis*. World Resources Institute, Washington, DC, USA. Available from <http://biblioteca.cehum.org/bitstream/123456789/143/1/Millennium%20Ecosystem%20Assessment.%20ECOSYSTEMS%20AND%20HUMAN%20WELL-BEING%20WETLANDS%20AND%20WATER%20Synthesi.pdf> (accessed December 2, 2022).
- NBC2. 2015. Conservation easements: paying to push panthers north. Available from <https://www.nbc-2.com/story/29180766/paying-to-push-panthers-north> (accessed July 1, 2020).
- Niemiec, R. et al. 2020. Public perspectives and media reporting of wolf reintroduction in Colorado. *PeerJ* 8:e9074.
- Pienaar, E.F., M.M. Kreye, and C. Jacobs. 2015. Conflicts between cattlemen and the Florida panther: Insights and policy recommendations from interviews with Florida cattlemen. *Human Ecology* 43:577–588.
- Pinkerton, E., A.K. Salomon, and F. Dragon. 2019. Reconciling social justice and ecosystem-based management in the wake of a successful predator reintroduction. *Canadian Journal of Fisheries and Aquatic Sciences*. NRC Research Press. Available from <https://cdnsciencepub.com/doi/abs/10.1139/cjfas-2018-0441> (accessed March 3, 2021).
- Pusey, A.E., L. Pintea, M.L. Wilson, S. Kamenya, and J. Goodall. 2007. The contribution of long-term research at Gombe National Park to chimpanzee conservation. *Conservation Biology* 21:623–634.
- Sakurai, R., H. Tsunoda, H. Enari, W.F. Siemer, T. Uehara, and R.C. Stedman. 2020. Factors affecting attitudes toward reintroduction of wolves in Japan. *Global Ecology and Conservation* 22:e01036.
- Saremi, N.F. et al. 2019. Puma genomes from North and South America provide insights into the genomic consequences of inbreeding. *Nature Communications* 10:4769.
- Seddon, P.J., C.J. Griffiths, P.S. Soorae, and D.P. Armstrong. 2014. Reversing defaunation: restoring species in a changing world. *Science* 345:406–412.
- Seeger, E. 2019. The panther's path. The Nature Conservancy. Available from <https://www.nature.org/en-us/magazine/magazine-articles/florida-panther-corridor/> (accessed June 24, 2020).
- Smith, D.J., R.F. Noss, and M.B. Main. 2006. East Collier County Wildlife Movement Study SR 29, CR 846, and CR 858 Wildlife Crossing Project. Page 141. SWFREC-IMM-2007-01, Southwest Florida REC Research Report. University of Central Florida and University of Florida IFAS. Available from [https://conservationcorridor.org/cpb/Smith\\_Noss\\_Main\\_2016.pdf](https://conservationcorridor.org/cpb/Smith_Noss_Main_2016.pdf) (accessed March 15, 2021).
- Swanson, K., D. Land, R. Kautz, and R. Kawula. 2005. Use of least cost pathways to identify key highway segments for florida panther conservation. *Proceedings of the 8th Mountain Lion Workshop*:10.
- Taylor, G., S. Canessa, R.H. Clarke, D. Ingwersen, D.P. Armstrong, P.J. Seddon, and J.G. Ewen. 2017. Is reintroduction biology an effective applied science? *Trends in Ecology & Evolution* 32:873–880.
- U.S. Fish and Wildlife Service. 1999. South Florida multi-species recovery plan. Atlanta, GA, USA. Available from <https://www.saj.usace.army.mil/Portals/44/docs/regulatory/SW/flpa2.pdf> (accessed November 29, 2022).
- U.S. Fish and Wildlife Service. 2008. Florida panther recovery plan, 3rd edition. Available from <http://dpanther.fiu.edu/sobek/content/FI/GO/00/02/36/00001/Panther%20Recovery%20Plan.pdf> (accessed December 2, 2022).
- U.S. Fish and Wildlife Service. 2012. Panther habitat assessment methodology. Page 14. Available from <https://ipac.ecosphere.fws.gov/guideline/assessment/population/8/office/41420.pdf> (accessed December 2, 2022).
- U.S. Fish and Wildlife Service. 2018. Florida panther. Available from [https://www.fws.gov/refuge/florida\\_panther/wah/panther.html](https://www.fws.gov/refuge/florida_panther/wah/panther.html) (accessed June 23, 2020).
- U.S. Fish and Wildlife Service. 2019, September. Conservation banking: incentives for stewardship. Available from <https://www.fws.gov/sites/default/files/documents/conservation-banking.pdf> (accessed December 2, 2022).
- USDA. (n.d.). Environmental Quality Incentives Program, USDA Natural Resources Conservation Service. Available from <http://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives> (accessed November 25, 2022).
- van de Kerk, M., D.P. Onorato, J.A. Hostetler, B.M. Bolker, and M.K. Oli. 2019. Dynamics, persistence, and genetic management of the endangered florida panther population. *Wildlife Monographs* 203:3–35.
- Warren, K. 2013, May 30. High-yo silver, away! Lone Ranger Forge comes to the rescue of endangered Florida panthers. Available from <https://www.fws.gov/news/blog/index.cfm/2013/5/30/highyo-silver-away--lone-ranger-forge-comes-to-the-rescue-of-endangered-florida-panthers> (accessed March 15, 2021).
- Wildlife Crossing. 2018. Available from <https://www.youtube.com/watch?v=iFJSfOsbcDs> (accessed March 15, 2021).

## GLOSSARY

1. **Stakeholder:** People or groups who will be impacted by a conservation action or regulation.
2. **Genetic introgression:** Genetic introgression occurs when new genetic material is introduced to a population when individuals from another population enter an area and breed with the resident population. Although introgression may occur naturally, individuals may also be moved among populations as a conservation tool focused on improving fitness; this approach may also be called genetic restoration or genetic rescue (Hostetler et al. 2012).
3. **Conservation easement:** Conservation easements are permanent or term-limited legal agreements that limit the use of land to maintain its conservation value. Easements may be part of a conservation bank.
4. **Conservation bank:** Conservation banks are lands that are permanently protected to offer benefits to vulnerable species (e.g., endangered species) and that have been awarded credits for this designation. These credits can be purchased by others whose actions (such as property development) may have negative impacts on the species in other parts of its range, as a mitigation strategy.
5. **Payments for ecosystem services:** Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment 2005). Stakeholders may be compensated for protecting or increasing these services directly (through monetary payments) or indirectly (e.g., through changes in tax status and liability).

## APPENDIX 1. QUESTIONS FROM THE EXERCISE

1. Why do you think the Committee focused on protecting habitat even when population numbers were low?
2. Ensure all areas are displayed (you should see Priority 1 and Priority 2 zones). Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 1". In the caption explain what the Panther Habitat Preservation Plan shapes identify.
3. Produce a map that only shows the **Primary** Zone of panthers. You can do this by selecting the **Hide feature** icon for the folders that contain the features associated with the Secondary and Dispersal Zones (and for the Panther Habitat Preserve Plan Areas Florida layer). Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 2". Provide a descriptive caption for what the image shows, including the size of the area (convert to km<sup>2</sup>). You can find this information by clicking on the Primary Zone in Google Earth; this will cause an information box with information about the selected area to appear (Figure 4). Information provided includes the area's size, type of zone, and link to metadata.
4. Next, add all the **Secondary** and **Dispersal** Zone layers to the previous map by selecting the **Show feature** (eye) icon next to the folder containing those features. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 3". Provide a descriptive caption for what the image shows, including the size of both the Secondary and Dispersal Zones (convert to km<sup>2</sup>). Since there are multiple areas that comprise the Secondary Zone, you will need to select each individual area, note their size, and calculate the total area in the zone. Note you can also expand the Secondary zone sub-layer and click on individual polygons to display the needed information.
5. Next, produce a map of only the **Dispersal** Zone layer by hiding all other zones and zooming

into this area. To see the habitat that comprises the dispersal zone, we will manipulate the transparency of the shape feature. You can select the **Edit feature** (pencil) icon (Figure 5) in the informational box that appears when you click on the dispersal zone. You can also find this icon if you hover your mouse over the Dispersal Zone shape feature (denoted by a polygon icon; Figure 5). Select this and change the fill color saturation level from 100% to 25% in the box that opens. Note you can also change the outline or fill color if you wish.

Now you should be able to see the habitat cover and shaded area of the dispersal zone simultaneously. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 4". In the caption, explain why the dispersal zone is essential to the continued success of Florida panther restoration.

6. What major landscape features do you observe in the Dispersal Zone?
7. Note you can add a placemark on your own to the map by selecting the **Add placemark** icon or button under the New feature menu (Figure 5). Select this icon and add a placemark to the area where the dispersal zone intersects the Caloosahatchee River. Name the placemark *River intersection*. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label the image "Figure 5". Note the importance of the river that runs through the dispersal zone in your caption.
8. What are the coordinates for your *River Intersection* placemark?
9. What is the benefit of being able to specify exact locations on earth to the management of natural populations? Give at least three clear examples.
10. Using the PrintScreen function on your computer or a similar screenshot tool, capture an image of your Dispersal Zone layer (it may still be semi-transparent) and your placemark marking the *River intersection* along with the features associated with the Panther Habitat Preserve Plan Florida layer. Label it as "Figure 6". In the caption discuss the relationship between the zones in the two layers.
11. In Google Earth, use the search tool to locate the *Black Boar Ranch* (Figure 6). On the resulting screen, select **Add to Project** to add a placemark for the ranch. Manipulate layers as needed to produce a map showing how the ranch relates to habitat and preservation zones. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 7". In the caption explain what you displayed and the importance of the Black Boar Ranch in terms of both habitat and panther species range.
12. Read the articles by Warren and Seeger. Based on these and other readings, name three reasons why choosing a conservation easement may be of value to the owner of a property. Also, name three reasons a property owner may choose not to enter a conservation easement.
13. To view the impact of vehicle collision on panther mortality, display the Panther Mortality from Vehicular Trauma layer. This layer shows all confirmed deaths due to vehicle collisions

collected from February 13, 1972, through January 2, 2021. You can display it with (or without) other layers to make an informative image. Notice the image includes evidence of occurrence north of the Caloosahatchee River. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 8". In the caption note any patterns or trends you see. Are collisions distributed randomly, or do they occur more in certain areas? Where?

14. Using information from the article, attempt to find the City Gate-funded wildlife crossing. As a hint, use the search tool to search for Immolakee, Florida, then follow Country Road (CR) 846 (also known as Immokalee Road) east of town. You may need to make one or more layers from your currently displayed maps transparent or not visible. When you find the intersection of CR-846 and County Line Road, use the measuring tool (Figure 6) to find an area approximately 3 miles before the intersection (note, you can change the units from meters to miles by selecting the down triangle in the measuring tool dialogue box). You should be able to zoom in and locate the crossing. Place a landmark icon here and name it *Wildlife crossing*. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 9". In the caption explain why the crossing is essential to protecting Florida panthers.
15. View the location of City Gate Commerce Park by turning on the placemark icon for the location in Google Earth. Make sure your image also shows the *Wildlife crossing* placemark. You can add any other layers you need to make an informative image or to offer insight on the placement of the crossing. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Label it as "Figure 10". In the caption discuss the benefits of allowing mitigation measures to take place in areas other than where the negative impacts on species actually occur. Are there any negative consequences to this approach to offsetting negative impacts on species?
16. Read about panther habitat conservation banking in Florida in an article by Sarah Leon-Kilpatrick (download it directly from this module's page at <https://ncep.amnh.org> or ask your instructor for the pdf version; Leon-Kilpatrick 2015). In which panther zones are the two banks discussed in the article located?
17. Do you consider establishing easements or species credits (via conservation banks) to be a payment for ecosystem services? If so, what service are they providing, and do you think it was worth the cost?
18. Given that attacks on pets and livestock are rare, why do you think such programs are valued by conservation groups and other stakeholders? List at least three reasons.
19. What do you think is the value of engaging stakeholders who may not be directly tied to the land used by panthers? Give at least three reasons engaging these stakeholders may be useful to conservation efforts.
20. How do you balance the desires of these stakeholders versus those who are directly impacted by panther restoration (like ranchers and pet owners)?

## Timelapse Extension

21. Once the map is focused on the area corresponding to the dispersal zone, use the scroll bar at the bottom to select the year **1984** (or earlier if possible). Press the **Play** (triangle) icon to begin a slideshow of images showing views of the area over time. Note the slideshow may automatically repeat. For easier comparison, pause the show and select the earliest year possible. Capture the image by using the PrintScreen function on your computer or a similar screenshot tool and paste it into your report document. Next use the scroll bar to select the most recent year. Capture this image as well and paste it into your report document. In the caption make sure you note the year that corresponds to each image (and their relative location). Using image marking tools in your document or screenshot tool, mark at least three areas regarding Panther habitat which have changed over time; you can do this by adding shapes over relevant areas.
22. What are the main differences between the two images? What are some possible causes of this?
23. Given the changes that have taken place in the dispersal zone over the past 25 years, what do you predict will happen in the next decade? How does this impact the need to preserve habitat for panthers?