

# ASSESSING URBAN FOREST PATCH HEALTH: A PROTOCOL



*Assessing Urban Forest Health: A Protocol* is the result of a collaboration among Baltimore Green Space; University of Maryland, Baltimore County; Johns Hopkins University; and the USDA Forest Service.



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# ABOUT THIS MANUAL

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**Assessing urban forest health is one of the many ways you can care for your environment. This manual is for anyone interested in learning more about the health indicators of your city’s forest patches, such as native plants, invasive plants, and soil health. Learning about urban forests is the first step in protecting them. Whether you are a resident, community organizer, or scientist, you can take part in monitoring and protecting the health of urban forests.**

## Using This Protocol

This manual is intended to provide an easily accessible guide for conducting research on urban forest patch health. Data collected through this protocol can be used in various ways. This protocol was designed to understand a series of baseline environmental measures that provide a snapshot of forest health. The results will provide an understanding of the soil quality, understory species, overstory species, and their relative dominance. Baltimore Green Space creates forest stewardship reports for the neighborhoods they work with to help them make decisions about land management. Baltimore Green Space has also compiled these data to create presentations drawing awareness to the abundance of native trees, soil health, and diversity of species in Baltimore’s urban forests. The data can serve as supporting evidence for land preservation efforts, since there are many assumptions about urban forests that are not necessarily backed by research in urban forests.

## Collaborating for Urban Forest Health

Collaboration is what connects people from all backgrounds to create a solution for a better future. Community science is community-based research—everyone, from neighbors to professional scientists, can play a part. Collaborating to assess urban forest health is important for creating new policies to improve and maintain urban forest patches to create greener and more resilient communities in the face of climate change.

As part of its urban forest health research, Baltimore Green Space partners with University of Maryland, Baltimore County (UMBC) to use lab equipment for conducting urban forest health research. In collaboration with the USDA Forest Service, and UMBC and Johns Hopkins scientists, Baltimore Green Space developed the sampling methods used in this project. Principal advising scientists were Ian Yesilonis, Matthew Baker, and Nancy Sonti, with periodic support from Charlie Davis, Morgan Grove and Katalin Szlavecz. The field technicians who helped develop these sampling procedures were Nels Schumacher, Perri DeJarnette, James Hughes, Laura Templeton, Alyssa Wellman Houde and Joshua Denicoff. Laura Templeton was the lead field technician in year two. The “Conducting Soil Analysis” protocol was written by Sarah Trejo and Sarah Ragen. The organic matter procedure was adapted from the Soil Ecology class taught by Dr. Katalin Szlavecz at Johns Hopkins University. Katie Lautar, of Baltimore Green Space, was the primary manager and designer of this project, with periodic support from the former Executive Director Miriam Avins.

All parties involved in the project have informed the development and adjustment of the project work. We are grateful to have the opportunity to study scientific questions about urban ecology together.

Special thanks goes to the field crew for their energy, enthusiasm, and commitment. Additional thanks goes to the USDA Forest Service and UMBC for funding our field crew.

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This manual was produced by Baltimore Green Space; UMBC CoLab interns Bella Dastvan, Tevyur Mosley, and Alida Schott; and UMBC Summer Forest Patch researchers, especially Caitlin Beckjord and Carol Frimpong.

Cover art illustrated by Bella Dastvan.



# WHAT ARE URBAN FOREST PATCHES?

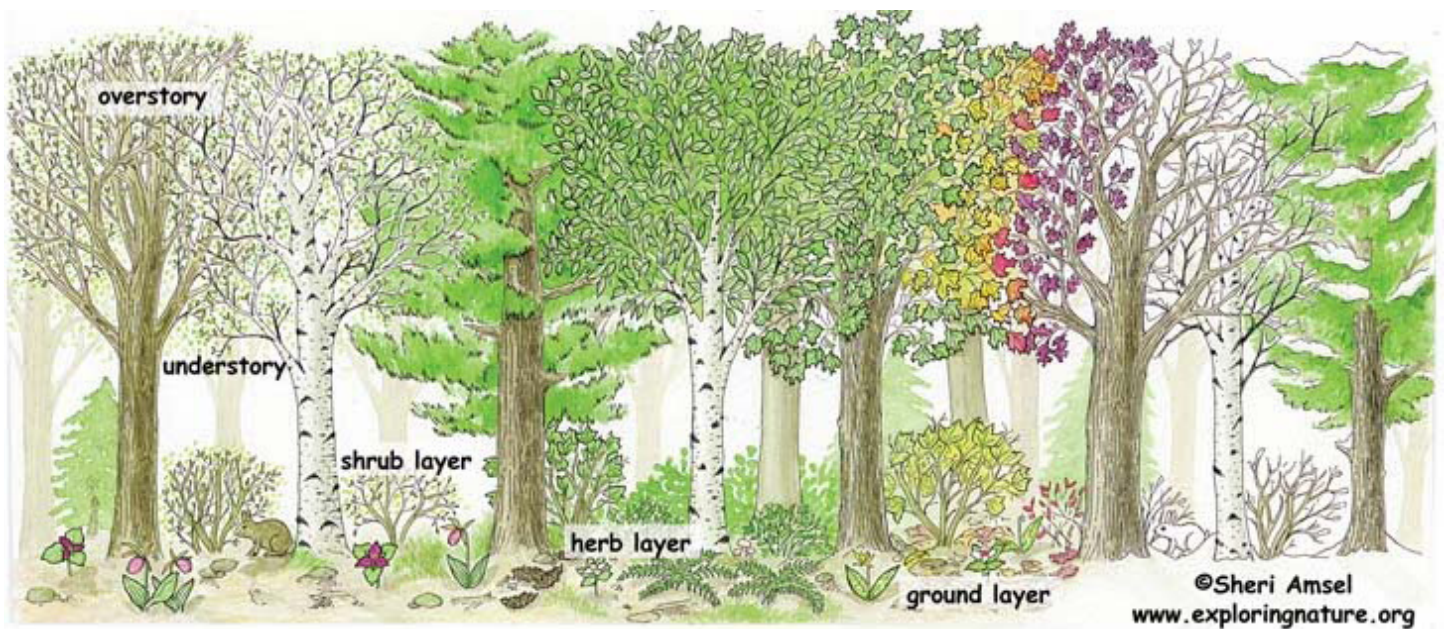
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Baltimore Green Space defines urban forest patches as areas with tree canopy covering at least 10,000 square feet with a minimum thickness of 100 ft. About 34% of Baltimore's tree canopy is made up of forest patches—14% of the tree canopy is within parks, and 20% of the tree canopy is outside of parks.



*UMBC Summer Forest Patch intern Caitlin Beckjord in a forest patch*

Forest patches have different layers starting from the bottom with the ground layer, herb layer, shrub layer, understory, and overstory (uppermost tree canopy).<sup>1</sup> Some forest patches grow in places not suitable for land development (e.g., wetlands, underground springs, steep slopes, and floodplains).



*Forest canopy layers*

A forest's health and the health of the surrounding environment depend upon one another. Forest patches provide a variety of ecosystem services, meaning environmental processes that benefit both humans and the environment. For example, urban forests help mitigate climate change through carbon sequestration. In this process, carbon dioxide, a greenhouse gas, is removed from the atmosphere by a plant's leaves through photosynthesis, and is stored as biomass in forms including dead wood, litter, and woodland soils. Patches of forest can harbor native plants and wildlife that lose habitat where cities are built, so they help preserve biodiversity threatened by development.

Urban forests also reduce runoff during rainstorms. Impervious surfaces (asphalt, concrete, buildings) prevent rainwater from soaking into the ground; instead, rain becomes runoff that causes flooding and can carry pollutants to nearby streams. In contrast, forests have fewer sources of pollutants compared with urban surface runoff from streets, lawns, and sewers.<sup>2</sup> Urban forests also reduce pollution in the air and soil. Trees can naturally restore contaminated soils in brownfields,<sup>3</sup> which are properties "where expansion, redevelopment or reuse may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant."<sup>4</sup>

The urban heat island effect occurs when buildings, roads, and other man-made structures absorb and emit the sun's heat, which makes cities hotter than rural and suburban areas. Beyond just providing shade, trees also cool cities by releasing water vapor, which absorbs a substantial amount of heat directly from the air. Urban trees can lower air conditioning and heating costs significantly.<sup>2</sup> Lower rates of asthma, cardiovascular disease, skin cancer, and other physical illnesses have been reported to coincide with urban forests.<sup>5</sup> In addition, exposure to nature can help students with ADHD and other mental illnesses to perform better during school.<sup>8</sup> The presence of urban forests can help to lower stress and aggression. Higher urban tree canopy coverage is correlated with higher property values and lower crime rates in nearby neighborhoods.<sup>6</sup> Urban forests encourage commuters to walk or bike, and overall promote more recreational activities.<sup>7</sup> In sum, green spaces and urban forests help build stronger communities with more social interactions and a sense of safety.<sup>9</sup> Urban forests make cities more resilient against the effects of climate change, such as soaring temperatures and more frequent storms and floods, and they protect biodiversity.<sup>10</sup>



# PREPARING FOR FIELD WORK

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**This section describes how to pick a research site and get the tools for research. It is important that you are prepared for field work and have the necessary field supplies to conduct your research successfully and accurately.**

## Selecting a Site

Forest patches are identified using Geographic Information System (GIS) analysis. In Baltimore, as our collaborative study of the city's forest patches has continued, we have been interested in minimally having a representative sample of Baltimore's forest patches. Some goals could include having a complete inventory, representative sample, targeting sites for conservation value, geographically balanced sampling, stratified random sampling, etc. (For a more detailed description of this work, see [Appendix C of "Baltimore's Forest Patches: Emerald Assets for Ecosystem Services."](#))<sup>11</sup> Forest patches outside of parks can be on multiple lots or on planned streets that were not built. The Baltimore Forest Patch Map displays forest patches that have thus far been identified using GIS (Appendix A).

Baltimore Green Space also produced the [Baltimore Forest Patch Atlas](#) locating forest patches in gridded sections of Baltimore City. However, when choosing patches to sample we first focused on sites held in easement by Baltimore City and then on sites closely stewarded by the community forest stewards we work with most closely. Our goals were to assess the health of the city held forests and cared for by community leaders to provide them with a tool for guidance on care and management.

## Getting Permission to be on the Land

In order to conduct any study of an urban forest patch, you will need to get permission from the owner of the land that contains the forest patch of interest. For liability purposes, you want to avoid trespassing. To do so, the first thing you need to know is whether the forest patch is on government-owned land or privately-owned land:

- Government-owned land: Public property is okay to enter unless it is restricted to certain people. If it is restricted, you will need to ask the city for permission to use the land for research purposes, and get the permission in writing if you can. Most natural areas are governed by parks departments so they may be a good place to start. Also, consider connecting with your city's Office of Sustainability if there is one.
- Privately-owned land: You will need to ask the owner for permission to enter the property for research purposes, and get the permission in writing if you can. State land records can be used to identify the land owner and their address.

Regulations differ among cities and states, so it is important that you look up your local laws related to rights on entering private, public, federal, and/or city properties. [The Citizen Science Guide](#) offers additional information for learning about trespassing laws in your state.



# Mapping GPS Coordinates of Forest Patches

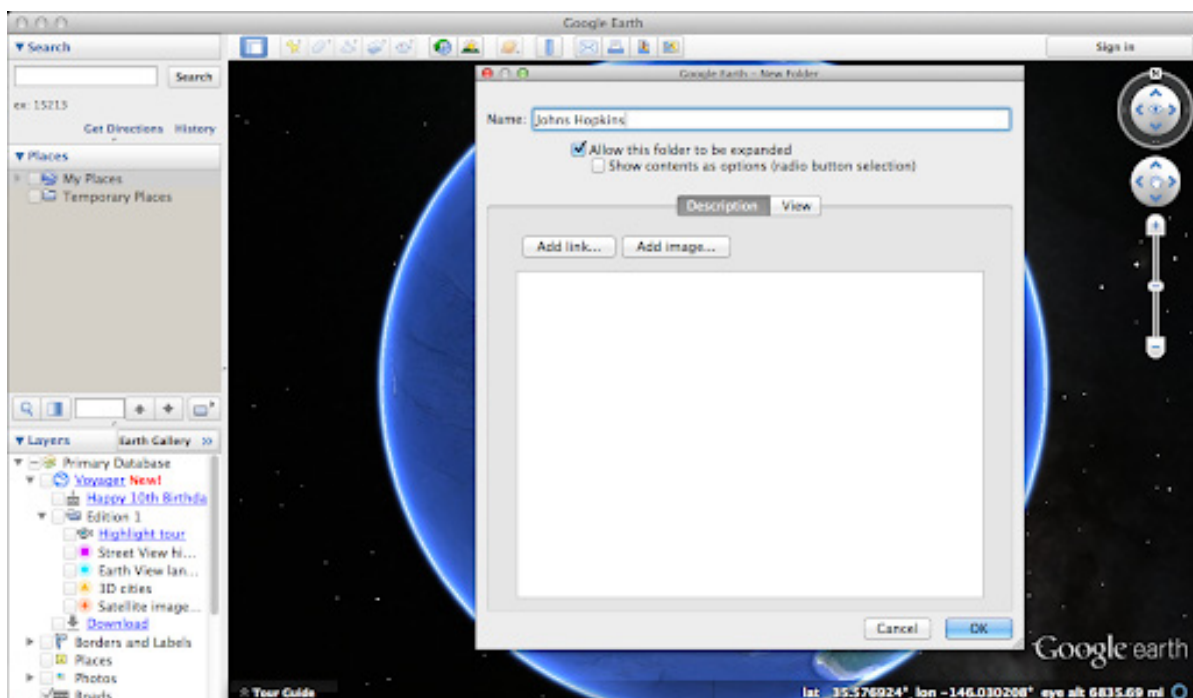
In this tutorial you will use Google Earth along with a forest conservation map to locate gridded GPS coordinates.

## Locate conservation site in Google Earth

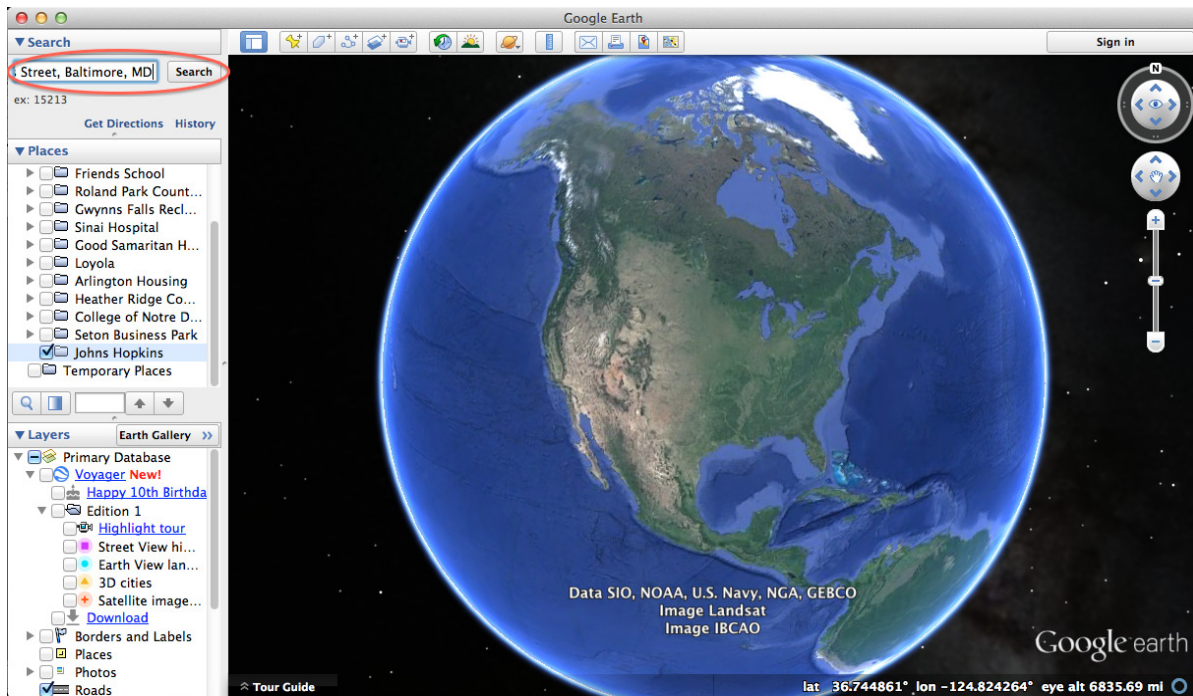
1. Open Google Earth.
2. Right-click [My Places]->[Add]->[Folder].



3. Name your folder and click [OK].

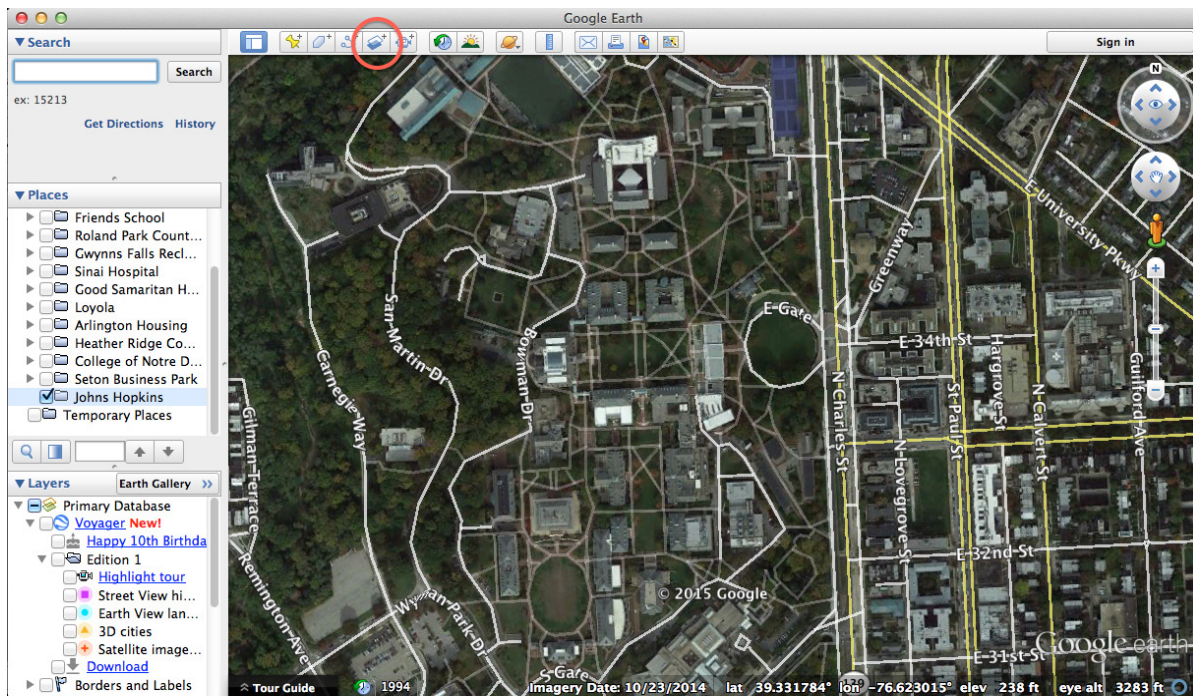


4. Enter the location address in the search bar. Click [Search].



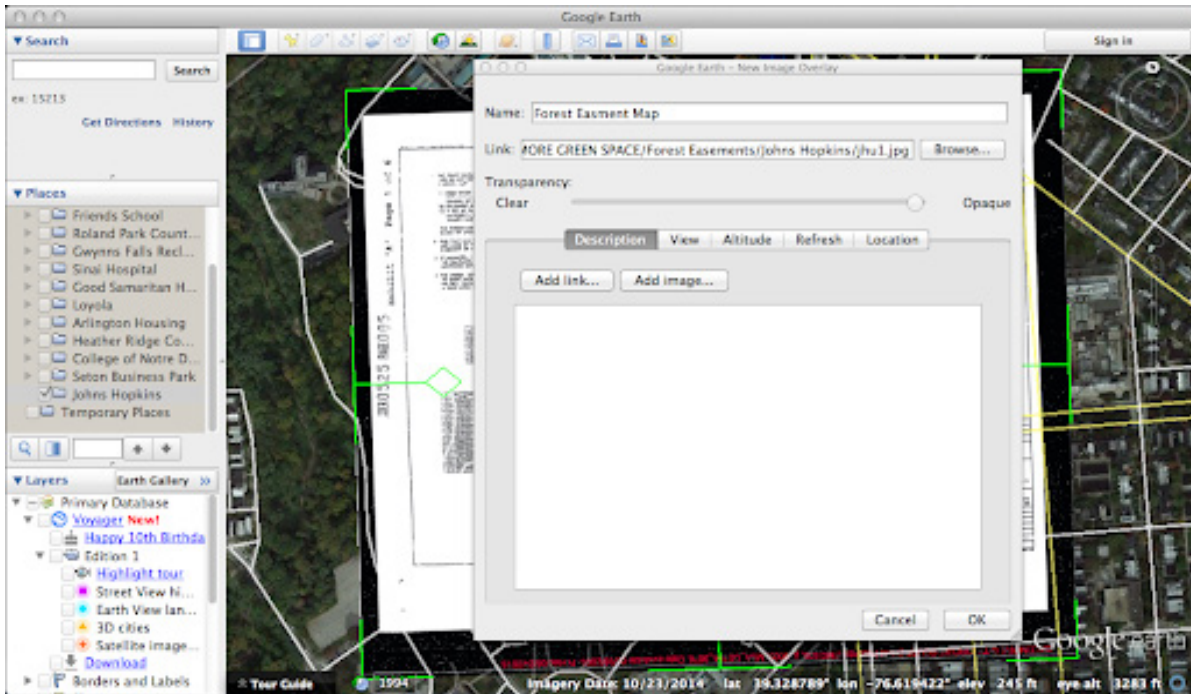
### Embed forest map over Google Earth Image

5. In the toolbar along the top, click the Add Image Overlay button.

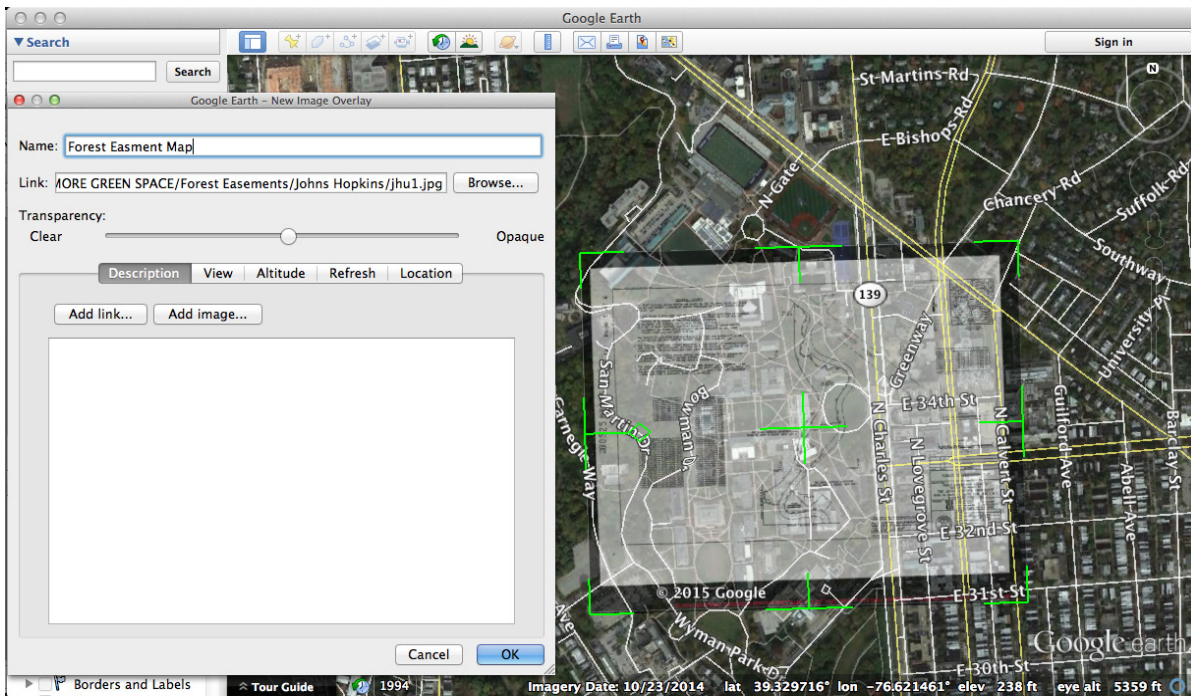




6. Name your map. Click the [Browse] button. Open the image of your forest map. (This image must be saved as a jpeg).

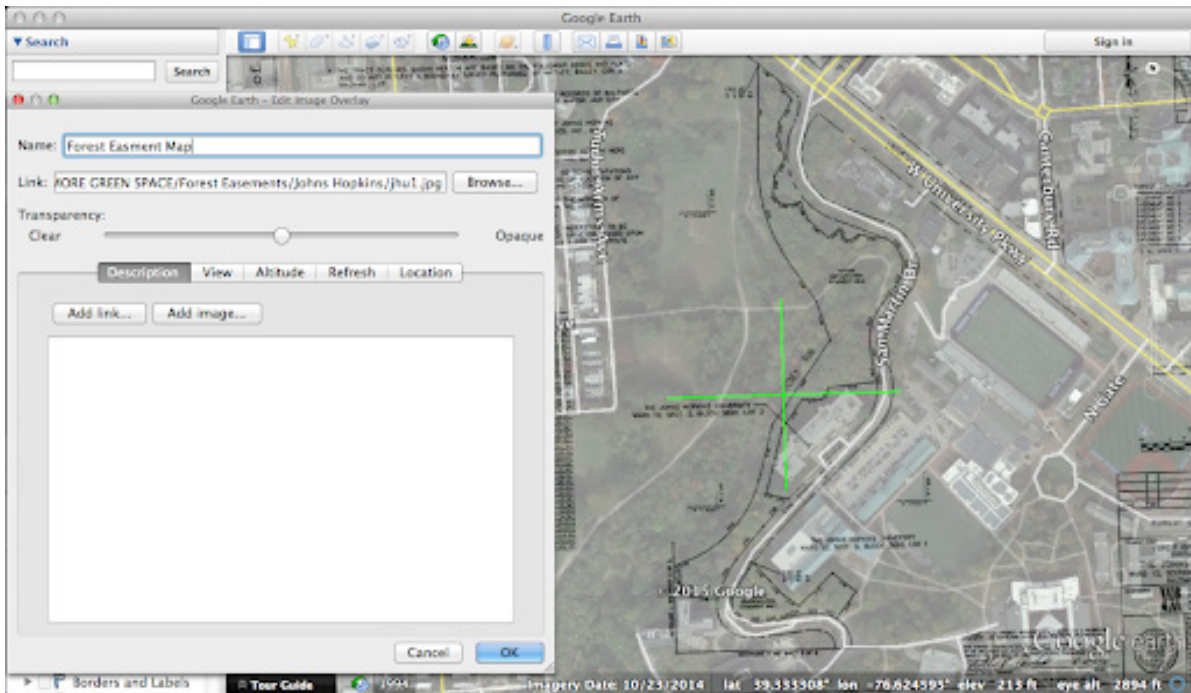


7. Adjust the “Transparency” slider so it’s halfway between “Clear” and “Opaque”. Move the Image Overlay window to the side so you can see the Google Earth window.

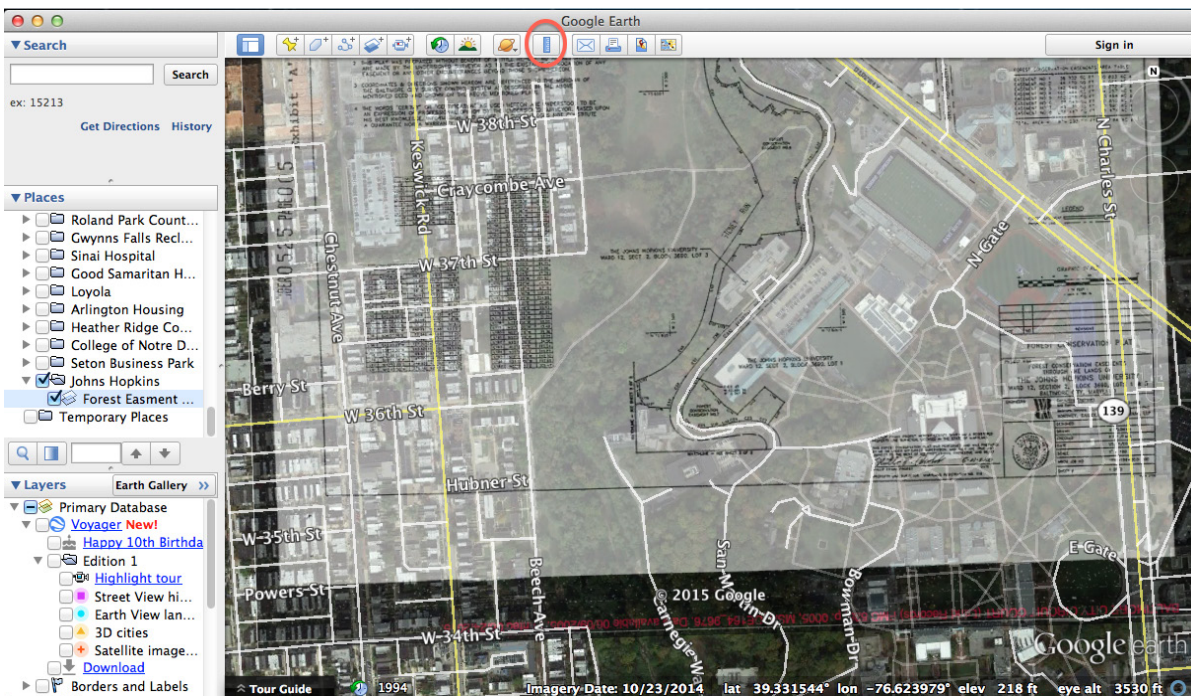


8. Adjust the map so it lines up with the Google Earth image. To scale, hold the Shift key and grab one of the corners of the image. (If you aren't holding the shift key, the image will become skewed or stretched). To move, hold the cross in the center. To rotate, hold the diamond.

**Warning:** There is no way to undo mistakes. If something is incorrect, click [Cancel] and restart from step 5. When the map is lined up, click [OK].

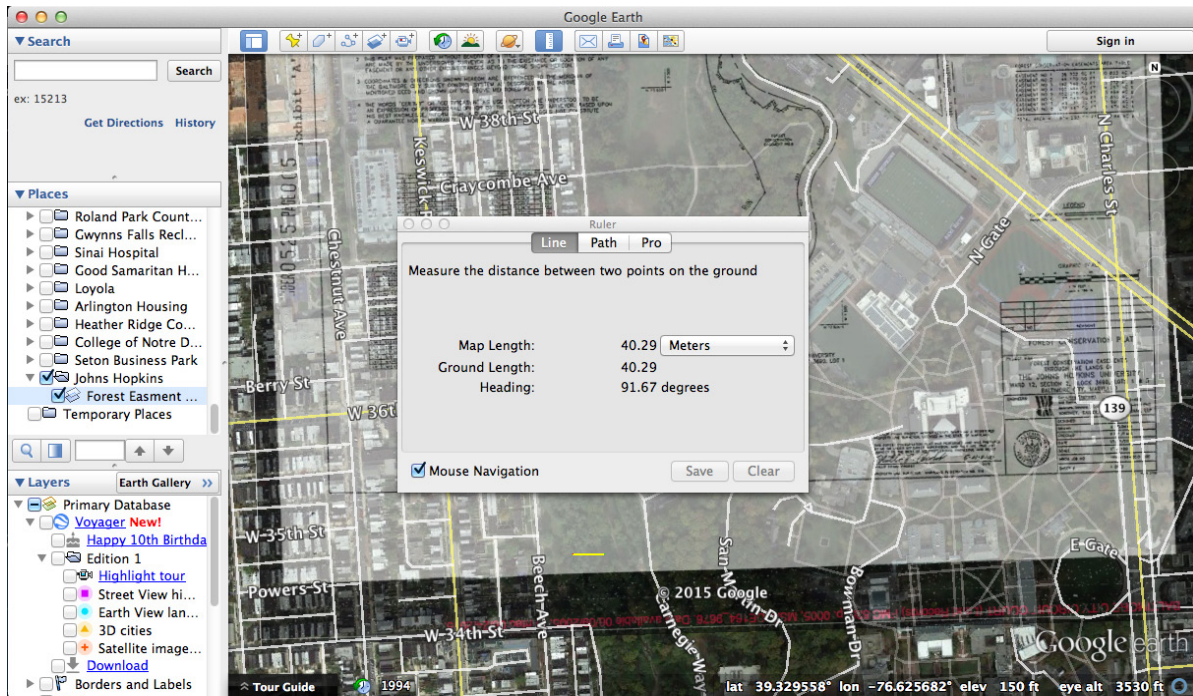


9. In the toolbar along the top, click the Show Ruler button.

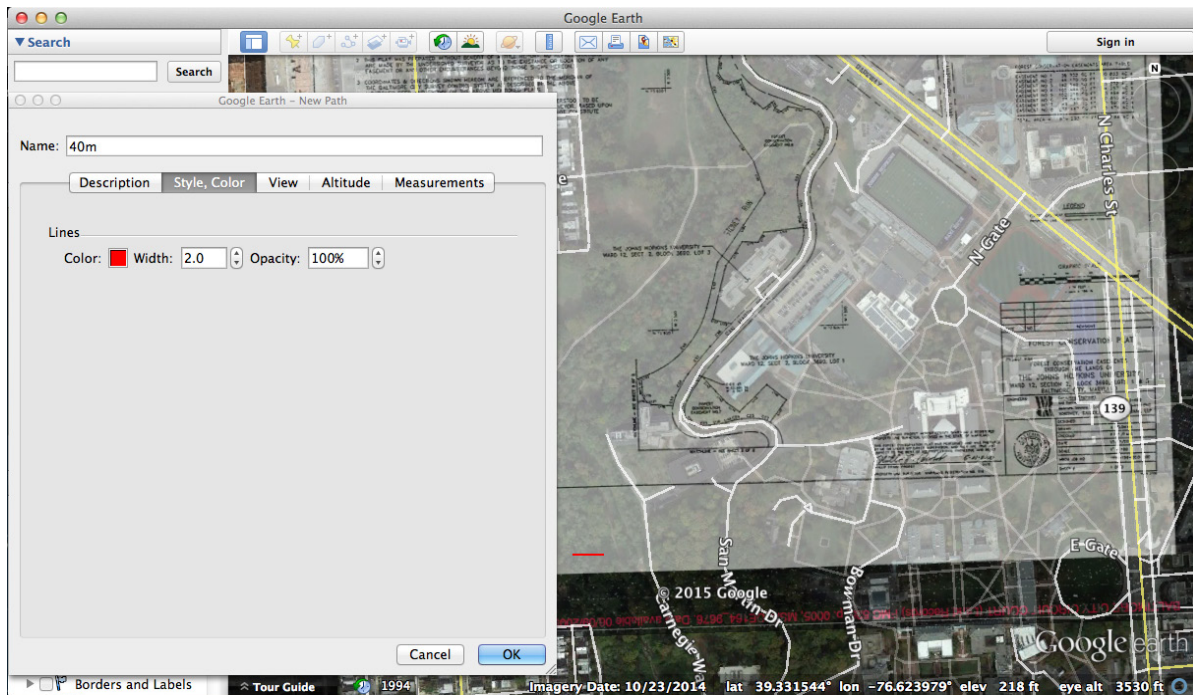




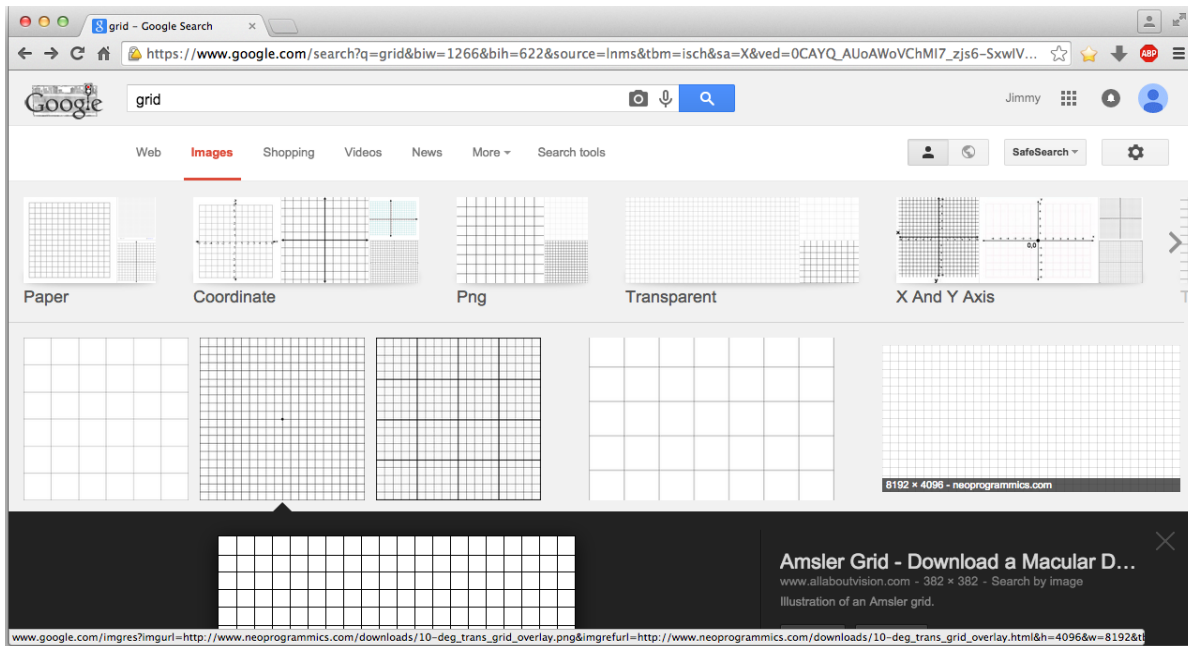
- Click any point on the map, and then make a straight line as you watch the “Map Length”. When you reach the length you want your grid spacing to be, click again. Finally, click [Save].



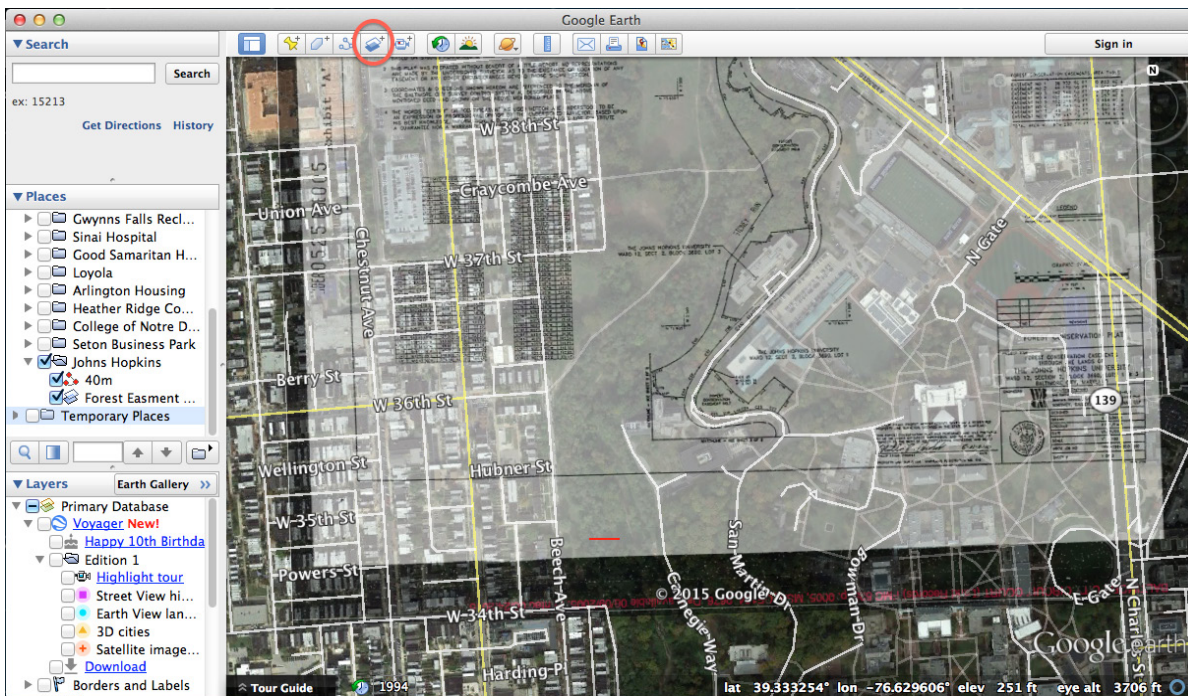
- Name your line. Adjust the color and width in the [Style, Color] tab. When done, click [OK].



12. Save an image of a grid from the Internet. (Convert it to a jpeg if it's not already.)

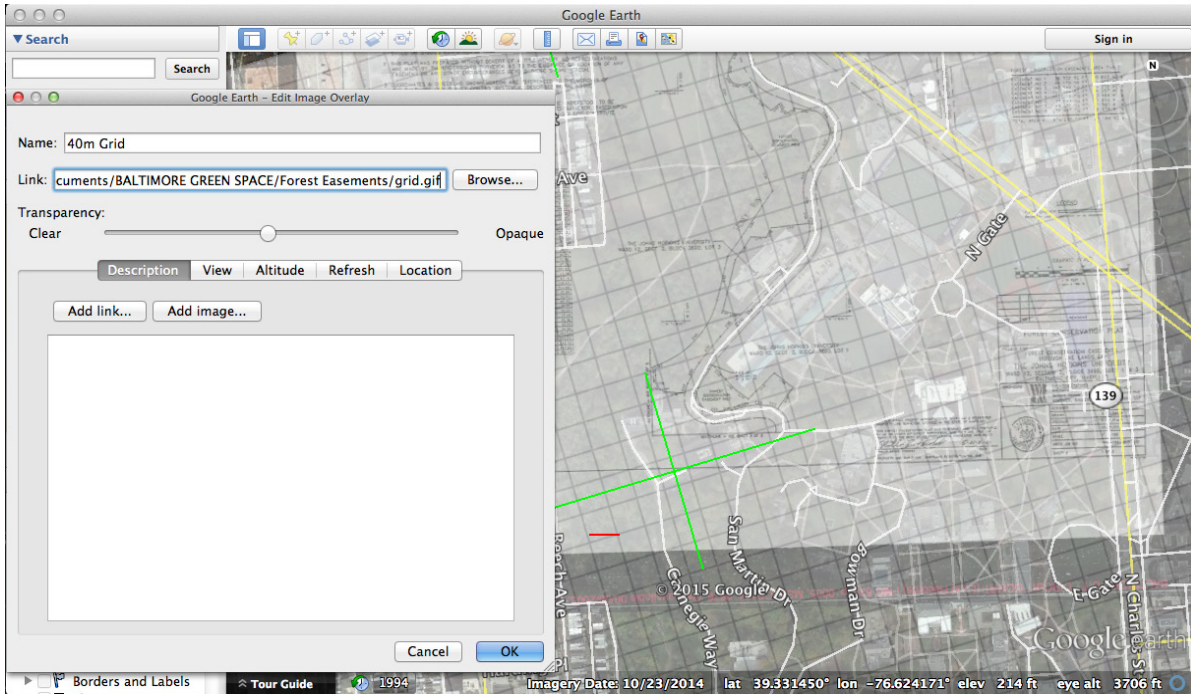


13. In the toolbar along the top, click the Add Image Overlay button.

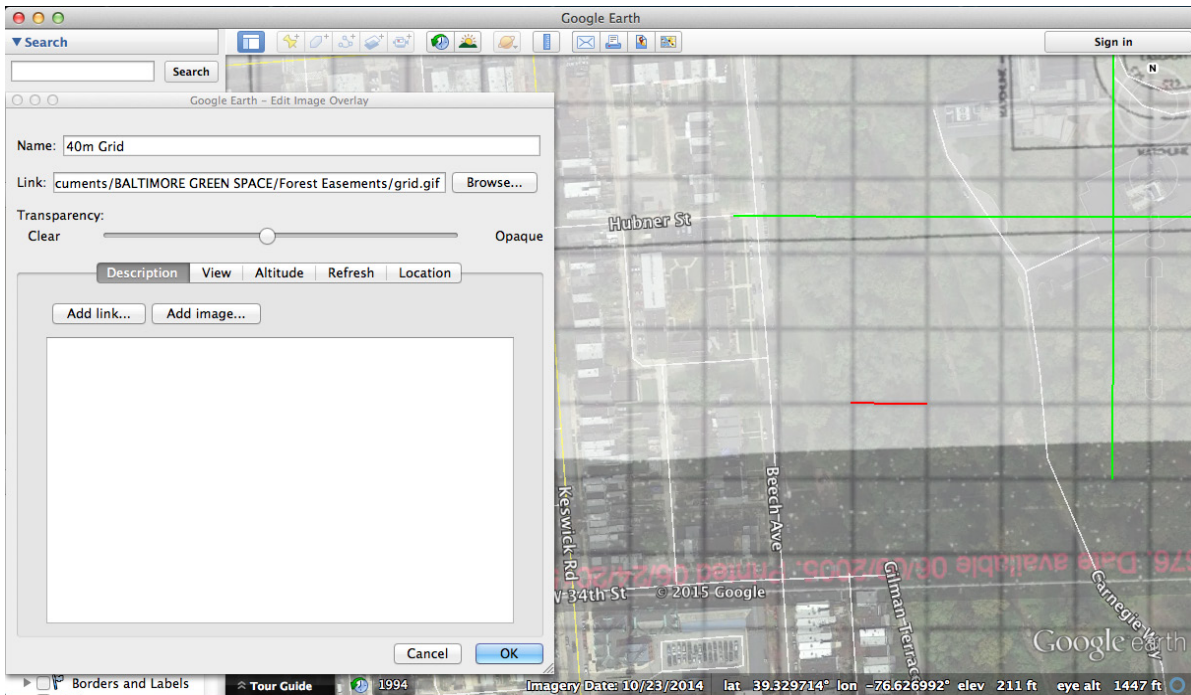




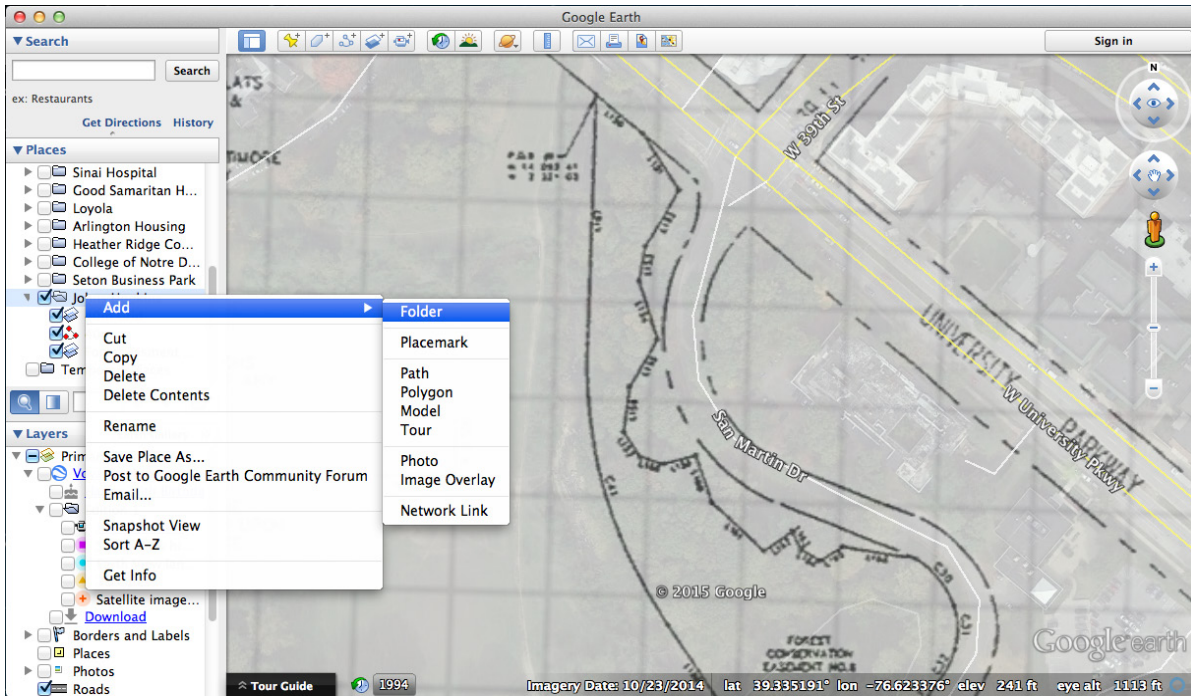
14. Name your grid. Click the [Browse] button. Open the grid image from step 12. Adjust the “Transparency” slider so it’s halfway between “Clear” and “Opaque”.



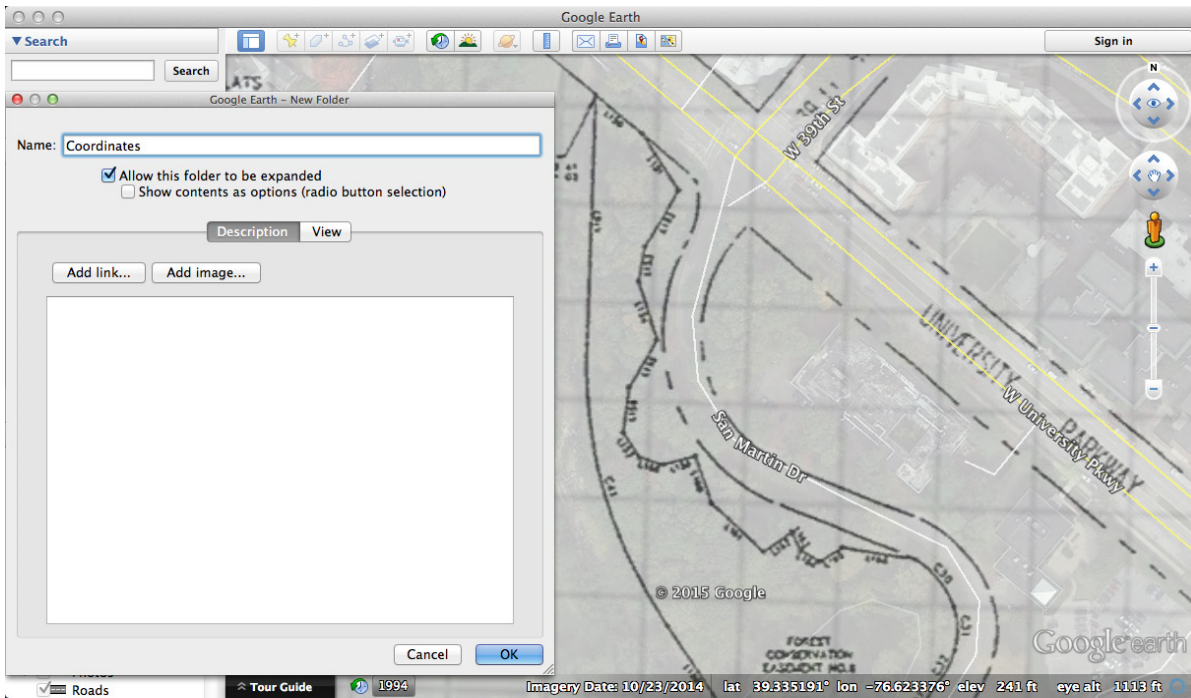
15. Repeat step 8 but instead of lining up the map with Google Earth, line the grid up with your measurement from step 11. Before clicking [OK] make sure your grid covers the entire patch/property.



16. Right-click [Folder from step 2]->[Add]->[Folder].



17. Name your folder “Coordinates” and click [OK].

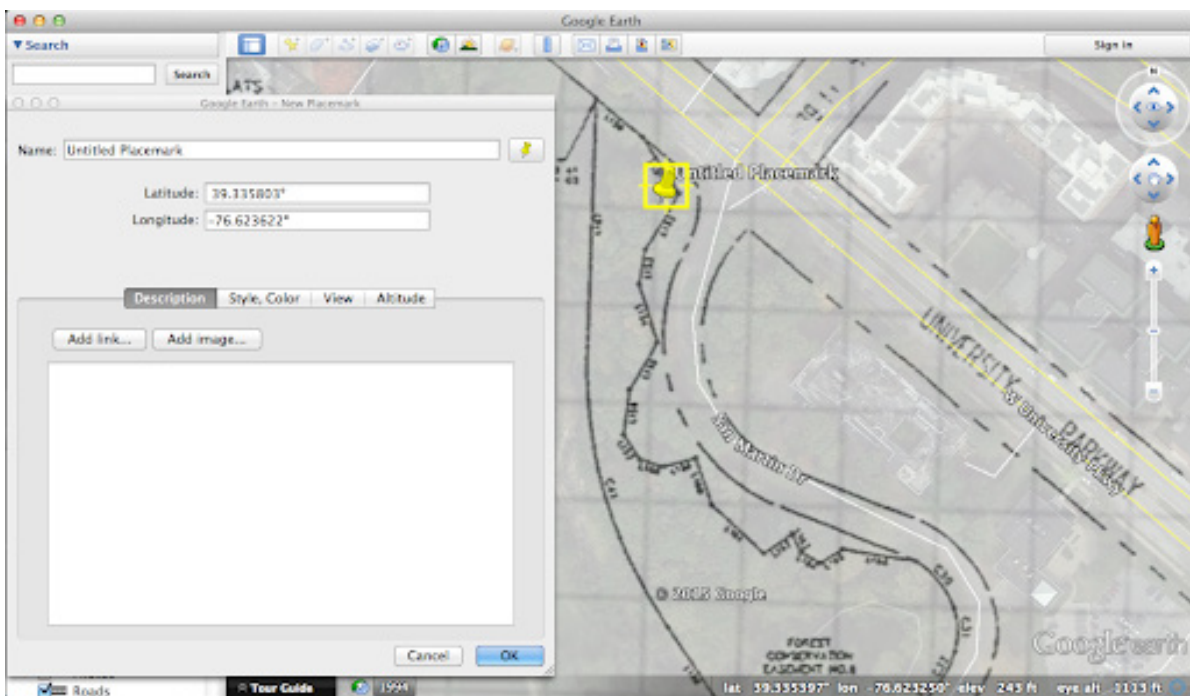




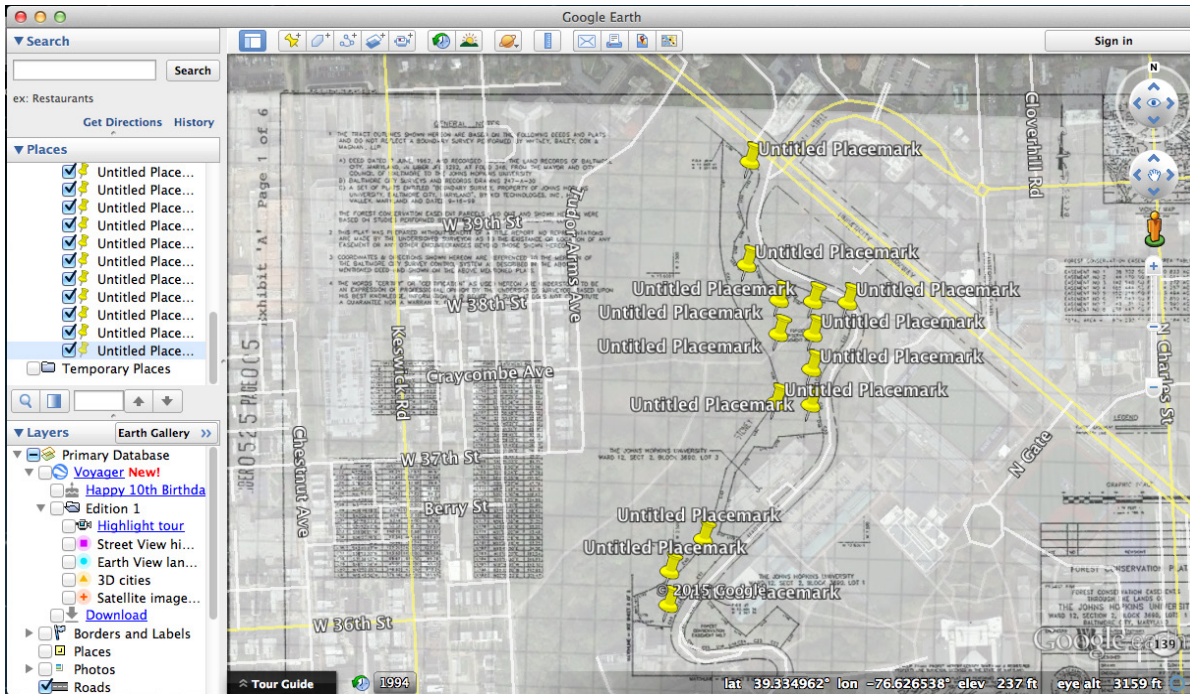
18. In the toolbar along the top, click the Add Placemark Overlay button.



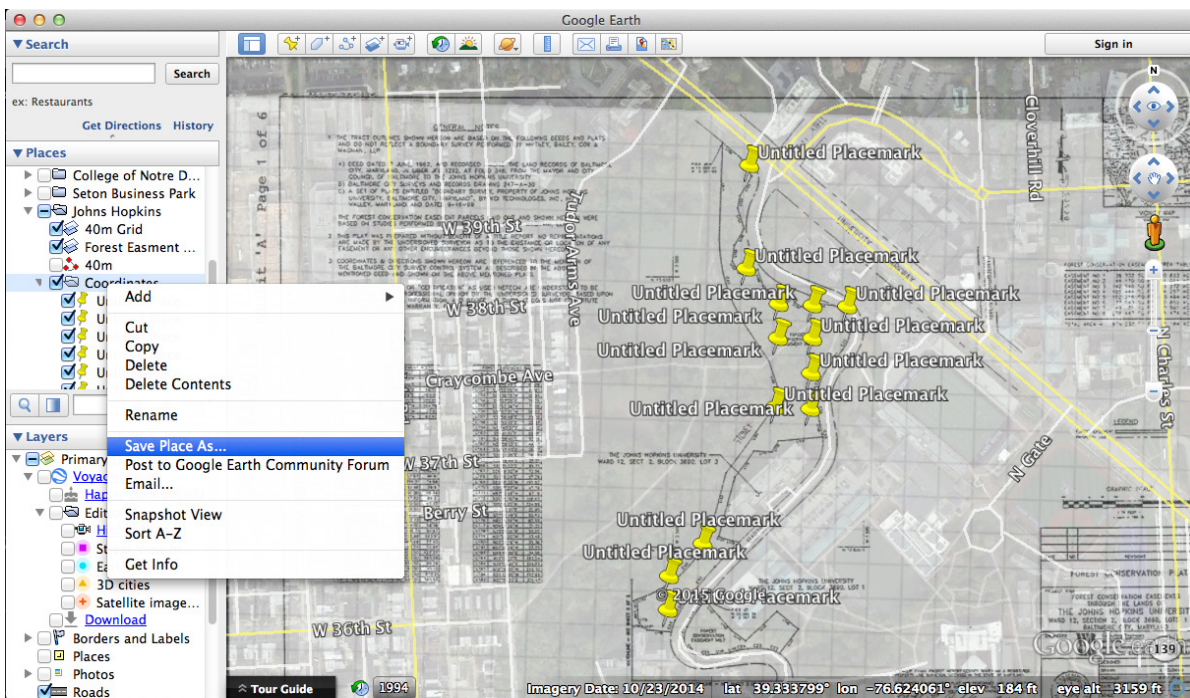
19. Click on the pushpin and drag it to a point on the grid that lies inside the patch. Click [OK].



20. Repeat steps 18-19 for every point inside the patch.

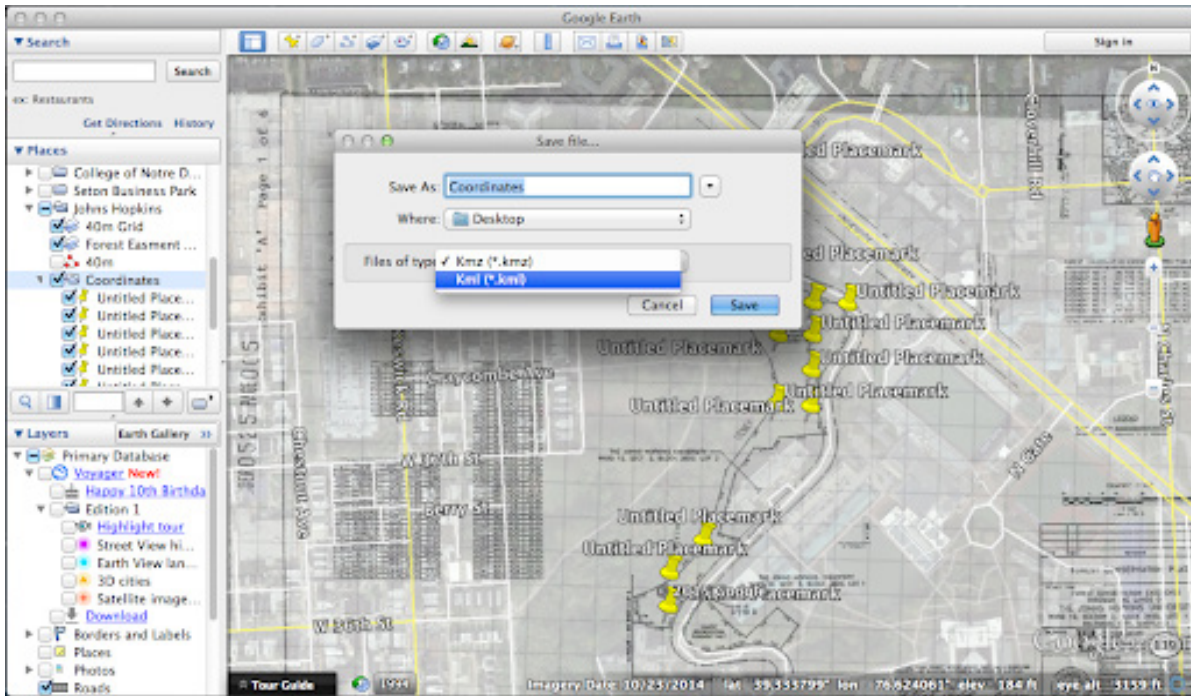


21. Right-click [Coordinates] folder->[Save Places As...].

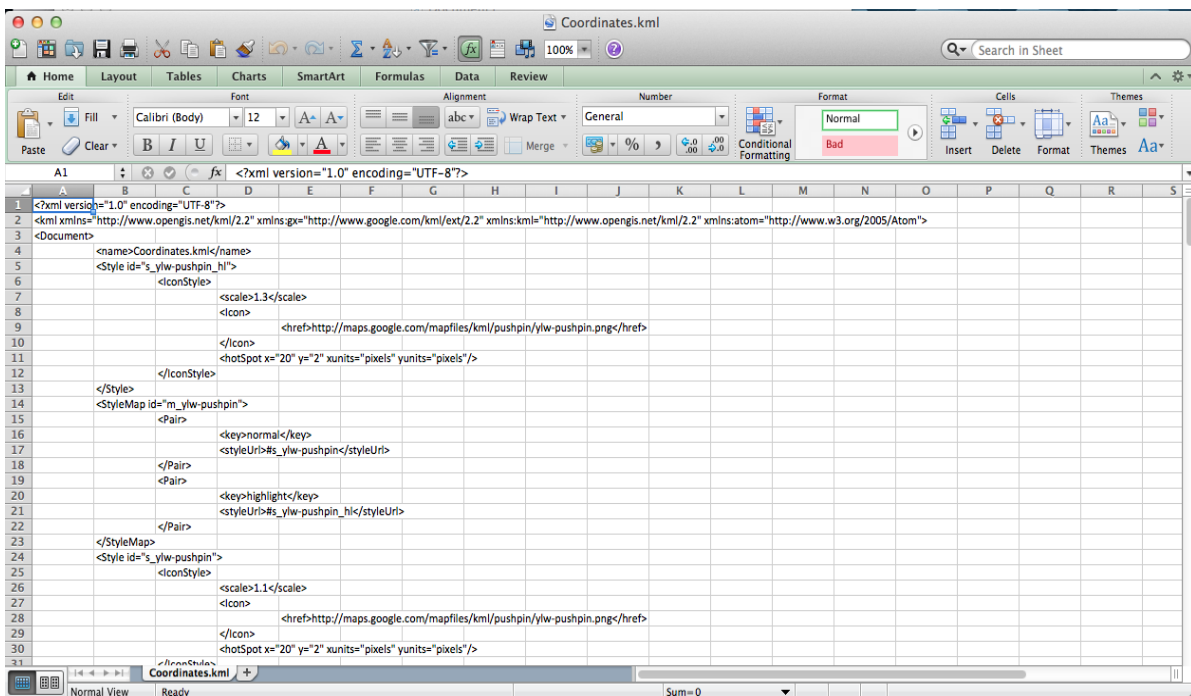




22. Name the file. Select a location. Make sure the file type is “.kml”. Click [Save].

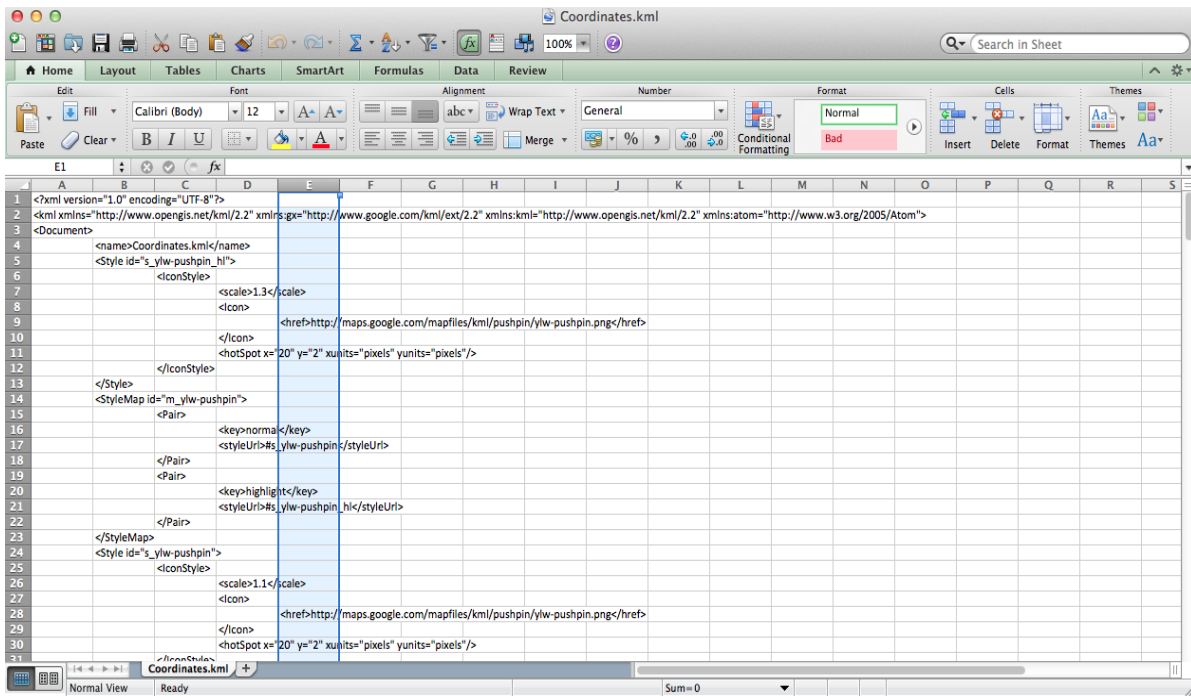


23. Open the file in Microsoft Excel.

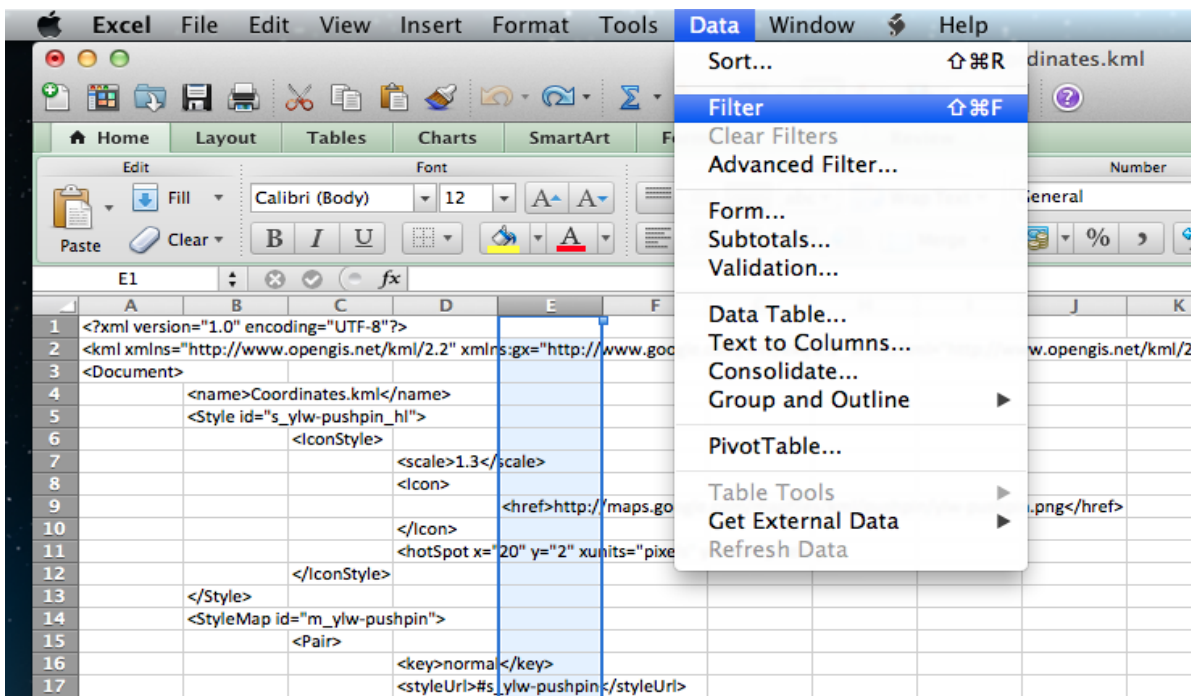




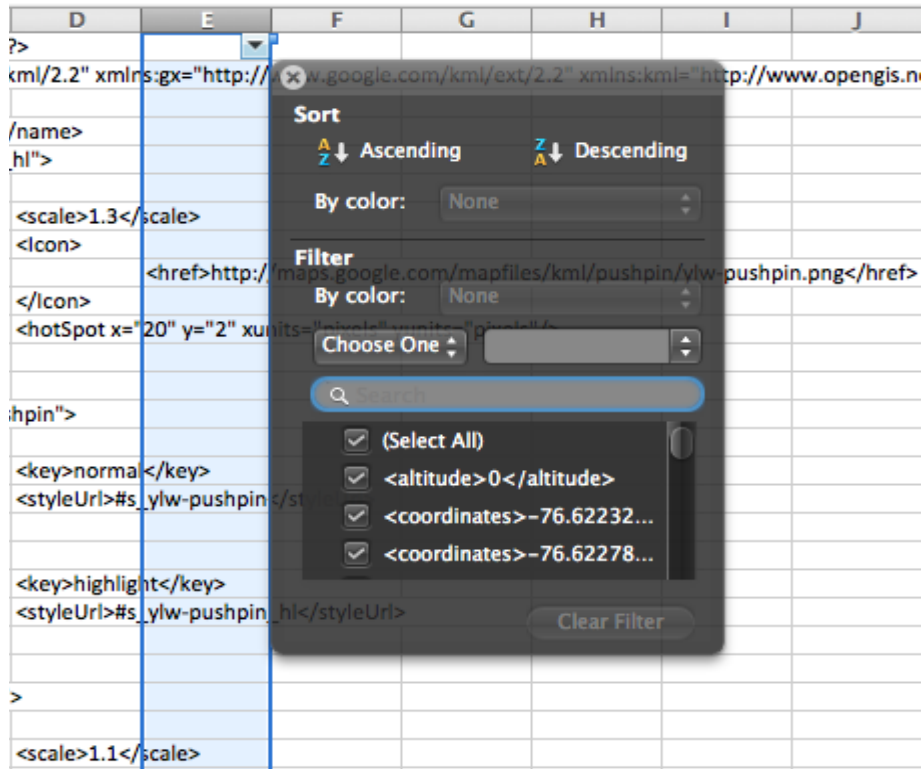
24. Select all of column E.



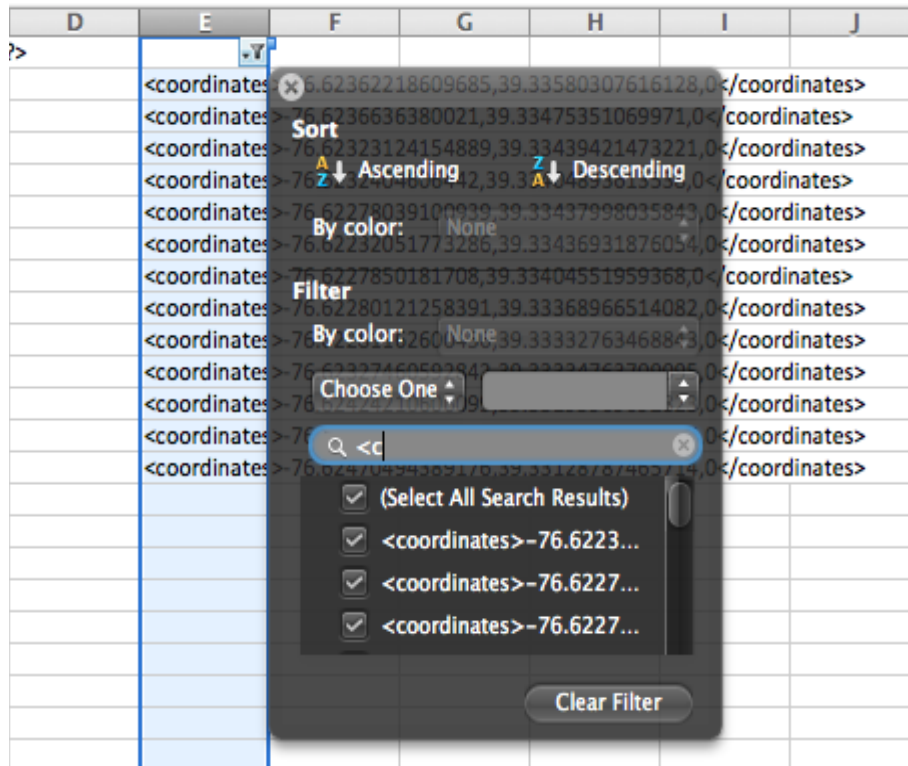
25. In Excel's menu bar, click [Data]->[Filter].



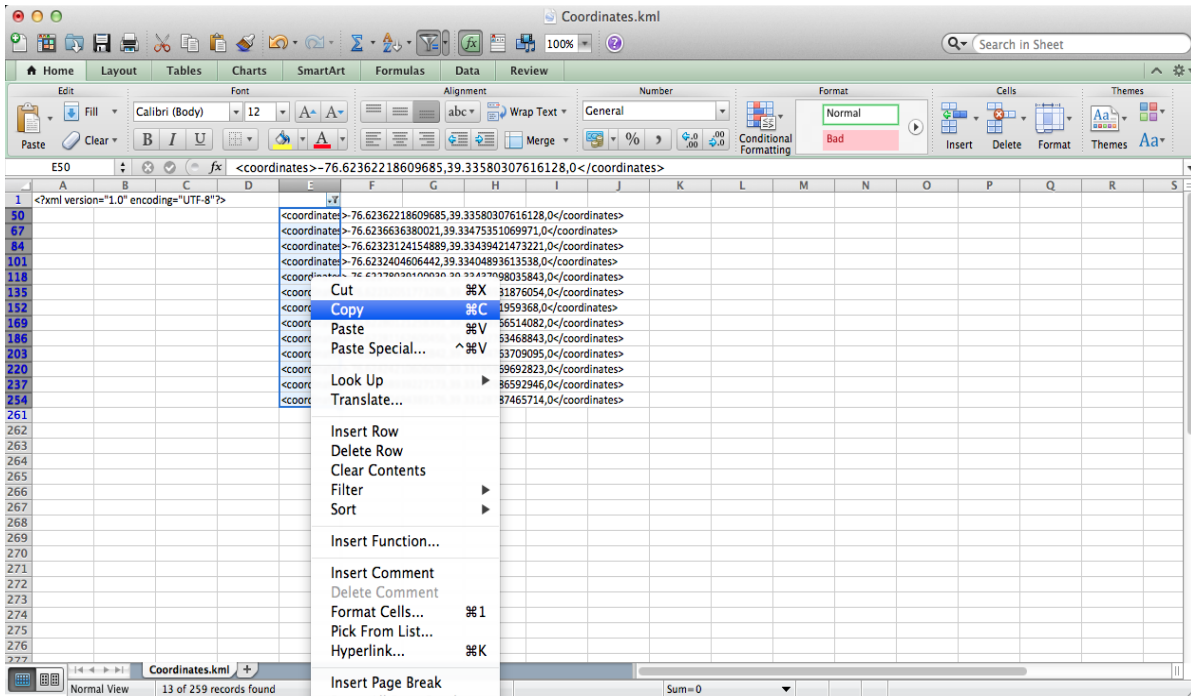
26. Click the arrow under column E.



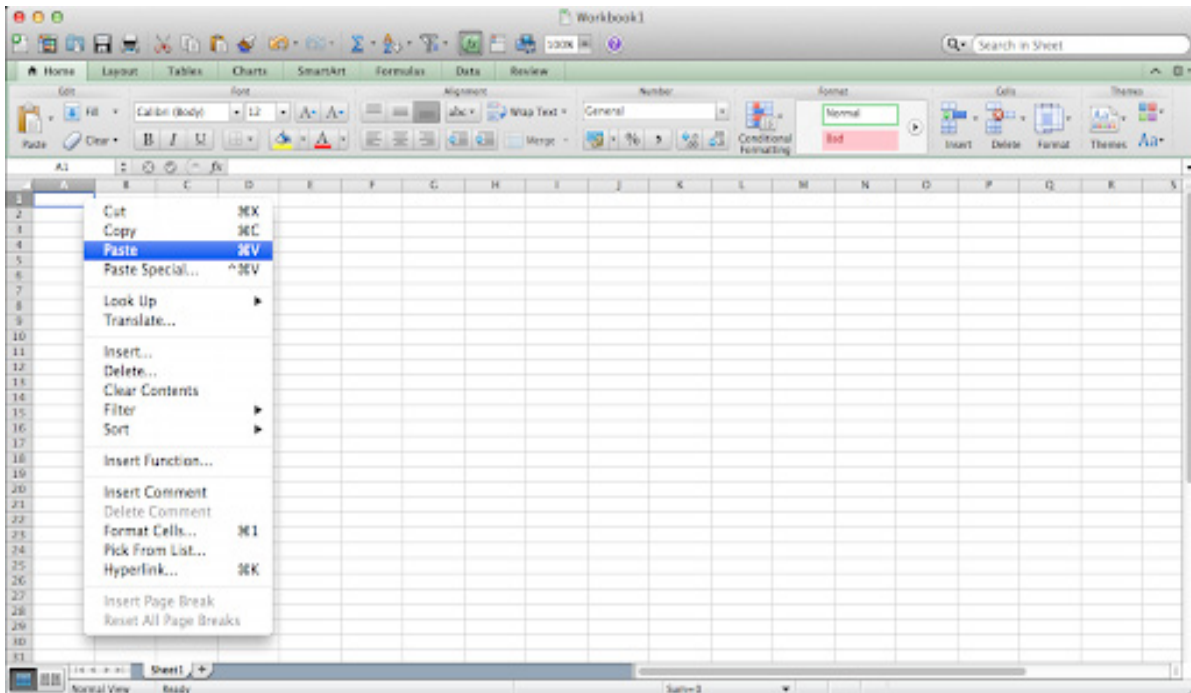
27. In the search bar, type "<c".



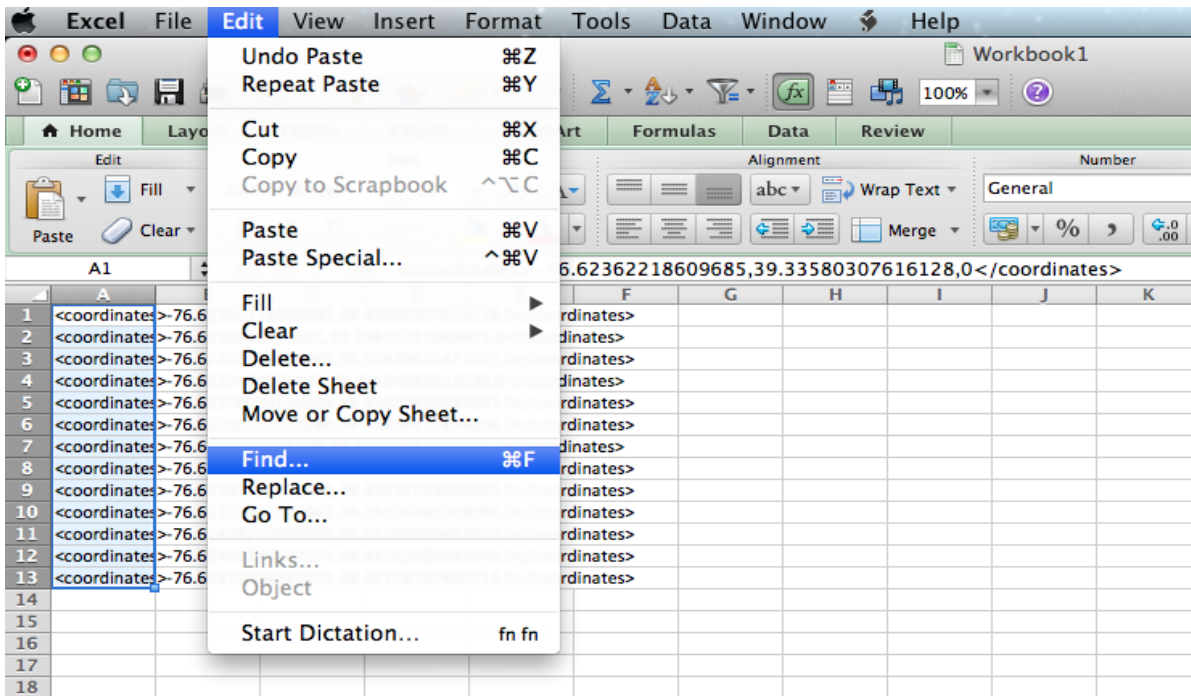
28. Click the “x” to exit the filter. Select the remaining cells and copy them.



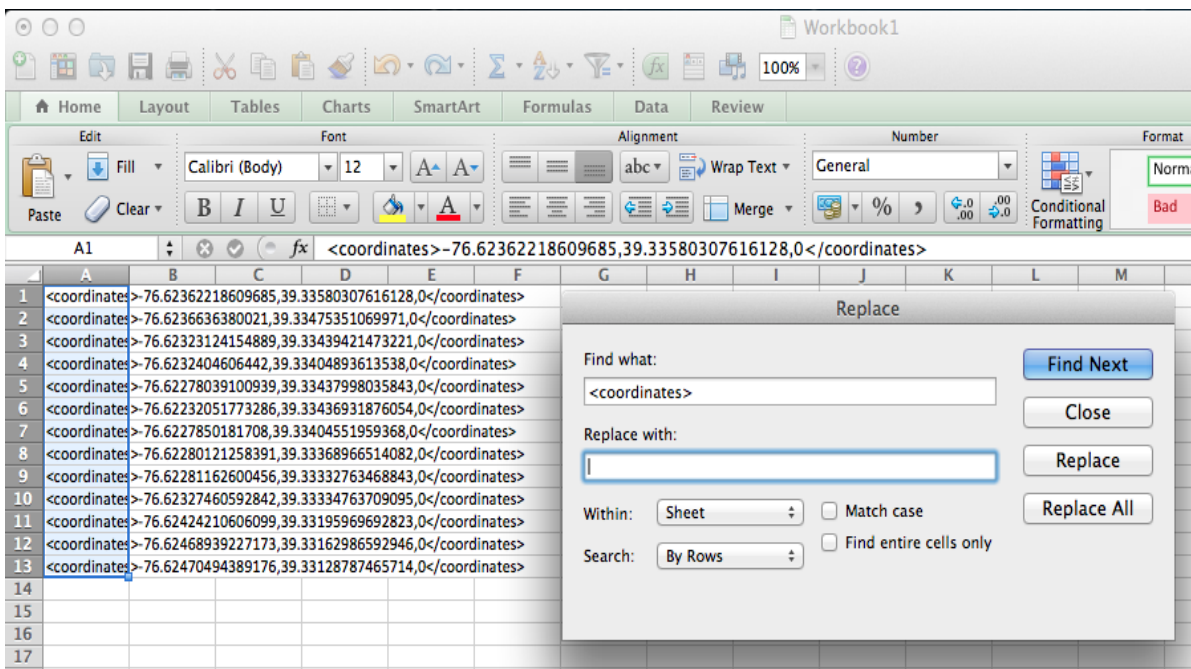
29. Open a new workbook in Excel. Paste the cells into this workbook.



30. In Excel's menu bar, click [Edit]->[Find...].

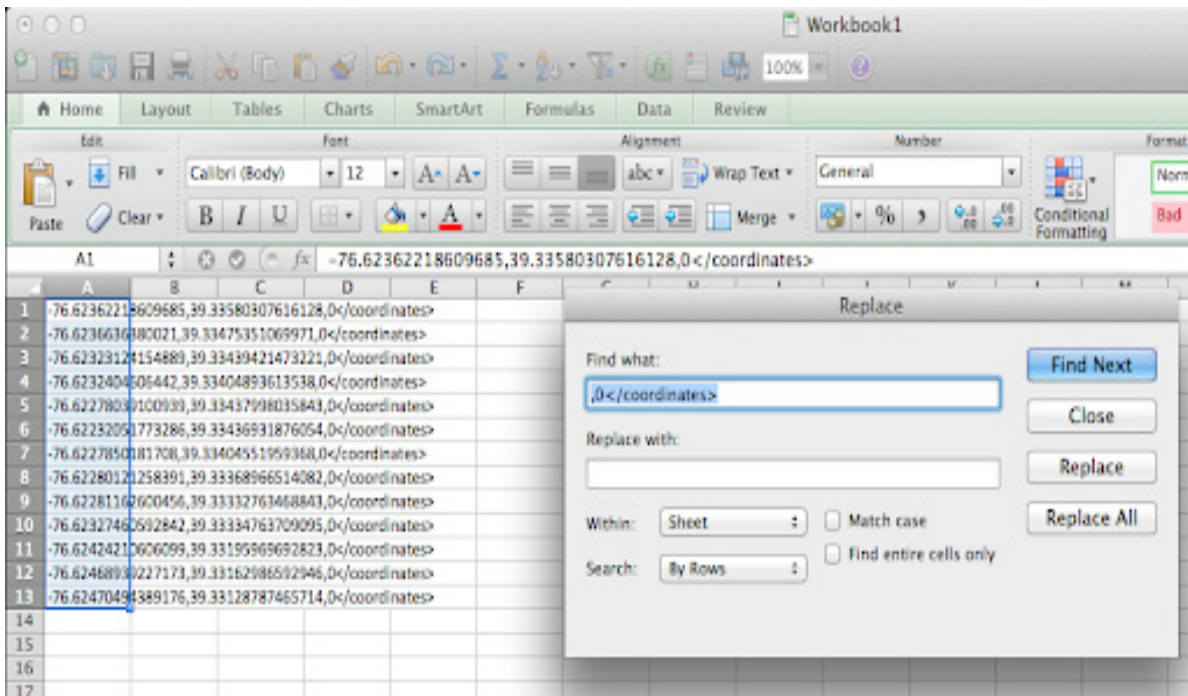


31. In "Find what:" type "<coordinates>". Click [Replace]. Leave "Replace with:" blank. Click [Replace All].

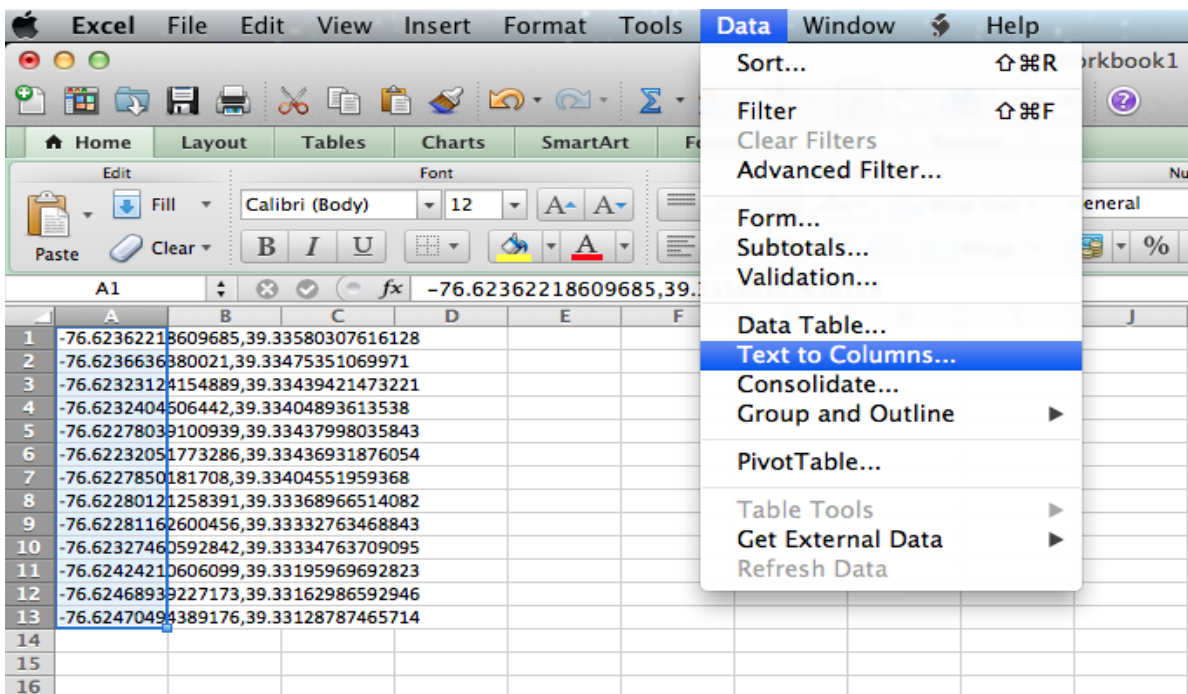




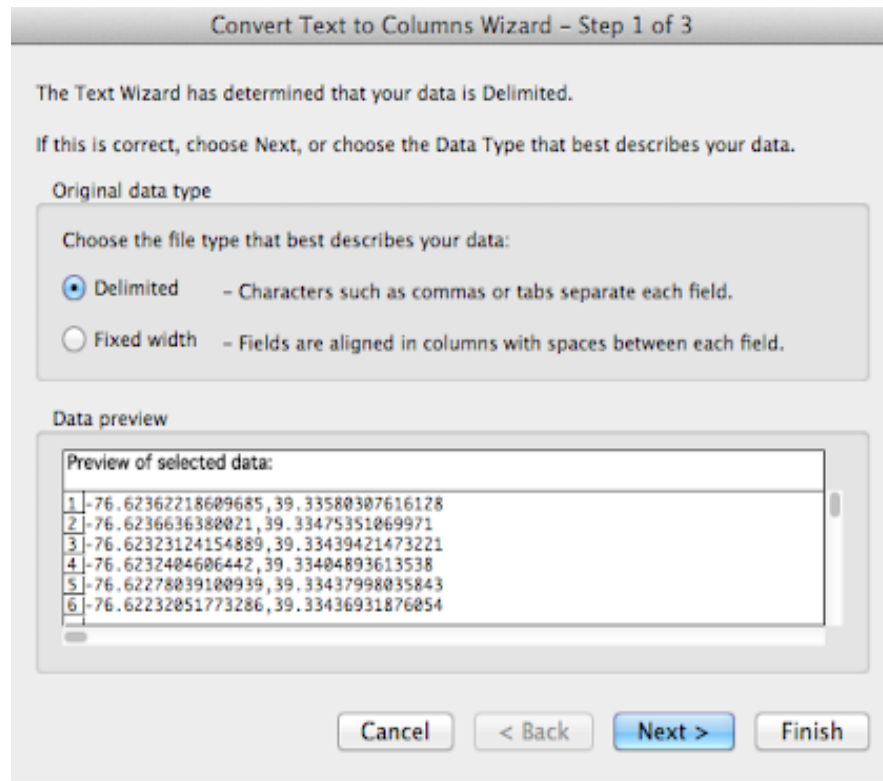
32. In “Find what:” change “<coordinates>” to “,o</coordinates>”. Click [Replace All]. Click [Close].



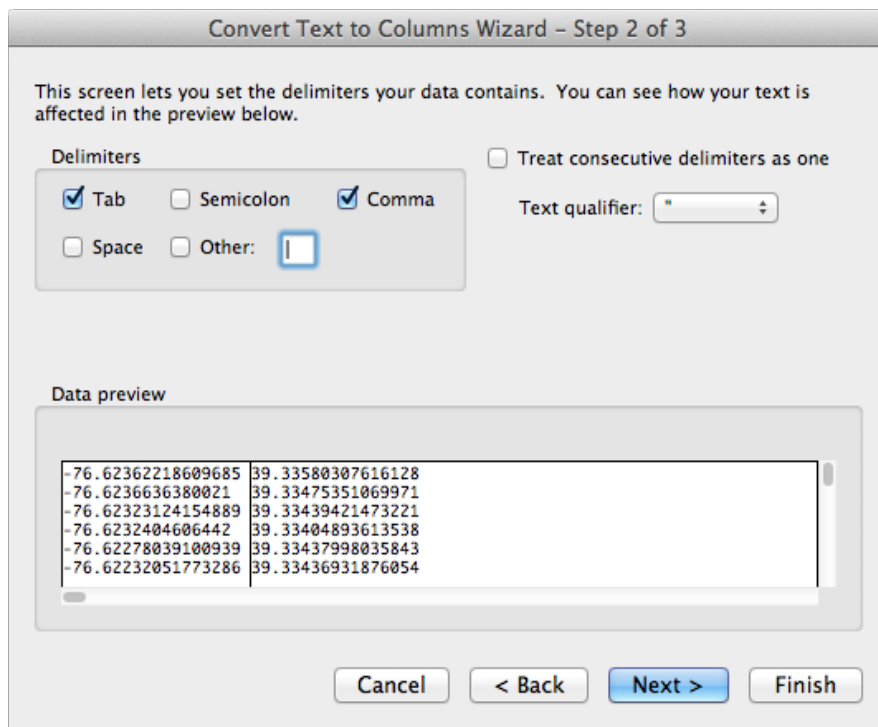
33. In Excel’s menu bar, click [Data]->[Text to Columns...].



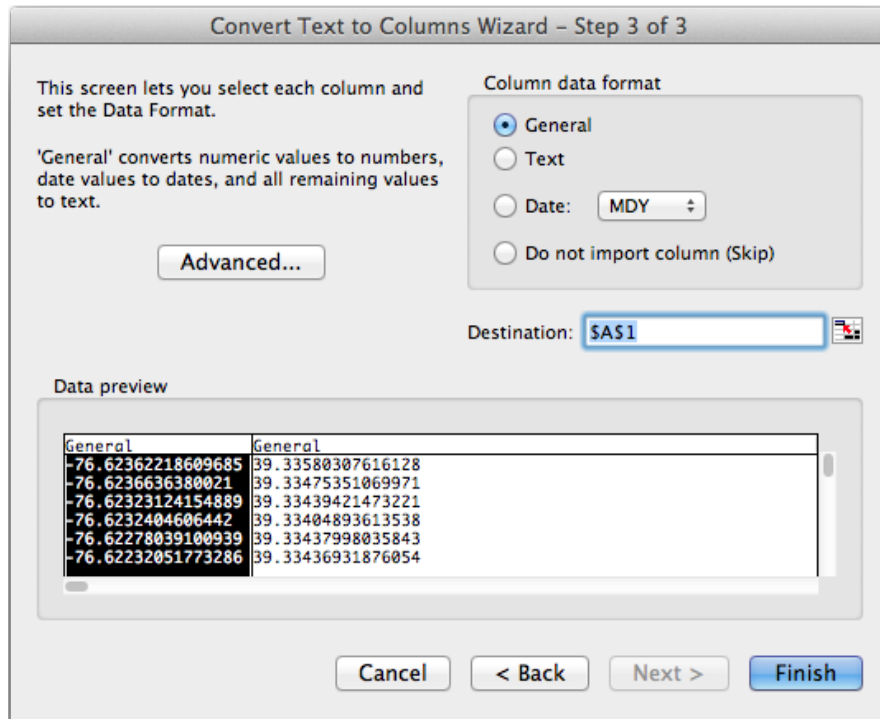
34. Select "Delimited". Click [Next >].



35. Select "Comma". Click [Next >].



36. Click [Finish].



37. Save the file. Now we have our GPS coordinates stored neatly into an Excel file. The left column is the longitude and the right column is the latitude.

	A	B	C
1	-76.623622	39.3358031	
2	-76.623664	39.3347535	
3	-76.623231	39.3343942	
4	-76.62324	39.3340489	
5	-76.62278	39.33438	
6	-76.622321	39.3343693	
7	-76.622785	39.3340455	
8	-76.622801	39.3336897	
9	-76.622812	39.3333276	
10	-76.623275	39.3333476	
11	-76.624242	39.3319597	
12	-76.624689	39.3316299	
13	-76.624705	39.3312879	
14			
15			
16			
17			



## Field Supplies

In order to collect data in the forest patch, you will need a number of field supplies. The Field Supply List is available in Appendix B. We recommend that you print out this list prior to conducting field work.

Before beginning field work, tally the total number of points in the urban forest patch that will be sampled. For each point you will need one sleeve, two caps, and a plastic bag to collect the bulk density soil sample. (Do not use the clear plastic sleeves, only use metal sleeves.) If applicable, contact your partner soil scientist with the number of these items needed for all measurements.

Here is a breakdown of some of the field supplies, and what they will be used for.

- **Quadrat frame:** This is a 1 meter by 1 meter frame used as the boundary of a sample site. These are easily constructed from PVC pipes.



*UMBC Summer Forest Patch interns hold a quadrat frame at a forest patch sample site.*

- **10 BAF prism:** 10 BAF stands for Basal Area Factor (in this case, this is measured by a factor of 10). The basal area is the cross section of a tree at breast height, i.e., 4.5 ft. The prism is used to determine whether the tree should be counted in the sample. The tree is included, and should be counted, if the offset tree stem viewed through the prism at breast height has some overlap with the tree stem outside of the prism. (See “Canopy” section on page 34.)
- **Munsell Soil Color Book:** This is a book containing the hue, value, and chroma of every shade of color. The sampled soil is compared to this book to find the exact color match. Soil color can indicate what the soil is made of.



*One chart from the Munsell Soil Color Book.*

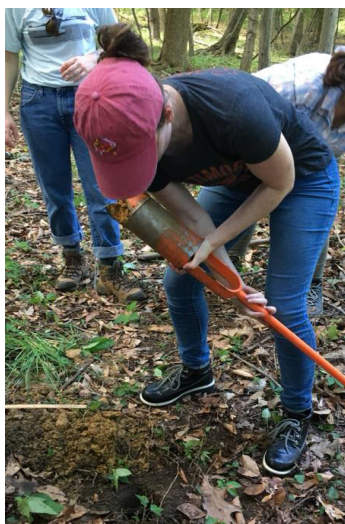
- **Soil Texture Flow Chart** (Appendix G): This flow chart has questions about the soil texture that will lead you to determine which type of soil is being sampled.
- **Percent Cover Diagram** (Appendix E): This sheet is helpful for determining the proportion of each groundcover species present in the quadrat.
- **Schumacher Vine Invasion Scale** (Appendix F): This scale is used to determine the severity of vine growth on trees.

- **Soil punch:** This hollow metal cylinder goes 20 cm into the ground to obtain a soil core sample. This will show the depth of the O and A layers in the soil.
- **Bulk density core:** This measures the mass of soil in a given volume (the cylinder). Bulk density is the mass divided by the volume. This measurement is expected to increase as soil becomes more compacted, but it also depends on soil texture and rooting density, as well as past disturbance. Compacted soils do not absorb or store water well, nor do they allow for aeration of plant roots.
- **Bulk density liner or sleeve:** This stainless steel ring or cylinder holds the soil core until analysis.
- **Bulk density caps:** These are caps that go on either side of the bulk density core sleeve to keep the sample properly stored until brought to the lab for analysis.
- **Ziploc sandwich bags:** These are for holding soil cores, sleeves, and caps.
- **Tecnu:** This over-the-counter soap is designed for cleaning and treating skin exposed to poison ivy, poison oak, and poison sumac. It can also be used to clean tools and clothing contaminated with poison oils. Isopropyl rubbing alcohol and Dawn dishwashing detergent are also effective for this. The oils of poison ivy should be removed within 10-20 min to avoid risk of skin absorption.
- **Squirt bottle with water:** This is used to wet a ball of soil to determine its texture.



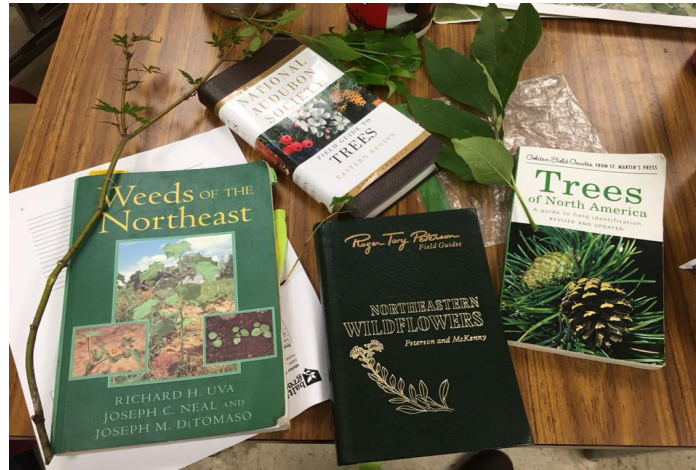
*UMBC Summer Forest Patch interns Caitlin Beckjord and Jennifer Strakna use squirt bottle to find soil texture.*

- **Auger:** This hollow metal cylinder and drill is used to drill down in the soil to collect a soil profile. Depth, soil texture, and soil color are determined for each soil layer within the auger.



*UMBC Summer Forest Patch intern Laura Wortman holds an auger.*

- **Tree ID guide:** A guide for identifying native and invasive trees/herbs in the urban forest patch. Here are some free online resources:
  - [iNaturalist](#) is an app that uses image identification and crowdsourcing to help identify plants in photos that you upload.
  - Resources for plant identification in Maryland:
    - [Maryland Tree Guide: Common Broadleaf](#) (PDF)
    - [Common Invasive Plants in Maryland](#) (PDF)
    - Towson University [Maryland Trees Collection](#)



*Tree identification guides used in the field.*

- **Penetrometer:** This is a metal pogo-stick-looking device that provides a relative measure of soil compaction for a given soil and for given previous weather conditions. This may be dependent on individual users too, so try to be consistent.

Not all of the supplies are affordable or easy to find at home. There are several avenues for accessing equipment to explore. For example, a nearby college or university may work with you to provide access to lab equipment for field work purposes. Local community networks including green teams, tree keepers, forest stewards and other local green-focused networks may also be interested in partnering with you. Forestry suppliers sell many of these materials retail.

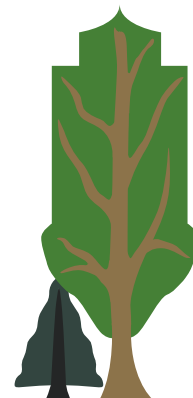


## Making Safety a Priority

Working with nature brings a certain amount of risk. You can minimize this risk in a number of ways. **Be prepared and bring a first aid kit!** To avoid rashes and stings, make sure you can identify the harmful plants and insects in your area, which may include poison ivy, stinging nettle, bees, and wasps. Anyone with serious allergies should bring their EpiPen.

### Tips for prevention

- Learn what poison ivy, poison oak, or poison sumac look like. The best way to prevent skin reactions is to avoid contact altogether.
- Clean garden tools and gloves immediately after use, as recommended in the section “Cleaning and Storing Tools”. Poisonous oils can linger on clothes and tools after contact, but regularly cleaning should eliminate remaining oils.
- Wear long sleeves, long pants tucked into boots, and thick non-penetrable gloves when working in areas with poisonous plants, thorny plants, and biting/stinging insects. Wash skin thoroughly with soap and water (or other oil removing substance) if contact is made with the poisonous plants. The sooner the skin is washed after exposure, the less likely a rash will occur.
- Be aware of ticks, and be prepared to check yourself for ticks after you have worked in the field. The blacklegged “deer” tick is common on the East Coast and the upper Midwest, and they can carry diseases, including Lyme disease. It is good practice to bring a pair of tweezers and a magnifying glass. The best way to remove a tick from the body is to flip the tick on its back, grab its head and mouth parts with the tweezers, and yank it away from the skin. Save the tick, put it in a ziploc bag, label it with the date and time the tick was removed, and store it in a freezer in case you need it later to help identify diseases.
- During summer sampling, watch out for heat exhaustion and heat stroke—this is especially important early in the season when the body is adjusting to heat after the cool spring. Signs of heat exhaustion include sweating, clammy skin, fast and weak pulse, nausea or vomiting, muscle cramps, tiredness or weakness, dizziness, headache, and fainting. In the event of heat exhaustion, you need to move to a cooler place, drink water, and get medical help immediately if your symptoms persist for over an hour. Signs of heat stroke include hot, red, dry, or damp skin, fast and strong pulse, headache, dizziness, nausea, confusion, and losing consciousness. A heat stroke is a medical emergency, and you need to call 911 immediately. While waiting for medical assistance, you should move to a cooler place, use cool cloths to lower the person’s body temperature, and do not give the person anything to drink. For more information, please visit [Warning Signs and Symptoms of Heat-Related Illness](#).





# WORKING IN THE FIELD

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**Now that you have gathered your tools and selected a forest patch to survey, it's time to get out in the field and put those tools to use collecting data. This section covers how to navigate to your GPS point and how to get data about soil, groundcover, tree canopy, and more at your forest patch. Make sure you have the following ready before you begin:**

- Supplies from Field Supplies List
- Printed Data Sheets
- Permission to be on land
- GPS coordinates of sampling locations

## Locating GPS Points in the Field

In the “Mapping GPS Coordinates of Forest Patches” section, you found the GPS coordinates of the forest patches you want to sample. The following instructions tell how to find the selected GPS point using a Trimble GPS. (Other units may have different instructions.)

1. Turn on Trimble GPS.
2. Use the stylus to navigate the touchscreen. Click on the Windows key at the bottom left corner of the screen. Select the “TerraSync” icon. The TerraSync program will open to the Status page.

### Enter location points into TerraSync (GPS)

Note: Many GPS units will not always work well under heavy canopy. In these cases it is possible to obtain coordinates for a nearby point outside the canopy, and then use a compass and field tape to navigate to points within the forest.

1. Open the top scroll tab in the upper left corner of the screen. The tab will say “Status”.
2. Select “Navigation”.
3. Open the second scroll tab labelled “Navigate.” Select “Waypoints”.
4. To make a new file, select “New” at the bottom of the screen.
5. Use the keypad icon located in the bottom center of the screen and enter in “File name” for the list of coordinates. Select “Done”. An empty screen will appear.
6. Open the “Options” tab in the upper right corner of the screen. Select “New”.
7. Use the keypad to enter the name of the point.
8. Enter the Latitude for a single point.
9. Enter the Longitude for a single point.
10. Enter “0” for the altitude.
11. Select “Done”.
12. Complete steps (6)-(11) to enter more points.

## Edit a point

1. Click the point to highlight.
2. Open the “Options” tab. Select “Edit”. Change information.
3. Select “Done”.

## Start navigation to a point

1. Find North on your compass to orient yourself. (The top of the GPS is “north.”)
2. With the top scroll bar set to “Nav,” select “Waypoints” from the other scroll tab. Turn on the sound by clicking the speaker icon at the top of the screen. The GPS will beep when you are close to the set point.
3. Click to highlight the name for the selected list of coordinates. Select “open” to view the list of coordinates.
4. Click to highlight the navigation point. Select “Set Nav Target” from the options scroll tab.
5. To begin navigation to a selected point, open the scroll tab that says “Waypoints” and select “Navigate”. (On this screen, the rotating arrow points to the direction of the target point.)
6. To view the points and your location relative to those points, select “Map” from the top “Nav” tab.
7. Begin walking to the point. (Note that the GPS has trouble finding your position relative to the set point when you are standing still and turning the GPS. If you are having trouble locating the point when you think you are close to it, zoom in on the map and continue to walk in the direction of the point.)

## Collecting Data

As you collect data, you will record your measurements in the Sample Data Sheet (Appendix C).

### Lay the quadrat and take a photograph

1. Once you reach the selected GPS location, spin around and put the quadrat frame down in a random direction.
2. Take a photograph of the ground in the quadrat as a record with an index card in the image that contains the point number and site ID number/name.



*A quadrat in Fairwood Forest, Baltimore, sampled in 2016.*

## Herbaceous/shrub layer

1. Record the percentage of bare ground, leaf litter, and vegetation within the quadrat.
2. Identify the plant species within the quadrat and record on the Data Sheet.
3. Estimate the proportion of the area within the quadrat that each plant species covers. The Percent Cover Diagram (Appendix E) is useful for this.
4. Note which of the species are invasive to your area.

## Penetrometer

The same person should do the penetrometer reading at the very least across the site but ideally across all sites. This is because it has so much to do with pressure. Much about the reliability of penetrometer measurements depends on both who is taking the readings and the state of the soil that day (e.g., wet, dry, etc).

1. Set up the penetrometer. (Use the larger tip for soft soils and the smaller tip for hard soils.)
2. Push the penetrometer tip 2-5 cm straight down into the soil as you pay attention to the gauge.
3. Take 5 readings: one at each corner of the quadrat and one in the center.
4. Record readings in Data Sheet.



*Alyssa Wellman Houde uses a penetrometer during the Summer Patch Sampling Project in 2016.*



## **Bulk density**

A bulk density core is taken at each sample point and saved for later analysis.

1. Set up the soil hammer with two bulk density sleeves (cylinders) stacked one on top of the other.
2. Place the soil hammer on the surface of the soil.
3. Hammer in the length of the sampler and then carefully remove it from the hole.
4. Cap the bottom cylinder and place it into a plastic bag to save it for lab work.

Bulk density, soil texture, and organic matter content will be determined later during lab work. (See the “Conducting Soil Analysis” section.)

## **Soil punch**

A soil punch (20 cm deep) is pulled at each sample point to get an idea of how deep the O and A horizons are and to evaluate the texture of the soil at the bottom of the soil punch.

1. Place the soil punch on the surface of the soil and push it down.
2. Pull the soil punch back up.
3. Measure the depths of O and A horizons from the surface.
4. Take a field textural analysis of the soil at the bottom of the punch following the Soil Texture Flow Chart (Appendix G).

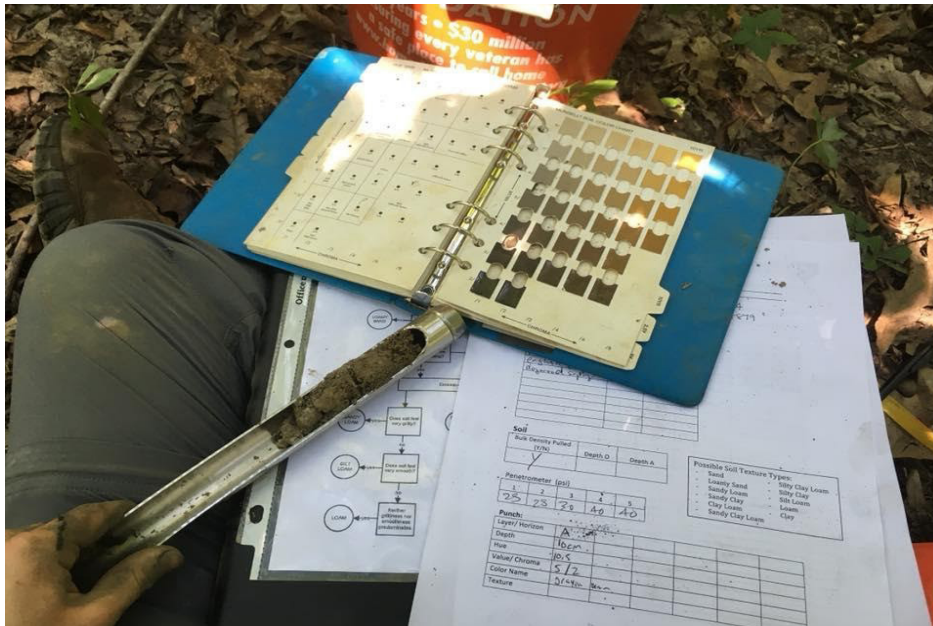


*Soil punch used at a forest patch sample site has O and A horizons marked by sticks.*

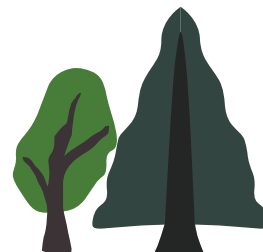
## Soil color

Determine soil color of the layers you identify in the soil punch. Perform the following steps using soil from each layer:

1. Take a small amount of soil (approximately 10 g, or about a tablespoon). Moisten the soil with tap water, allowing it to soak in. (It is easier to use an intact ball of soil, but loose soil works as well.)
2. Hold the moistened sample behind the frames of the Munsell soil color chart. Maryland soils are typically on the 7.5YR or 10YR charts.
3. Move the soil between frames to determine the closest match.
  - a. Use the masks included (probably found in the back of the binder) with the guide to more easily facilitate color matching. It is unlikely that you will obtain an exact match.
  - b. It can be helpful to unfocus your eyes so you see larger splotches of color rather than the small differences.



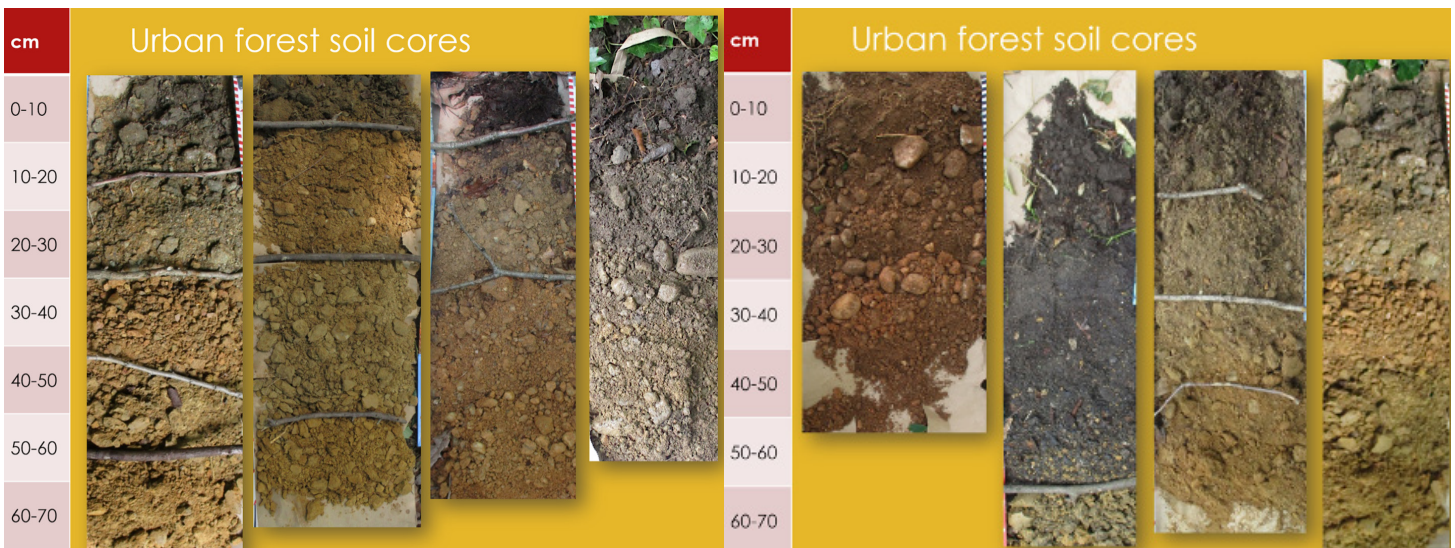
*Comparing a soil core to a Munsell soil color chart.*



## Auger

At least one soil auger must be pulled at the site. If the topography changes over the site (high and low areas or slopes), pull an auger in each location. For example, if there is a sloping region in the forest patch, pull an auger at the high region, on the slope, and at the low region. Depth and soil color are determined for each layer within the auger.

1. Drill down into the soil until the bucket is filled.
2. Remove the bucket and invert on a tarp or clear patch of ground, being careful to keep the approximate shape and location of the excavation relative to the surface.
3. Repeat steps 1-2 until you reach a depth in the soil where it is too rocky to continue drilling, or you reach a depth of 6ft, whichever happens first.
4. Identify the approximate depth at which the color or texture of soil changes. These different colors and textures are the soil layers.
5. Measure how far down from the surface these color changes occur.
6. Compare the soil with the charts in the Munsell Soil Color Book to determine hue, value, and chroma of each layer:
  - Hue: Red, green, and blue are examples of a hue. In this book, hues are identified by color code (ie. red = R).
  - Value: How light or dark the color is. The lower the value, the darker the color.
  - Chroma: How weak or strong a color is. The higher the value, the more vibrant the color is.
7. Take a photograph of the soil profile as a record.



*In these urban forest soil cores, you can see the color and textural changes, marked with sticks in some examples.*

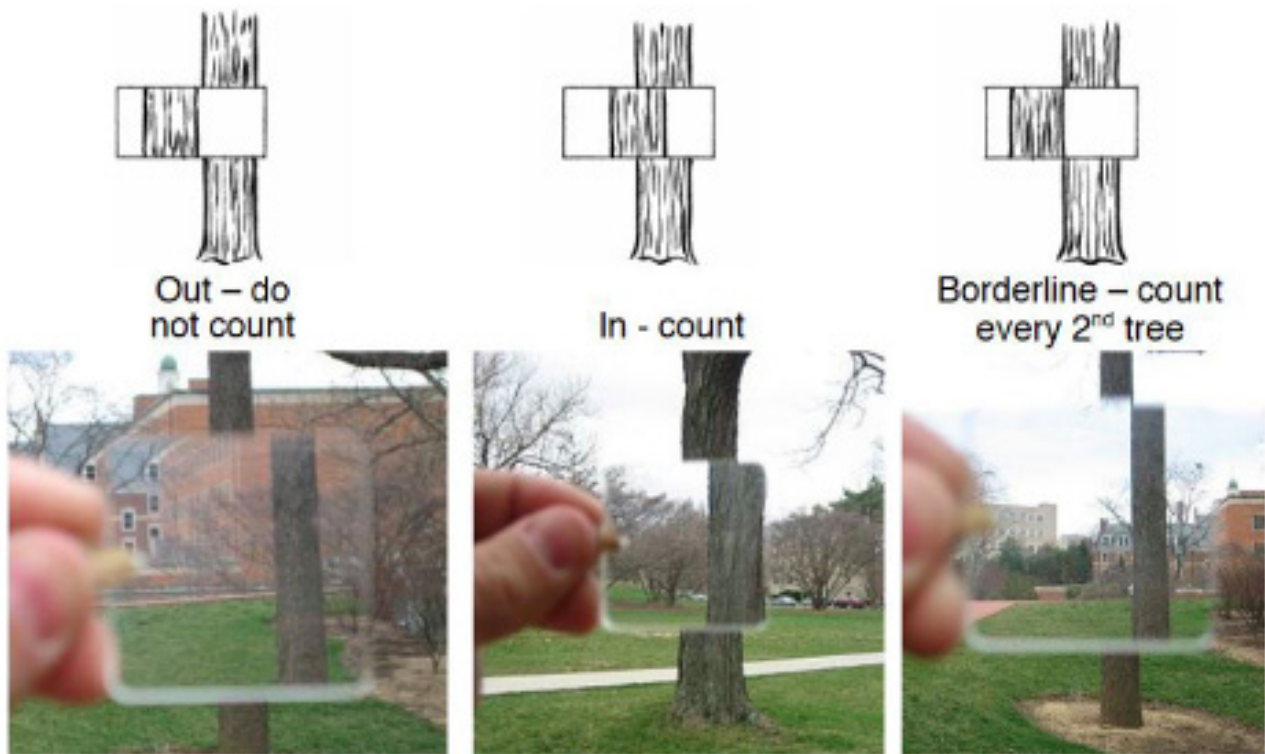




## Canopy

Use a 10 BAF prism to determine which trees are inside the plot and large enough to count, and identify those trees.

1. Hold the prism at the sampling point, close one eye, and look through the prism so that the top of the prism divides a tree at breast height (4.5 ft above ground). The prism will refract the image of the tree. If there is overlap between the tree and its appearance through the prism, it is counted. If there is no overlap, the tree is not counted. If just the edges of the tree and its image through the prism touch, it is a borderline tree, and every other borderline tree is counted.
2. Note what species the tree is in the Data Sheet.
3. Refer to the Schumacher Vine Invasion Scale (Appendix F) to rate how overgrown vines are on the tree and record in the Data Sheet.
4. Keeping the prism over the sampling point, turn in a circle to look at each tree around you and determine if it should be counted. Repeat steps 2-3 for each tree.



## Additional notes

1. Take note of any evidence that the forest patch is being used by people.
2. Record anything else notable about the forest patch.

# AFTER FIELD WORK

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This section discusses the process of properly managing equipment and analyzing soil cores.

## Cleaning and Storing Tools

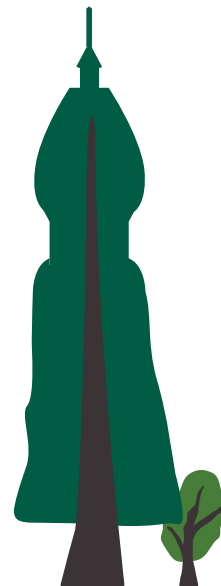
Protecting and managing tools is essential to maintain your equipment over the years. It also keeps from spreading possible contaminants to other users. Proper maintenance should be done in the following ways:

1. Wipe down tools with alcohol to remove poison ivy oils before putting them in vehicles.
2. For metal tools used in soil, wash after use with a water hose. Use a hard-bristle brush for tougher soils (e.g., clay) to prevent damage and paint thinner to remove sap from sticky plants.
3. Wipe tools or spray with a light coat of motor oil to prevent rusting. If the tools already have severe rusting, use sandpaper or hard-bristle brush to remove it.
4. Sharpen tools at the end of the season, although regularly would be best to keep the tools fully functional.
5. Once tools are clean and sharp, store them in a closet, garage, shed, or shipping container. Keep tools off the ground to prevent moisture, rust, and dulling.<sup>12</sup>

## Storing Soil Samples

Samples should be stored in plastic or metal containers and transferred to a lab to be stored in a cool and dry place, commonly refrigerated.

**Warning:** Sample containers that may have high concentrations of contaminants must be stored separately.



## Conducting Soil Analysis

After gathering the soil samples in the field, the next step is to analyze the soil composition. This protocol will provide instructions on how to prepare the sample for analysis, measure bulk density, and assess soil type.

### Materials

- Bulk Density
  - Bulk density cores with soil samples
  - Aluminum trays
  - Drying oven
  - Small serrated knife or saw blade
  - Calipers
  - Scale (to 100th place)
  - Tin foil
  - 2mm soil sieve
- Organic Matter
  - Crucibles
  - Kimwipes
  - Analytical balance
  - Spoon or scoopula
  - Furnace
  - Dessicator
  - Forceps
- Safety gear (e.g., heat-resistant gloves, goggles, latex or nitrile gloves, lab coat or apron)
- Permanent marker



*Equipment in Dr. Katalin Szlavecz's soil lab at the Johns Hopkins University Homewood Campus. The furnace is the white door below the fume hood in the background. The drying oven is the large gray box in the foreground.*



## Before you start

Safety gear is not required for most analyses—except for removing hot samples from the furnace or oven—so wear clothes that you don't mind getting dirty. Latex or nitrile gloves and a lab coat or apron provide an extra layer of protection if you think you need it. You are working with soil samples, so be prepared to get dirty!

Before testing the soil samples, make sure your workspace is clean and organized. Keep soil samples separate from each other (in capped bulk density cores, plastic bags, etc.) and have all materials and tools easily accessible. The following are some tips that might be helpful during analysis:

- **Place a sheet of aluminum foil on the lab bench** to catch any loose pieces of soil that can fall when removing samples from bulk density cores, plastic bags, etc. The samples can easily be transferred from the foil to an aluminum tray or other storage location.
- **Label everything.** It can be incredibly difficult or impossible to distinguish unlabeled samples. Consequently, samples should be labeled when collected. If they were not, use a system that allows you to distinguish between sites and samples within each site (e.g., “MD4” for Maryland School for the Blind, collection point 4). Label any trays used to transfer or store samples. Be consistent and clear in your labeling system. It's helpful to keep a master list of sample IDs to avoid repetition.
- **Stay organized.** There's no set way to keep your workspace organized, so arrange everything in a way that makes sense to you. It can be helpful to set up everything in a line along a long lab bench or at different stations at smaller tables.
- **Use a tray to carry samples.** When working with multiple samples, always use a tray to transfer them between the lab bench and the oven, etc.
- **Clean as you go.** If you spill some soil on the lab bench, make note of the spill and then collect as much as you can and return it to the sample. Clean the rest up to avoid mixing with other samples.

## Bulk density

1. **Dry the cores** by preheating an oven to 105 °C and place the samples on aluminum trays into the oven once it has reached temperature until samples are dry. If the cores are still in the metal cylinders, place the cylinders into the aluminum trays as well. Each core should have its own tray, clearly labeled using a sharpie.
  - a. Carefully remove the plastic caps on each end of the cylinder before placing cylinders in trays. Do this slowly because it's easy to spray soil everywhere if you try to remove the caps too quickly. It can be helpful to use a thin metal spatula to loosen the seal of the plastic caps.
  - b. Be sure to scrape any soil sticking to the caps into the aluminum trays.
  - c. It's okay if the sample isn't entirely in the cylinder. There can be loose soil in the tray.
  - d. If the soil isn't contained by a metal cylinder but is in a cylindrical clump, try to preserve its form as well as possible.
2. **Measure volume** of bulk density core samples.
  - a. If the core is still in a metal cylinder, saw off the ends of the sample that protrude from the metal cylinder with the serrated knife or saw to make flush with cylinder rim. Remove from the cylinder. Measure the length and diameter of the core using calipers.
  - b. If the core was not in a metal cylinder, measure length and diameter using calipers unless the sample no longer retains cylindrical shape.
  - c. If the sample no longer resembles a cylinder, simply use the measurements of the metal cylinders used to take the bulk density sample. This will result in an imperfect volume, but it is better than nothing.
  - d. To find the volume, use the following equation:  $Volume = \pi \times (diameter/2)^2 \times length$ . Record this volume.

3. **Measure the mass of the core.** To do so, place a clean aluminum tray on the scale, press tare, place core on tray, and record the mass displayed on the scale.
4. **Calculate the bulk density** of each core by dividing its mass by its volume. Record the bulk density. **Note:** This bulk density calculation does not account for the loss in mass or volume due to the removal of objects during sieving in the next step.
5. Sieve soil to **remove debris greater than 2 mm in size.**
  - a. Place a sheet of aluminum foil under the sieve and then sift the soil through the 2 mm sieve. Be careful while sifting—sharp pieces of broken glass and small stones can be present.
  - b. Wrap the sifted soil, the fine earth fraction, up in the sheet of aluminum foil and set it aside.
6. Place an aluminum tray on the scale, press tare, and **measure the mass of the portion of the sample left in the sieve** (debris larger than 2 mm). Record this mass, place the foil-wrapped fine earth fraction into the tray, and set it aside in case you need to reference it in the future.
7. **Calculate bulk density** of the fine earth fraction.
  - a. First, subtract the mass of the debris (step 6) from the mass of mass of the soil core (step 3) to find the mass of the fine earth fraction.
  - b. To find volume, we first estimate the volume of the removed debris by dividing its mass by  $2.65 \text{ g/cm}^3$ , an estimate of the density of rock. Then, subtract this calculated volume from the volume of the soil core (step 2). That is,
 
$$\text{Volume of fine earth fraction} = \text{volume of core} - \text{mass of debris} / (2.65 \text{ g/cm}^3)$$
  - c. The correct bulk density of the soil is the new mass divided by the new volume.



*A lab bench set up is shown on the right. Each sample from the site is contained in the aluminum foil and trays, and samples are organized numerically. In the foreground, a 2-mm sieve sits on a sheet of aluminum foil. Any materials too large to fit through the sieve are transferred to the aluminum tray for weighing.*



## Texture

Follow the USDA soil texture flow chart (Appendix G). Make sure soil samples have been sieved. (To sieve, follow step 5 in the section on bulk density.)

- 1. Spoon approximately a tablespoon of dry soil into your palm.** Use whatever amount you are comfortable holding in your palm. It may be easier to use more. Experiment with the amount until you find what you like.
- 2. Add water slowly and knead into the soil until the soil is plastic and moldable.** The soil should hold together well and not be crumbly or runny.
- 3. Determine if the soil is sand** using the USDA soil texturing field flow chart. If not, continue.
- 4. Roll the soil into a ball.** Place between thumb and forefinger (as shown in the chart) and squeeze away from you to form a ribbon that has equal thickness and width throughout. Allow the ribbon to dangle over your finger. Keep squeezing until the ribbon breaks from its own weight.
- 5. If the soil does not form a ribbon,** it is loamy sand. If it does, measure the approximate length of the ribbon and continue along the texturing flow chart.
  - If the ribbon is less than 2.5cm (about 1 inch), the soil will be one of the following types: sandy loam, loam, or silt loam.
  - If the ribbon is between 2.5cm and 5.0cm (1-2 inches), the soil will be one of the following types: sandy clay loam, clay loam, or silty clay loam.
  - If the ribbon is longer than 5.0cm (2 inches), the soil will be one of the following types: sandy clay, silty clay, or clay.
- 6. Excessively wet a small pinch of soil** in your palm and mix with the tip of your finger. It should look like very loose mud. Rub the mixture with your forefinger to determine its texture. Follow the texturing flow chart to determine the soil type.

## Organic matter

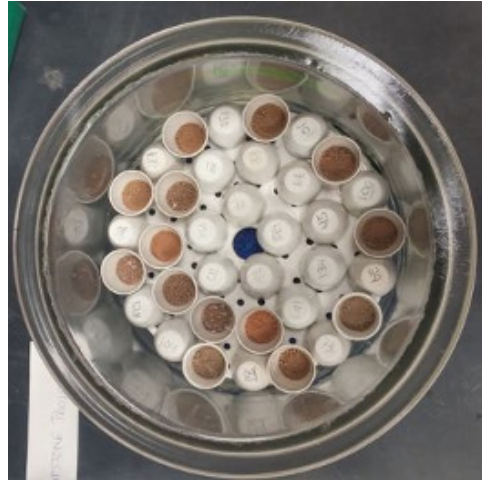
Measure after bulk density and texture.

- 1. Clean crucibles.** Dry using Kimwipes. After washing, wear gloves and avoid touching the crucibles with bare hands. Use forceps to move the crucibles. Fire the crucibles at 450 °C for 4 hours to attain absolute dry weight. Weigh each crucible using the analytical balance and record its ID tag and mass.
- Using a spoon, **weigh 1-4 g of sample in each crucible.** Use 2 replicates for each sample. Record the mass. A replicate is a repetition used to obtain consistent results. In this case, you'll measure the organic matter of each sample twice to make sure the results are accurate.



*Weighing organic matter samples and crucibles in the analytical balance.*

3. Place the crucibles in the furnace. Turn on the furnace and fume hood. When the furnace reaches 450 °C, record the time. **Burn the samples in the furnace for 4 hours.** Turn the furnace off and let it cool.
4. Carefully remove the crucibles from the furnace. Place in a drying oven at 105 °C for several hours. When cool enough to handle, transfer crucibles to desiccation chambers. When the samples reach approximately room temperature, **weigh the crucibles using the analytical balance** and record the combined mass of the crucible and the sample.



*Samples in the desiccation chamber after removal from the drying oven. Empty crucibles are used to prevent filled crucibles from tipping over when the chamber is moved.*

4. **Rinse and dry crucibles** before reusing.
5. **Calculate and record the percent organic matter.**
  - a. Subtract the (crucible + sample after firing) mass from (crucible + sample before firing) mass to obtain the total organic matter burned off.
  - b. Divide this value by the initial mass of the dry sample [(crucible + sample before firing) - (crucible)] to obtain percent soil organic matter.
6. **Calculate and record the coefficient of variation.** This is calculated by dividing the standard deviation ( $\sigma$ ) by the mean ( $\mu$ ).  $\sigma$  can be calculated using the Excel spreadsheet function STDEV or an online calculator.

## Standard Data Entry

It is important to keep track of where and when data were collected. Make sure to save your data in an organized way, such as Excel spreadsheets with dates and sampling locations specified. It is also important to enter species names the same way each time so that you can easily determine how many times you saw a certain plant. The “Tree and Plant Codes” (Appendix D) provides standard codes for species that are found in the Baltimore area.

In general, if Excel or some other spreadsheet is used, there should be a separate sheet for canopy samples, ground cover, and soils. For canopy, each tree should receive a separate row, even trees of the same species, because each will have its own vine invasion score. The point number and the patch number should be in separate columns and be listed for each tree. For ground cover include the patch number, point number, and each species with its fractional cover or construct a site/point (rows) by species (columns) matrix. Sample spreadsheets are in Appendix H.

# GLOSSARY

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**10 BAF (Basal Area Factor) prism:** A wedge shaped prism used to select which trees to count in a sample plot.

**A level horizon:** Also called topsoil, this layer, or horizon, is made up of mostly minerals with some organic material incorporated.

**Auger:** A soil auger is a hand drill with an open center that removes a sample of soil.

**Brownfield:** Defined by the Environmental Protection Agency, “A brownfield is a property where expansion, redevelopment or reuse may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant.”

**Bulk density:** The dry weight of soil per unit volume of soil. Bulk density is commonly used as a proxy for determining the amount of soil compaction.

**Carbon sequestration:** A plant’s ability to store carbon dioxide from the atmosphere back into organic biomass (trees, leaves, branches, roots).

**Community science:** Community-based scientific research; non-professionals work with professional scientists to gather data and may also help analyze it.

**Climate change resilience:** The ability to predict, prepare, and respond to hazardous events linked to climate change such as coastal storms, flooding, and global warming.

**Ecosystem services:** Environmental processes that benefit both humans and the environment hand in hand.

**Impervious surfaces:** A surface that cannot absorb or infiltrate rainwater (ex/: asphalt, buildings, concrete).

**O level horizon:** Layer, or horizon, of soil made up of organic matter; may not be present in all soils.

**Organic matter:** Soil that consists of plant or animal tissue in various stages of breakdown (decomposition).

**Penetrometer:** A device used to measure soil compaction that consists of a long probe, which is pushed into the soil, with a pressure gauge on top.

**Quadrat frame:** A square frame used in biodiversity sampling; it is placed on the ground at a sample site and the organisms within it are counted and identified.

**Soil texture:** The relative content of various sized particles, such as sand, silt, and clay, in the soil.

**Urban heat island effect:** The effect of buildings, roads, and other man-made structures absorbing and emitting the sun’s heat making urban areas more hot compared to rural and suburban areas.

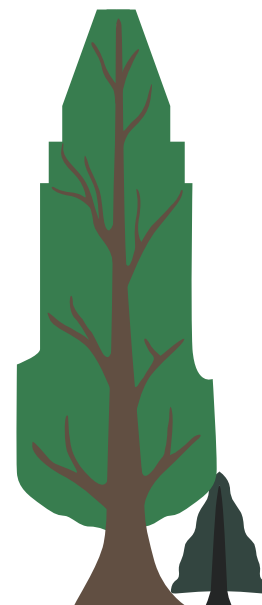


# RESOURCES

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Below are resources mentioned in the manual:

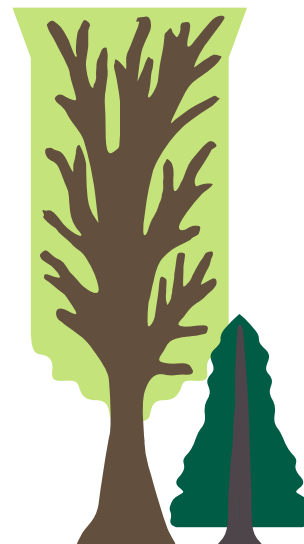
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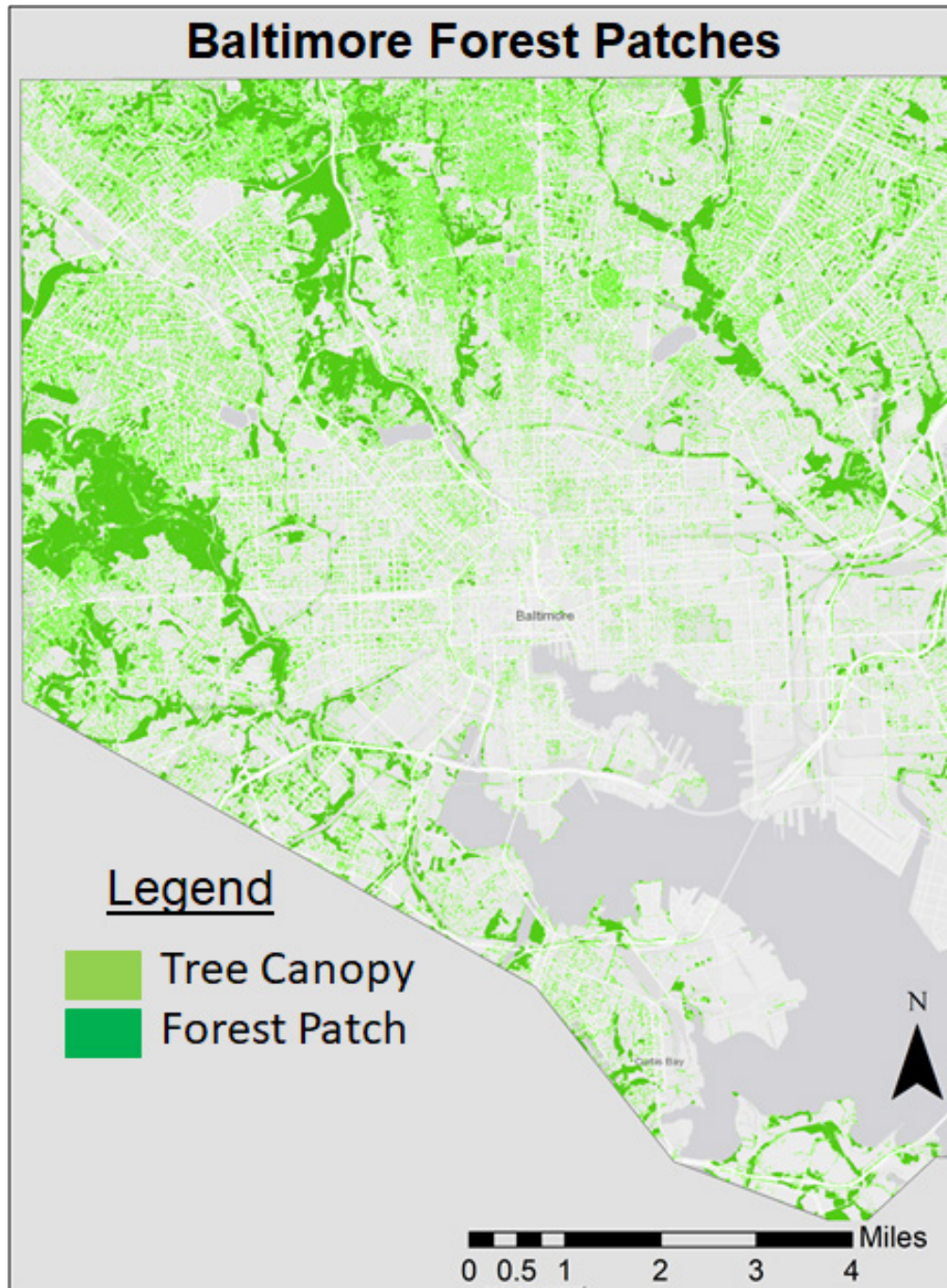


# APPENDICES

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## Appendix A. Baltimore Forest Patch Map



## Appendix B. Field Supply List

- 10 BAF prism
- 1m square quadrat frame
- Auger
- Binoculars
- Bucket
- Bug spray
- Bulk density caps\*
- Bulk density corer (soil hammer)
- Metal bulk density sleeves\*
- Camera
- Clipboard
- Dry bag
- Field sheets
- First aid kit
- Flags
- GPS unit
- Hand sanitizer
- Large knife/ machete/ lawn clippers
- Large paper shopping bags
- Magnifying glass
- Measuring tape (for auger)
- Munsell soil color book
- Nitrile/ latex gloves
- Paper towels
- Pencils
- Penetrometer
- Percent calibration/ cover sheet
- Rubbing alcohol
- Sharpie
- Shumaker scale sheet
- Site coordinates
- Small hand towel
- Soil punch
- Soil texture flow chart
- Squirt bottle with tap water
- Tecnu
- Tree ID guide/ field book
- Tweezers
- Ziploc bags\*

\*Before beginning field work, tally the total number of points that will be sampled. For each point you will need one sleeve, two caps, and a plastic bag to collect the bulk density soil sample. (Do not use the clear plastic sleeves, only use metal sleeves.) Contact a soil scientist with the number of items needed to complete each measure for the field season.

# Appendix C. Sample Data Sheet



### Meter Frame Data Sheet

Date: \_\_\_\_\_

Name Field Tech: \_\_\_\_\_

Point # \_\_\_\_\_

GPS Coordinates: \_\_\_\_\_

#### Herbaceous/Shrub Layer:

Species Name	%Cover	Invasive Y/N

% Cover total: \_\_\_\_\_ (Should add up to 100%)

### Soils

Soil texture:

Bulk Density Pulled (Y/N)	Depth O	Depth A	Munsell Hue	Chroma	Value	Penetrometer psi				
						1	2	3	4	5

Circle One

Sand	Loamy Sand	Sandy Loam	Sandy Clay Loam	Sandy Clay	
Silt Loam	Silty Clay Loam	Silty Clay	Loam	Clay Loam	Clay





**Meter Frame Data Sheet**

Date: \_\_\_\_\_

Name Field Tech: \_\_\_\_\_

Point # \_\_\_\_\_

GPS Coordinates: \_\_\_\_\_

**Tree Canopy Count:**

Enter invasion for each using the Schumacher 0-5 Scale

Species Name	Total Count	1	2	3	4	5	6	7	8	9	10

**Auger**

**Picture Taken** \_\_\_\_\_

	A	B	E	I	C
<b>Depth</b>					
<b>Hue</b>					
<b>Chroma</b>					
<b>Value</b>					

**Human Uses**

- Evidence of public access/use (0 to 4 scale) \_\_\_\_\_
- Evidence of stewardship (0 to 4 scale) \_\_\_\_\_
- Evidence of dumping (0 to 4 scale) \_\_\_\_\_
- Informal Trails (y/n) \_\_\_\_\_
- Encampment / Sleeping Area (y/n) \_\_\_\_\_
- Evidence of adult recreation (needles/condoms/beer cans/undergarments) \_\_\_\_\_
- Informal / Improvised Sitting Places (y/n) \_\_\_\_\_
- Fire Pit (y/n) \_\_\_\_\_
- Memorial / Shrine / Sacred Symbol (y/n) \_\_\_\_\_
- Bird Feeder / Birdbath / Bird Box / Bat box (y/n) \_\_\_\_\_



**Meter Frame Data Sheet**

Date: \_\_\_\_\_

Name Field Tech: \_\_\_\_\_

Point # \_\_\_\_\_

GPS Coordinates: \_\_\_\_\_

Other

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## Appendix D. USDA Tree and Plant Codes

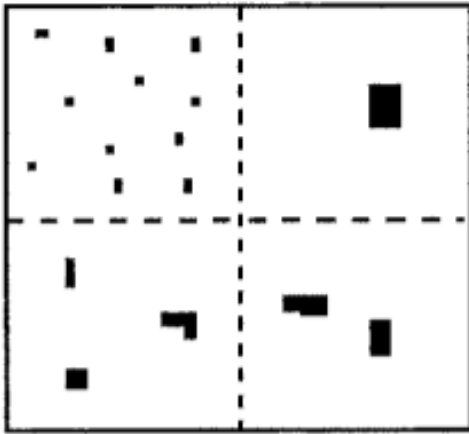
Common name	Scientific name	Code
Box Elder	<i>Acer negundo</i>	ACNE2
Japanese Maple	<i>Acer palmatum</i>	ACPA2
Norway Maple	<i>Acer platanoides</i>	ACPL
Red Maple	<i>Acer rubrum</i>	ACRU
Silver Maple	<i>Acer saccharinum</i>	ACSA2
Sugar Maple	<i>Acer saccharum</i>	ACSA3
Buckeye sp	<i>Aesculus</i>	AESCU
Ailanthus	<i>Ailanthus altissima</i>	AIAL
Silk Tree/Mimosa	<i>Albizia julibrissin</i>	ALJU
Common Serviceberry	<i>Amelanchier aborea</i>	AMAR3
Canadian Serviceberry	<i>Amelanchier canadensis</i>	AMCA4
Pawpaw	<i>Asimina triloba</i>	ASTR
River Birch	<i>Betula nigra</i>	BENI
Paper Mulberry	<i>Broussonetia papyrifera</i>	BRPA4
American Hornbeam	<i>Carpinus caroliniana</i>	CACA18
Bitternut Hickory	<i>Carya cordiformis</i>	CACO15
Pignut Hickory	<i>Carya glabra</i>	CAGL8
Mockernut Hickory	<i>Carya tomentosa</i>	CATO6
Catalpa SP	<i>Catalpa Scop.</i>	CATAL
Common Hackberry	<i>Celtis occidentalis</i>	CEOC
Eastern Redbud	<i>Cercis canadensis</i>	CECA4
Atlantic White Cedar	<i>Chamaecyparis thyoides</i>	CHTH2
Flowering Dogwood	<i>Cornus florida</i>	COFL2
Hawthorn sp	<i>Crataegus</i>	CRATA
Eastern Hayscented Fern	<i>Dennstaedtia punctilobula</i>	DEPU2
Persimmon (common)	<i>Diospyros virginiana</i>	DIVI5
American Beech	<i>Fagus grandifolia</i>	FAGR
White Ash	<i>Fraxinus americana</i>	FRAM2
Green Ash	<i>Fraxinus pennsylvanica</i>	FRPE
Unknown Ash	<i>Fraxinus species</i>	FRAXI
Ginkgo Tree	<i>Ginkgo</i>	GINKG
Honey Locust	<i>Gleditsia triacanthos</i>	GLTR
Kentucky Coffeetree	<i>Gymnocladus dioicus</i>	GYDI
American Holly	<i>Ilex opaca</i>	ILOP
Butternut	<i>Juglans cinerea</i>	JUCI
Black Walnut	<i>Juglans nigra</i>	JUNI
Juniper L.	<i>Juniperus</i>	JUNIP
Sweetgum	<i>Liquidambar styraciflua</i>	LIST2
Tulip Tree	<i>Liriodendron tulipifera</i>	LITU
Osage Orange	<i>Maclura pomifera</i>	MAPO
Cucumber (Magnolia) Tree	<i>Magnolia acuminata</i>	MAAC
Crab Apple (southern)	<i>Malus angustifolia</i>	MAAN3
Mullberry SP	<i>Morus</i>	MORUS



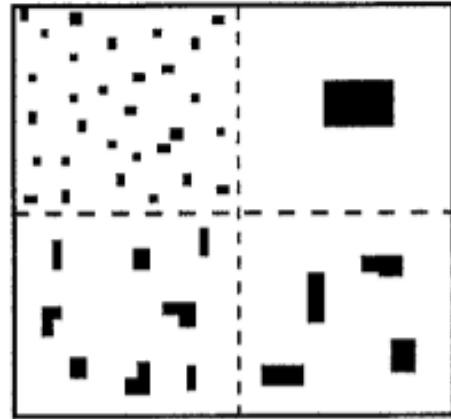
<b>Common name</b>	<b>Scientific name</b>	<b>Code</b>
White Mulberry	<i>Morus alba</i>	MOAL
Red Mulberry	<i>Morus rubra</i>	MORU2
Black Gum	<i>Nyssa sylvatica</i>	NYSY
Paulownia/Princess Tree	<i>Paulownia tomentosa</i>	PATO2
Norway Spruce	<i>Picea abies</i>	PIAB
Pitch Pine	<i>Pinus rigada</i>	PIRI
Eastern White Pine	<i>Pinus strobus</i>	PIST
Virginia Pine	<i>Pinus virginiana</i>	PIVI2
American Sycamore	<i>Platanus occidentalis</i>	PLOC
Eastern Cottonwood	<i>Populus deltoides</i>	PODE3
Sweet Cherry	<i>Prunus avium</i>	PRAV
Black Cherry	<i>Prunus serotina</i>	PRSE2
Callery (Bradford) Pear	<i>Pyrus calleryana</i>	PYCA80
White Oak	<i>Quercus alba</i>	QUAL
Scarlet Oak	<i>Quercus coccinea</i>	QUCO2
Southern Red Oak	<i>Quercus falcata</i>	QUFA
Swamp chestnut Oak	<i>Quercus michauxii</i>	QUMI
Chestnut Oak	<i>Quercus montana</i>	QUMO4
Pin Oak	<i>Quercus palustris</i>	QUPA2
Willow Oak	<i>Quercus phellos</i>	QUPH
Northern Red Oak	<i>Quercus rubra</i>	QURU
Post Oak	<i>Quercus stellata</i>	QUST
Black Oak	<i>Quercus velutina</i>	QUVE
Black Locust	<i>Robinia pseudoacacia</i>	ROPS
Black Willow	<i>Salix nigra</i>	SANI
Sassafras	<i>Sassafras albidum</i>	SAAL5
Bald Cypress	<i>Taxodium distichum</i>	TADI2
Northern White Cedar	<i>Thuja occidentalis</i>	THOR
American Basswood	<i>Tilia americana</i>	TIAM
Little Leaf Linden	<i>Tilia cordata</i>	TICO2
Eastern Hemlock	<i>Tsuga canadensis</i>	TSCA
American Elm	<i>Ulmus americana</i>	ULAM
Siberian Elm	<i>Ulmus pumila</i>	ULPU
Slippery Elm	<i>Ulmus rubra</i>	ULRU
Blackhaw Viburnum	<i>Viburnum prunifolium</i>	VIPR
Japanese Zelkova	<i>Zelkova serrata</i>	ZESE80

To find tree and plant codes for your area, search for your local plants in the USDA's plant database at <https://plants.sc.egov.usda.gov/home>.

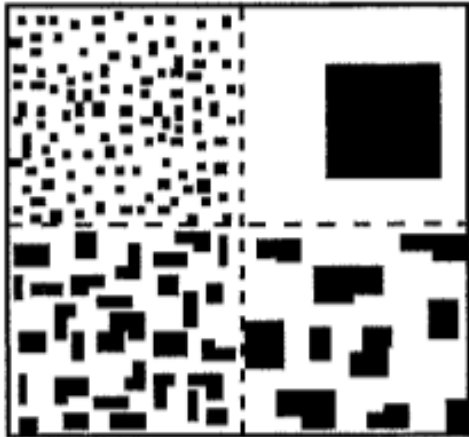
## Appendix E. Percent Cover Diagram



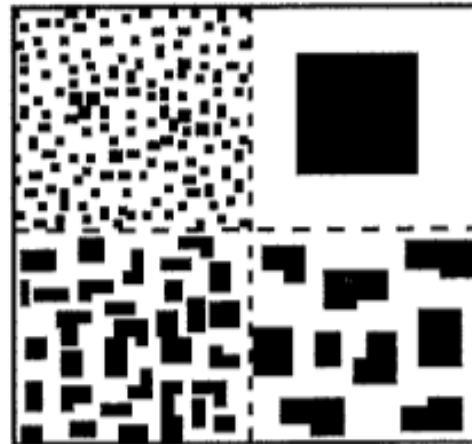
2%



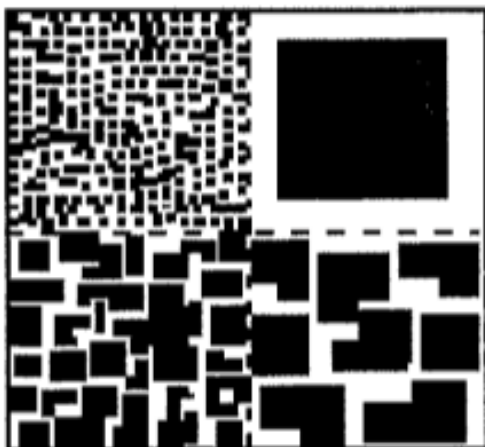
5%



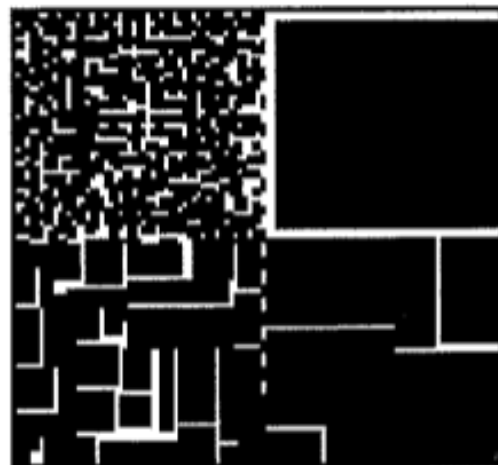
20%



25%

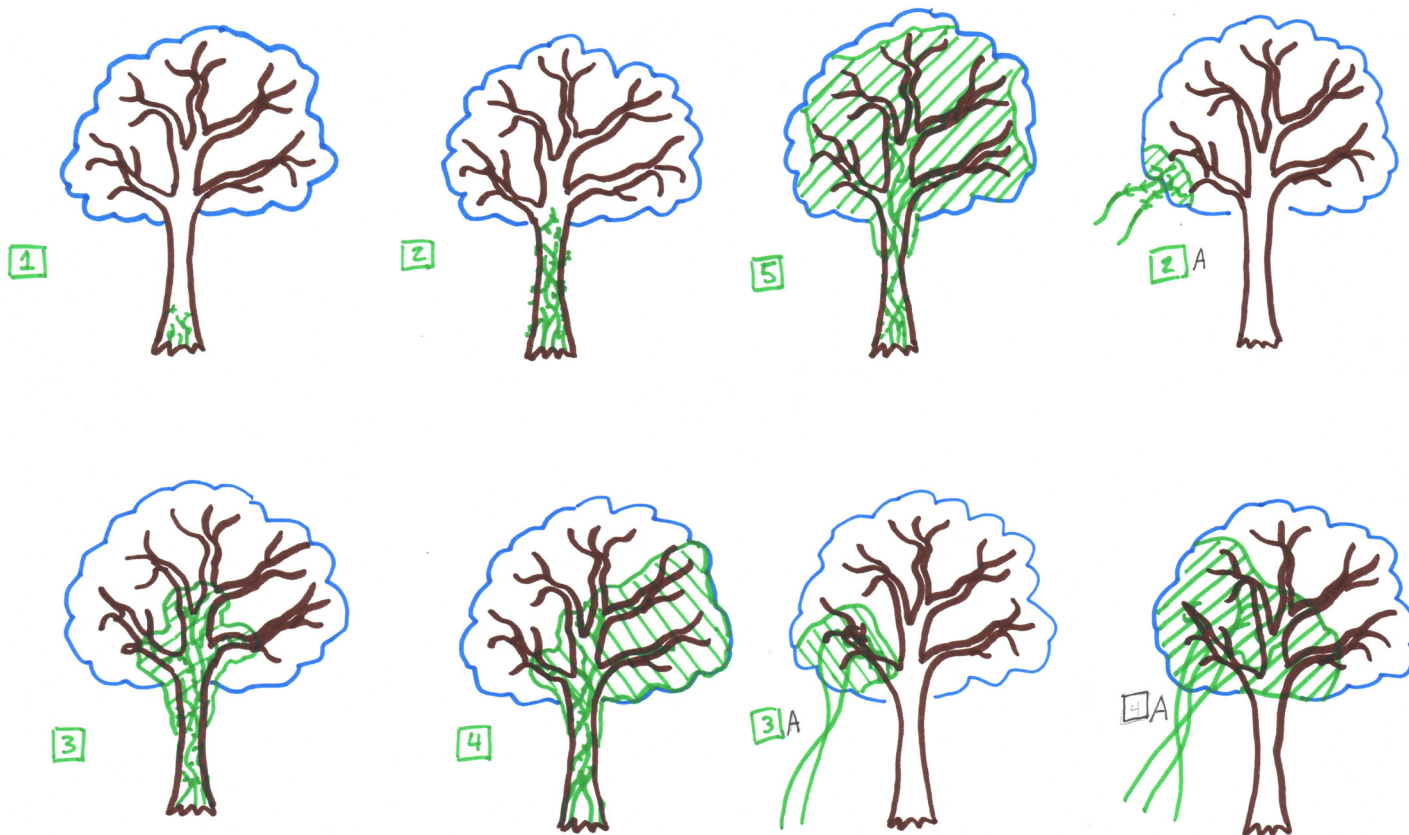


50%



90%

## Appendix F. Shumacher Vine Invasion Scale



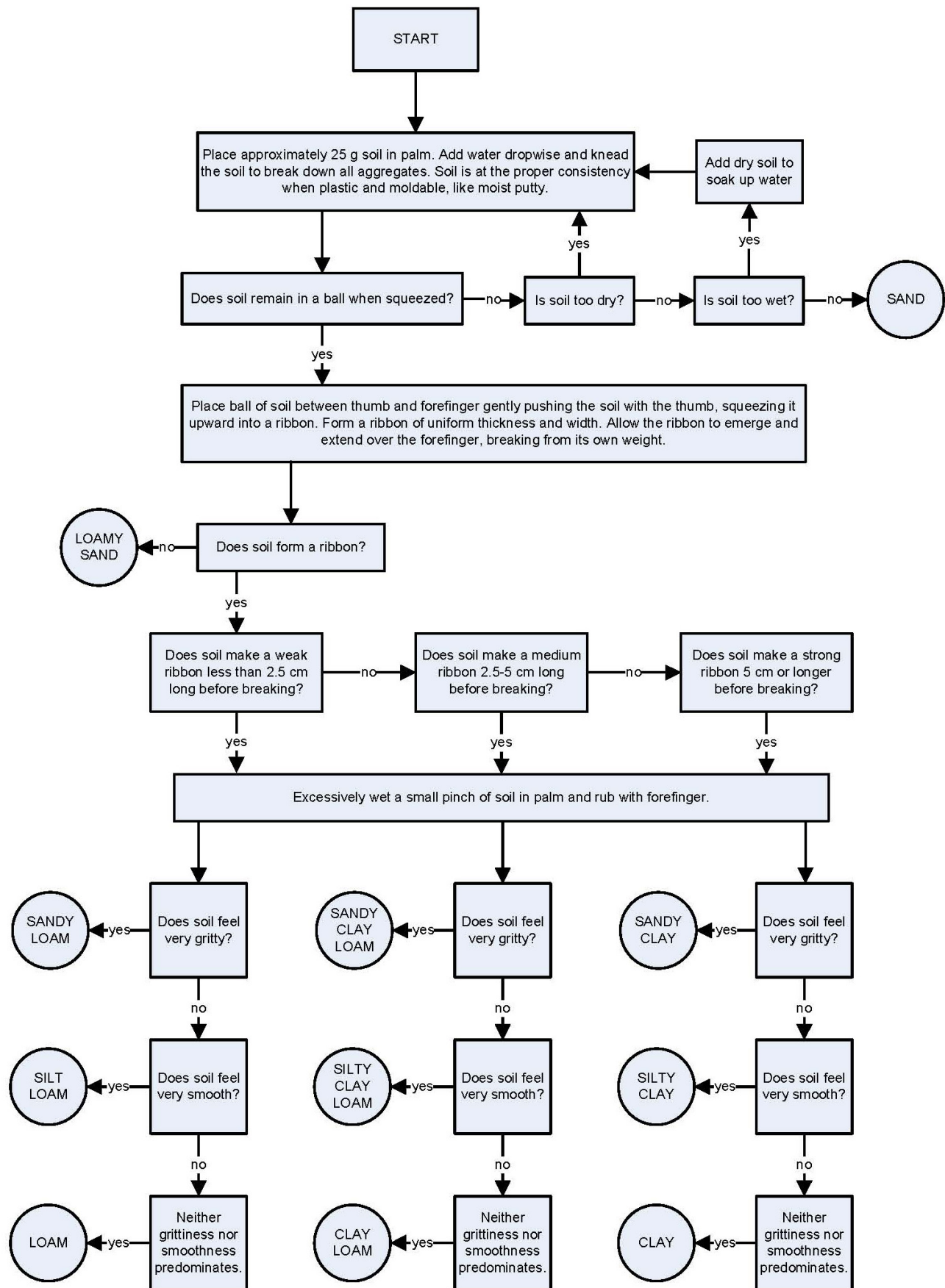
1. **Vines not yet established:** Young vines are just beginning to establish themselves on the tree's trunk. For older trees, this usually means that the vines have only grown several feet up the trunk. For young trees it can mean the vines have grown less than a foot.
2. **Vines fully established:** The vine, or vines, are fully established on the trunk but have not reached a height where the tree's major limbs branch from the trunk. Basically, this means that the vines have grown over the majority to the tree's trunk, but are not yet threatening the tree's canopy.
3. **Vines threatening tree canopy:** For this designation, the health of the tree is severely threatened. The vines have begun to spread onto the major limbs of the tree and are occupying a significant portion of the interior space on the upper limbs, however, the vines leaves are not yet shading out any significant portion of the tree's canopy.
4. **Tree canopy being destroyed:** For this designation, a significant portion of the tree's canopy has been occupied by vine foliage. Additionally, the vine is now receiving direct sunlight and the tree's crown light exposure has been diminished. At this point, the tree's ability to grow is being hindered by the vine, and the health of the tree is diminishing.
5. **Tree lacks adequate foliage to survive:** At this point, the tree is still alive, but completely overcome by vines. Basically, the foliage of the vine has grown over the vast majority of the foliage of the tree. Individual tree leaves or small branches may still be receiving sunlight but the tree's ability to thrive is totally compromised.

### Designations for vines growing laterally into trees (not growing up the trunk)

- 2A. **Vine is established** and has begun to spread into the canopy of adjacent trees. (the adjacent tree is the tree now being ranked)
- 3A. **Vines have grown** around major branches and are secured in the canopy of the adjacent tree.
- 4A. **Vines have overgrown** a significant portion of the tree's canopy, and the health of the tree is being impacted.
- 5A. **The vast majority of the foliage** of the tree is no longer receiving adequate sunlight because it has been overgrown by the foliage of the vine; the tree's ability to thrive is totally compromised.



## Appendix G. Soil Texture Flow Chart<sup>13</sup>



## Appendix H. Sample Data Templates

### Patch ID template

	A	B	C	D	E	F
1	Patch Number	Patch Name	Patch Street Address	Longitude	Latitude	Field Season
2						
3						
4						

### Herbaceous/shrub layer template

	A	B	C	D	E
1	Point Code	Species Code	Percent Cover	Less than 1 Percent	
2					
3					
4					

### Penetrometer template

	A	B	C
1	Point Code	Measurement Number	PSI Value
2			
3			
4			

### Soil punch data template

	A	B	C	D	E	F	G	H
1	Point Code	Layer Number	Starting Depth (mm)	Ending Depth (mm)	Hue	Value	Chroma	Texture
2								
3								
4								

### Auger soil profile data template

	A	B	C	D	E
1	Auger Number	Layer Number	Color	Texture	Additional Notes/Anomalies
2					
3					
4					

### Canopy data template

	A	B	C	D
1	Point Code	Stem	Species Code	Schumacher
2				
3				
4				