Going Places with GPS

Easy GPS Activities for Clubs, Classrooms and Beyond

Roger Palmer and Anita Palmer

Going Places with GPS

V1 .4

To our nephews and nieces who have slept on uncomfortable couches, cots, office furniture, and even our classroom floors, all the while feigning interest in campfire hot dogs and slightly burned hamburgers. While the accommodations were always rugged, the concepts you willingly explored gave you a much deeper understanding than you would have by reading a textbook or sitting in one of our classrooms.

Thank you AJ, Stephan, Leah, Luke, David, Hannah, Annie, and Jennifer for helping us to debug the activities in this book over the past nine years.

To Rebekah, Carly, Erin, Rachel, Henry, Sara, Ella, Ava, and Michael, hurry and grow up! We need new subjects for our next book!

Thank you to Joseph Kerski, for believing in us. Through the multitude of late nights developing lessons, days on end with little sleep, and years of friendship, we are thankful for your continued support. We know that many of the lessons in this book are a product of our joint schemes and dreams.

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Acknowledgements

We would like to acknowledge and thank the following for permission to use their materials in various ways in the book.

Screenshots of Garmin eTrex® H GPS menus. Used courtesy of Garmin Inc.

Screenshots of EarthCache website. Used courtesy of Geological Society of America

Screenshots of geocaching website. Copyright 2010. Groundspeak, Inc. Used with Permission

Screenshots of projects created with ESRI® ArcGIS software.

Various maps and aerial photos from Terraserver-USA, NASA Worldwind, and U.S. Geological Survey.

Photographs of geocaching fun by Richard, Kris, Jasmine, Max and Archie Pole in Canterbury, England

Introduction

Using global positioning systems (GPS) has fast become as important to us as our cell phones. We have GPS units in our cars, on our boats, in our backpacks and as a part of the functionality of our mobile phones. GPS units allow us to have spatial reference or to know where we are at any point in time. This technology has provided broad opportunities in our lives, in work, education, and entertainment. This book is intended to introduce the reader to the many fun and exciting uses of GPS both in the classroom as well as out. If you are a classroom teacher, 4H leader, technical educator, Boy or Girl Scout leader, community volunteer or student, this book will provide the foundation and activities you need to get started on your exciting journey with GPS.

How should you use this book? Start by examining the graphic illustration of the basic GPS unit and comparing it to your GPS unit. You can always look for these same basic features on any GPS unit you own. Then proceed to the first of the three main sections of the book indicated by two asterisks (**) in the Table of Contents. This section is entitled *Getting Started.* The activities in this first section should take you through basic functionality of the GPS and how to navigate through the buttons. As you progress through these basic, getting started activities, they will solidify the "buttonology" of the GPS and with practice, create muscle memory in your brain and fingers! This section also introduces the GPS user to exploration of latitude and longitude as well as navigating grid systems on Earth.

The second section provides a myriad of fun and educational games and activities. You will be gratified with your newfound skills and will enjoy activities people can engage in around the globe with their GPS units. The third and final section, *GPS as a Tool,* will extend the use of your GPS into a valuable data gathering instrument. You will be able to assign a location to data and photos as well as map the data in a GIS such as desktop ArcGIS or ArcGIS Explorer, or on a visualization tool such as Google Earth. The sky is the limit with what you can use your GPS to accomplish!

The activities in this book are the culmination of fourteen years of using GPS units with our students in North Dakota and Nevada, as well as in the teacher trainings we conduct around the United States and abroad. In an effort to share what we have learned, we are publishing this book. We hope you enjoy using your GPS units along with these activities. So we encourage you to grab your GPS, take along a friend or family member, and have fun exploring the great outdoors!

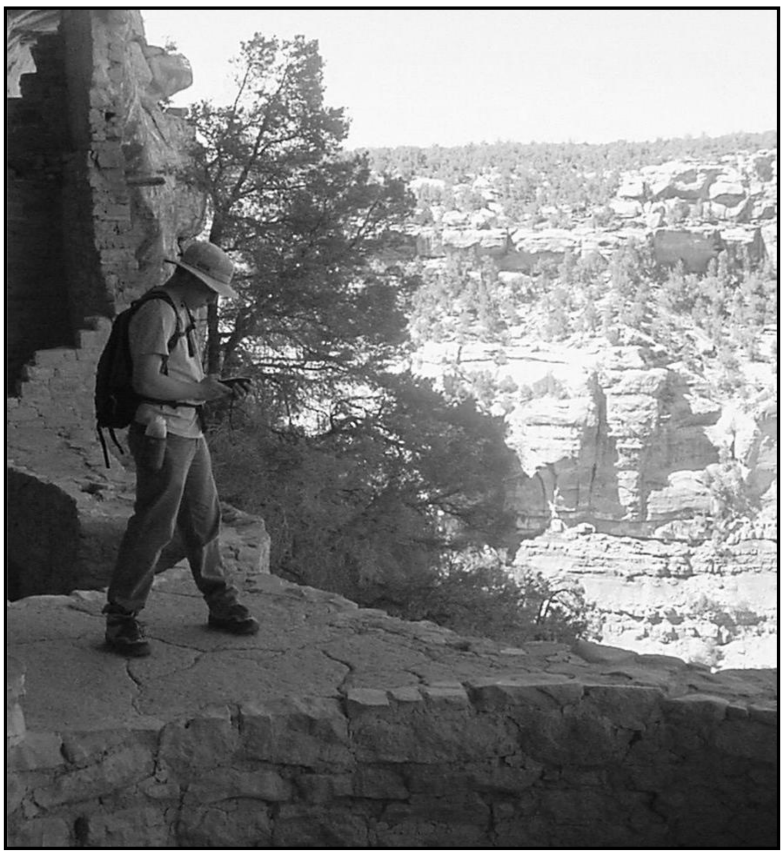
Roger & Anita Palmer

Getting Started

Nothing familiarizes you better with the interface of a GPS unit than having a few simply described exercises to practice. You will start with the screens of the entry model Garmin eTrex ® H GPS receiver. As you become familiar with them, you will be able to easily transfer your skills to any other sport based GPS units on the market. The activities in this section can be done alone, with friends, or with whole groups. While these activities are meant to be enjoyable in their own right, they are designed to build your understanding of how the GPS works and how to use the measurements for orientation.

"It's a dangerous business, Frodo, going out your door. You step onto the road, and if you don't keep your feet, there's no knowing where you might be swept off to."

Bilbo Baggins, Lord of the Rings



AJ in a cliff dwelling at Mesa Verde is captivated with where he is!

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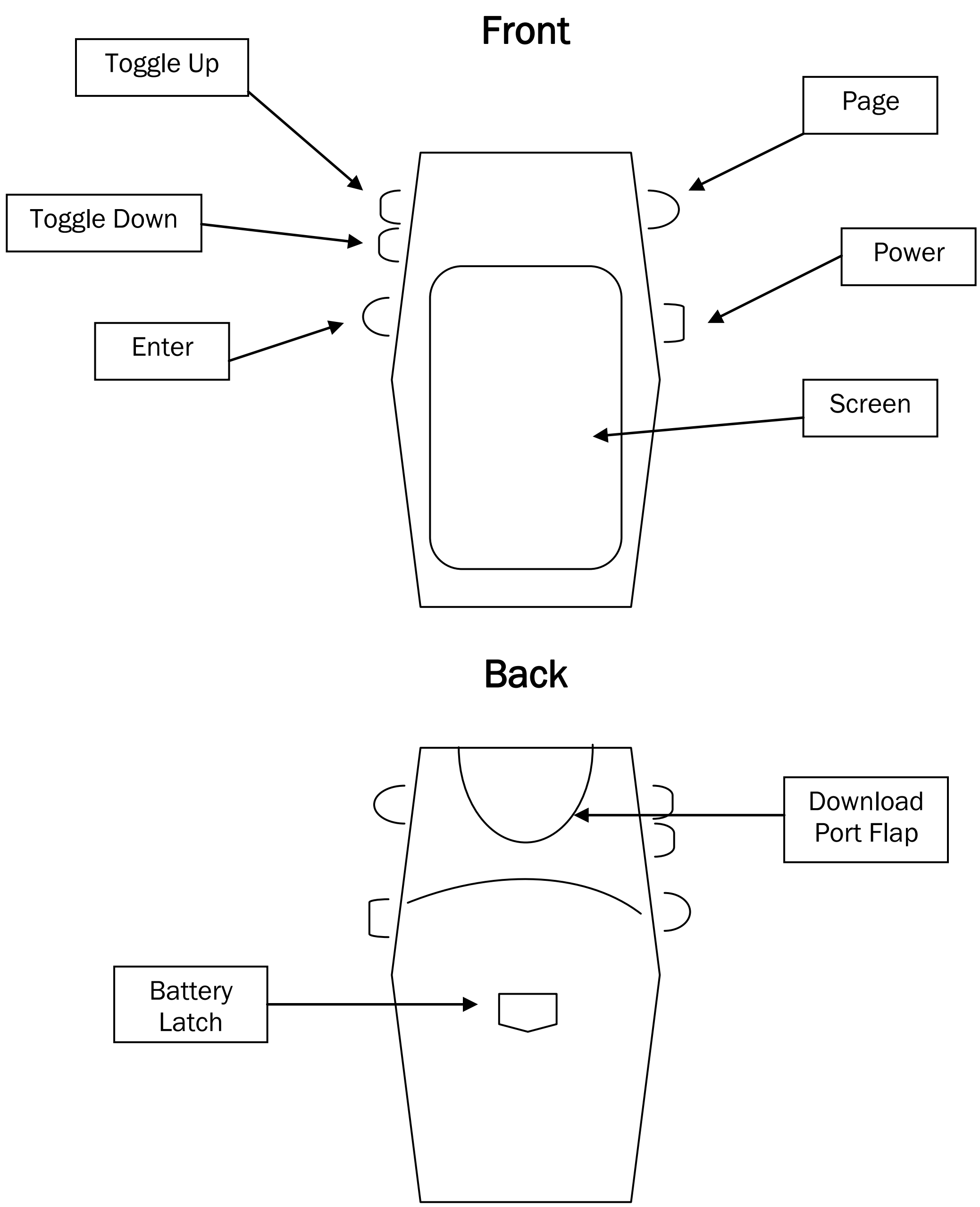
GPS Hardware

All the images in this text will assume use of a Garmin eTrex® H GPS unit. The entire Garmin eTrex® series GPS units all have the same shape, size and button configuration as the Garmin eTrex® H with the addition of a few pages and/or buttons in the higher end models. The image on this page illustrates the basic hardware of the Garmin eTrex® GPS units. If you have a GPS unit from a different manufacturer, you should still be able to use the images and exercises in this book, with your own specific GPS unit.

Throughout the text, you will be provided with a graphic next to the GPS screenshots indicating which button you are pressing on the GPS unit.

The button that is in bold will be the one you need to press. If there is an asterisk (*) next to the button, that means there are special functions associated with the button.



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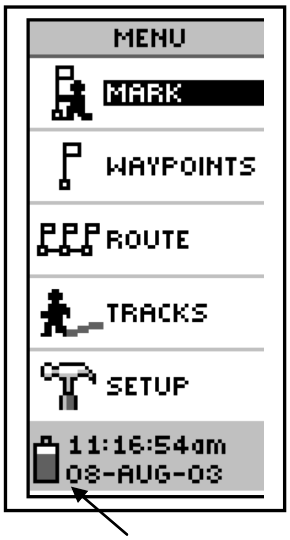
Maneuvering Your GPS

There are generally four common windows on all GPS units. Pushing the upper right or Page button on the eTrex® H units switches between the pages. The two toggle buttons on the upper left have different functionality on each page. This exercise gives you a brief explanation of the functionality of each screen and menu item. With GPS in hand, navigate to each page and orient yourself with the images and descriptions of each GPS page function. (Remember to press the Page button until you arrive at the proper screen.)

WINDOW 1: <u>Menu page</u>



Saves your current location. You may also save by holding the enter button down until the flag guy shows up.

Edits, renames, or goes to a point from your current position.

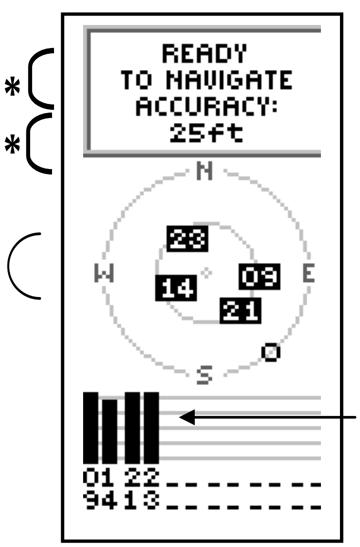
Saves a set of waypoints into a special group.

Turns on-off breadcrumb trail as often as you describe.

Defines coordinate system of your waypoints: dd, dm, dms, UTM…set your North arrow to magnetic or geographic, or set units to metric, statute or nautical.

Make sure your battery is more than half full before going out into the field.

WINDOW 2: <u>Satellite Reception page</u>



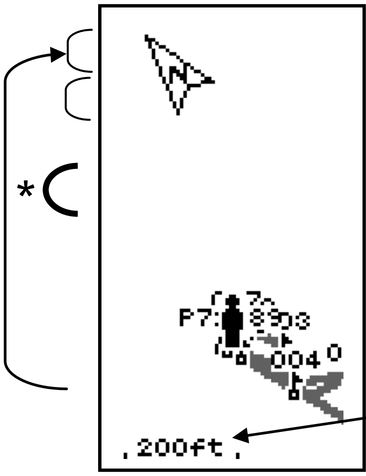
While the GPS is figuring out where it is, the accuracy won't be good enough to depend upon. Accuracy of less than 50 feet is best. Do not depend on the readings until the "Ready to Navigate" message appears.

These numbers show where the satellites that are being received by your GPS are located. The outer circle indicates the horizon, the next circle is 45 degrees higher, and the center dot is directly overhead.

The bars tell you the strength of the signal from any particular satellite. The GPS uses the four strongest signals to get a fix and report your position. The satellite numbers appear below the bars. At left, satellites 09, 14, 21, and 23 are being received by the GPS.

* The toggle buttons control the brightness when on this page.

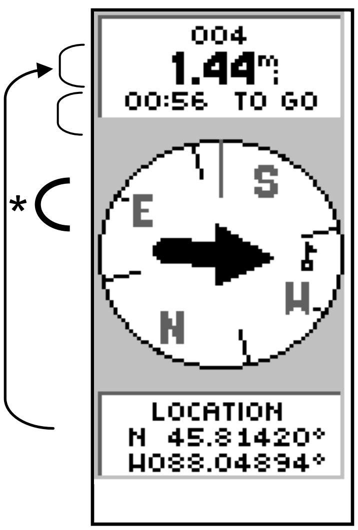
WINDOW 3: **Map Trail page**



* Enter button changes North up, Track up, or turn on/off WPT labels

Scale. Zoom in/out with the toggle buttons on the upper left side of the eTrex® H. Toggle down to zoom into map.

WINDOW 4: **Navigation page**



The top box shows the point you are navigating towards, distance, and estimated time to arrival.

You must keep moving for the compass to be accurate.

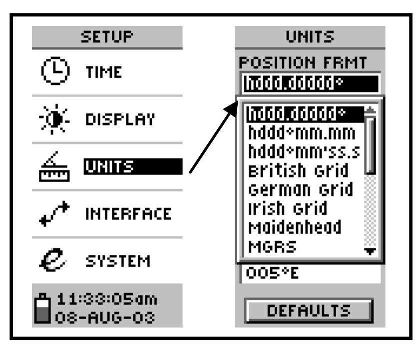
If you choose to "go to" a point you saved earlier, the arrow will show the direction you need to go (must be moving for several steps for it to work well).

The bottom info box can show speed, location, and time, by scrolling through the toggle buttons on the left side of the eTrex® H.

* Enter button allows you to stop navigating

BIG TIP: To save a waypoint at any time, click and HOLD the enter button for a second and the flag guy will show up. Then click enter a second time!

TIP #2: Set the units to Decimal Degrees if mapping your data in a GIS (hddd.ddddd°) or Decimal Minutes for Geocaching (hddd mm.mmm)



Lightning Strikes

GPS is a bit like a game of Marco Polo. Students around the pool are sending voice signals and one person with their eyes closed is trying to find their way around the pool to catch his or her friends. The difference for a GPS is that it knows where the satellites are and it is trying to figure out its own location! Trying to find the distance you are from a satellite is a little like trying to find out how far you are from lightning when it strikes in a storm. For every mile you are from lightning, the thunder takes five seconds to reach you. If it takes 10 seconds, you would be two miles from the lightning. If it takes only one second you would be 1/5 of a mile or about 1000 ft (300m) and you should probably take cover!

A GPS uses this idea to find your location. The GPS receives information from the satellite much like a radio receives songs from a radio station. The "song" from the satellite contains information on where the satellite is currently located. Also, encoded within the signal, is the information of when the signal was sent. Your GPS calculates the distance between you and each satellite it is able to pick up. This information will give you the distance you are to a known location. If you know your distance to several locations then it narrows down where you might be located.

Answer the following questions to help students realize how GPS is calculating your location.

1. What is the shape of all the points 2 cm from the dot in the question mark at the end of this sentence?

2. What is the shape of all the points at an equal distance (5 m) from one of the walls in the building nearest your current location?

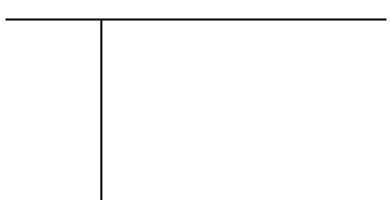
3. What is the shape of all the points at an equal distance to two walls perpendicular to each other (such as the corner of a room)?

4. Draw the shape of the set of points 1 cm from the following figures:

a. •

b. ______________________________

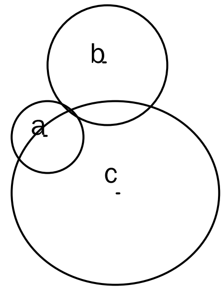
5. What would the shape of the area be that is less than 1 cm from the top horizontal line but also within 2 cm from the vertical line?



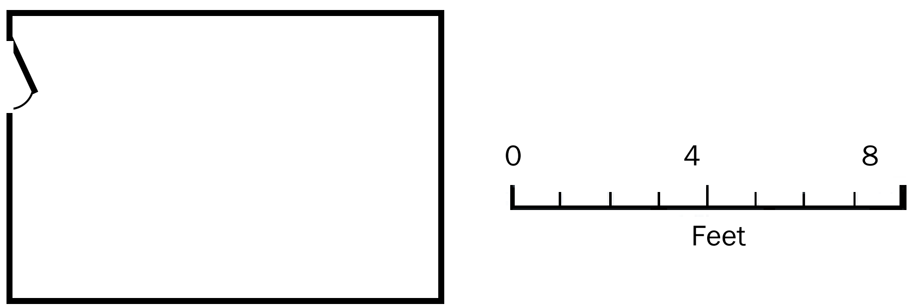
6. On Earth's surface or a flat map, what would the shape of all the points 150 miles from New York City look like?

7. Dallas and Houston are about 225 miles apart. How many possible places can be both 150 miles from Dallas and 150 miles from Houston?

8. Draw a box around the region that is 1cm from point a, *and* 2cm from point b, *and* 3 cm from point c:



9. If you were within 6 feet from the door and 3 feet from the wall in your room, where are all the places you could possibly be? Use the scale bar and show these places in the model below:

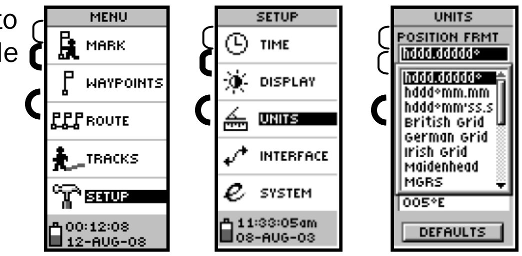


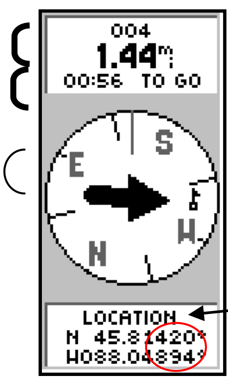
10. Using the scale on the map, what city is roughly 600 mi from Chicago, 950 mi from Minneapolis and 750 mi from St. Louis?

Finding Lines of Latitude and Longitude on the Ground

You may have noticed that on many maps there are lines and borders on them that you can't see or find when you are at these locations on the ground. While true in the visible sense, if you were to go to court in a legal case to find the border of someone's property or to find the Prime Meridian, there are tools to help you reach these invisible lines. You can use your GPS to find one common example, the lines of latitude and longitude. These lines will be particularly evident if you have several people, each with their own GPS unit.

1. Once your GPS has locked on to the satellites and is ready to navigate, make sure that your receiver is showing latitude and longitude in decimal degrees. *Note 1





2. Have your group spread out into a circle around the leader and have each person press the page button until all participants are looking at the Compass page. Use the toggle buttons on the upper left side of the unit until the information window under the compass reads *Location.*

3. Ask several group members to read the last 3 digits of their latitude. (Remember, latitude is the number that is preceded by N or S for north or south of the equator)

4. In your head, add about 30 to this number and round it to the closest 10s group. So if you have a latitude of N45.81420º have everyone walk until the reading becomes N45.81**450**º.

Important: Remind the group that they are not all trying to get to the same spot but to stop once the last 3 decimal places of latitude on their own GPS unit reads **450**. (Focusing on the last three numbers is easier when walking and the other numbers won't change at this scale.) Of course if you want to remind your group to walk in a north-south direction (point out which way is north), you will save some time from them finding it.

5. Once everyone has found this latitude, take a look at the shape that students are standing in. You can tell your group they are roughly standing on a line of longitude. (Not a whole number line but some decimal part of a degree.) Errors in the signal may make it a less than perfect straight line but students should get the idea. This also works better if the students spread out before they start walking.

Now, ask several people in your group to look at the longitude on their GPS unit and read their values. Looking only at the last three decimal places, add or subtract roughly thirty from one of the numbers called out. If you are at W88.04**894**º then ask your group to find the longitude of W88.04**860**º. Again confirm the shape of the group once they reach their destination as a line. How does this new line relate to the orientation of the previous line they made?

6. Finally ask the participants to find the place where these lines of latitude and longitude cross. ie. N45.81450º and W88.04860º. Your group may remember the general shape of the two lines and extrapolate where they will cross but just in case they aren't thinking this way, you can remind them that the point is somewhere along the line on which they are all currently standing. So follow the line one way or the other until they reach the point you have read to them. (You may want to simplify this last task to read just the last two digits for them to find. In our example this would be N.xxx50º and W.xxx60º .

7. Look at the area your group covers. This will give you an idea how accurately the GPS can measure a point. Typically this will be an area about 10m x 10m.

Figure a. This satellite picture of Boulder, Colorado shows the road known as Baseline Rd. running along the 40º N latitude line. You will determine some fraction of a latitude and longitude line that runs near your school or base of operation. (Image courtesy of Terraserver-USA)

Special note for younger participants:

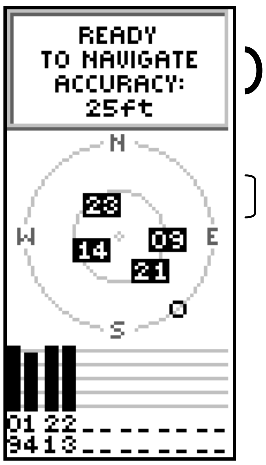
*Note 1 Younger groups may find it easier to use the UTM projection mode in the GPS as it measures how many meters north or south of the equator you are and how many meters you are from a reference line of longitude. While they are large numbers, they are always positive whole numbers which may be easier than the decimals dealt with above. The choice to use latitude and longitude in degrees was made because most schools are teaching this system and it is certainly simpler than using or explaining degrees with minutes. Eventually if you like to geocache, it is most common to use the degrees and minutes representation but for now it is easier with decimal degrees or UTM.

Finding Points

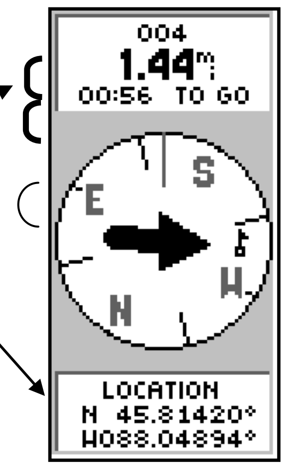
GPS Navigation team members:______________________, ______________________, ______________________,

The GPS unit is a wonderful tool for saving where anything exists. Use the coordinates given below to find your way back to spots we have located around the school grounds. Give a short description of the locations, save a waypoint there and continue on through the list. When finished, meet the rest of the group back at the lab.

Make sure that the GPS is on. Once you are ready to navigate, page to the compass or navigation page (with the upper right Page button). Move around the grounds until the coordinates in the bottom of the GPS units match those on your worksheet. Hint: It is easiest to get one coordinate to match at a time.



If the "location" window doesn't show on the bottom of the compass page, use the toggle buttons on the upper left side of the unit to switch what data is shown.



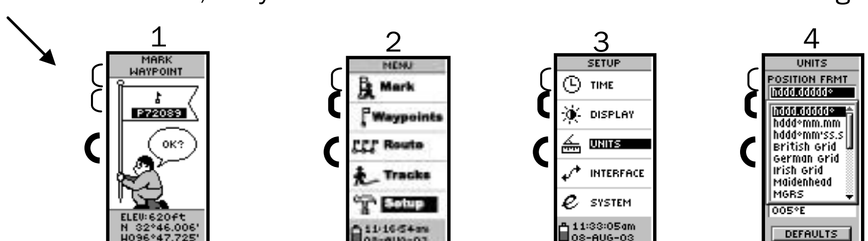
Waypoint #	Describe this location	Latitude	Longitude
# 1		° N	°W
# 2		° N	°W
# 3		° N	°W
# 4		° N	°W

Sample X and Y data given below

Once you have reached each destination, save your waypoint by clicking and holding the "enter" button just below the toggle buttons until this screen appears.

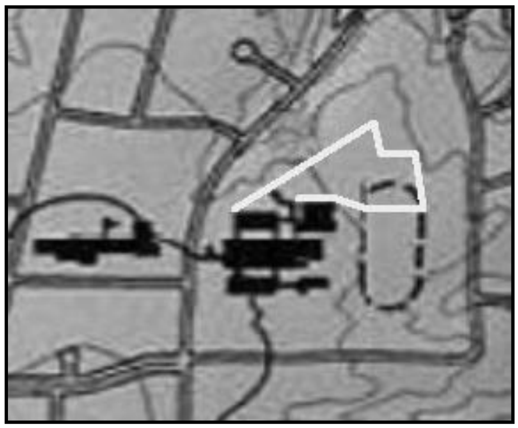
Then click the enter button one more time to save it. Describe the locations on the blanks of this sheet and return back to your starting point or your class building.

Note: To use in a GIS, set your GPS coordinate information to decimal degrees: hddd.ddddd



Finding Points (continued...)

Teachers or leaders: (Do not copy this page as part of a participant handout.) You can either check your students work by their descriptions or you can turn on their GPS tracks on the map page and look to see if the shape of their track matches where you wanted them to go. You could also get them to take a digital picture of each location for their proof of each group getting to the appropriate spot. This is a good early on exercise as students are getting used to the GPS interface. Finally if you have younger students you can go out and save the points with one GPS and share them between several GPS units using the DNR GPS upload and download function described in Take a Hike (and share it.) Using DNR GPS, you can also walk your intended course then download the coordinates and paste them into the table of a word processing document such as on the previous page before printing them off. If it is easier, write down the coordinates from your GPS to a master copy of the handouts before giving them to your group.

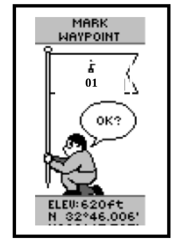


Example of what your students might write down in the blanks of their data gathering sheet.

Waypoint #	Describe this location	Latitude	Longitude
# 1	Corner of Student parking	30.75000 °N	-97.78793 °W
# 2	Home base of baseball field	30.75078 °N	-97.78826 °W
# 3	East side of end zone	30.75002 °N	-97.78752 °W
# 4	Back Gym Door of School	30.75016 °N	-97.78804 °W

Hide and Seek

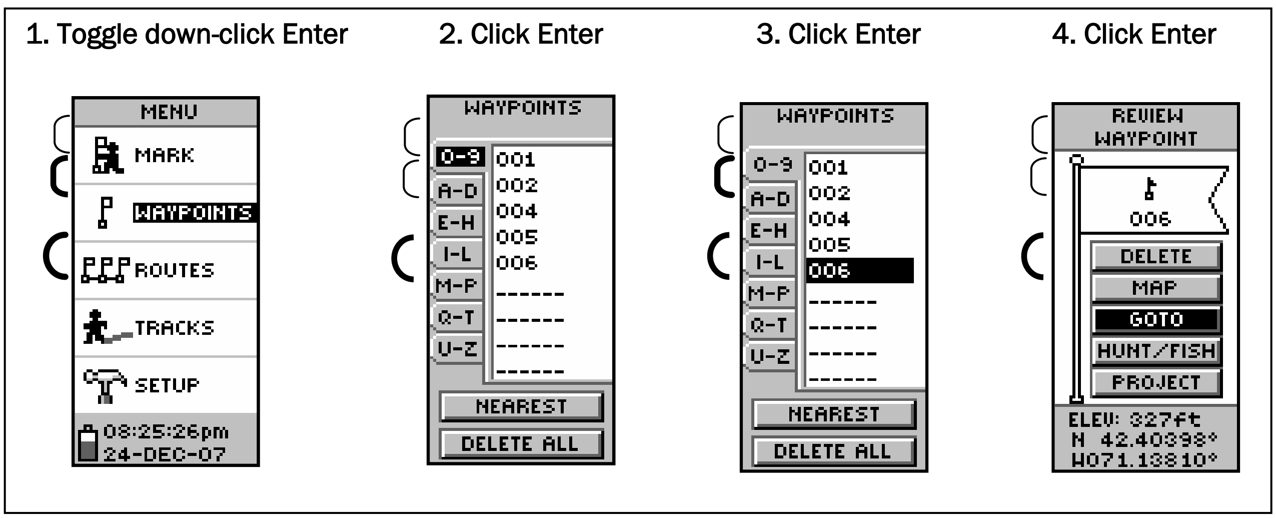
This is an easy quick activity to brush up on finding waypoint

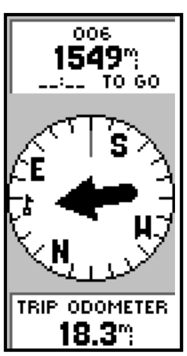


s someone else has already saved before. A deck of cards is a nice tool but any numbered sheets of paper, or other unique trinkets would work as well. This works well in a classroom sized area outdoors.

1. Hand each person a playing card or an object to place around the training area. Tell them to leave the card or object sitting somewhere that can easily be found. Before leaving that spot, save a waypoint by clicking and holding the Enter button (lower left). The flagman will appear. Click the Enter button a second time to save the point.

2. After placing their cards or objects, everyone returns to the starting point, and exchanges GPS units with another person. Each person presses the Page button until they get to the main menu of the GPS they have just traded. Highlight the word Waypoints, and click Enter. Navigate to the last waypoint in the list. Select *Go To* and press the Enter button. (See following images for description)





3. The compass page will appear with distance and a direction to find the playing card or object. (Remember, the arrow only works while you are moving and once you are within 20 feet you should look for the object.)

4. For more practice, participants should return to a central location, exchange GPS units with others, and repeat steps 2 & 3 until everyone has looked for several items. On the last time out, have everyone pick up the objects and return them to you.

5. An easy variations could include the teacher or leader preparing an interpretive walk around the school grounds and uploading saved points to a computer using the free DNR GPS tool. (You will need a GPS download cable to do this.) Then upload the points back to the rest of the GPS units before sending the class or group out with a worksheet describing what to do at each of the sites that have been chosen. Refer to Take a Hike (and share it) describing this lesson in more detail.

6. There are other variations that are good to try. Geocaching is really just a form of hide and seek. A favorite alternate is to pick out any number of locations and write a riddle, poem, or clue about what is at each spot that you want students to look for, describe, or take a picture of. On a worksheet with the clues, each student must describe the object or physical feature they think the clue describes. An example follows.

Aye, mate - The hunt for the perfect picture!

You will be using the GPS to guide you along a path. There are seven stops along the way; at each location you are to take a picture of what your group believes is described at that spot plus take a couple pictures of the surrounding beauty with your team members in action. When you return to the computer lab, download your pictures remembering the eight best photos you took to copy back to your computer. The sample clues:

1.) Start down the path off the back lot,
take the right path once your GPS is hot.
Up and over small hill you'll be there in a whistle,
what you want a shot of is the head tall old ______.

2.) Look around for the flowers near the next site to shoot,
lower cursor to WPT 002, *Go To*, then scoot.

3.) Cranium rock looks like a fossilized egg,
stuck high off the path midst a rocky crag.

4.) Waypoint number four shows nature at best,
one force tearing down the other holds fast.
Tree roots stabilizing the wash is its job,
holding the canyon from sliding down like a mob.

5.) Point five holds a treasure of fruity delight,
look up above the road at about twice your height.

6.) Before reaching the last point your paths will diverge,
one less traveled and rocky, the other covered in ferns.
Here's where to follow your GPS with care,
take a picture at the fork of which trail led you there.
(Both paths lead back so choose the one that looks best to your group. Don't worry what the others choose.)

7.) The last waypoint takes you under the guardian trees,
standing silent like sentinels protecting your ways.

8.) Take one last picture once you've reached the road,
be careful of cars, now return to download. (You can turn off your GPS and camera.)

Picture #	Description	Your top eight pictures
_____	________________________________	
_____	________________________________	
_____	________________________________	
_____	________________________________	
_____	________________________________	
_____	________________________________	
_____	________________________________	
_____	________________________________	

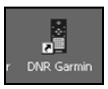
Take a Hike (and share it)

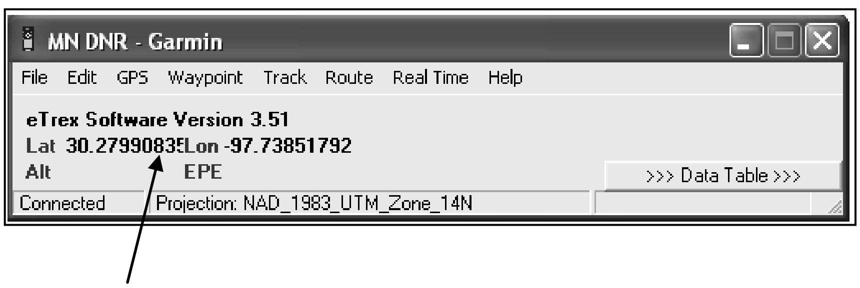
Install this free GPS utility that downloads waypoints from your GPS into tables, ArcView Shapefiles, or KML files. http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html (Or do a Google search on "DNR GPS" and follow the first link.)

These files can be used in the free GIS tool ArcExplorer Java Edition for Education (AEJEE), the full desktop GIS ArcGIS 9.x, ArcGIS Explorer, or Google Earth.

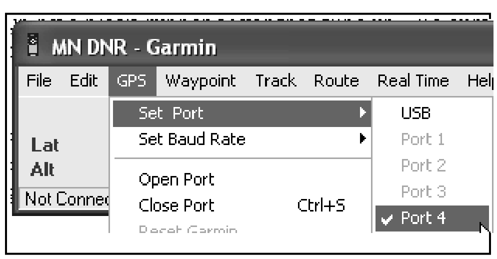
1. Attach GPS unit to computer via your download cable. (Some of the cheapest cables are on eBay – search for GPS download cables- (~$10-16 with shipping).

    a. Plug download cable into the USB or serial port on the computer.
    b. Plug the download cable into top/back slot in the GPS unit. This slot is covered up by a black rubber cover that will flip up. Be sure to slip the cable in with the "notch" in the cable matching the GPS's plastic "ridge." Refer to GPS diagram on page 9.
    c. Turn the GPS unit on.
    d. Double-click on the DNR Garmin icon located on the desktop. If the DNR Garmin program automatically recognizes the GPS unit you will see the following screen.





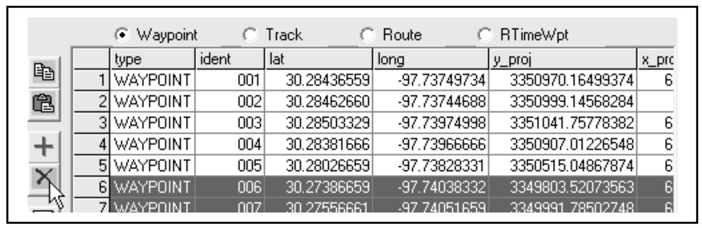
    e. If there is no black text in this area, use the GPS dropdown menu to Set Port. Try each port until it says "connected" at lower left.



2. Download points you have saved on your GPS unit to your computer.

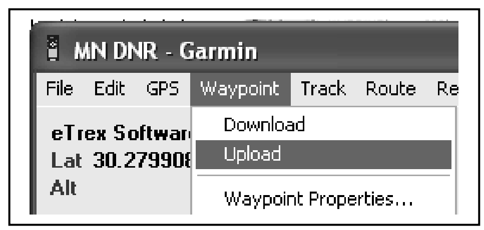
   a. Click on the Waypoint Menu item and then the Download button. This will download any Waypoints you saved by holding the Enter button (flagman appears).

   b. If there are many points in your list from other hikes, you can highlight and delete the unwanted points before saving or sharing them with other GPS units. This does not delete them from your GPS.



3. Your GPS can easily turn and upload these same points back into a new GPS. Take the GPS units with which you want to share the information.

   - Attach the cable to the back of another GPS
   - Make sure the unit is on
   - Go to the Waypoint menu
   - Choose to upload these points into the next GPS



   a. Continue this process with all the rest of the GPS units you have for others to experience the hike.

   b. Make a worksheet or trail interpretive guide and have others use the GPS “go to” function to follow your path answering questions designed for them by the naturalist or instructor.

   c. Find incentives for participants who find all the items in the walk or who answer questions correctly. Having a timed competition may be an exciting way to increase interest in topics from local history to following nature trails to fulfilling class assignments!

Streets and Avenues

Understanding location information is critical for people working with GPS. The following game can be a good precursor that helps bring up a common reference system (latitude, longitude) with which people learning GPS can relate. Fun for young and older alike, this is a variation on the game of tag.

Have your group line up in rows with an equal number of people in each row. Each person should be in an arm's length apart from the person to the front, back and sides. One person is chosen to be "it" and is the chaser and one person will be chosen to be chased. All the participants will face the group leader and stretch their arms wide to overlap the person's arms in the neighboring rows. This will form straight passageways that will be called streets. Those playing tag must stay within these streets and may not cross the outstretched arms even just to tag another player. The person being chased may replace themselves into the matrix by tapping the back of any of the other players or "street posts" in the rows. This new person must then enter the game and will become chased by the person who is "it". If the chaser taps the chased, then roles are reversed and the game continues. You may want the new "it" person to wait a few seconds before they can tap back in order for the original chaser to have a chance to get a head start into the streets.

Figure a. The roads of Detroit show obvious patterns of streets with occasional avenues breaking up the long city blocks. (Photo by Roger Palmer)

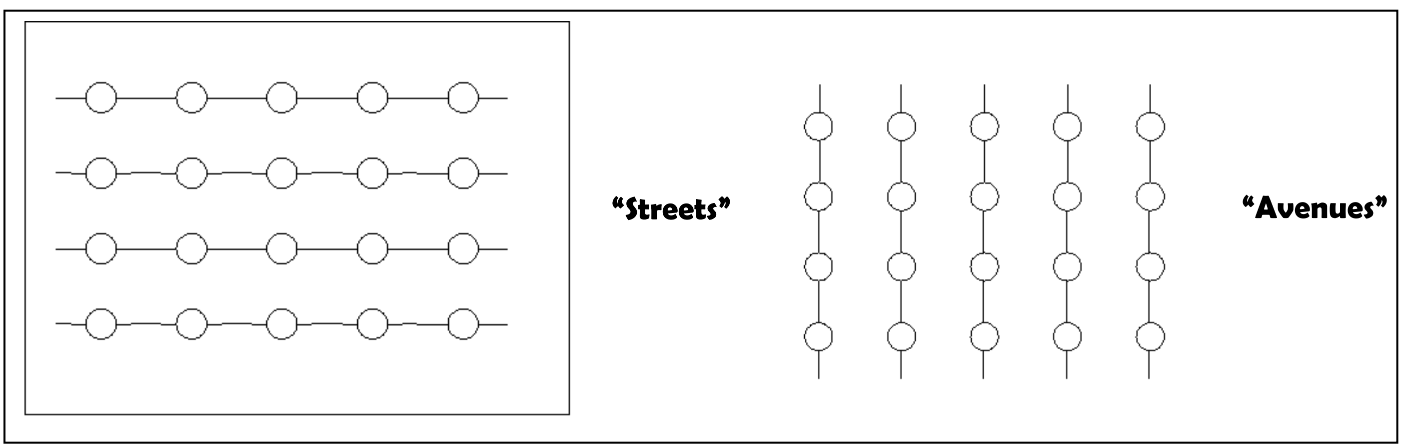


Figure b. Student arrangement for *Streets and Avenues*. Students stretch out arms to form "streets" or when "avenues" called they turn and form perpendicular lines with their arms to run up and down for those playing.

Periodically a person (the group leader) should call out "Avenues". All the people forming the streets will then turn 90° and form columns that those playing must stay within. After a short time, the leader can call the group to form "Streets" again as you continue to play the game. The game can be played for a set time, a set number of people to rotate in, or a set number of people who are "it". Using Grid Town as a follow up activity may help for a better understanding how streets and avenues relate to GPS.

Streets and Avenues (continued…)

Upon returning to a seating area/workspace, hand out a copy of your local phone book or a screen shot of your local area in Mapquest or a similar map engine. An example is given below. Ask people where they live. Find a couple of addresses that are located in the numbered street and avenue areas of your town. If no one's address is within these areas, make up an address like 1029 South 5th street and write it on the board. Have students locate where you are on your map and ask them to describe how they would get to the address on the board. (Generally the idea is to drive on any street until you reach the 10th avenue block then you follow the avenue until your reach 5th street or vice versa.) As the instructor, pretend you are driving and you can call out the house addresses as you are getting closer or farther from the assigned address to engage your students and so that you model finding places on a gridded surface like addresses in a city. (Or eventually coordinates from your GPS!) Emphasize that you find one part of the address first (avenue) before finding the second part (street number).

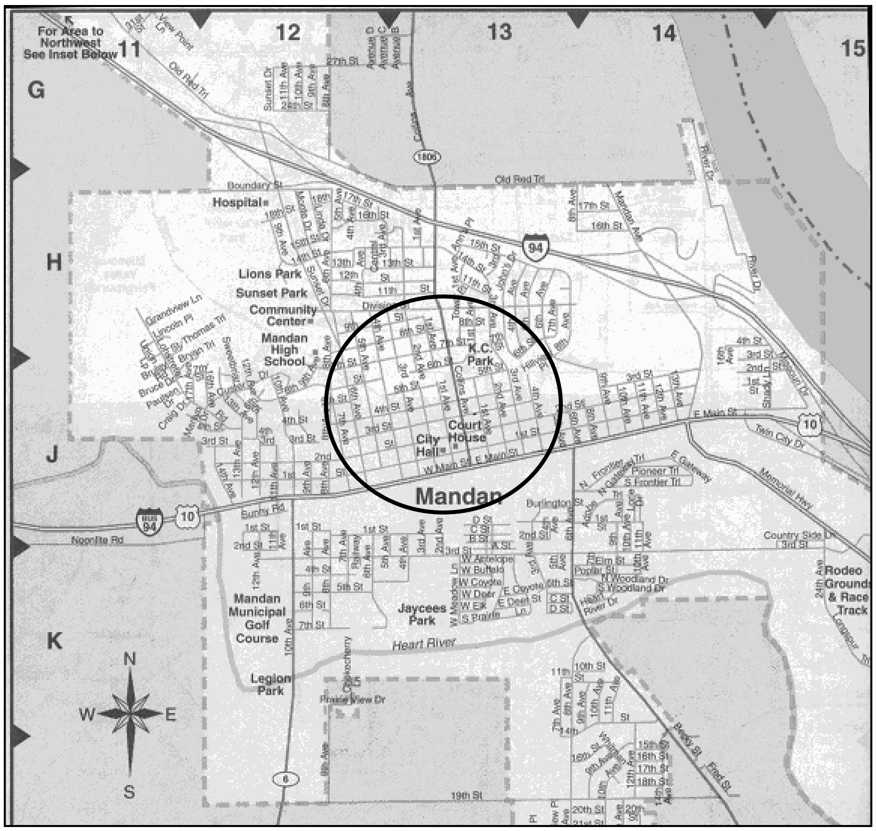


Figure c. A typical city map from a phone book or online mapping website. The circled area contains mostly numbered streets and numbered avenues. This is a good comparison to what you will be doing to find points on your GPS.

Possible Questions

a. Can you find 300 4th Ave?

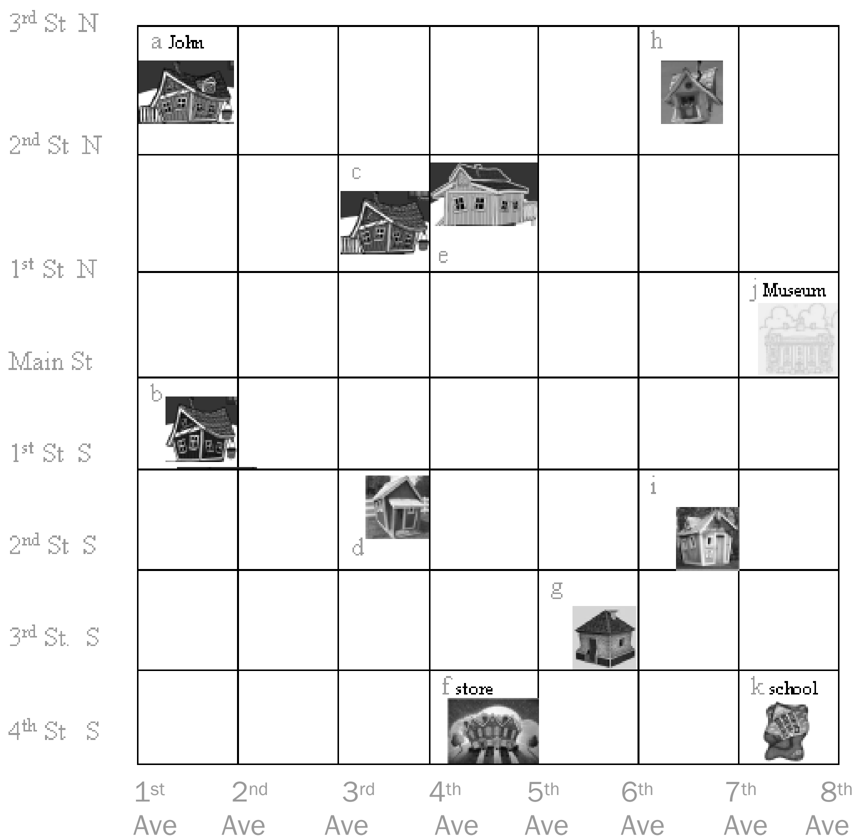
b. What might the address of City Hall in the center of the circled part of town be?

c. If the City Hall address were on the same street, how would it differ from the Court House?

d. Write out how you would drive from City hall to Mandan High School.

Grid Town

Many cities in the US have sections of town built on numbered streets and avenues. Navigating in these sections is familiar to most but good to think about when learning about grid systems. Assume that John lives at the corner of 3rd St. N and 1st Av or "a". Assume you are measuring to the corner nearest the letter



1. If John wants to visit a friend at d, describe what he must do to get there using streets.

2. How far does John live from b?

3. How far is John from h?

4. What is the distance from the school to the store?

   From the School to the Museum?

   What is the distance from the store to the museum?

Grid Town (continued…)

These three sites form a common sized triangle called a Pythagorean triple. What are some common Pythagorean triples?

5. How many blocks will John travel if he visits the store? (Measure the distance on a separate strip of paper then compare it to the length in city blocks. Compare your results with the distance formula if you are comfortable with this.)

6. How far (in blocks) would John travel by road to get to his friend's house at i?

   What if he walked straight to his friend's house at i?

7. Describe the drive from g to c.

8. Starting from John's home, how would you get to 650 3rd Street south? Write this out below:

9. If you are looking for a geocache at 3432600N, 601325W and you are at the point 3432600N, 601300W how far and what exact direction would you need to walk?

10. Your gps says that you are at the point 6543200N, 701695W and you want to travel to the point 6543230N, 701655W

    How far away is this point? (this is a Pythagorean triple)

    and roughly what direction would you need to walk? N, E, S, W, NE, NW, SE, SW

11. If you were at the point 6000000N, 500000W describe how you would find an EarthCache located at 6000090N, 499500W.

Teacher or Leader: (Do not copy this page as part of the student handouts)

Students may use a number of different methods to calculate distances on their maps. Upper level students can use the distance formula $d = \sqrt{x^2 + y^2}$. Geometry students call this the Pythagorean Theorem and may also recognize common right triangles such as the 3-4-5, 5-12-13, 7-24-25 or 8-15-17. For younger students, determining distances could be as simple as marking the distance between points on a small note card then moving the paper alongside the streets to count and estimate the distance.

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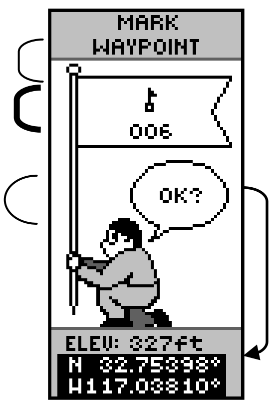
Far and Away

The *Go To* function on a GPS makes it much easier than walking around until your coordinates match the location for which you are looking. You can also edit the point you are about to save so that it matches a known location without needing to visit the location beforehand. Once it is edited you can find how far this place is from your current location. You can even tell which direction it is located. On the back is listed several large cities in the United States and a few around the world that you will enter one by one into the GPS. You can do this from your desk before going outside to get reception. Then when you go outside and get a lock on your location, use the *Go To* feature to find out how far and in which direction these cities are from your hometown. As this is only an approximate, you only need to change the first three digits in the coordinate and it keeps the exercise less tedious.

1. To edit a coordinate, you must act like you are going to save a point by clicking and holding the lower left (Enter) button until the flag man shows up. These are the coordinates for the first city you are working on – Boston.

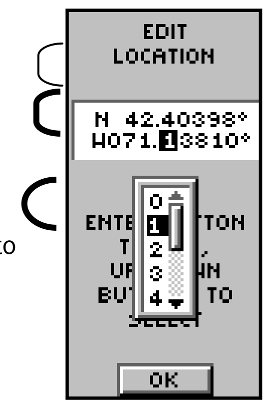


a. Toggle down to the coordinate information

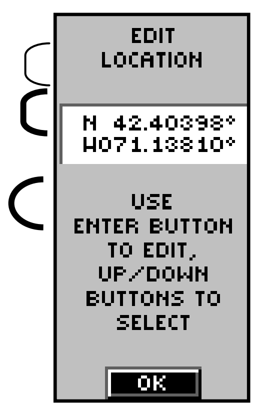
Click the Enter button to start editing.

b. Toggle over to the digits that need to be changed.

Click Enter to change the number.

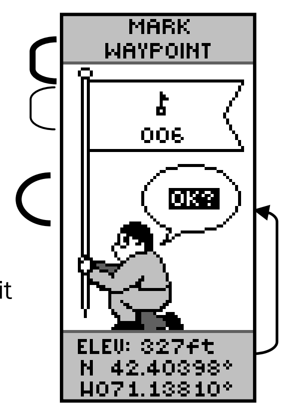


c. You need only change the first 3 digits of each coordinate. Then toggle to OK at bottom and Enter



d. Toggle back up to OK? And click Enter.

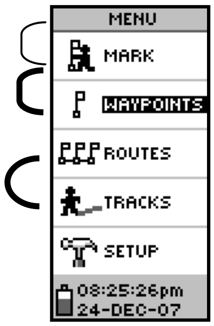
Saving the point will allow you to navigate to it in the next step.



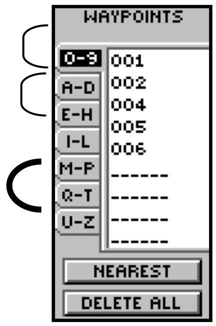
Far and Away (continued…)

2. Now that this point is saved in the GPS memory, navigate to it from the main Menu page. Click the Page button (upper right) until you reach MENU.

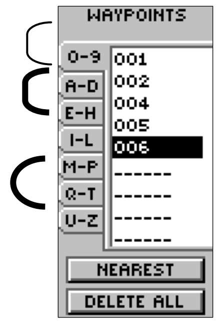
a. Highlight waypoints and click Enter



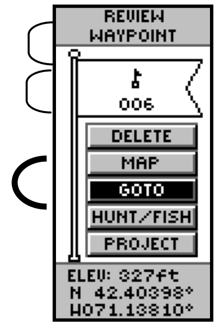
b. Click Enter

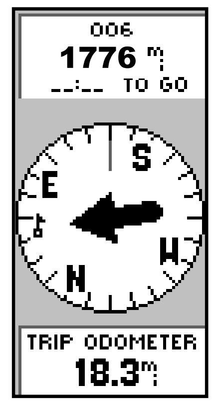


c. Toggle down, click Enter on last



d. Click Enter, *Go To*





The compass page will appear with distance and direction to the point you have chosen. Write these two variables into your table below. Then navigate to the next point in your list to complete the page.

3. Find the distances to the following cities (the directions on the front walked you through the coordinates for Boston):

City	Lat(N)	Long (W)	Distance	Direction
Boston:	42.4°	71.1°		
Los Angeles	34.0°	118.4°		
Houston	29.8°	95.4°		
Miami	25.9°	80.2°		
Seattle	47.6°	122.4°		
New York	40.6°	74.0°		
New Orleans	30.0°	90.1°		
Mexico City	19.4°	99.1°		

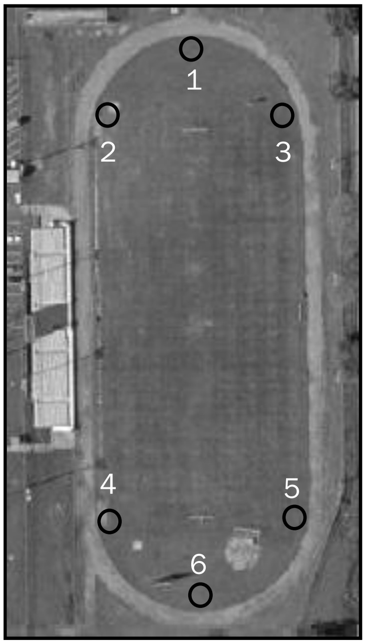
Which cities are farther from your town?

Miami	25.9°N	80.2° W
or		
Havana, Cuba	23.1°N	82.1° W
Paris	48.9°N	2.45°E
or		
Rio De Janeiro	22.8° S	43.5°W

(For classrooms, enter these points while inside, out of satellite reception. Then go outside to get signal and use the *Go To* each point to finish the worksheet.)

Take Me Out to the Ballgame

Your school grounds and a GPS can turn any features around your school into ready-made geometry lesson. This will also get your students out to measure in the real world. For your first time out, it helps to measure fields oriented N-S or E-W because the math is much easier.



1. Determine the area of this football field in Dallas from one end zone to the other using the UTM coordinates from a GPS. UTM is a projection that measures your distance north of the equator in the y field and your distance east or west of a line of longitude in the x field. (It is a Cartesian coordinate system.)

1. 3619674N, 701530W

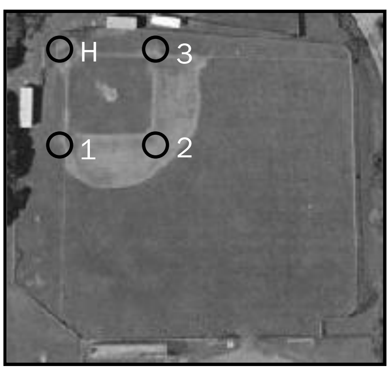
2. 3619654N , 701503W
3. 3619654N, 701565W

4. 3619534N, 701503W
5. 3619534N, 701565W

6. 3619504N, 701530W

Width of infield = difference between point #2 and #3 in meters
W =
Length = difference between point #2 and #4 in meters
L =
Area = L x W =____

Extra credit: What is the total area inside the track?



#2. Notice that the first 3 or 4 numbers in the UTM coordinates above don't change. Therefore you need only use the last 3 digits to make the calculations simpler. Determine the area between home, first, second and third base.

H : 501N, 767W
3rd: 501N, 742W
1st: 475N, 767W
2nd: 475N, 741W
W =____________
L =_______________
A = __________________

Extra credit: Estimate how many times larger the whole baseball playing field is than just the infield.

#3. Go to any local softball in-field and GPS the bases to see if your field is the same area as the high school baseball infield in the previous example. Make sure your GPS is set to UTM (you will only need the last 3 digits from both Latitude (N) and Longitude (W))

H: __________, __________ 3rd:__________, ____________

1st: __________, __________ 2nd:__________, ____________

L=________ W=__________ A= L x W =________

Or...Go to the 4 corners of a local soccer field to see which is bigger, the soccer field or the football field?

__________, __________ __________, ____________

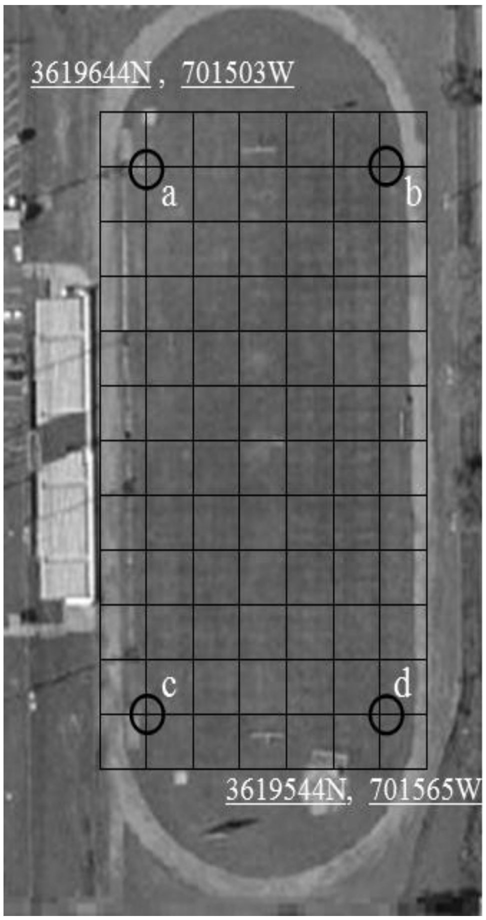
__________, __________ __________, ____________

L=________ W=__________ A= L x W =________

Take Me Out to the Ballgame (continued…)

The Algebra of Position

As in the previous exercise, the area of places around your school can be measured based on the coordinates of key points on facilities. The coordinate system in use is called UTM and its units are in meters north of the equator and meters west of a set line of longitude. Now we will work to determine the formula of the line that runs through the edge of the football field shown below. This is great practice for using standard format formulas for lines y = mx + b where m is the slope and 1/m is the slope of a perpendicular line.



1. What are the coordinates of point a on the map?

2. What are the coordinates of point b?

3. What is the formula of the western (left) side line in the image ($\overline{ac}$)?

4. Use the point slope formula to determine the line between points a and d.

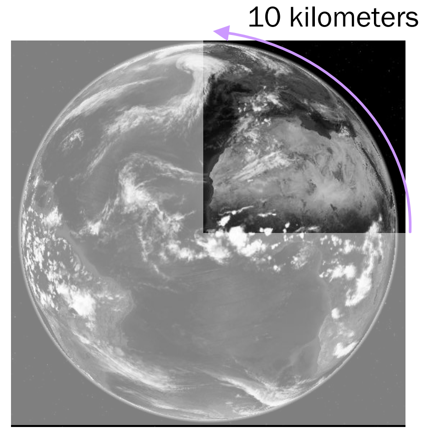
5. What is the formula for the 50 yard line? (The perpendicular bisector of $\overline{ac}$)

6. Are the two lines $\overline{ad}$ and $\overline{bc}$ perpendicular? Use slope to prove or disprove this theory.

7. Use your GPS and gather data along some school feature to determine the formula of the line along this feature. Make sure that your GPS is set to the UTM projection before using DNR GPS to download the points.

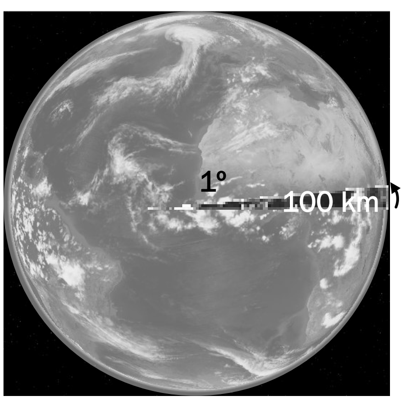
A Walk Around the World

The world is a large place. Historically, it was quite an accomplishment to figure out how large Earth is. It took quite some time just to convince some people that the world was even round. Common sense reasoned that if you started walking and never turned back, then you should never return back to your spot. The distance around the world became a great challenge for many philosophers to estimate. Eratosthenes was one of the first scholars to do so. He was a mathematician at one of the most important libraries of the world. This was in Alexandria, Egypt around 200B.C. He was the first to estimate the earth's size based on measurements. Several other estimations have taken place but it was the 18th century French who were the first to get it quite accurately. You may be surprised to find out that their effort helped France determine the length of one meter and establish the metric system. The attempts at finding Earth's size can be summarized in the following thought process.



If you walked from the equator to the North Pole, what fraction of the world will you have walked? __________ If this distance were 10 km, how far would it be the rest of the way around the whole world? _________________km

Perhaps walking from equator to pole is too great a challenge for an explorer to measure. Walking a smaller portion of the Earth and measuring it would still be possible. So, if a circle is cut into 360 degrees, perhaps you could walk one degree and find the distance between the two points one degree apart. The world would then be just 360 times larger than this distance. One degree is still quite a large distance to measure on the ground but it was eventually accomplished in France with many years work. Several teams followed these measurements at the equator and the poles to insure that the world was indeed round and not squished or stretched. Two teams who succeeded in measuring the length of a degree concluded the world was just barely fatter around the equator and for most practical purposes could be considered a perfect sphere. Using this information, the length of the meter was officially set to 1/10 millionth of the distance from equator to pole.



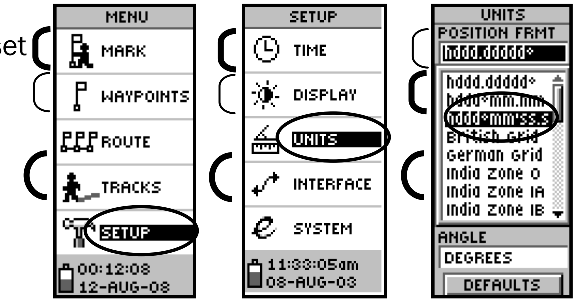
If the distance between two points one degree apart were 100 kilometers, how far would it be around the whole world? __________________km

Your GPS unit can show you both the fraction of the world you travel and the distance that this journey takes! You can save a point and then using the *Go To* function, choose to walk some smaller amount than one degree. Perhaps traveling 1/60th of a degree would make it easier to measure this distance. Just as an hour is split into 60 minutes, each degree can also be split up 60 times. 1/60th of a degree is called a minute.

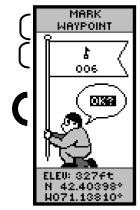
This is a manageable distance to walk or ride in a day! Most groups may still not want to walk this far. Fortunately, each minute can be cut further into 60 creating a measure called seconds. If there are 60 seconds in a minute, and 60 minutes in a degree and 360 degrees around the whole planet, how many seconds are there around the world? ____________________ seconds around the world.

You are now ready to go and measure the distance around the world. By saving a point and walking either straight north or south of this saved point for 1 arc second, you could use the *Go To* function to determine how far you walked in that arc second. Then since there are 60x60x360 seconds around the world, you can determine the total distance around the world.

1. First turn on your GPS and find your Menu page so you can set your units to degrees, minutes and seconds.

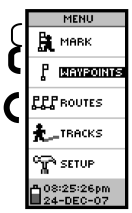


2. Let your GPS get a fix then save your current location. Remember! Press and **hold** the Enter button in any screen on the GPS to get the flagman and then click enter again to save your waypoint.

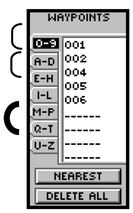


3. Page to the main menu and choose your current location to *Go To*.

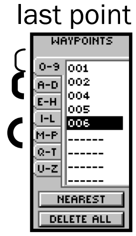
a. Highlight waypoints and click Enter



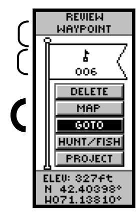
b. Click Enter



c. Toggle down, click Enter on last point

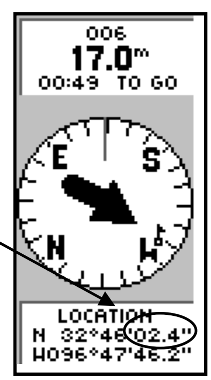


d. Click Enter to *Go To*



4. Click up on your toggle buttons until you show your LOCATION info in the bottom screen.

5. Make a note of what the seconds are and start walking either north or south. (Make sure to keep the W information from changing.) Walk until you have traveled 1.0 "seconds north or south from your starting position. The distance you have covered on the ground is in the top box.



Use the space below to calculate the distance around the world.

Circumference of Earth =

Is your path around the world as large if you walk in the east-west direction as it is in the north-south direction?

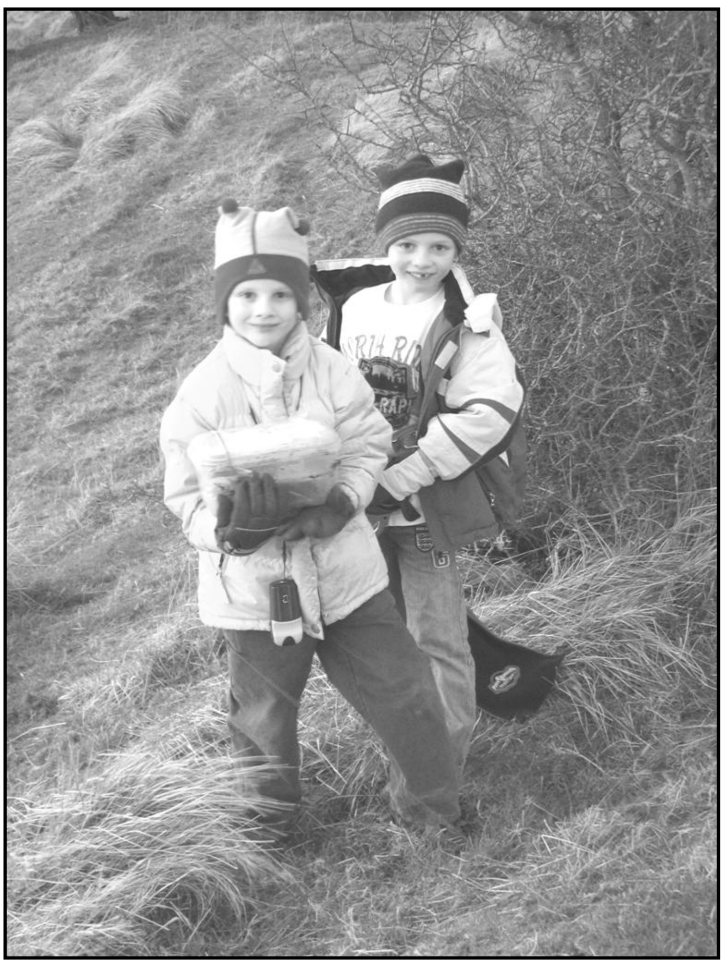
If it is different, why is it different?

Games and Activities

Learning is never more profound than when it is active and you are having fun!   Games using GPS make the time fly and make learning a rewarding workout that sticks with you. The educational theorist, William Glasser, claims we learn 10% of what we read, 20% of what we hear, 30% of what we see, but 70% of what we talk about, 80% of what we experience and 95% of what we teach another. The best part for us happens when others choose to get into their own GPS activities.

If you tell me I may forget, show me and I will remember, but involve me and I understand.

Chinese Proverb



Max and Archie are having great fun finding a geocache in Canterbury England!

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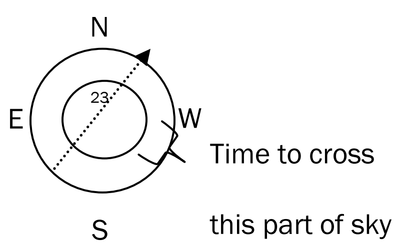
Stargazing

The GPS system is composed of 3 parts of a system. You have already been exposed to the local receiver. This is no more than a specialized radio for receiving signals from satellites to determine the position of the GPS. These satellites are kept synchronized and functioning from a broader support system on the ground run by the United States military. But is there any proof these satellites existence? GPS satellites are in orbit around Earth about 12,600 miles above the surface. During the day, you would not be able to see them for the same reasons we do not see the stars. The sun's scattered light is much brighter than that which we receive from the stars. The exception of course is the light from the moon which we can see during the day. Yet, on a nice clear night, perhaps out of town away from city lights we should be able to find satellites if we just knew where to look. Lucky for us the satellite page on any GPS tells us exactly where to look at any given time. The series of circles or "bulls eye" page is a map of the sky showing where the satellite signals are coming from.

This is a great camping or night hike activity for any group of GPS enabled adventurers. A good pair of binoculars or small mounted telescope can make for a great night looking for satellites. You may want to start the search for satellites that are close to the center of your sky map on the satellite page. Satellite #23 in the diagram should be crossing straight overhead. If you hold the GPS and orient the device to match the directions to true north, west, east and south, the labeled satellites will be in the sky where the map labels them. Satellites are not bright objects in the sky and they appear even smaller than some stars but you will have the advantage of seeing them moving against the fixed background of the stars. Satellites are much slower than meteors or meteorites (shooting stars). They cross the sky at about the speed a jet crosses the sky. You may find other satellites moving about in addition to the GPS constellation of objects as there are thousands of different satellites in orbit. The sky view page on your GPS can guide your hunt for the satellites that are part of the NAVSTAR GPS system.

If you are not using a telescope or binoculars, the satellite page can still be used for engaging activities. See if you can estimate how fast satellites travel. Time the satellite from one ring or center to the next. Use this time to figure out the speed (v= d/t)!

Hint: What part of a total orbit does the satellite cross from one ring to the other? Assume the satellite does half of an orbit (180°) if it crosses the whole circle.



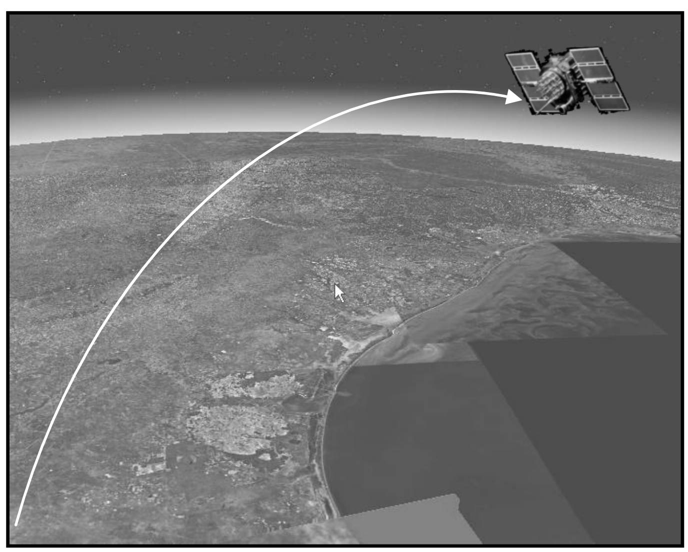


Figure a: Satellite numbers will move across the sky view page as they pass by overhead. This page will provide a map of where to look for them in the night sky.
(Image provided by NASA Worldwind)

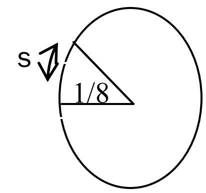
Extra Credit: Can you figure out which satellites are in the same orbits with each other? There should be six different orbits across the sky.

Group Leaders would not want to copy this side for students

* Two strategies for estimating a satellite's speed:

1. Estimating the speed that a satellite is moving makes students move through many assumptions. But it is a great exercise in estimation. For instance, if you assume the satellite is moving on a circle with a 12,600 mile radius, (around the student instead of around the world) then the time it takes the satellite to move ¼ of the way across the hemisphere or 45 degrees might take about an hour and a half. Figure out what portion of a full orbit the satellite travelled and divide this by the time it travels this distance:

Distance around this orbit = $2 \pi r = 2 \pi\, 12{,}600 \sim 79{,}200$ mi



s = (1/8)*79,200 mi = 9,896 mi

velocity = 9,896 mi/ ~1.5 hr

velocity = 6,600 mi/hr! That is still an underestimate.

2. A second estimate more accurately considered. Adding the world's radius to the satellite's orbit height:

r = 3,900 mi + 12,600 mi = 16,500 mi

The satellite's total path around the earth (its circumference) = $2 \pi r$ = 103,400 mi

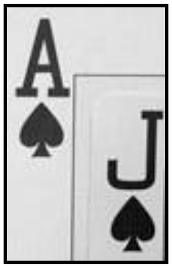
From your measurement of the time it takes the satellite to go between two of the circles on the navigation page (1/8th of the way around the planet) divide this into the length of the path the satellite travelled.

Speed = d/t = (1/8 · 103,400 mi) / ~1.5hr

Speed = 8,620 mph

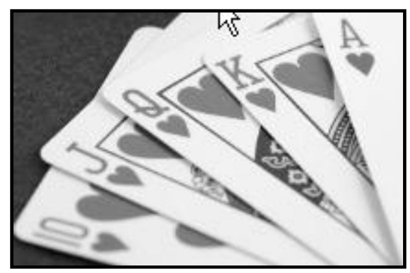
GPS Card Games

The following games can be used with playing cards or alternatively, you can use numbered index cards.



Black Jack: Place two cards in 21 places around your back yard, in a field where you are camping, or around the school yard. Save the waypoints of the locations of each of the pairs of cards and bring them back to your computer to share between units using DNR GPS. Refer to the *Take a Hike (and share it)* lesson. Students will then be asked to use the *Go To* function to start finding cards. Students will pick up the two cards at their first location to see who has a combination that adds up closest to 21. Face cards are worth ten points and the Ace can be either eleven points or one point depending on the player's choice. A player can decide if they want more cards and to search for a different pile. They must play the first two cards picked up at this location unless someone else has already picked this pile up. By going to another pile for more cards, students can choose to pick up the top card. If they still want another card, they must pick this second card at this location. Should the player still need more cards they can choose to continue to another pile but once a card is picked up it must remain in their hand even if it drives the players total over 21. Once players are satisfied they have the hand they will hold onto. players return to find which player has the highest cards without going over 21. An alternate version would require the dealer to first deal themselves a hand before going out to place the rest of the cards in the field.

Poker: To play, the dealer splits the cards into five closely equal piles. The dealer then goes around the area and records a waypoint for each pile left at the locations. The 5 locations are then shared to the other GPS units using DNR Garmin. This time each player must visit each of the five decks to pick any card of their choosing to create the best poker hand. The player can look at all the cards but pick only. Players may not switch cards from their hand to the pile. The players then return to play their hands in normal poker style. To save time on subsequent hands, the same sites may be used for several rounds until everyone is familiar with the hidden card sites. The dealer may have to use the function to replace the missing cards between rounds.

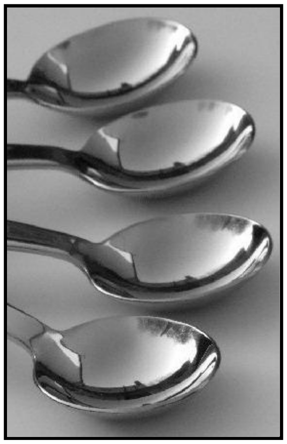


Two Card Draw: This game is played the same as poker but the dealer can hold back two cards per player so that on return the players can draw up to two cards before playing their hands.

Gold Digger: This variation can be played by pre-dealing an entire five card hand for each player. The dealer then hides the hands in the area of play marking waypoints for each hand. On return the waypoints are shared to all GPS units whereupon the players may use the *Go To* function to find any of the hands located on the grounds. If the hand doesn't look very good, the player may choose to leave this hand face down exactly where he or she found it and proceed to look for one of the other hands located at a different *Go To* waypoint. Eventually all players return to play knowing that some players may have seen some of the other hands.

Hand Me Down: This variation is the same as the original where the dealer hides 5 sets of cards but on return, players must pass two cards to their neighbor first to the right then to the left on alternate rounds.

As a reminder the order of hands goes: highest single card, two of a kind, two pair, three of a kind, straight, flush (all one suit), full house (two of one number, three of another number), four of a kind, straight flush (all one suit in numerical order), five of a kind, royal flush (all one suit in numerical order, 10 through Ace).

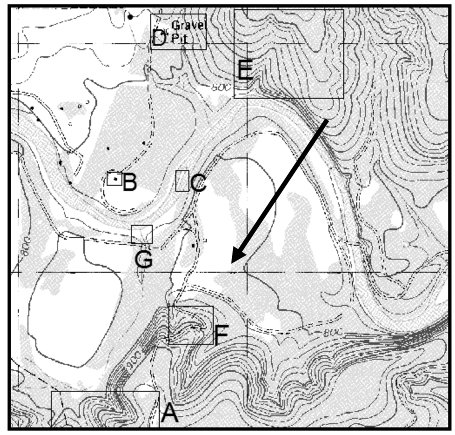


Spoons: While an old time favorite, this variation can add quite a physical element to the game. Some one outside the game must hide the spoons and share the coordinates to other units via DNR Garmin. You can also write the coordinate location down on separate sheets of paper. The object of spoons is for each player to get four cards with the same number or royalty. The dealer starts pulling one card at a time from the draw pile. Before they can draw a second card the player must discard one of the cards in their hand to the player on their left. Each player is trying to get four of the same numbered cards before any of the other players do. The player on the left may start drawing cards provided to them from the previous player and discarding their excess cards to their left. Once any one of the players reaches four of the same card types (all four aces, four twos, etc...), then the player must lay down their cards and search for the hidden spoons. The players may either enter the coordinates for the spoons into their GPS or use the location information on the compass page to guide them to the location of the spoons.

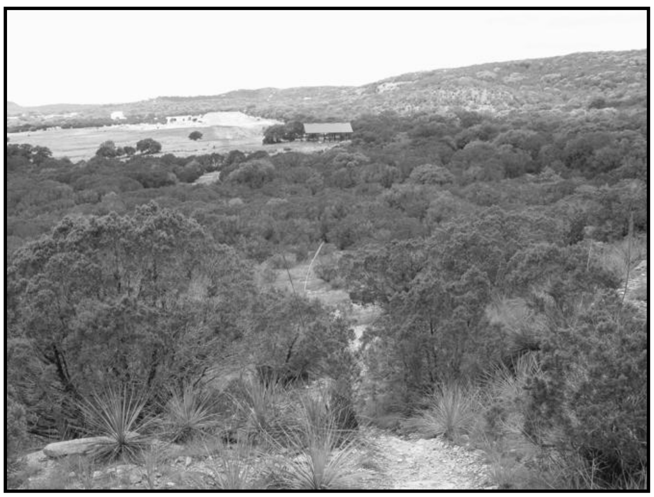
Many times once one player throws their matched set of cards down, all players will typically scramble to get their GPS and start running for the location. Some times this can get a little rough but plenty of fun will be had in the process. In hiding the spoons make sure not to put them in places that may place the players in danger; on roadways, near cliffs, or even areas of low lying branches or potholes. This is especially important for novices that may not be looking at where they are going while navigating to their destination.

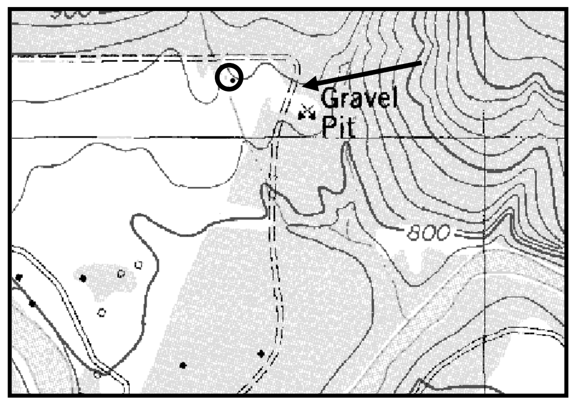
Reading a Topo Map - Teacher

Draw an arrow where the tail is the camera's position and the arrowhead is your line of sight on each topo map. Then answer the question below each map.

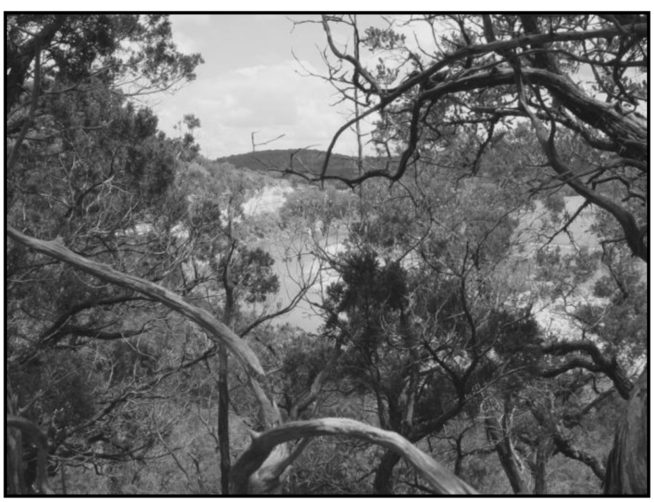


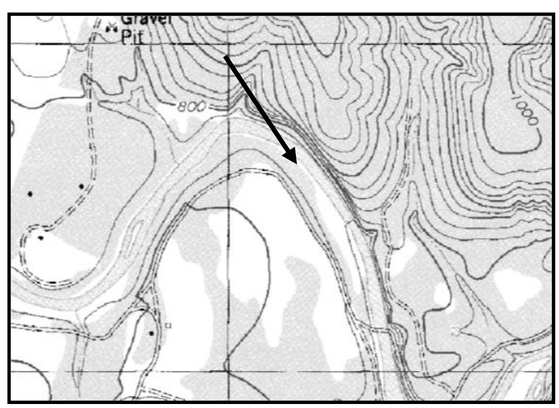
What are the lines in the distance in the picture?
Roads





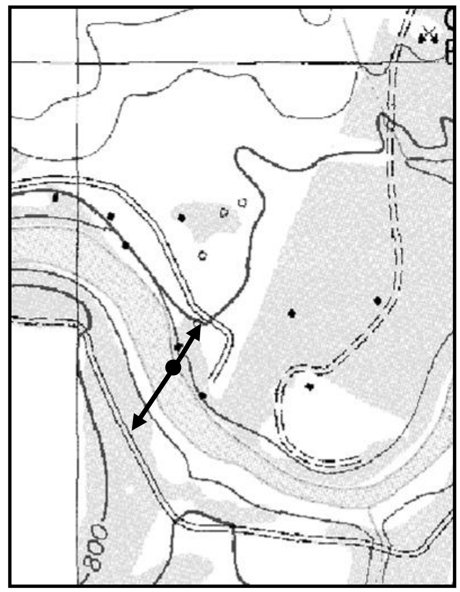
What represents buildings on a topo map?
Squares



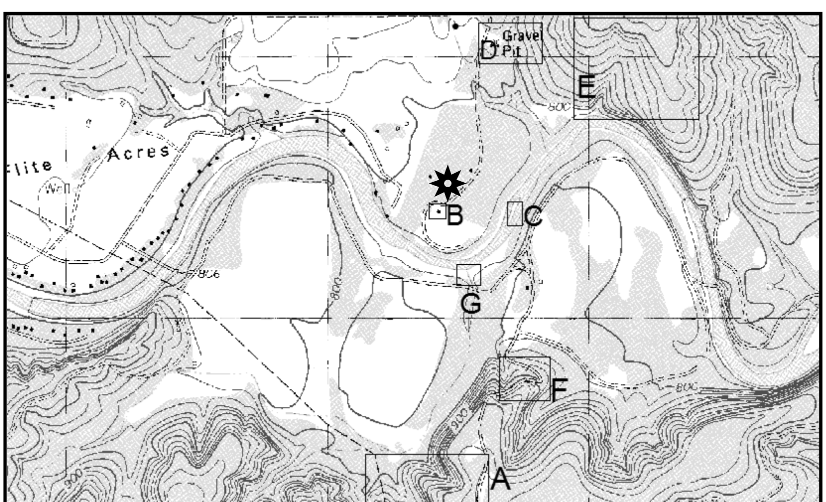


What is that feature in the background between the trees? The river

Looking one way



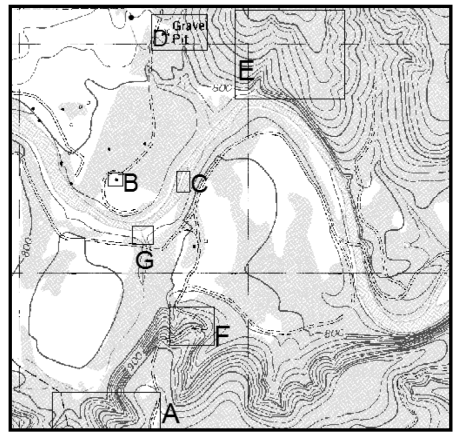
Looking directly opposite, where would you be standing to see these two pictures?



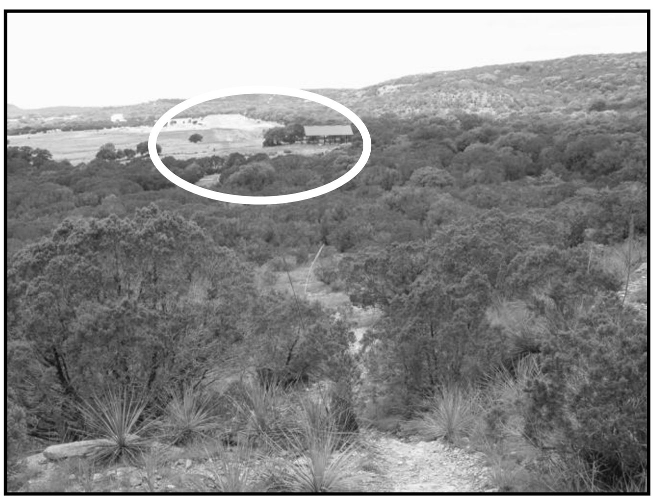
Look around you here at camp, see if you can find some of the landmarks boxed and lettered in the picture at the left.

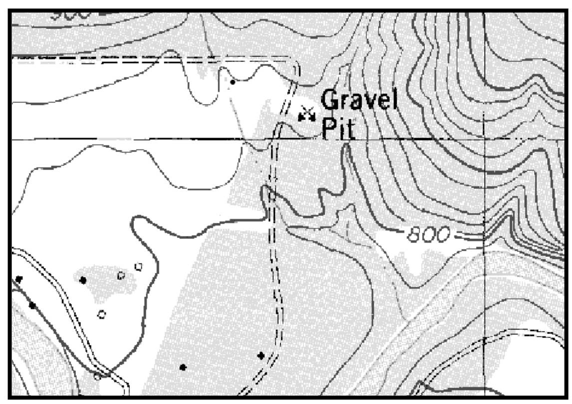
Reading a Topo Map - Student

Draw an arrow where the tail is the camera's position and the arrowhead is your line of sight on each topo map. Then answer the question below each map.

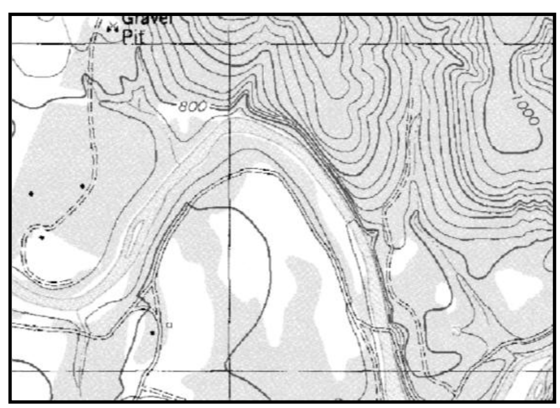


What are the lines in the distance in the picture?



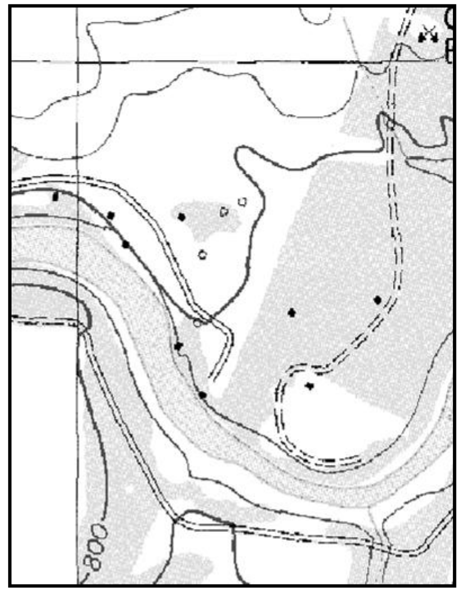


What represents buildings on a topo map?



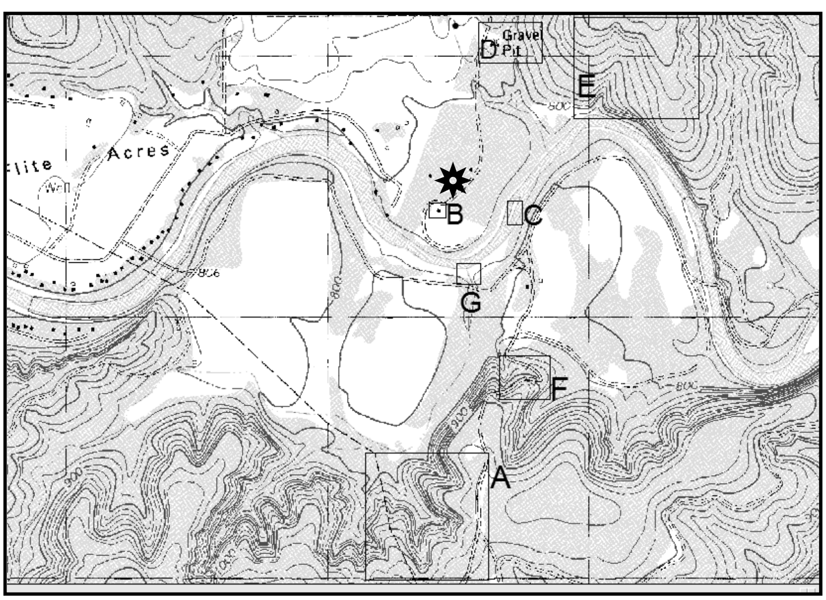
What is that feature in the background between the trees?

Looking one way



Looking directly opposite.

Where in the above topo would you be standing to see these two pictures?



Look around you here at camp, see if you can find some of the landmarks boxed and lettered in the topo at the left.

You are there ✸

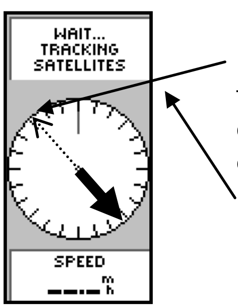
Orienteering for GPS

Orienteering is the act of getting from one location to another off road and sometimes even off marked trails. Three important facts are needed when orienteering, a sense of what direction you need to travel, the distance some point of interest is from you and any type of map that can show important features along the way. The typical tools of this trade are a compass to indicate direction, a little practice in understanding your own stride for distance and a topographic map to show land features along the way.

This activity is not meant to replace good books on orienteering techniques but rather to show you how your GPS can act as any of the three tools mentioned previously for orienteering.

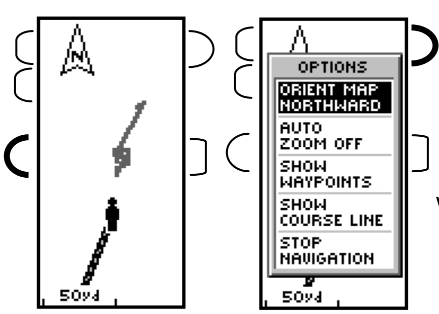
Some of the techniques for finding direction depend on the type of GPS you have as well. More expensive units have electronic sensors to measure Earth's magnetic fields and they can be used with caution as compasses.

For many sport GPS units, such as the Garmin eTrex® H, it is critical to remember that they are not compasses. GPS units measure your location. If your location changes, it determines the direction of that change. The Compass page works only when you are moving in a straight line for at least several steps consistently. If you are not moving, your Compass page will not be reliable at all. Determining direction from your GPS is a little like reading a book upside-down. You will need to save your location, set the *Go To* function to your current location then walk so that the arrow points 180° from where you want to go.



Intended direction: It is nice that if you know the direction you need to travel, the farther you are from your starting point the more accurate your heading becomes. (This is the case as long as you keep the pointer 180° from your intended direction)

While you are out hiking, the map page has been creating a rough trail of where you have traveled if your tracks have been turned on.*1 The most convenient way to backtrack if needed is to use this page to follow your trail from where you've come. Make sure to set the GPS to *Orient Map Ahead*. From the map page, click the Enter button once to bring up the options popup window. Click a second time to switch between Map Northward and Map Ahead capability. The north arrow only appears in the Map Ahead mode.



This may seem confusing but if the top choice in the pop up box reads as shown to the left, you are in the correct mode. If this is the case, you should click the Page button on the upper right to get out of the popup window without changing the map display.

The *Map Ahead* mode will act much like a map that is being thumbed. You can just follow the trail on your unit, turning the same direction the trail in the map appears to turn in order to successfully backtrack. Unlike thumbing a map, you will never need to turn the GPS. The map turns for you because it is in *Map Ahead* mode. Putting the GPS in the *Map Northward* mode makes the map page work like a standard map held normally with the north end (top) of the page away from you.

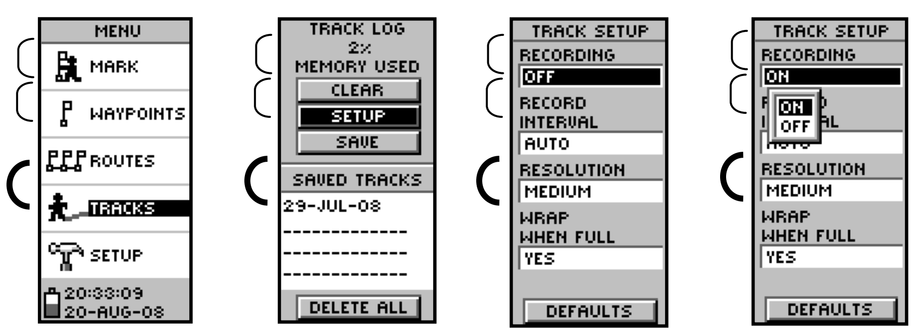
During orienteering there is often a time challenge to finish before other teams do. Using the *Go To* your starting position may be tricky while running across the field. You may want to use the GPS to first determine your direction of travel as shown above, then pick a landmark out in the distance that you can head toward so that you can keep your head up and watch the trail ahead. Periodically glance down to check your distance on the GPS to see when you may be approaching your next control point.

The GPS can also help you understand how far you travel by using it to help measure your pace size. This is usually accomplished by counting your steps in either 100m or 100ft increments. If you are out camping, finding a marked, even distance like this can be a challenge to measure your pace against. Using the *Go To* function from your current location then count your steps until you are 100 m (or a 100 ft) from your beginning position. If it takes you 85 steps to go a 100 meters, use this as your base to estimate distances on the orienteering field. If the next object is 210 m from your current location, you would count 170 paces in the direction you need to travel. For longer distances it is critical to keep track of 100 counts. Folding your fingers, marking tics on a sheet of paper, putting small rocks in your pocket are just a few techniques to keep track of longer distances.

A few things to remember about your hundred pace count:

- It increases (takes more steps) up hill, against a strong wind or in bad weather, in snow or mushy ground or at night.
- It decreases down hill, with the wind, or in clear even terrain or when you are in a hurry!
- Experienced orienteering participants may still be counting steps and using compasses when it comes to racing but GPS units can still open up a fun lifetime sport by helping you navigate in unfamiliar territory with a few basic principles.
- Practice these concepts by setting up a short course in a local field with a set of points to follow!

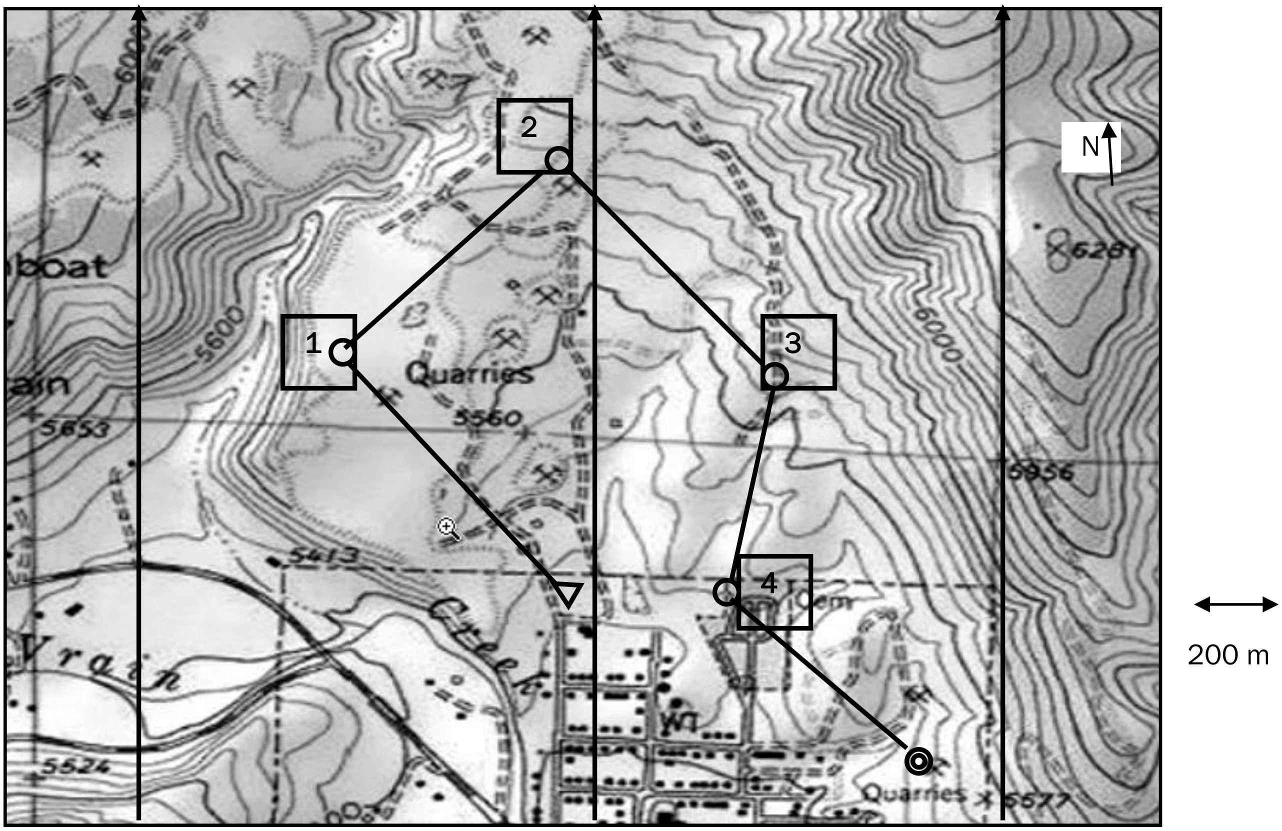
*1 To turn your track on or off, move to the main menu and highlight the word tracks:



Setting Up an Orienteering Course

Finding a good topographic map (topo) today is easier than you think. Many different virtual globes stream the U.S. Geological Survey series maps directly into them. When you use the Google Map viewer on geocaching.com, it has a button at the top that will display most regions with a topo map background. NASA's free virtual globe, Worldwind has a layer that pulls in topo maps. There are also several websites that serve local topo maps such as Terraserver-USA.com, Topofusion, or Topozone/trails.com (this is a membership site). Even ESRI's ArcGIS has an online map server that will stream topographic maps to your desktop application.

So find the area where you want to set up your course and screen capture the topographic map as shown in the example below. Some of the services such as NASA Worldwind will even add an appropriate coordinate grid. Pressing the *PrtSc* key on any computer keyboard will put the image of your screen into the clipboard (virtual storage area on your computer), then open any presentation software such as Adobe Illustrator, Microsoft Word or Powerpoint, Paintshop Pro, or various free tools such as Paint, and paste in the image of the topo.



Place the North arrow on your topo using the Draw tool bar in a word processing document. A scale can be included in some software programs. ArcGIS will allow you to "Insert" a scale bar in the Layout mode. Google Maps will have the scale bar in the lower corner. Print off several of the topographic screen shots to be used by participants without any markings on the map. For the master map from which participants will copy the location of the control points, use the Draw tool bar in the AutoShapes pull down menu to place appropriate shaped icons for your control points. Numbers or letters can be placed on the map by inserting text boxes and removing their outlines and background colors from the text box properties. (Double click the text box for properties.)

Several very informative sites that can guide you in your orienteering program development should include:

http://www.williams.edu/Biology/Faculty_Staff/hwilliams/Orienteering

http://www.4orienteering.com/

http://www.learn-orienteering.org/old/

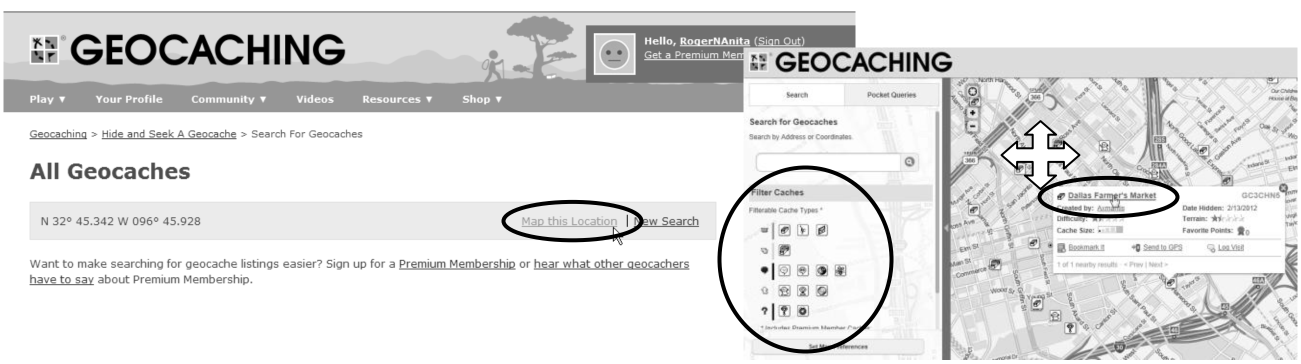
http://www.nzorienteering.com/coaching/kiwisport_manual/KiwiSport%20Orienteering%20Coaching%20Manual.pdf

Geocaching - The GPS Treasure Hunt

With the excitement of movies like *Pirates of the Caribbean* and *Indiana Jones*, who doesn't like the thrill of clues leading to hidden treasure? Geocaching.com offers exactly that.

1. Navigate to www.geocaching.com. You will see that you must create a login. Follow the form and provide the requested information. A functioning email address is required but your email is NOT shared with other geocachers and it will receive only periodic updates about events and news from Groundspeak.

2. Login and type in the zipcode where you want to look for these hidden puzzles. No worries if you don't know the zip, type in your home zip code and click the "Map this Location" link. Zoom out then move quickly across the country once the map appears.



3. Once you've found the area you are interested, zoom in until you start seeing all the caches in this area. There is a symbol legend informs you of the various kinds of caches you might want to pursue. Click on the map icon for the short description and the link to get the gps coordinates for the cache.

4. Once you find a site of interest, save a point in your GPS unit and edit it to match the listed coordinates. Use your *Go To* function to find the particular hidden objects. (Practice using the Far and Away exercise p. 31.) Finding them can still be a challenge because of local terrain, accuracy (or inaccuracy) of GPS unit, etc. Remember, you may be looking for a golf ball sized container in an area the size of a tennis court! Don't give up, keep looking!

Different Types of Geocaches:

Traditional Caches may be hidden ammo boxes, Tupperware, film canisters… and contain at least a log and possible things to trade. Some are much harder to find than others. The general rule for cachers: take something out, put something in.

MultiCache: This is the location for the first cache with a set of clues that eventually lead you to more clues and a final cache with goodies. Sometimes the clues are coordinates other times they may be directions (an offset cache).

EarthCache: a virtual based cache that leads participants to interesting earth focused places where they might learn about the importance of an area or perform tasks that help them gain an appreciation for the processes taking place where they visit.

Mystery Caches: Catch all for puzzle based caches. When timed, these are great testing grounds for new and interesting challenges.

Letterboxing Cache: Hiding spots listed by clues instead of coordinates (although some include coordinates). The containers hold stamps to be used on the participants notebook and the seeker leaves a stamp on the log book.

VirtualCache: An interesting site that has no container but has an educational task related to the area. These are great for schools, scouting, learning local history, etc about an area you are visiting. Usually these have some task you must complete to log such as find the owner's name of some haunted mansion. These are no longer createable geocaches but are housed at Waymarking.com.

Web cam cache: Older cache type moved to waymarking. Participants must capture themselves on video webcams doing some task in order to log the cache.

Reverse Cache: Housed at waymarking.com, these sites are locations of places or things that people log because a community member wants to start collecting them. They could be haunted houses, museums, historic sites. Generally things of interest to some communities. User visits a site in the category and logs it's location and description.

WhereIgo: This is a downloadable cartridge to be played on a spatially enabled phone, handheld computer or multimedia gps. As you enter areas defined by coordinates multimedia tasks pop up to guide you on your journey.

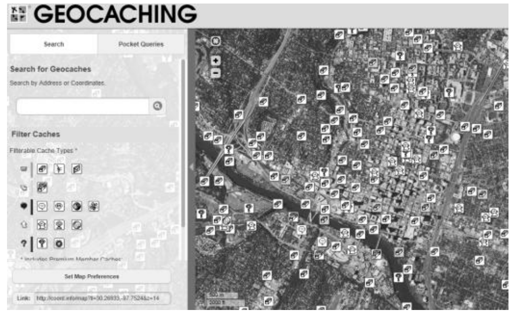
Event Geocaches: Usually a local meeting of participants set up an event for social interaction or competition. Generally archived after the event.

Cache in trash out events. Larger community events or a community service and social competition.

Mega Event Cache: An event cache that involves over 500 people.

Geocache Touring

When planning your geocaching trip, find sites of interest that match what you wish to accomplish in the time period you have allotted. Use the geocaching.com in the Google Maps link to find sites close together.



Copy and Paste the interesting sites into a word processing document so that students can have the coordinates and clues all in one area.

What to do once you are at your sites:

- Have your students take 3-5 minutes to write down what their reactions are to the site (create a brief journal entry, what does it feel like, how is the site useful to the community, etc.)
- Keep a field notebook and have them write down information, make drawings
- Measure things at a location
- Take pictures for students to create presentations once finished
- Make rubbings of textures from leaves to stone surfaces
- Look for fossils, pick up trash, read the signs
- Create a worksheet for students to answer question or look for relationships (sample below)

A Somber Reminder
N 30° 17.102 W 097° 44.385
UTM: 14R E 621204 N 3351042

Go to the coordinates and try to figure out what unmarked piece of Austin history is here (it's not the Jefferson Davis statue). Go to: http://www.creativeworlds.com/geocaching to see if you are right. We are sorry if this geocache offends anyone, but it's such a rare, unknown piece of Austin history that we thought it would be a good idea for a virtual cache. Hint: If you are standing where Jefferson Davis is standing, look 6 spaces to his left.

Virtual Cache Mania III
N 30° 17.029 W 097° 44.380
UTM: 14R E 621213 N 3350907

This building proudly stands at 307 feet tall. The designer of this building is Paul Cret. The building was completed in 1937. Upon reaching the coordinates of this building, take a seat on the bench. What building did you find? What do you see in the fountain behind you?

The Archive War
N 30° 16.426 W 097° 44.325
UTM: 14R E 621314 N 3349794

The cache is an historical marker in downtown Austin near the state capitol building. It is a little known fact that a war was waged right here in Austin, Texas. It wasn't a large war. Well, maybe it wasn't really a war, more like a battle -- a small *battle. I guess you could call it a skirmish. Whatever you call it, cannon shots were fired and a chase ensued. When you arrive at the coordinates of this cache you will find yourself in front of a rather impressive edifice. In front of this edifice is a historical marker that relates the tale of this war. After visiting this site please email me the date as well as the name of the building that is behind the marker.*

The Tree That Wouldn't Die
N 30° 16.283 W 097° 45.341
UTM: 14R E 619688 N 3349512

An easy park-and-grab. Tucked away just east of downtown is this special piece of Austin history. Some of you have already guessed the identity of the tree in question. To get credit for this cache, visit the listed coords, read the plaque, email me the year that is mentioned in the last sentence. A web search on the names listed on the plaque should help to explain the name of this cache.

Virtual Cache Mania IV (Antoinette's Leap)
N 30° 19.269 W 097° 46.407
UTM: 14R E 617919 N 3355009

Legend says that it was once called Antoinette's Leap, named after a damsel in distress who leaped to her death to avoid capture from Indians that killed her lover, who fought to his death to defend her. First, name the place that you visited and the person's name on the monument atop this peak? This person donated the land where this landmark resides.

Extant Frame Structure
N 30° 16.000 W 097° 43.901
UTM: 14R E 622002 N 3349015

On a hill near downtown Austin you will find a lovely relic, reminiscent of the days when Texas was a Republic. Nestled in a quiet, green corner of the bustling modern capital of the State of Texas, the French Legation was originally built in 1840-41 to be the residence of Monsieur Jean Pierre Isidore Dubois the chargé d'affaires who represented the government of France in the Republic of Texas. The Legation became the home of Dr. and Mrs. Joseph Robertson in 1848, remaining in their family until 1949, when it was acquired by the State of Texas. Under the custodianship of the Daughters of the Republic of Texas, the site has been lovingly restored and furnished with items original to its time period. It is the oldest extant frame structure in Austin.Also take a look at the Capitol from the front porch of the house. The view is one of only three protected views of the capitol in Austin. In order to verify your visit to this cache please answer the following question: Who was the original owner of this land and what is the year mentioned in the last line?

Austin's Pig War
N 30° 15.995 W 097° 43.897
UTM: 14R E 622009 N 3349006

You will be looking for a match holder which only contains the log and some wee little pigs! The museum does not have to be opened as this cache is located outside the one of the gates. Please replace just as you found it…there is only one way it can go back in & give a hard push so it wouldn't fall out! Thanks and Have Fun!

It seems that Austin did indeed have its own Pig War in 1841. The King of France sent Monsieur Jean Pierre Isidore Dubois to Texas to improve relations with the young Republic of Texas but his lavish lifestyle and arrogant attitude made him unpopular around town as soon as he arrived. While waiting for the French Legation to be built, Dubois had to rent living quarters on the corner of Pecan Street (now Sixth Street). A few blocks away lived Richard Bullock who owned not only the first hotel in Austin but also owned several pigs that freely roamed the streets of Austin. Now those pigs were hungry and started making it a daily routine of eating corn from the Frenchman's stable. They even invaded his bedroom and ate his expensive, imported linens and some diplomatic papers. Furious about the roaming pigs invading his stable and home, Dubois ordered his servant to shoot the pigs and those orders were carried out. The Pig War broke out when Bullock ran into the servant on the street and bloodied his nose in a fight over the killing of his pigs. Dubois demanded justice. When denied, he broke diplomatic ties and left Austin never to live in the French Legation not even one night! Bullock and his pigs were hailed as heroes!

EarthCaching

While many geocaches are sites that have objects to find in your community, there are also sites that are interesting places in their own right. One class of geocache is called an EarthCache. They are listed within the geocaching.com site with the requirement that they must be virtual (no physical cache) and are places where you can learn more about the earth science or physical geography of your area. The key to posting an area as an EarthCache is that it must have an educational value and tasks associated with the area make them valuable for personal knowledge or for bringing your children or a class of students or a club of some sort to investigate. Earthcache.org is an ancillary site that organizes the list of just these sites and is a useful place to start when planning excursions.

If you are brand new to EarthCaching, spend a few minutes reading the "What is an EarthCache Site" link shown on the left. For the rest of you, enter the site and follow the Advanced search link on the left side to access the list of all EarthCaches.

Following the EarthCache Listings link allows you to narrow your search by region or type of earth feature. This can be handy if you want to learn more about a certain topic such as erosion or glaciers. Choosing to increase the number of records shown per page helps sort through the list to find sites of interest faster.

Advanced Search: Click the link to search by Country, State, or Classification

Records per Page : 20

Clicking on the header lines will order the list in alphabetical or reverse alphabetical order. Clicking on the waypoint link will then bring you to the geocaching webpage with the description of the site. You will need a geocaching login to get the coordinates for these sites which is free and easy to sign up for in the getting started link in the upper left corner of this page.

Records per Page : 20

Record (1..20) of 3645 — Page 1 of 183

Type	Country	StateProv	waypoint	Classification	developer
	USA	Michigan	Clinton River Headwaters	Glacial Feature	MI Chickenlegs
	USA	Wisconsin	Parry Spring Artesian Well EarthCache	Hydrologic Feature	The Tapps
	USA	Tennessee	CT Natural Bridge Earthcache	Erosional Feature	BackBrakeBilly
	USA	Tennessee	Hwy.154 Natural Bridge Earthcache	Erosional Feature	BackBrakeBilly
	USA	Tennessee	Middle Creek Arch #1 Earthcache	Erosional Feature	BackBrakeBilly
	USA	Ohio	Earthquakes and the Richter Scale	Historical Site	Trail Jogger
	USA	Virginia	Falls Of The Straight Branch	Hydrologic Feature	Johnson Party of 6

Once you've found a site you will wish to visit, either screen capture and past the pages into a single word document or write down the coordinates to enter into your GPS or enter the coordinates directly into your GPS and keep a reference notebook or sheet of paper which matches the site names with waypoint numbers to help keep track of sites in the field. An example of one of the sites is listed below. You can copy the text of the clue information and logging requirements below each screen shot of location.

The posted coordinates lead you to the entrance of the Barton Springs natural area. From I-35 or downtown Austin, head west on 1st Street to Congress Avenue. Head south on Congress to Barton Springs Road. Then head west on Barton Springs Road until you enter the Zilker Metropolitan Park area. The Barton Springs access will be on the south side of Barton Springs Road.

Once you enter the Barton Springs area, you will find ample parking. Depending on the time of year that you visit, and also how old you are, there may be a small admission fee. The possible fee ranges from zero to three dollars.

Barton Springs is the fourth largest natural springs in the state of Texas. It was created millions of years ago, as a result of a land shift that created the Balcones Fault.

Barton Springs is the main discharge point for the Barton Springs segment of the Edwards Aquifer. The Edwards Aquifer is a well known karst aquifer.

The aquifer is composed of limestone from the Cretaceous period, and it is about 100 million years old. The limestone is full of caves and conduits, and fissures and fractures. Over time, these voids in the limestone have grown and enlarged due to forces such as faulting and the dissolution and erosion of the limestone by water. This results in a karst aquifer made up of limestone with large void spaces.

Then, water that originates from rainfall enters the aquifer through various entry points, and flows through the chambers and caves, and fills the voids. Hydraulic pressure forces are at work here, and the pressure differences are what drives the water flow throughout the aquifer, and eventually out through exit locations, such as Barton Springs.

In order to claim this EarthCache as a find, you must complete the following four requirements:

- Photo #1 (by the marker)
- Photo #2 (measuring the temperature)
- Email me the water temp: 68° C
- Email (What is the area where water enters the aquifer). [Water enters the aquifer through the recharge zone and exits through springs. (like Barton!)]

If there is no EarthCache in your area, think about creating one! There is an unlimited supply of subjects in every neighborhood and you can earn awards through the EarthCache Master Program!

GPS as a Tool

GPS is more than just knowing where you are, it is even more about knowing where you want to go. The following pages will introduce you to ways that GPS can add value to your projects from school assignments to enhancing your personal photography. Adding location to measurements of any kind gives projects credibility and authenticity whether it is a primary school water monitoring project to a high school physics day at an amusement park or even enhancing your favorite travel photographs a GPS will become an artist's paintbrush in any hand.

For once you have tasted flight you will walk the Earth with your eyes turned skywards, for there you have been and there you will long to return.

Leonardo daVinci

Roger, with a group of teachers, checking his bearings and gathering data.

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Using DNR GPS to download and Create ArcGIS Shapefiles

You can install this free GPS utility that downloads waypoints from your GPS into tables, ArcView Shapefiles, or KML files.   You can enter this directly or Google search “DNR GPS” and follow the first link. (http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html)

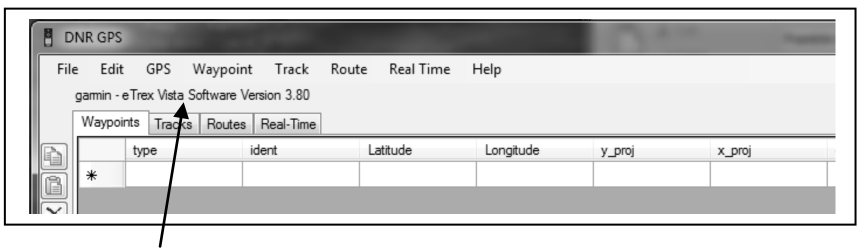
1. Attach your GPS unit to your computer via at download cable. (Search for cables at RNRplace.com or on eBay – search for GPS download cables ~$10-16 with shipping).

    a. Plug download cable into the USB or serial port on the computer.

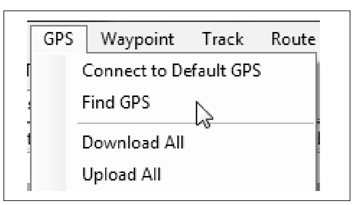
    b. Plug the download cable into top/back slot in the GPS unit. This slot is covered up by a black rubber cover that will flip up. Be sure to slip the cable in with the “notch” in the cable matching the GPS’s plastic “ridge.”

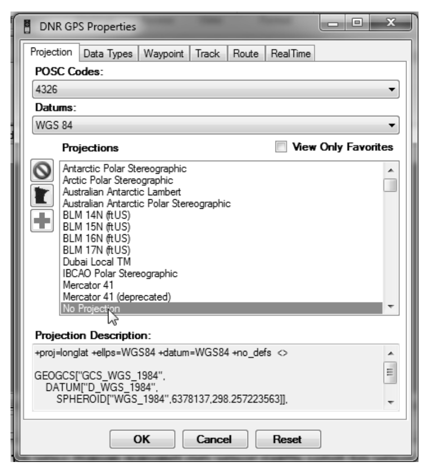
    c. Turn the GPS unit on.

    d. Double-click on the DNRGPS icon located on the desktop. If the DNR GPS program automatically recognizes the GPS unit you will see the following screen.

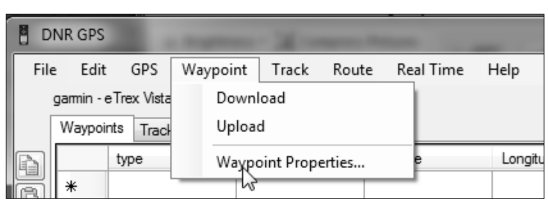


    e. If there is no black text in this area, use the GPS dropdown menu to Find GPS.





    f. Under the Waypoint pull down menu, Choose Waypoint Properties to set the projection to GCS_WGS_84.



(The window claims you are setting your data to no projection, but you can see in the Description box on the bottom that it is set to a geographic coordinates projection with a world geodetic system 1984 datum. This is now the default setting so even if you never set this it will still work as long as some-one else doesn’t change it on your computer.)

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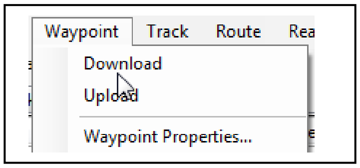
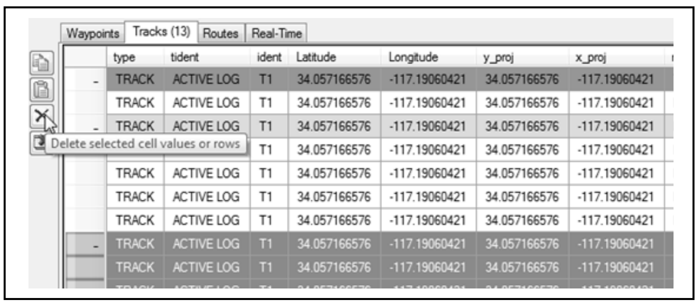
2. Download the waypoints you have saved on your GPS unit to your computer.

    a. Click on the Waypoint Menu item and then the Download button. This will download any Waypoints you saved by holding the Enter button (when the flagman appeared).



    b. If there are any points or tracks in your list from other hikes, you can highlight and delete the unwanted ones before saving or sharing them with other GPS units. This does not delete them from your GPS.



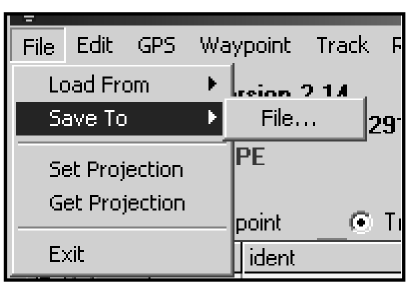
    c. Your GPS also automatically saves points regularly as a breadcrumb trail if you have turned the trails on feature. Click on the Track menu item and then the Download choice. This will download any Tracks you saved (or still in the active log memory).

    d. Your track download will contain many more points than those in Waypoints. These points were gathered automatically every few seconds as determined in your tracks setup area of the GPS.

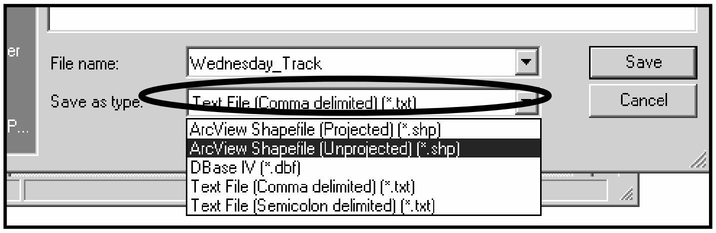
3. Save Points to Shapefile for use in ArcGIS.

    a. Click on File > SaveTo > File

    b. Navigate to C:/ArcProjects/... or where ever you are saving the project's files.



c. Give the file a name and select ArcView Shapefile (projected) in the “Save as type” pulldown menu. This method will make your shapefile compatible with any data added in ArcGIS. Saving them projected works because you set the waypoint properties as stated above in 1.f.

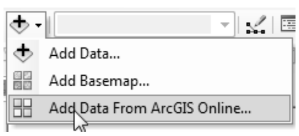


4. Map these points in ArcGIS - ArcView

a. Start ArcMap

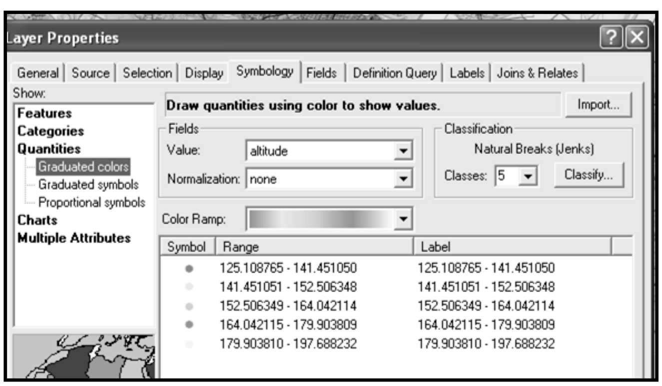
b. Add the shapefile  that you saved from the GPS waypoints and/or tracks.

c. Add a georeferenced photo of your home area using the File pull down menu and choose “Add Data From Resource Center…” in ArcGIS 9.x. (In ArcGIS 10 it is accessed from the add data button) This opens a web browser of ArcGIS Online basemaps where you can search for and add Topography or Imagery for your GPS data to be displayed upon.



d. Zoom in or out to include your city, neighborhood, school property, or study area.

5. Thematically map the points in an appropriate color scheme to show spatial patterns using whatever variable you were measuring.



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GPS Data Collection in the Field to map in ArcGIS

1. Using a handheld GPS receiver for storing a location while out in a field class can be an accurate way to store where you have been out collecting data. The easiest way to take advantage of your GPS is to make a table of data that you will be collecting such as the table below.

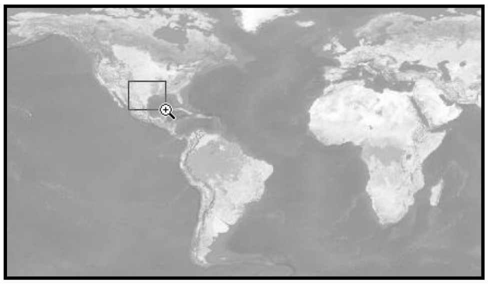
Location gps #	Description or Field Notes	Easting Longitude	Northing Latitude	Pic #			

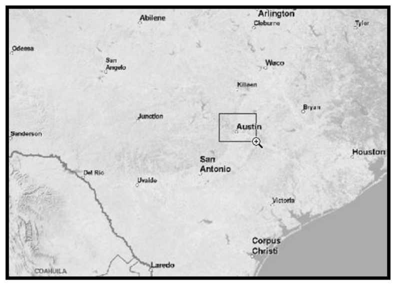
2. Once you have collected your data onto this single sheet, enter it into a spreadsheet program.

You will need to save this spreadsheet as a (.dbf IV), (.txt) or (.csv) file type so click the file menu and "Save as" this type from the bottom of the dialogue box that appears. Save the file in an easy to find data directory such as C:\FieldProjects. Close the spreadsheet program and start up a GIS such as ArcGIS.

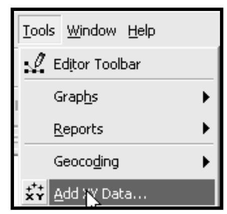
3. Inside of ArcGIS, add a base map appropriate to your region. While finding good maps of topography or aerial imagery may require some local knowledge of data providers for your region, there are webbased services available through ESRI using the File pulldown menu and “Add Data From Resource Center…”. This opens a web browser of ArcGIS Online basemaps that add Topography or Imagery for your GPS data to be displayed upon. You can even explore these maps without software by going to and choosing one of the make a map choices at the bottom of the page. (If you drag your saved .txt file onto this map online it will map up to a thousand points in this interface!)

4. Back in ArcGIS, choose to add one of the layers to your project, then  zoom to the area where your project is occurring:

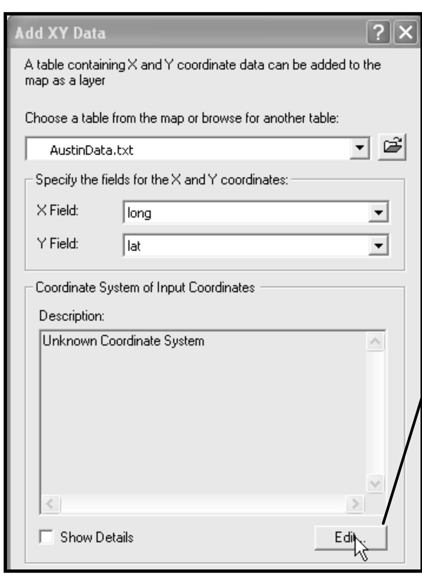


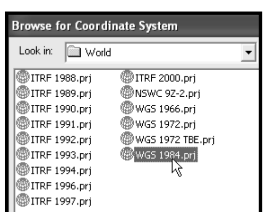


5. Once you have zoomed into the appropriate area, you can add your table of data using the “Tools” drop down menu to “Add XY Data”.



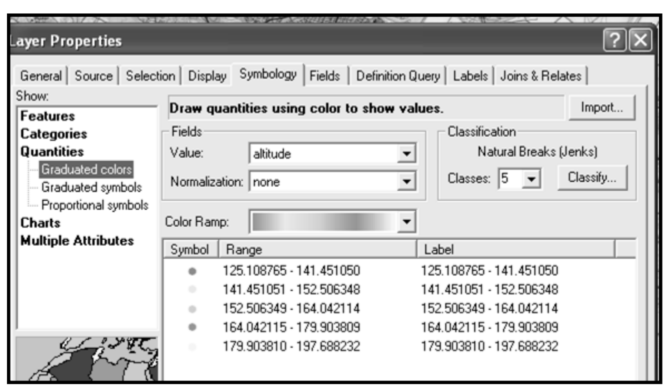
Maneuver to your C:\FieldProjects folder to find your data table. Make sure to fill in the appropriate fields for X and Y:





6. Assign the projection information by clicking the edit button and choosing the geographic world projection WGS 1984. This is the projection in which all GPS units collect data.

7. Thematically map your data to tell your story!



GPS Physics Calculations

GPS units work based on an incredibly accurate time signal that satellites, circling the globe, produce with the aid of on-board atomic clocks. These are further synchronized each orbit with ground stations that systematically correct any time loss compared to a single standard timepiece. This precise time is broadcast from the satellites to GPS receivers all over the planet. The signal has information to keep even the most inexpensive GPS receiver synchronized in order to determine how much time passes from the satellite until the signal reaches your position with amazing accuracy. The satellite signal communicates three other important pieces of information to your GPS. Which satellite the signal comes from, the location of the satellite, and the time the signal left. The electronics inside your GPS then quickly calculates how far you are from various satellites circling the planet. This process is much the same as your ability to know how far away lightning is by counting how many seconds it takes the thunder to reach you. (Every five seconds indicates a mile farther).

How does this information allow you to know where you are located? Think of these descriptions. What is the shape of all the points 10km from a particular location? The answer would be a circle of 10km in radius. What is the shape of all the points 15m from a wall? The answer here would be a line parallel to the wall. How many places could you be if you were 5m from one wall of the room you are currently studying and 6m from the wall connected to it? The answer here can only be at one location in the room. In the same way, knowing your distance from several spots on the Earth allows you to be at only one location that fits all those conditions. So what good is that? What can you do with this information? Refer to the Lightning Strikes lesson in the Getting Started section of this book.

Knowing your location especially in Cartesian coordinates (in meters north or south and meters east and west) allows you to start to do all the physics and mathematical operations covered in algebra, geometry, trig, and calculus. So if you've got a set of locations and times from your GPS, you are just about ready to get started. Typically your location is stored as solid angles from the prime meridian in England (longitude) and the equator (latitude), these are listed in degrees, minutes and seconds. These units were used because they were originally measured using time pieces but they aren't nearly as practical today. Degrees with decimals fixes the problem of a base 60 number system but we are still left in a world of angles, not positions in the standard units of meters. Luckily there is one set of projections that will move us into Cartesian coordinates. This set is known as the UTM or Universal Transverse Mercator projection.

To think about projections, imagine a light bulb at the center of Earth to project country borders, shapes of rivers or any other position information out onto a screen that surrounds Earth. The shape of the screen determines the projection. Conic projections are often used for the U.S. such as the Albers projection where the screen receiving the shadows is a cone like a dunce cap sitting on the North Pole. Many projections exist to minimize the distortions that are created in the projecting process. Mercator projections are cylinders that surround the earth as a basketball would be surrounded by the net when passing through the hoop. The Transverse Mercator projection occurs when the cylinder shaped screen is turned 90° more like a golf ball traveling into a pipe. This projection works for only the narrow slice of the earth close to where the earth is touching the "pipe". Therefore, there are 60 different UTM zones required to best represent the world. Each UTM zone covers an area of the earth shaped like a section of an orange. The sections start at the International Date Line and work their way east. The continental United States runs from zone 10 to 19 as shown in this image from the U.S. Geological Survey.

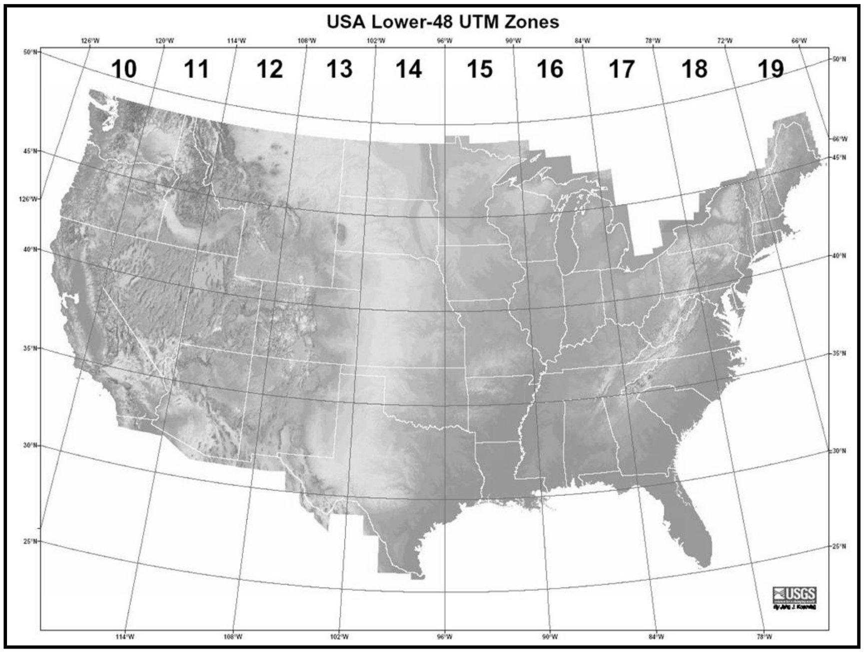
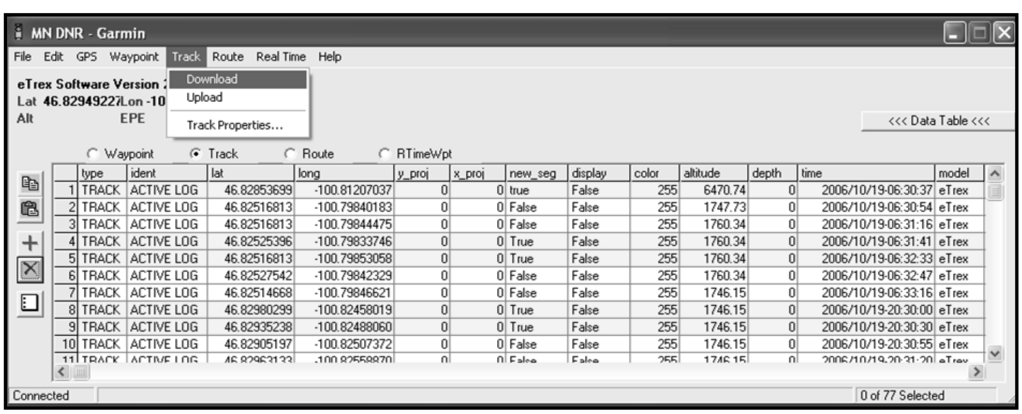


Image from U.S. Geological Survey
http://rockyweb.cr.usgs.gov/outreach/GPS/UTM_Zones_USA48.jpg

Your GPS can be switched to report position information in the UTM zone appropriate for your area of the U.S. (or the world) by entering the Setup choice from the Menu page. On entering this page, choose Units and switch to UTM by hitting Enter on the position format choice. This will allow you to scroll down to find the "UTM/UPS" setting. Hit your Enter button again then the Page button back to one of the other pages. Regardless of the mode in which you collected your points, they can be changed back and forth after the fact as well.

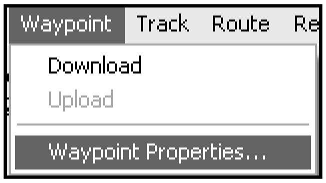
Once you realize that you are saving both position and time information we are ready to start with calculations to determine speed and acceleration. Take your GPS turn it on and travel somewhere by car, or go jogging or bicycling. Make sure that the GPS is locked in and slowly accelerate onto the highway, down a hill, or start by walking slowly over a football field. Speed up until you are running as fast as you can. (Make sure to take at least a minute to accomplish this.)

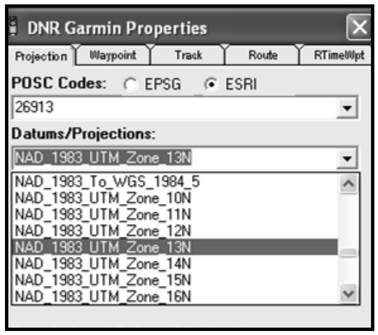
1. Download, or type in your position and time information to the second! Unfortunately, no time information is available for the downloads from your waypoints but WILL be available in your track information. Use one of the download programs to obtain your track such as DNR GPS. (Make sure to get the data in UTM projection – See Step 2).



	type	ident	lat	long	y_proj	x_proj	new_seg	display	color	altitude	depth	time	model
1	TRACK	ACTIVE LOG	46.82853699	-100.81207037	0	0	true	False	255	6470.74	0	2006/10/19-06:30:37	eTrex
2	TRACK	ACTIVE LOG	46.82516813	-100.79840183	0	0	False	False	255	1747.73	0	2006/10/19-06:30:54	eTrex
3	TRACK	ACTIVE LOG	46.82516813	-100.79844475	0	0	False	False	255	1760.34	0	2006/10/19-06:31:16	eTrex
4	TRACK	ACTIVE LOG	46.82525396	-100.79833746	0	0	True	False	255	1760.34	0	2006/10/19-06:31:41	eTrex
5	TRACK	ACTIVE LOG	46.82516813	-100.79853058	0	0	True	False	255	1760.34	0	2006/10/19-06:32:33	eTrex
6	TRACK	ACTIVE LOG	46.82527542	-100.79842329	0	0	False	False	255	1760.34	0	2006/10/19-06:32:47	eTrex
7	TRACK	ACTIVE LOG	46.82514668	-100.79846621	0	0	False	False	255	1746.15	0	2006/10/19-06:33:16	eTrex
8	TRACK	ACTIVE LOG	46.82980299	-100.82458019	0	0	True	False	255	1746.15	0	2006/10/19-20:30:00	eTrex
9	TRACK	ACTIVE LOG	46.82935238	-100.82488060	0	0	True	False	255	1746.15	0	2006/10/19-20:30:30	eTrex
10	TRACK	ACTIVE LOG	46.82905197	-100.82507372	0	0	False	False	255	1746.15	0	2006/10/19-20:30:55	eTrex

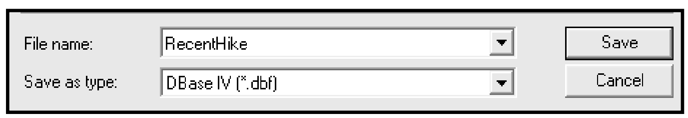
2. To get your position information projected choose your Waypoint pulldown menu and in Waypoint properties choice set your projection to UTM zone 13N for most of Colorado (zone 12N for the western edge of CO). Notice how far down the list that the UTM projections occur. We'll use the projected coordinates for the speed, acceleration and slope calculations. We won't save these points into shapefiles until the calculations are completed.



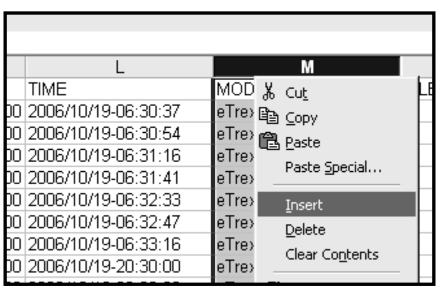


3. Change the time field.

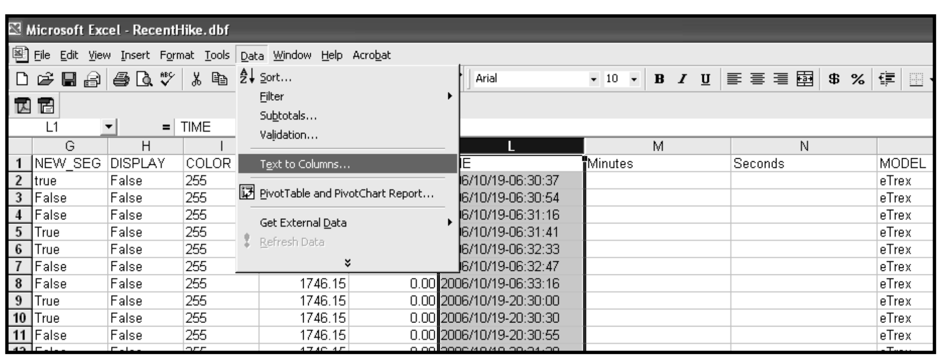
   Currently the time field is combined with the date. In order to calculate speeds we will need to separate the time from the data and separate the hours, minutes and seconds into separate fields. Save the current file as a .dbf file as shown below in order to accomplish these manipulations in excel.



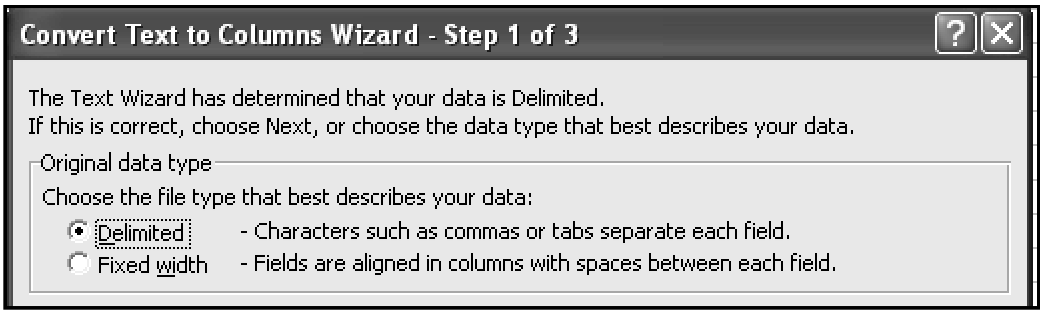
4. Open this file in Excel and insert in two new columns for your minutes and seconds data by right clicking the column after "Time". Label these as "Minutes" and "Seconds."

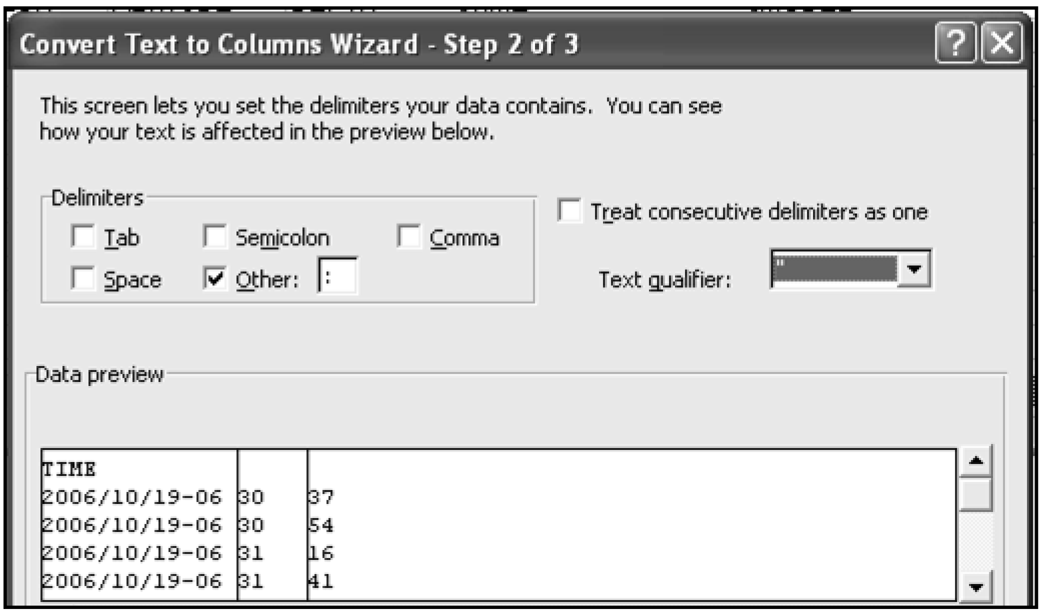


5. Highlight the column that has the time information as shown below. Use the Data pulldown menu to change the Text to Columns…



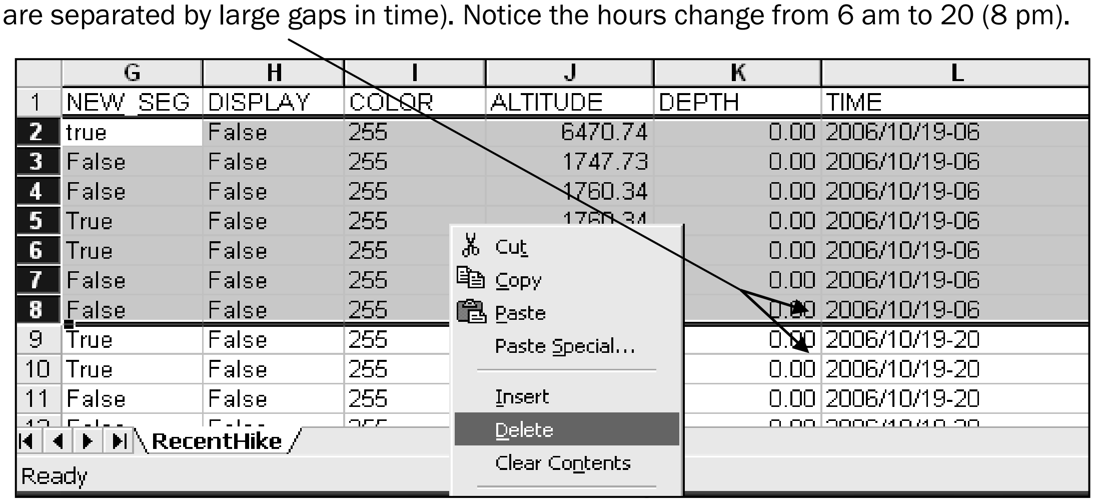
6. The wizard will walk you through splitting this column into separate pieces by using a delimiter as shown here.



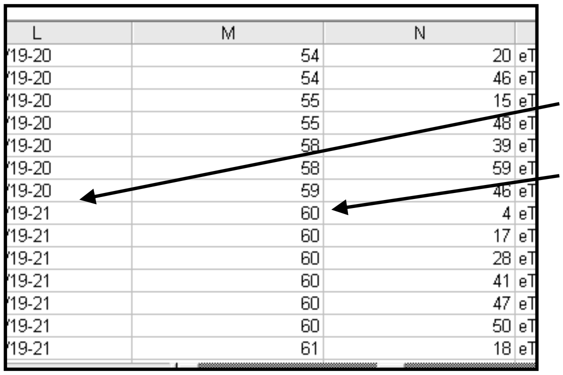


7. Click the “Finish” button to parse (break apart) your new columns with the critical times.

8. Also make sure to delete any events in the track log that aren’t a part of this experiment. (You will find these are separated by large gaps in time). Notice the hours change from 6 am to 20 (8 pm).



9. The last step is to turn your minutes into seconds so that the entire time of the event is stored in a relative time scale from the beginning of the event.

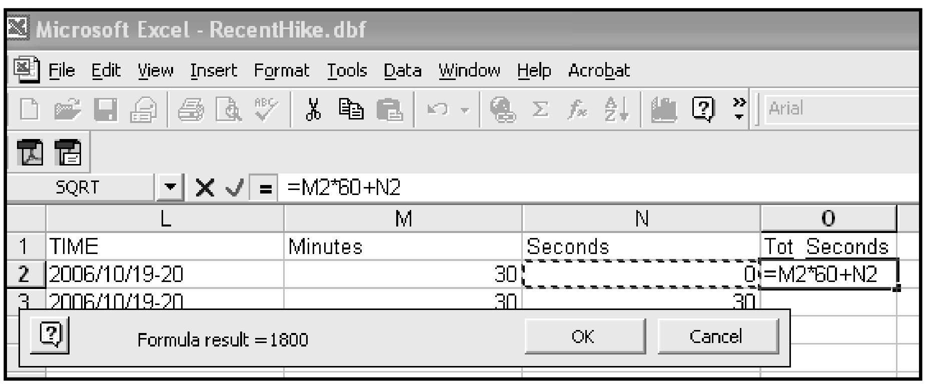


In any experiment that occurs over the top of the hour, go into the spreadsheet and add 60 to the “minutes” column. For two hours, you will add 120 to the “minutes” column. For three hours, you will add 180 to the “minutes” column and so forth.

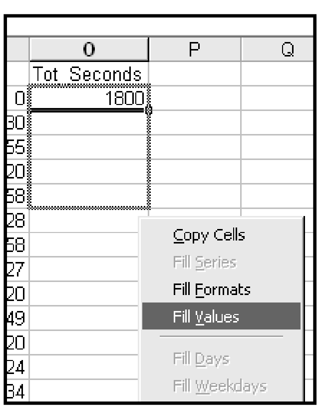
Notice the hour change is reflected in the minutes as well.

This was originally recorded as 0 minutes.

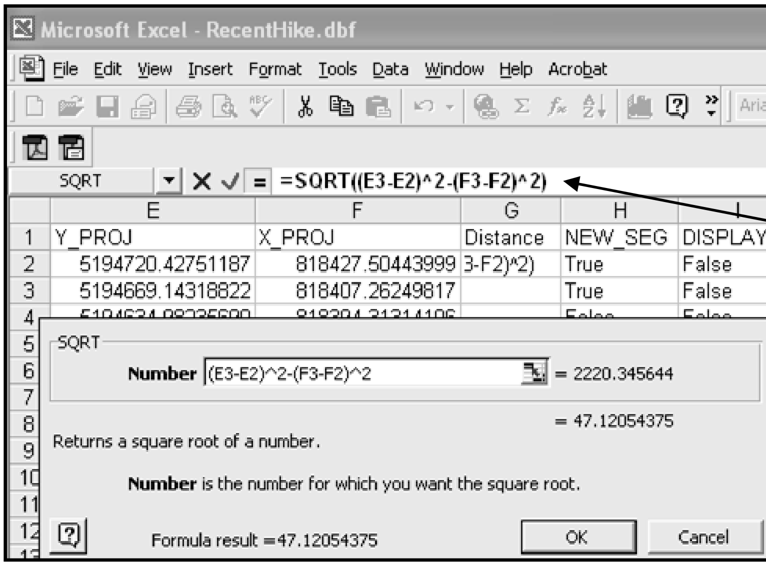
10. Finally, create a new column to calculate the conversion of minutes + seconds into total seconds. This can be calculated by taking the minutes column * 60 and adding the seconds column into a new column called tot_seconds. (You can delete the “Model” and “Filename” columns.) Don’t forget to first click on the equal sign.



11. Once one column is filled in with this formula, you can fill the rest of the columns in with the same formula by right clicking the lower right corner of the cell you just finished and drag down the rest of the column. Choose the “Fill Values” from the pop up menu as shown below:

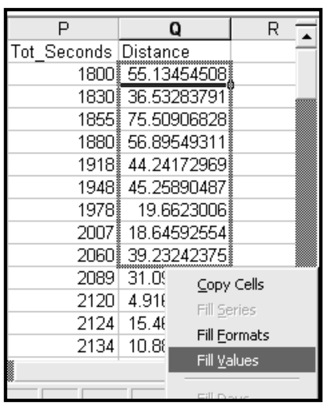


12. The formulas for speed are = distance traveled/time. We have calculated the time in a single unit so we must now calculate distance traveled. This we can get from the Pythagorean theorem turned into the distance formula dis = $\sqrt{\Delta x^2 + \Delta y^2}$

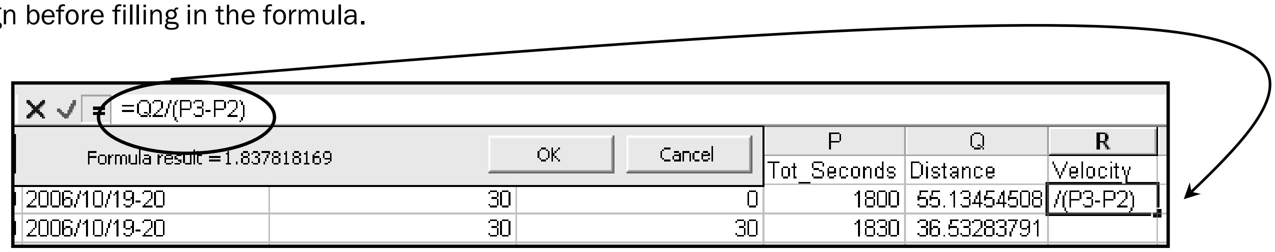


In Excel, the formula will look like this. (This screenshot has the distance column next to the projected coordinates only to illustrate where the cells are coming from. Your distance column can be at the end of the table.) The distance is in meters due to the UTM projection.

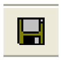
13. Right click the bottom right corner of the cell you have calculated and stretch the selection down through the bottom of your table to calculate all distances (“Fill Values”) between GPS points.



14. Finally you can calculate your velocity by creating one last column and calculating the V = dist/Δtot_seconds. The formula for this is given below. Click in the first cell below velocity then on the equal sign before filling in the formula.

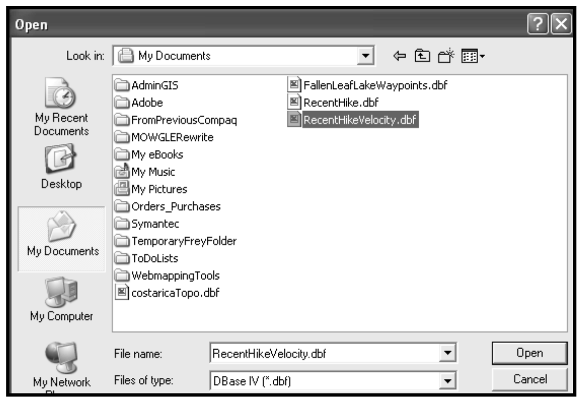


15. Fill in the values for the rest of the column and you will be ready to plot the velocity of your movements from your hike/bike/car ride.

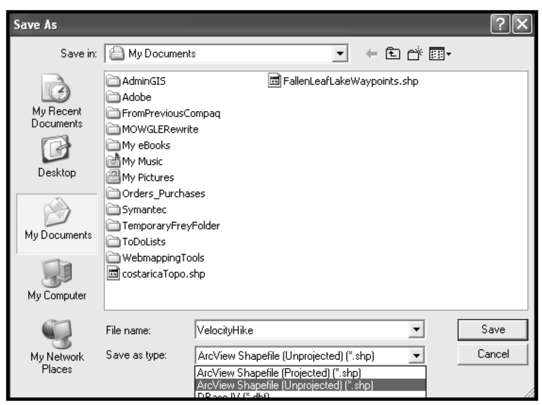


This concludes the calculations for your table but we will now open up DNR GPS and convert this table into a shape file so that you can add this to any GIS package able to read this format. Save your work as an .xls or .csv file if you have Office 2007 or a .dbf file if you have Office 97 – 2002. Save it with the new name RecentHikeVELOCITY.dbf to differentiate it from the original. (Excel always asks if this is what you want to do – say yes and close Excel).

16. Start DNR GPS and open your new file using the file pull down menu as shown:



17. You may now save this text file as an "ArcView Shapefile (Unprojected) that is readable by many GIS programs.



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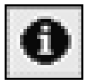
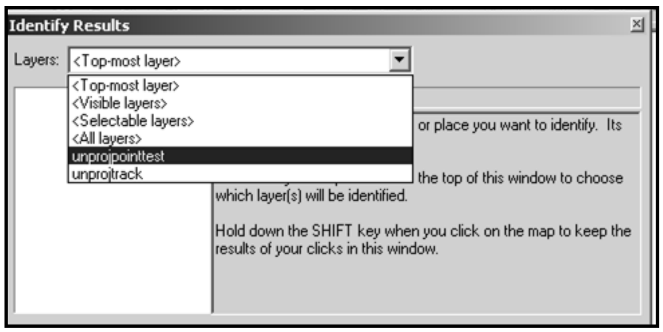
Hotlinking Documents to GPS Points

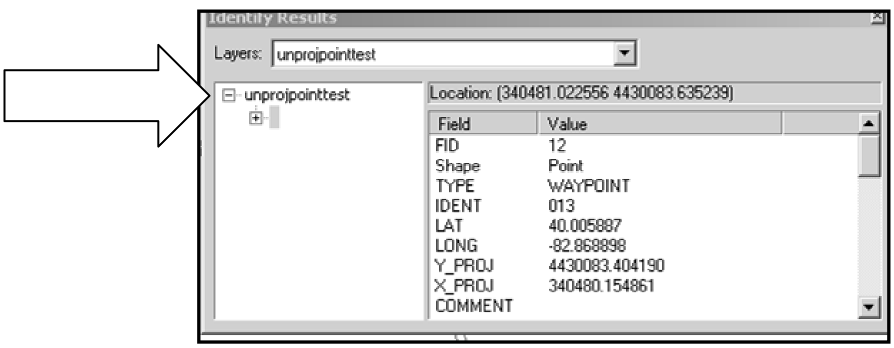
It is very fun and engaging to hotlink a photo to your GPS points on the map. This is also referred to as geotagging photos. There are several ways to hotlink photos but this is one of the fast and simple way to hotlink in ArcGIS.

1. Click on the Identify  button.

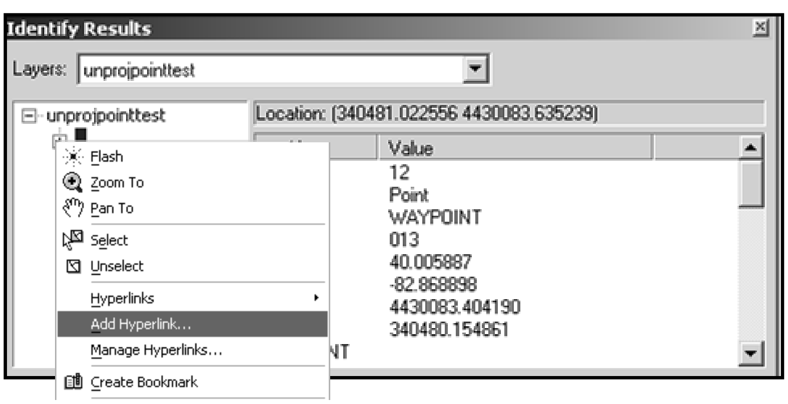
2. In the Layer pull down menu, select the layer of points you wish to hyperlink your photos to.



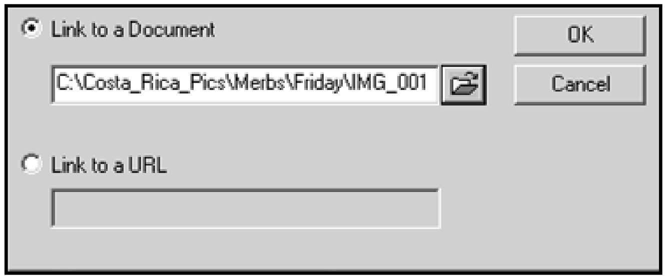
3. With Identify button, click on the point where you wish your picture to be hotlinked. Information for that point will be pulled up and a "+" sign is visible in the left box in the Identify Results Window.



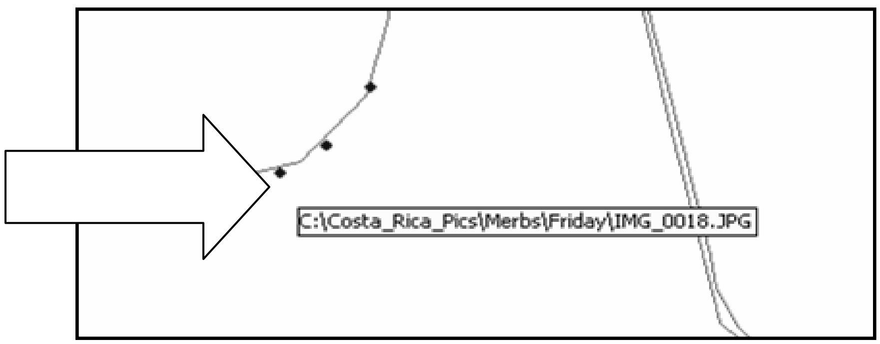
4. Right click on the tiny gray box to the right of the "+" sign in the left window and click Add Hyperlink.



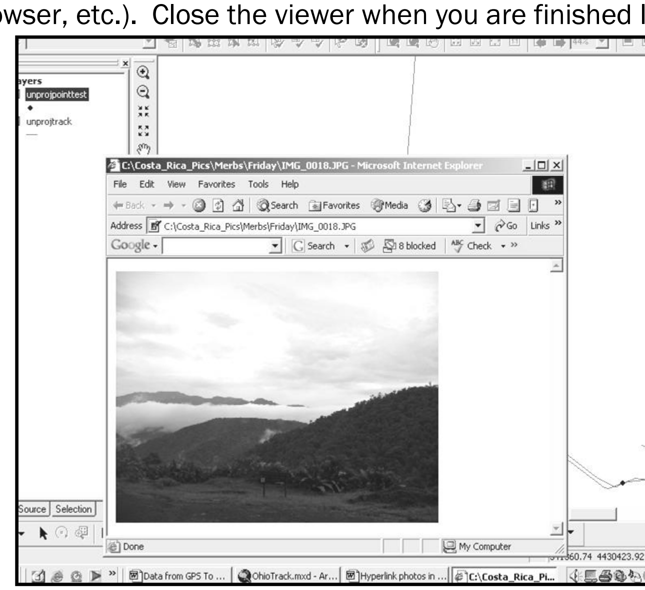
5. Browse to the folder where your pictures are stored by clicking on the folder under Link to a Document. Click on OK.



6. Click on the Hyperlink Lightning Bolt button and hover it over the point where you linked your picture (the bottom tip of the lightning bolt is the “sensitive” part). The lightning bolt will turn black and the link will be displayed on your screen. Click.



7. Your picture should pop up in whatever program is your default for reading images (Windows Picture & Fax Viewer, Irfanview, web browser, etc.). Close the viewer when you are finished looking at the picture.



8. Repeat steps 2 – 7 to link additional photos.

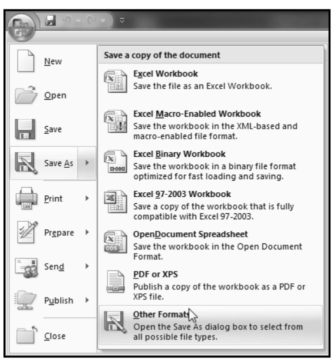
Note: In Step 5, you could choose to link to a website by clicking on the Link to URL radio button.

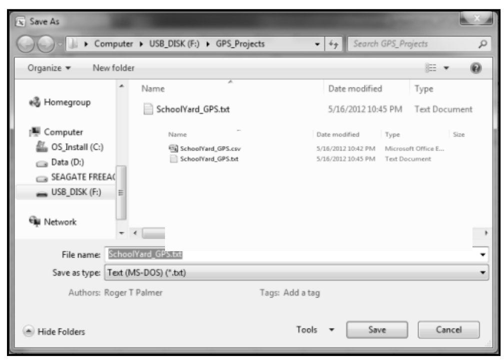
Mapping Points from a Table to the Free ArcGIS Online Interface

1. Turn your GPS on and explore your school grounds for areas of interest to your subject. Click to save waypoints at these points of interest. Things you may want to look for are places with a variety of plants in a garden or at the edge of the school away from football or soccer fields. You might look where garbage accumulates on your campus. Perhaps mark the cell phone signal strength around your campus. Water quality is also a common project as well as temperatures around campus to see the value of shade trees versus parking lots or grassy fields. For added impact, take a picture and mark it's number on a form of your design. An example form is shown below.

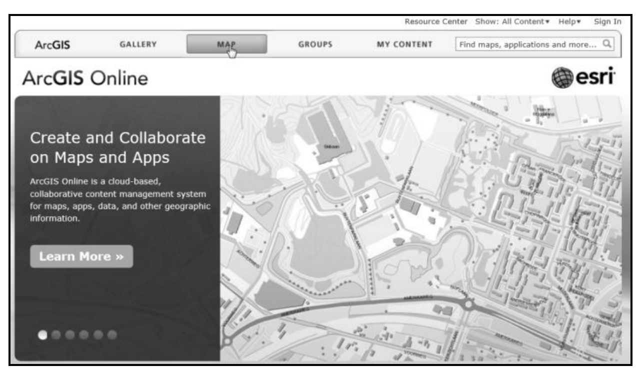
Wpt #	Latitude	Longitude	Picture #	Organism photographed	

2. Back in the classroom type up your table in excel and save it as a comma separated value file (.csv) on a pen drive with a name like FieldWork.csv.

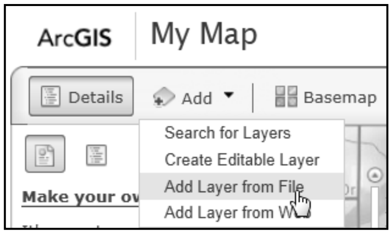




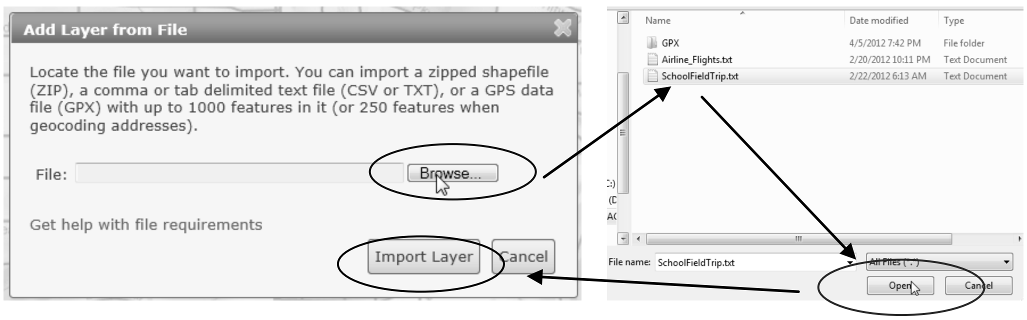
3. Open your browser to www.ArcGIS Online interface to create a map of your trip. Click the MAP button at the top of the web page.



4. Inside the map, click the Add pull down menu to import your points to a map of the area.

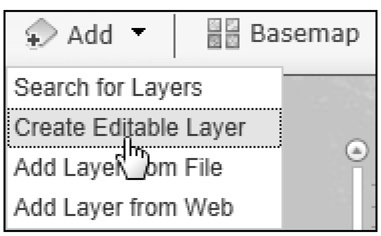


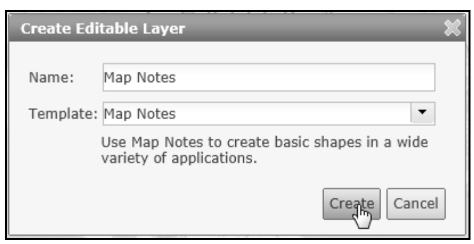
Browse for the table that you saved on your local drive.

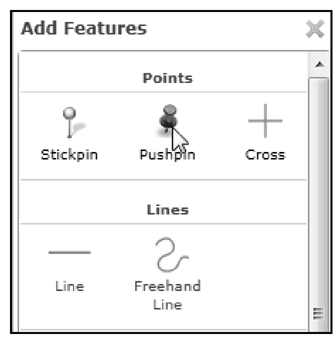


Click Open, then Import layer and the map will automatically zoom to the map where you were studying the environment.

5. Add an editable feature to your map, then add the pin, line or polygon onto your map.







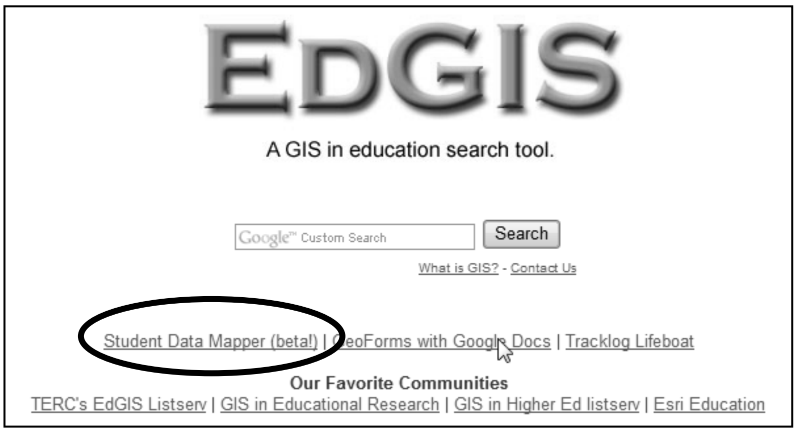
Click on each pin to edit and or add a photo.

Look for an image online using google images or go to your own picassaweb, flickr, or mobile me account. Find the picture you want to use, right click the image and choose properties (IE) copy image location (firefox) or copy url (chrome) then return to your map. In the pop-up box that appears when editing your pin, paste in the url of the image you found in the previous search. If the url is from a secure server (http**S**:\\) delete the "s" after http. Click the ok button and get out of the editing mode to see the pop up with the picture.

Automatically Mapped Questionnaires or Field Forms

The simplest mobile web data entry form is the Student Data Mapper Site allows you to quickly create forms which generate new maps with each data submission. You might use these to remove access to seeing the cumulative data in spreadsheet format and only expose the accumulating data on a map for your students.

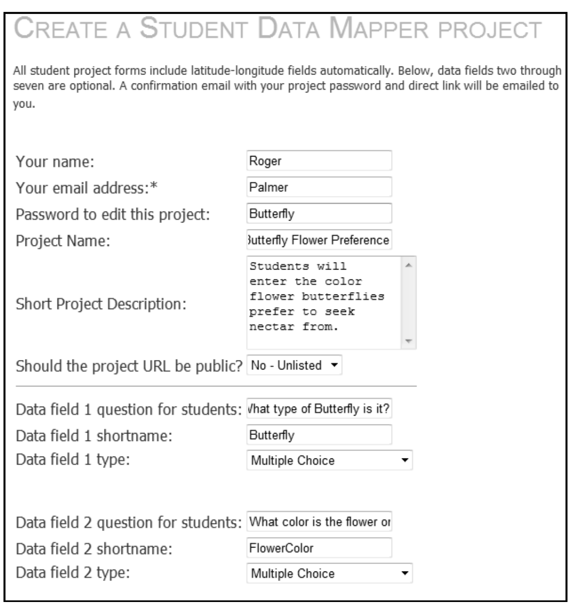
1. Go to www.edgis.org and choose the student data mapper link at the bottom of the page.



2. Click on the Create Project link.

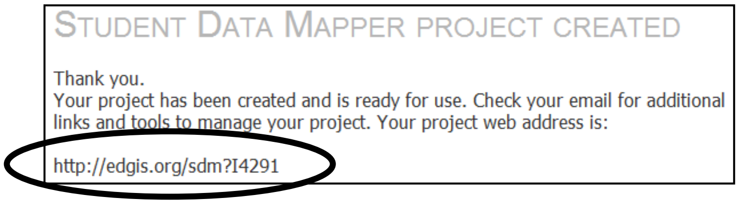
   • Create your Student Data Mapper project

3. On the form, type in the data questions you want your students to be able to take part in collecting for your class project. You can enter up to 7 data fields



4. Submit your form and finish filling out any multiple choice fields before Completing the Project Creation.

5. Copy the url where this form will be posted for the duration of your project. You can copy this url to a small note card as a reminder to students when they reach the field. Students will then access it on their mobile phone browsers.



6. Go to the fieldtrip area you want your students to measure the phenomena.

7. Have students measure and enter the values into the mobile forms at the listed url on their note cards. Mobile phones with GPS will automatically fill the forms location information otherwise students will have to fill in these fields from a handheld GPS or another student's mobile phone coordinates.

8. After entering each value in the survey, click  , all data will be submitted to a spread sheet and loaded to a map showing the locations of all collected data.

9. To gather more data points, use the  button to fill out the browser form and submit again.

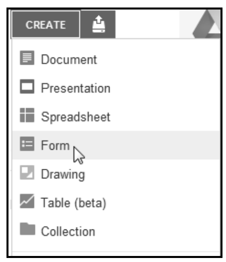
10. At any time, you can also request a table of your group submitted data or view a map of where your data has been collected. (This map viewer will not allow you to thematically map the values of the collected data, you would have to import the downloaded table into an ArcGIS or ArcGIS Online project and thematically map them.)

Making a Mobile Phone Auto-map Form for ArcGIS Online

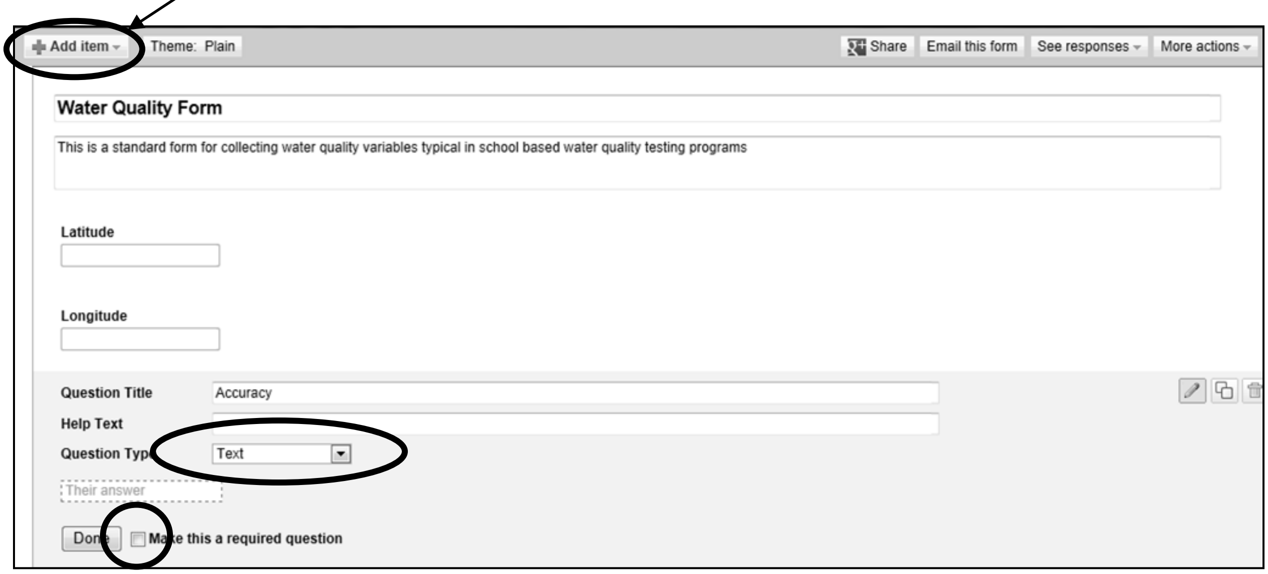
1. If you don't already have one, create a google account by going to google.com and in the upper right click Sign in or click create an account for free. and make a gmail login and password.

2. Once logged in,
   a. Look for the area called documents in the top of the page, you may have to choose the "other" google tools to find it. (This will soon be renamed Google Drive)

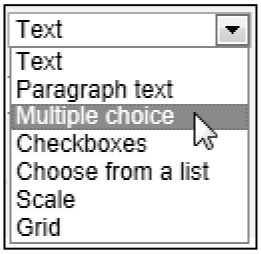
   b. At the top left of the google docs page, click the drop down arrow to create a new form.



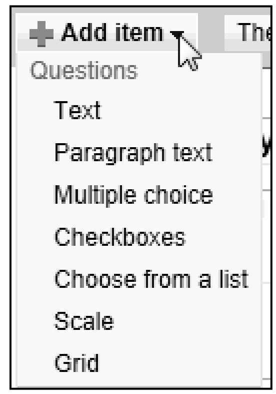
3. For this process, you must enter the first three fields in this order:
   a. Fill in the first question with: Latitude type: Text, but do not make it required
   b. Double click into the second question box: Longitude type: Text, not required
   c. After filling in the first question, and then using the second question box provided, you may only add questions using the Add Item Button to create a 3rd question: Accuracy, Text, not required



4. Type in any other fields you want collected for your study.
    a. If you want to make sure your students choose only specific values choose different Question Types from the entry form such as check box, multiple choice, or choose from a list.

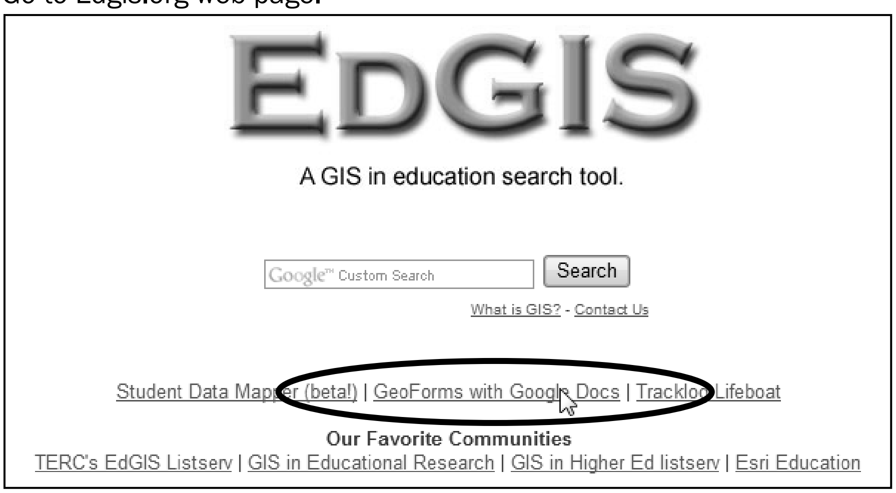


    b. You can add unlimited questions to the rest of the form but you MUST use the add item button due to the way the java code gets scripted. If you add questions in other ways, it will look ok on the form but will not work correctly in this process. It is usually best to create your form from scratch again if you don't like the way your form turned out.

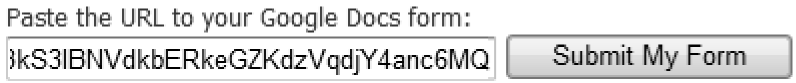


5. Save your form and copy the url of this form from the bottom of the page

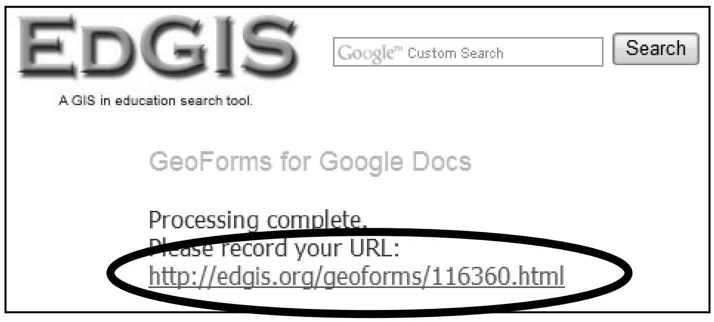
6. Go to Edgis.org web page.



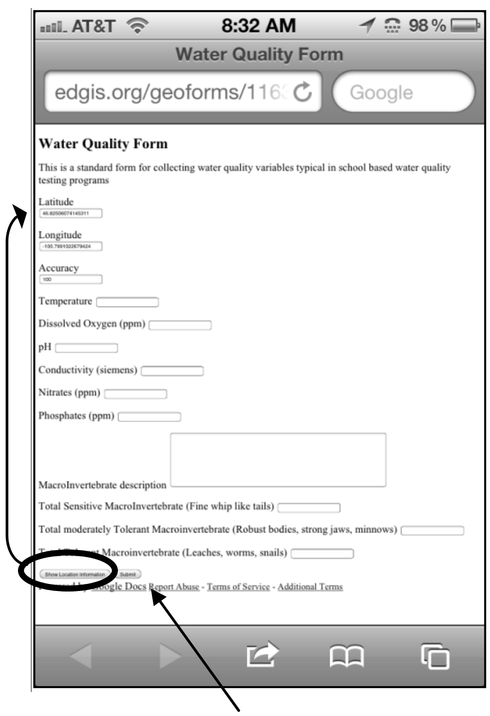
7. Paste the url of the google form you've just created into entry box of this page. (This will embed a little button in your google form that automatically fills the GPS location and accuracy information from your smart phone's built in GPS.



8. A new url will be given which you can use to point your smart phone's web browser to this online form. Any and all phones pointing to this form can add data independently to your google doc form.



9. Besides the questions you've created to be filled out by your students, there will be a button at the bottom of the form that allows you to click and enter in your current position to the first three lines of your form. (Along with the time)

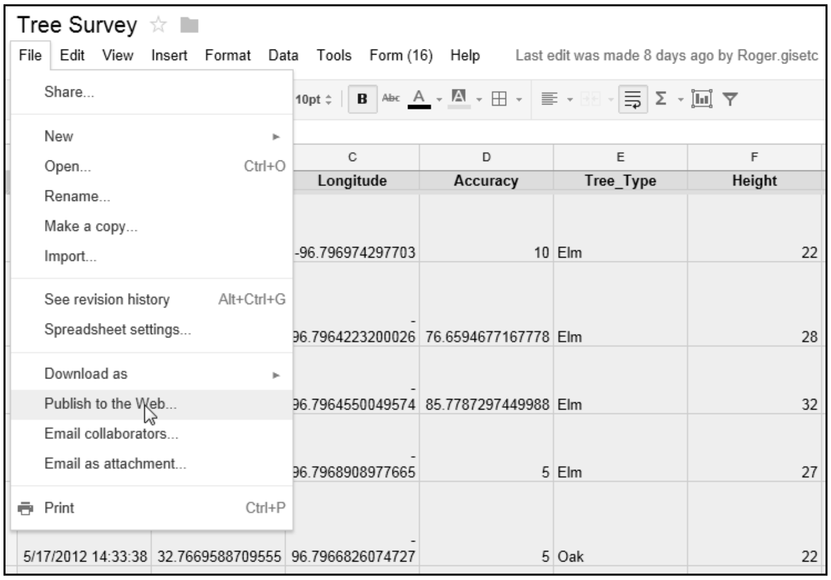


10. Once the form is filled out students can submit one line of data to your form by clicking the submit button on the bottom.

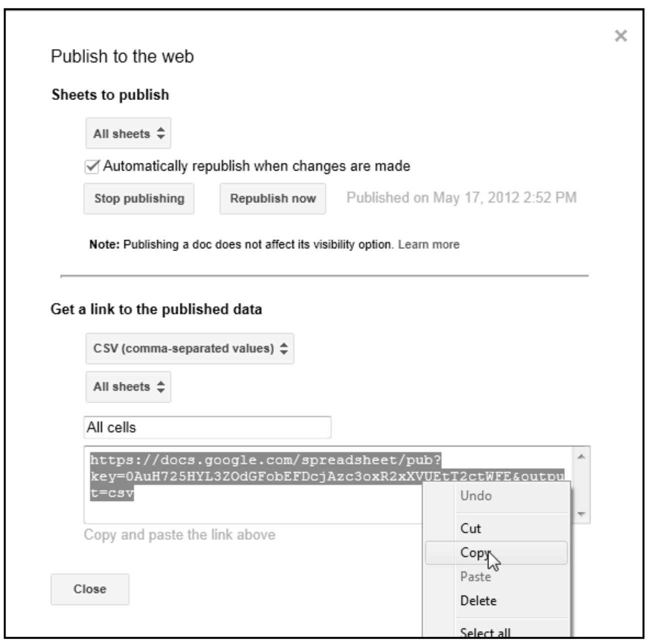
11. Back in your computer lab, open your form in google docs.

12. To make your form accessible to map on ArcGIS Online, at the top right of the form, click: File > Publish to the web > web based .csv file type.

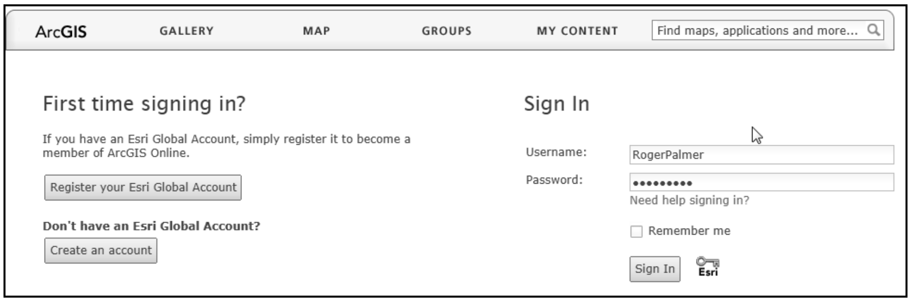
Hotlinking Documents to GPS Points (continued...)



13. Save the form as a web based .csv file. Make sure to automatically republish the form each time new data is added. Highlight, right click, and copy the url of this file type, again it should end in csv

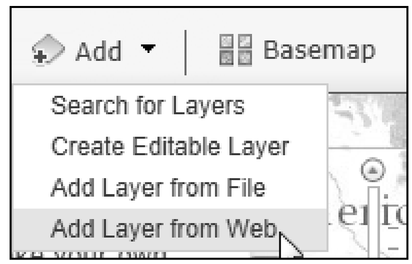


14. Go to ArcGIS Online.com and login. If this is your first time, create a login.



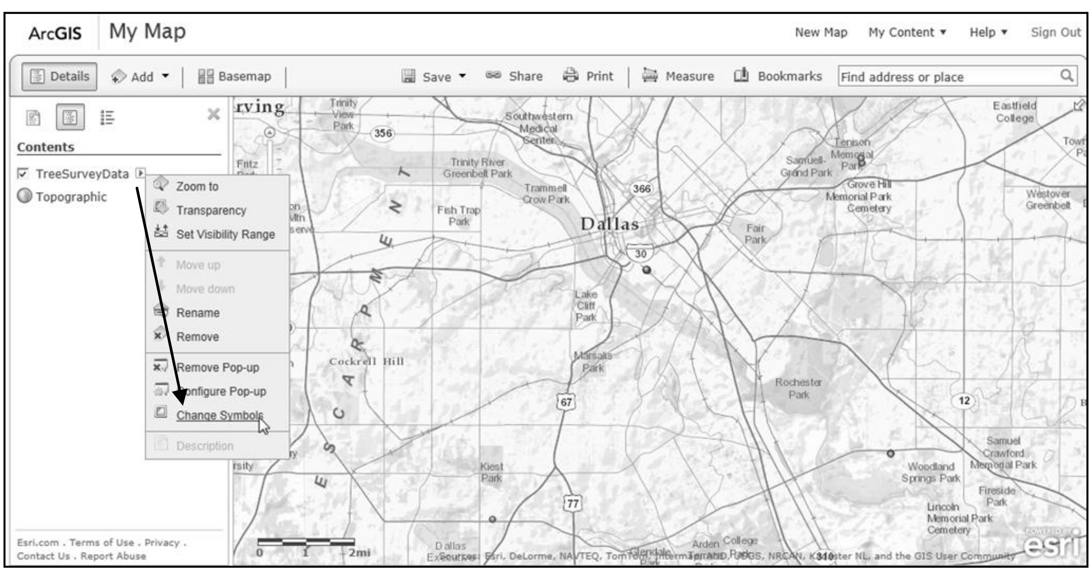
15. Open a new map from either the online map viewer or the arcgis explorer online from the link in the bottom right hand corner. 

16. Click the add data button drop down menu, choose to add data from the web,

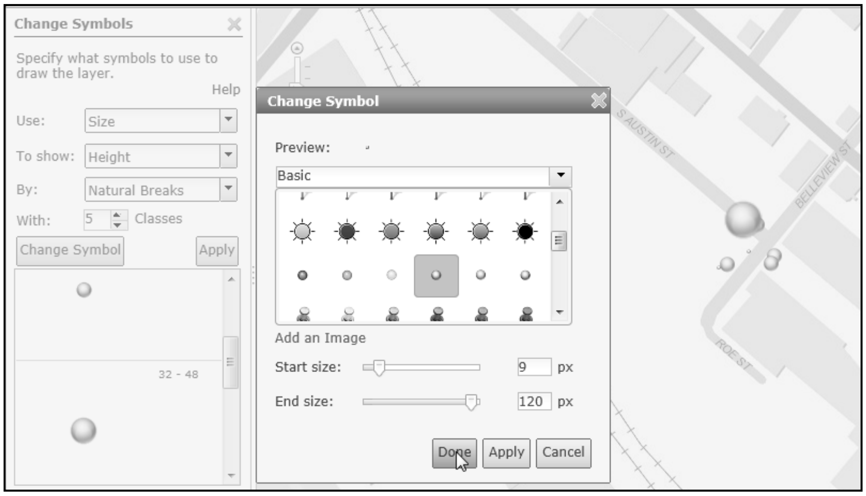


17. Paste in the url of your google form saved as a csv file. (note, you can only add up to a 1000 points of collected data at a time using this method. If you want more you will need to create more google forms for each 1000 points.

18. Thematically map your data based on a value you have collected by clicking on the right arrow of your collected data and ***Change Symbols.***

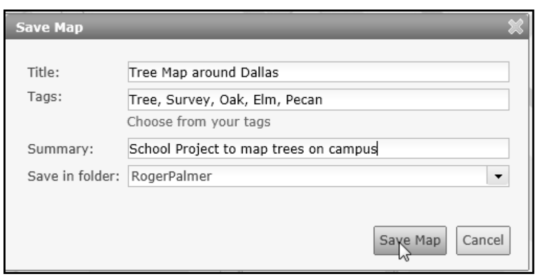


Choose an appropriate symbol, control the start and end size, then apply your changes.



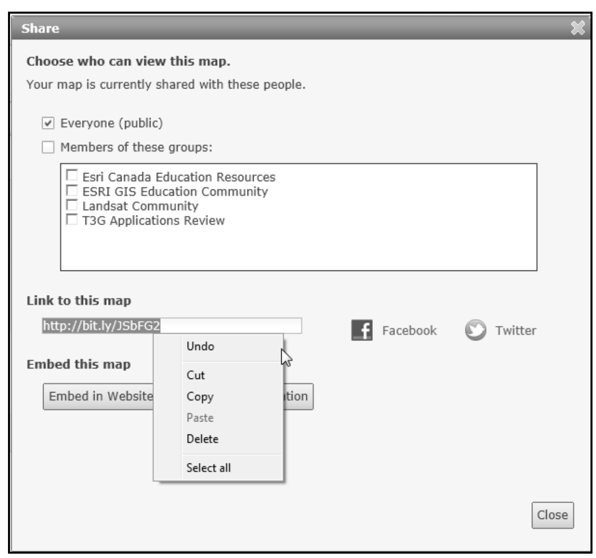
19. Save your map 

and make sure to add a title and related words that help others discover your maps within your communities or shared groups.



20. Click the Share button 

and copy the URL to email this map link to others or copy the embed code to post this map into a website or in a blog. The map will be automatically updated each time you or your students enter more data to the form.



Strategies for Using different GPS configurations for Groups

GPS technologies can and should be used in all different settings, with people of all ages and for fun and education.

One GPS unit

1. One student collects location (latitude/longitude) while the rest of the class or group collects notes, samples, draws pictures, makes rubbings, describes the settings, takes notes from interpretive signs, tells the story of how the class reached the position, measures objects, or estimates sizes or densities. Ask class to switch persons using the GPS unit often so that as many as possible get to experience the device. Student with the GPS calls out the number of the waypoint at any stop. They write down the number in their notes to access when they are back at school.

2. Change the GPS unit to UTM and work on your students' ability to use the distance formula between points. Have the student with the GPS call out two different coordinates and calculate the distance between them. The distance formula is the square root of the difference of the northings squared added to the difference of the eastings squared. The more common formula representation looks like this $d = \sqrt{(\Delta x)^2 + (\Delta y)^2}$.

3. Check out the unit to students to find local geocaches, handing in any assignments that may be associated with community sites. Students can create their own geocaches or EarthCaches. Try to allow each student access to the GPS once per semester.

A few GPS units

1. Obtain or print out topographic maps from USGS, Terraserver, NASA WorldWind, TopoFusion, MSN Bing, ESRI's ArcGIS Explorer, Google Earth, or a commercial vendor such as Topo Maps USA from National Geographic. Have students without GPS units work together with the GPS operators to find their current locations and to find EarthCaches. On longer trips, students can regularly plot their position on this printed map. Make sure to turn on the lines of latitude and longitude before you print the map.

2. Split students into teams and assign jobs so that they can produce a report by the time they return, simulating real "on the job" fieldwork. Each student focuses on different aspects of the area: terrain, soil type, texture, rock description, major land forms, etc.

3. Have students break into as many groups as you have GPS units to practice finding GPS points using a deck of cards. The first GPS holder walks away from the group and drops a card at least ten feet from any of the other teams' cards. The GPS holder marks the position and returns back to their team who sets the GPS to *Go To* the card. Each member of the team must determine their card from the other teams as a relay. The next person completes their turn by whispering the correct card into the lead person's ear. If they found the wrong card they must look again for the correct card before handing the GPS to the next person. (For more detailed directions, refer back to the *Card Games* section of this book.)

4. Make as many teams as you have GPS units and have each team create a very quick EarthCache writeup. Hand the description and activity to one of the other teams and everyone can race to find and finish each other's activity.

Strategies for Using different GPS configurations for Groups (continued…)

GPS for each student

1. Each student creates a journal of their experiences during class fieldtrips.

2. Encourage groups of students or families to visit more EarthCaches and geocaches.

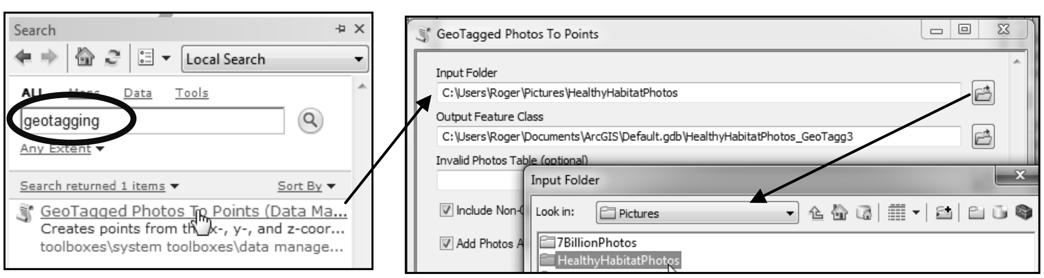
3. Set up several EarthCaches that are close to the school for technique building. Develop more locations that are farther away so students will have to visit them on their own.

GPS on smart phones (For more detailed instructions, look for our new book: Geotagging Media)

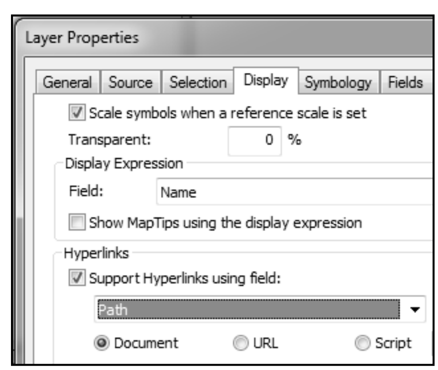
1. Use a dedicated GPS app to follow a trail. Email your file to your school email. Download and save the file (usually it will be a .gpx format) to your computer. From the computer lab, add the file into either an online map like ArcGIS.com where you can thematically map the data you have collected. Google maps or google earth will allow you to show your data. ArcGIS also allows you to add these .gpx data by searching for the GPX conversion tool. Double click the tool link and you will be able to search your hard drive for where you've saved the .gpx file. Choose where to save your file, click OK and the points will then appear on the GIS interface.

2. Create a web based mobile form as described in the previous two exercises. Type up questions for water quality, species mapping, tree surveys, social conditions, graffiti, building age survey, or whatever you come up with. They can be scientific, social, economic, technological, or even pop culture. (One of the surveys on edgis.org, actually request people to describe what they call carbonated beverages.)

3. Taking pictures on your smart phone actually encodes your position on the image. Email yourself from the field. Download all your pictures into a folder and in ArcGIS use the search function shown in the first step. Look for "geotagging" and point to the folder with all your pictures. The software will make a layer you can double click then put a point wherever the picture location was recorded and you can make the image linkable.



Open the newly created layer properties and in the display field, choose to support hyperlinks then click OK. Use the hyperlink tool to click on any of the dots and you will see your pictures pop up in whatever your default picture viewer.



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