

igure GT2. Schematic graphic of

Interested in a National Park's Geology?

(We have Something for Everyone from Geo-Tourists to Serious Scientists!)

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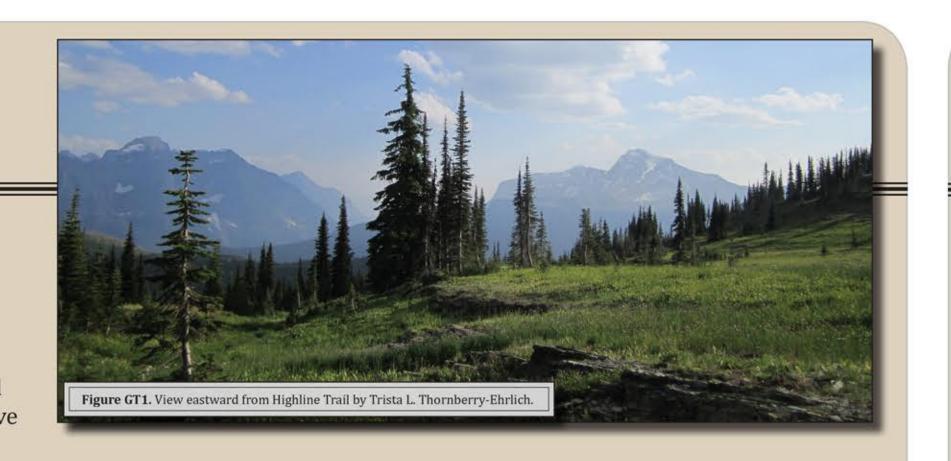


igure GT3. View over Grinnell Glacier by Trista L. Thornberry-Ehrlid

GRI Recommendations:

2. Download the GLAC GRI Report from the GRI Publications page.

Step 1: I downloaded the GLAC GRI Report first and browsed the Geologic History, and Geologic Features and Processes chapters for some background information (see figures GT1 - GT 5). The easy-to-read text and illustragraphics helped me to understand the geologic story of the park before embarking on my own tour.

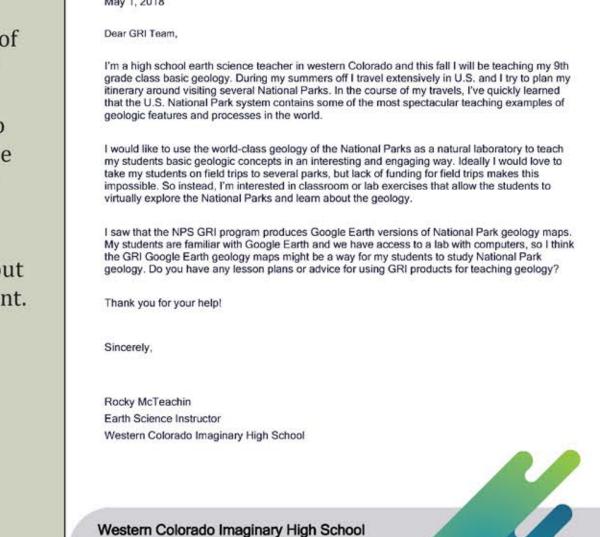


Educator: Are you an educator interested in teaching your students about the geology of a park?

Teacher Use Example: eam is regularly approached by teachers

oking for ideas and resources to aid in he U.S. National Parks. This example uses rom a high school earth science teacher to sing GRI products: Google Earth product Figures ED5 and ED6), ancillary map rmation document (Figure ED3), and eport (Figures ED2 and ED4) to learn about the geology of Dinosaur National Monument

I saw that the NPS GRI program produces Google Earth versions of National Park geology maps. My students are familiar with Google Earth and we have access to a lab with computers, so I think the GRI Google Earth geology maps might be a way for my students to study National Park geology. Do you have any lesson plans or advice for using GRI products for teaching geology?



Home of the fighting unicoms!

Hoc ludum est simulare

GRI Recommendations: The GRI Google Earth Product along with the Geologic Report. Ancillary Map Information Document, and Map Layout are excellent tools that allow students to virtually explore a park and learn about geologic features and processes. There are many possible ways to use the products in the classroom. Here's one idea that encourages students to use the GRI products to go on a virtual scavenger hunt and explore a park and learn about the geology. Sample Exercise:

Geologic scavenger hunt exercise (classroom lab or homework assignment)

Example Park: Dinosaur National Monument (DINO) Assumptions: Students have access to computers with Google Earth, ability to view PDFs, interne access, and basic understanding of Google Earth. Teacher has basic understanding of geologic concepts and Google Earth.

Instructions: 1. Download the DINO GRI Report from the GRI Publications page.

2. Download the DINO Google Earth KML data from the GRI Publications page.

3. Extract files from dinokml.zip, then double click on "dino_geology.kmz" In Google Earth, create new folder in "My Places" in the Places Table of Contents (left hand side of screen) by right clicking "My Places>Add>Folder" Name folder: DINO_StudentName

For each of the questions explore the GRI Google Earth Product and use the GRI Report (dino_gre_rpt_ view.pdf) and the GRI Ancillary Map Information Document (dino_geology.pdf found in dinokml.zip) to answer the questions below. When asked to find a location, use the "Add Placemark" tool (looks like push pin on the Google Earth

tool bar at top of screen) and name it an appropriate name such as "StudentName - Q1: Sandstone" and save it to the folder you created (DINO_StudentName). For questions where you are asked to trace a feature, use the "add path" tool and save it to the same folder.

At end of exercise, save your marked locations by right clicking on the folder you created "DINO_ StudentName>Save Place As" and created a .kmz file named DINO_StudentName.kmz Submit saved .kmz file to teacher for discussion/evaluation/grading.

Example Questions:

ool) locations where you would find:

ool) locations where fault crosses:

a) Road b) River

with "add path" tool)

Bryce Canyon National Park

the GRI report for BRC (Authored by: Trista

Thornberry-Ehrlich)

prominent hoodoo ar

park visitor attraction

is majestically shown

with nearby hoodoos

within the scenic Paria

BRCA - Geologic Unit Labels

tal Geologic Map of Bryce Canyon National Park and Vicinity, Utah

Figure PM6. The BRCA GRI KML data displayed in Google Earth. The view

including the spectacular Thor's Hammer hoodoo. Pop-ups associated with th

BRCA - Geologic Units

Thor's Hammer, a

Geologic Resources Inventory Report

Natural Resource Report NPS/NRPC/GRD/NRR-2005/002

the present Paria Amphitheatre, as well as active processes that continue to erode the amphitheatre and the park's amazing landscape.

The report also made several suggestions pertaining to the inventorying and monitoring of the Paria Amphitheatre, including conducting a

also addressed the formation of the geologic hoodoos, as well identified several processes that cause and/or accelerate their erosion (see

figure PM4). As with the amphitheatre erosion, the report also listed several inventory, monitoring and research considerations on how to

landslide inventory and analysis, producing a rockfall susceptibility map, and performing a trail stability study (see figure PM3). The report

Question 1 - Find and mark (with "Add Placemark"

a) Sandstone b) Limestone c) Shale

Question 2 - Find and mark (with "Add Placemark" ool) locations of geologic units of following ages

(Type Unit Name in Description Field when you create

a) Quaternary b) Cretaceous c) Jurassic

Question 3 - Find and mark (with "Add Placemark"

Question 4 - Find and mark (with "Add Placemark"

Question 5 - Find and mark (with "Add Placemark"

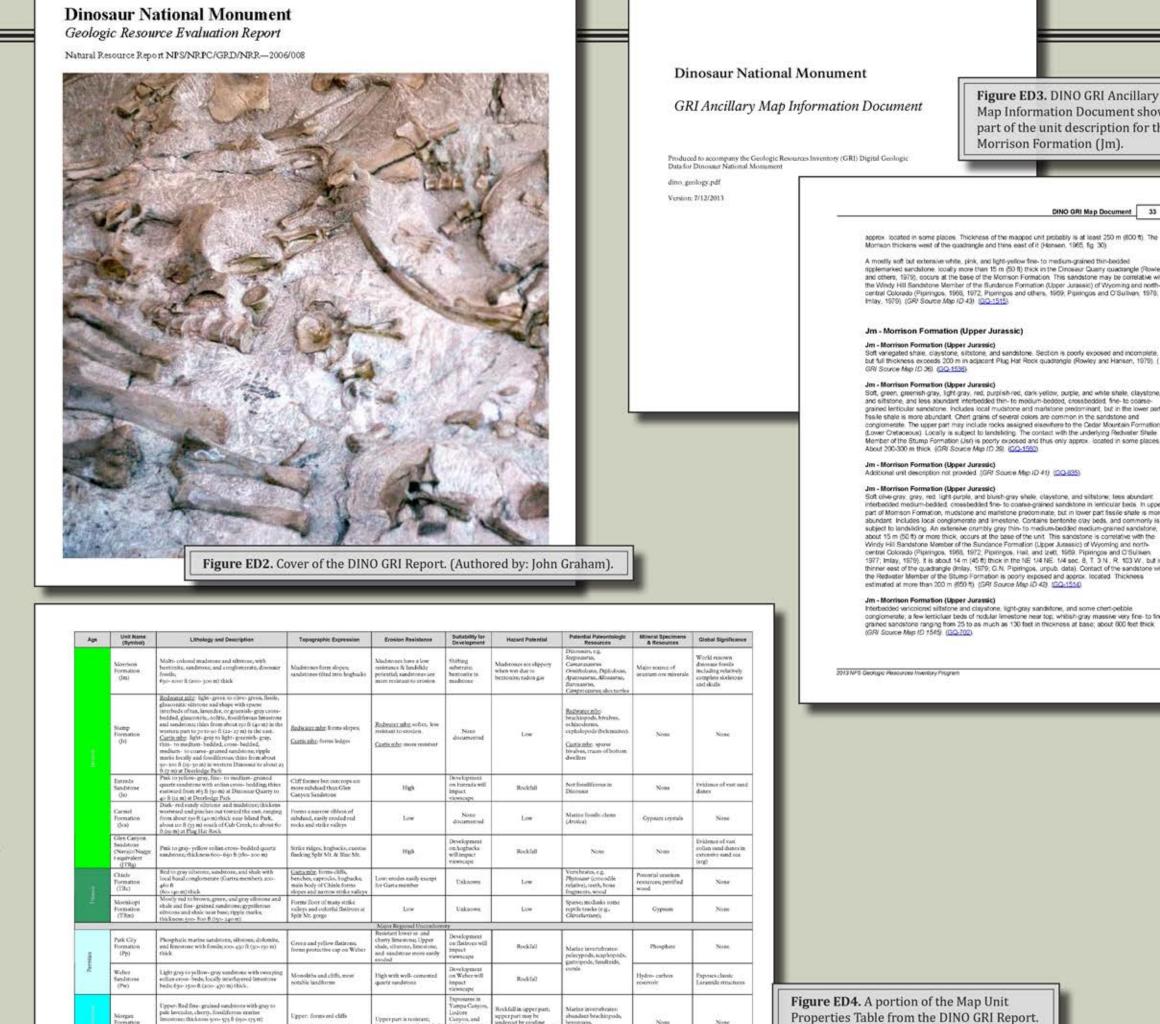
Question 6 - Find and mark (with "Add Placemark"

Question 7 - Find the Split Mountain Anticline (Tra

tool) a location where you might find a fossil

tool) location where you might find an alluvial fan

ool) location where you might find landslide deposits



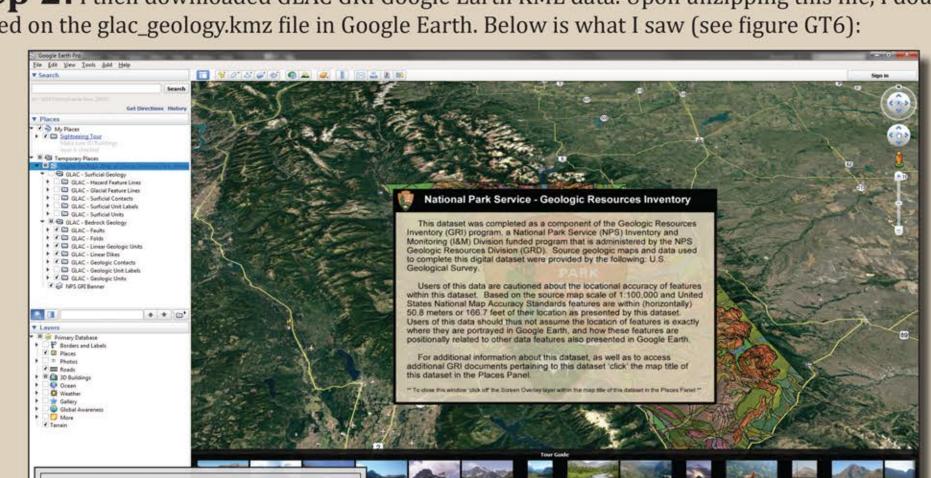


Skills: I am a casual user of Google, Google Earth, and Adobe Reader. I am an amateur rockhound with instinctive

Approach: I go to the visitor center at the park and ask about Google Earth KML data that include geologic

curiosity, and a basic knowledge of geologic terms and concepts. I can read most basic maps.

nformation. The park ranger/interpreter points me to the Geologic Resources Inventory.



Step 4: I then placed the mouse cursor on a particular color on the map and clicked, and a pop-up containing information about that unit appeared (see figure GT 8). This information provided a bare minimum of information. I would like to know more and I notice there is a link to a GLAC GRI Ancillary Map Information Document so I open that. This link brings me to a PDF that had very detailed information about the unit (see figure GT9). I may not understand ALL the vocabulary, but at least I know more about what I see out the car window. I decide to make a little road guide for myself with screen shots and accompanying text.



blue-green algae

Step 3: Zooming in with the roads layer on (see figure GT7), I could see the trace of Going-to-the-Sun Road beneath the geologic

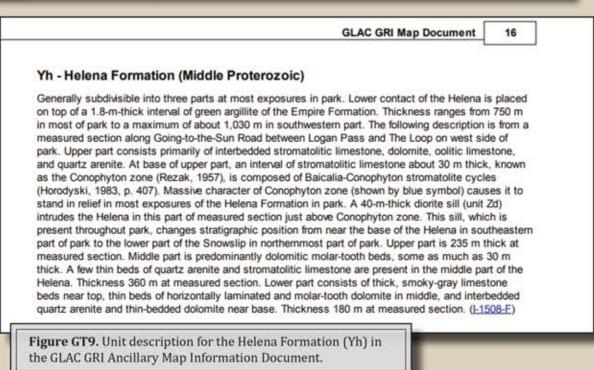
units draped over the 3-D aerial image of the park. This allowed me to identify prominent landmarks and views along the route.

Layers of algal remnants

figure GT4. Diagram showing layer-by-layer buildup of fossil algae by Trista L. Thornberry-Ehrlich.

and calcite precipitate

GLAC - Geologic Units - Helena Formation U.S. Geological Survey I-150 Helena Formation Middle Proterozoic dataset are available within the GRI ancillary map information .pdf document: glac geology.pdf Figure GT8. GRI-formatted Google Earth pop-up window.



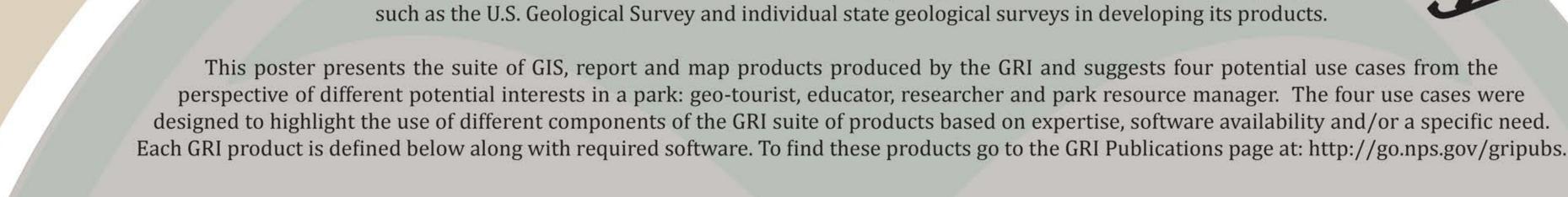
. Plants- redwood stumps; palynomorphs (pollen and spores); leaves,

4. Mollusks (clams and snails) and ostracods (microscopic crustaceans)

Figure RS1. Section of GRI FLFO report detailing paleontological resoruces (Authored by: Katie KellerLynne).

2. Diatom mats (see "Sedimentation and Fossilization" section)

3. Spiders, insects, and myriapods (multi-legged arthropods)



Digital Geologic-GIS Data Digital geologic map product designed to reproduce all aspects of traditional paper maps in a GIS.

1) ESRI Geodatabase holding thematic layers of geologic data along with unit information and source map tables. 2) ESRI map document (mxd) and layer files containing map symbology and other display parameters. 3) Ancillary map information document (see below). 4) FGDC Compliant Metadata in FAQ format. 5) GIS Readme File introducing the GRI and serving as an entry point for using GRI digital geololgic-GIS data.

Download File Contains:



A lightweight KMZ file that provides a basic visualization of GRI digital geologic-GIS data draped over Google Earth imagery and elevation data.

) GRI digital geologic-GIS data with custom balloons showing GIS data The incredible fossil record at Florissant, which consists of organisms attribution and links to important NPS websites. 2) Ancillary Map Information that are not ordinarily fossilized, has enabled paleontologists and geolo-Document (see below). 3) FGDC Compliant Metadata in FAQ format. 4) GIS Readme File gists to reconstruct a relatively brief moment of time at the end of the introducing the GRI and serving as an entry point for using GRI digital geologic-GIS data. Eocene Epoch (about 34 million years ago). The fossils at Florissant are Required Software: Google Earth

Ancillary Map Information Document

A PDF document that contains source map surround information and supplements the GIS product.

1) Source map citation information. 2) An Index map showing NPS boundaries and the extent of GRI digital geologic-data.

3) Geologic unit ages and descriptions. 4) Geologic Cross Sections. 5) Correlation of map units. 6) All other pertinent

images and information contained in the source publications used by the GRI. This document is found in the GIS download

zip file, the Google Earth KML download zip file, and is available online through links in the GRI Google Earth KMZ map.

Required Software: An internet browser or PDF viewer like Adobe Acrobat.

ArcGIS 10.4, Environmental Systems Research Institute (ESRI) Inc., http://www.esri.com

Google Earth Pro, Google Inc., http://www.google.com/earth/index.html

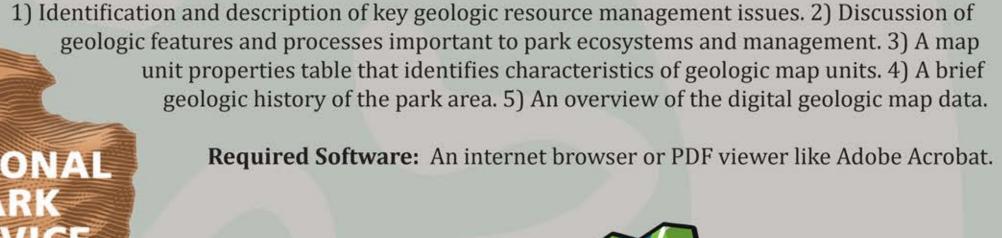
Service (NPS) Natural Resource Challenge. The goal of the GRI is to increase

understanding of the geologic processes at work in parks and provide accurate geologic

information for use in park decision-making. Sound park stewardship relies on understanding

natural resources and their role in the ecosystem, of which geology is the foundation. The GRI program is a

rtnership between the NPS and Colorado State University (CSU), and relies heavily upon mapping organization



The GRI Geologic Report is a comprehensive report that provides

an in depth discussion about the geology of a specific park.

showing features from the GRI digital geologic-GIS data

1) Geologic data draped over hill shaded relief and geographic base map information such as roads and major water bodies. 2) Relevant park locations of interest such as park

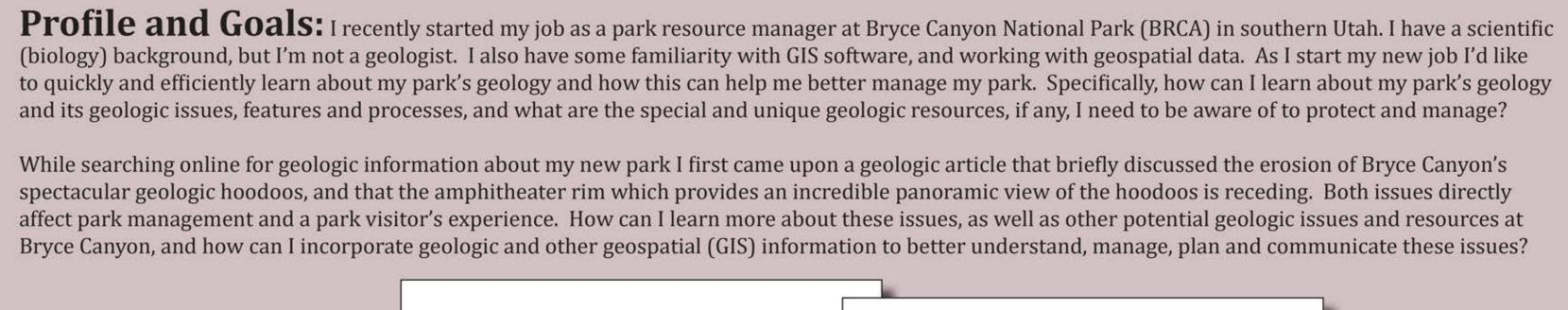
entrances, visitor centers, campgrounds and other popular park attractions. Required Software: An internet browser or PDF viewer like Adobe Acrobat.



Thor's Hammer

lings Landsal/ supernions

Park Manager: Are you a park manager seeking geologic information for resource management decisions?



Approach: While browsing my park's library I came upon a hardcopy of the BRCA GRI Report that discusses in detail the geologic history, issues, features and processes the park, and addresses these in a manner intended for a park resource manager such as me.

Figure ED5. Screen capture of the DINO GRI Google Earth KML product

Step 1: The BRCA GRI Report (see figures PM1 and PM2) provided detailed information pertaining to the slope processes that created Geologic History.....

Table of Contents

BRCA - Geologic Units - Claron Formation, pink limestone member

U.S. Geological Survey, I-2108

National Park Service - Geologic Resources Inventory

(GRI) program, a National Park Service (NPS) Inventory an

nitoring (I&M) Division funded program that is administered by the NPS ologic Resources Division (GRD). Source geologic maps and data use complete this digital dataset were provided by the following: U.S.

Users of this data are cautioned about the locational accuracy of feat ithin this dataset. Based on the source map scale of 1:24,000 and Untates National Map Accuracy Standards features are within (horizontal

meters or 40 feet of their location as presented by this dataset.

data should thus not assume the location of features is exact are portrayed in Google Earth, and how these features are pos id to other data features also presented in Google Earth.

additional information about this dataset, as well as to access nal GRI documents pertaining to this dataset 'click' the map title of

se this window 'click off the Screen Overlay layer within the map side of this dataset in the Places P

middle to lower Eocene

Claron Formation, pink limestone member

Geologic unit descriptions, as well as source map ancillary information and graphics (if applicable) dataset are available within the GRI ancillary map information .pdf document: brca_qeology.pd

Appendix A: Geologic Map Grap Appendix B: Scoping Summary.

Park on July 13-14, 1999, to discuss geologic

KML product showing a possible solution to example

question 4 (unit mapped as QI - Landslide deposits).

Report. Sections within the report relevant to the geologic hoodoos and amphitheatre erosion, "Slope rocesses", "Erosion of the Paria Amphitheatre and "Hoodoo Formation and Present Condition", are shown in figures P3 and P4.

Figures PM3 & PM4. Sections within the BRCA GRI Report noodoo formation and present condition.

elevant to Paria Amphitheatre slope processes and erosion, and **Step 2:** The report further provided detailed information pertaining to the

slope processes that created the present Paria Amphitheatre, as well as active processes that continue to erode the amphitheatre and the park's amazing landscape. The report also made several suggestions pertaining to the inventorying and monitoring of the Paria Amphitheatre, including conducting a landslide inventory and analysis, producing a rockfall susceptibility map, and performing a trail stability study. The report also addressed the formation of the geologic hoodoos, as well identified several processes that cause and/or accelerate their erosion. As with the amphitheatre erosion, the report also listed several inventory, monitoring and research considerations on how to best study, manage and preserve

Step 3: From the report I learned that amphitheatre erosion, principally landslides and rockfalls could be modeled by producing susceptibility maps. From my basic knowledge of GIS I'd think the GRI Digital geologic-GIS data could be used with digital slope data to predict where landslides and rockfall might occur. To obtain the BRCA digital geologic-GIS and KML data (displayed in figures PM5 and PM6, respectively) I went to the GRI Publications page, and from there found the NPS Data Store record for the data. To pursue this I plan to contact the NPS Geologic Resources Division and the Geologic Resources Inventory, and seek assistance in to developing such maps. As for monitoring the hoodoos I'd think my park would have a GIS dataset of prominent hoodoo locations. From here a monitoring plan of hoodoo erosion, including perhaps visitor impact, could be developed!

Researcher: Are you a researcher interested in conducting geologic research in a park?

Paleontological Resources

fruits, seeds, and flowers

5. Vertebrates- fish, birds, and mammals

Profile: I am a graduate student interested in prehistoric ecosystems. I know a number of different organisms are preserved (see figure RS3) at Florissant Fossil Beds National Monument (FLFO), and have chosen this park as a study area to begin gathering data. **Skills:** I am well versed in reading scientific literature, and have pre-existing familiarity with both general geologic concepts as well as more specific familiarity with my study focus. I am at least moderately capable with ArcGIS and have access to it on school

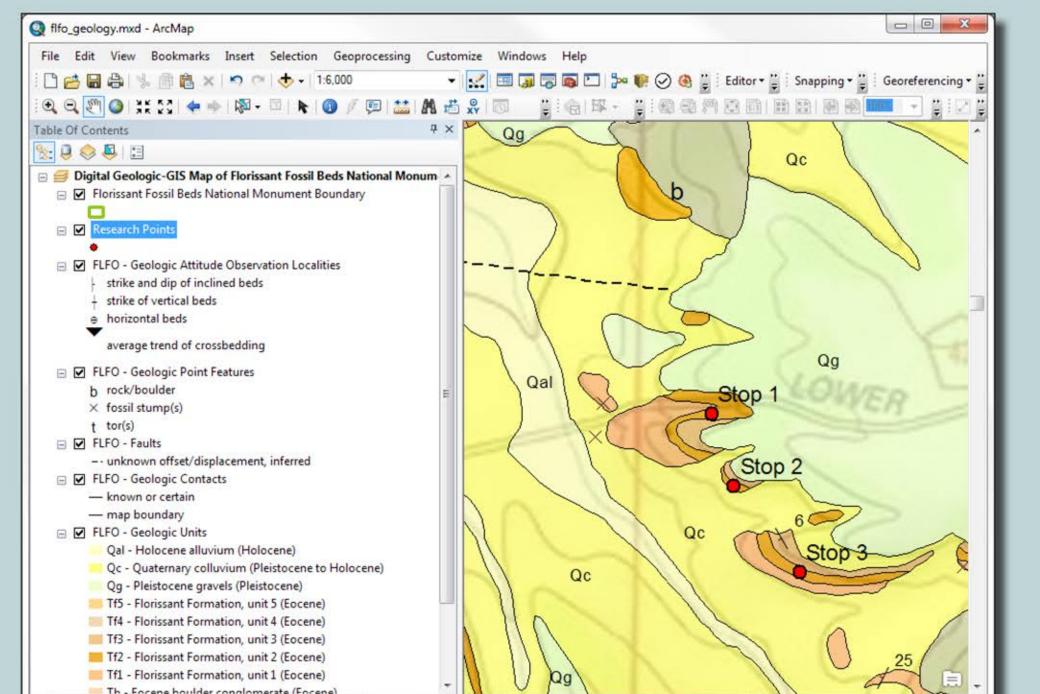
Preliminary Research: I began by downloading and reading the FLFO GRI Report to get a better sense of both the park's geology and the history of fossil collection (see figure RS1). Citations in the report lead me to paleontological oublications that could be useful in my research.

Planning: I planned my fieldwork with the Google Earth KML (see figures RS2 and RS4) by tracing a path leading me by exposures of the fossil-rich Florrisant Formation (Tf) (see figure RS3 and RS5). From those locations I could walk sections of the geology to better understand the paleoenvironment.

> FLFO - Geologic Units - Florissant Formation, unit Florissant Formation, unit 3

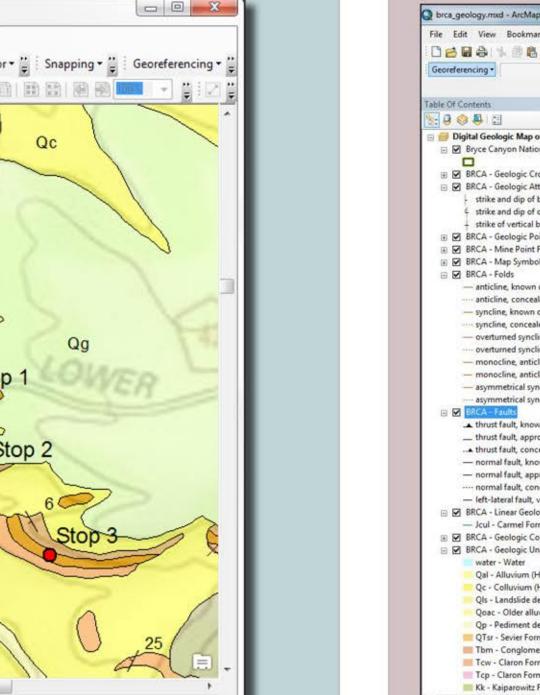
Future Work: I found that I could also easily import the path I created in Google Earth into an ArcMap project along with the GIS data and my stations. From there I taken from a drone to better define my field area. Having all this data in one place will be very useful in managing future fieldwork and for creating map graphics for publications. Additionally, I can use this collection of data to perform more sophisticated spatial and statistical analysis to aid my

plan to import elevation data and georeferenced aerial photos



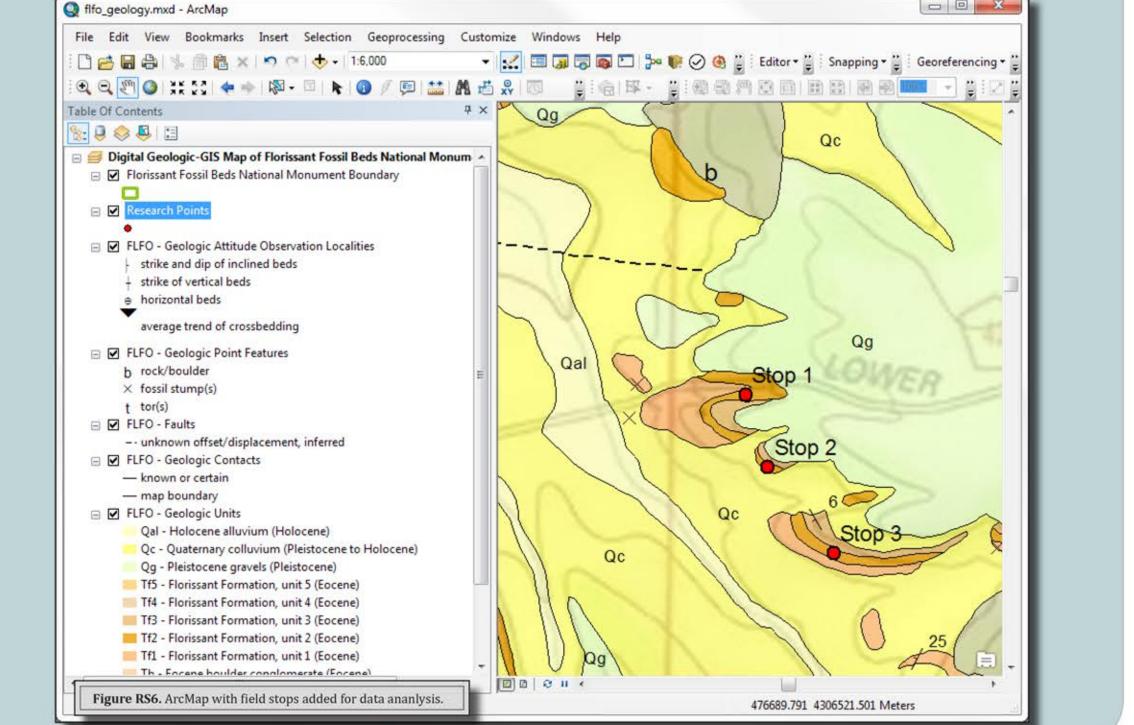
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< Selectable layers> ☑ BRCA - Geologic Attitude Observation Localities ☐ BRCA - Geologic Units ation: 398,017.472 4,166,408.632 Meters --- anticline, concealed overturned syncline, known or certa monocline, anticlinal bend, approximate __ thrust fault, approximate middle to lower Eocene ... thrust fault, concealed - normal fault, known or certain normal fault, approximate ☑ BRCA - Linear Geologic Units BRCA - Geologic Contacts Qoac - Older alluvium and colluvium (Holocene and Pleistocene) Figure PM5. The BRCA GRI Digital Geologic-GIS data displayed in ArcMap. - Sevier Formation (Pleistocene and Pliocene) Much of the Paria Amphitheatre is comprised of the pink member of the n - Conglomerate of Boat Mesa (Oligocene) Tcw - Claron Formation, white limestone member (middle to lower Eocer Eocene-age Claron Formation (Tbp, shown in pink). The park's geologic Tcp - Claron Formation, pink limestone member (middle to lower Eocer hoodoos are formed within this unit from frost-wedging and rain erosio Kk - Kaiparowitz Formation (Upper Cretaceous)



best study, manage and preserve the hoodoos.

Figure RS2. Google Earth view showing field trip path in black. Figure RS4. View of the FLFO Google Earth KML showing planned geologic sections in blu **Execution:** After collecting field data I added it to the FLFO GRI Digital Geologic-GIS Data in ArcMap (see figure RS6) which allowed me to visualize the distribution of various fossil species in the park. Additionally, I created a series of points from my field stops which represented various paleoenvironments, with which I was able to analyze the frequency at which particular species were found in particular environments. Figure RS5. Fossilized tree stump within the Eocene-age Florrisant Formation (Tf) (courtesy NPS



File Edit View Tools Add Help