i-Tree

Eco

User's Manual

v. 4.1.0

i-Tree is a cooperative initiative

About i-Tree

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban and community forestry analysis and benefits assessment tools. The i-Tree tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the environmental services that trees provide and assessing the structure of the urban forest.

i-Tree has been used by communities, non-profit organizations, consultants, volunteers, and students to report on the urban forest at all scales from individual trees to parcels, neighborhoods, cities, and entire states. By understanding the local, tangible ecosystem services that trees provide, i-Tree users can link urban forest management activities with environmental quality and community livability. Whether your interest is a single tree or an entire forest, i-Tree provides baseline data that you can use to demonstrate value and set priorities for more effective decision-making.

Developed by USDA Forest Service and numerous cooperators, i-Tree is in the public domain and available by request through the i-Tree website (www.itreetools.org). The Forest Service, Davey Tree Expert Company, the Arbor Day Foundation, Society of Municipal Arborists, the International Society of Arboriculture, and Casey Trees have entered into a cooperative partnership to further develop, disseminate, and provide technical support for the suite.

i-Tree Products

The i-Tree software suite v 4.0 includes the following urban forest analysis tools and utility programs.

i-Tree Eco provides a broad picture of the entire urban forest. It is designed to use field data from randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and value to communities.

i**-Tree Streets** focuses on the ecosystem services and structure of a municipality's street tree population. It makes use of a sample or complete inventory to quantify and put a dollar value on the trees' annual environmental and aesthetic benefits, including energy conservation, air quality improvement, carbon dioxide reduction, stormwater control, and property value increases.

i-Tree Hydro (Beta) is the first vegetation-specific urban hydrology model. It is designed to model the effects of changes in urban tree cover and impervious surfaces on hourly stream flows and water quality at the watershed level.

i-Tree Vue allows you to make use of freely available national land cover data maps to assess your community's land cover, including tree canopy, and some of the ecosystem services provided by your current urban forest. The effects of planting scenarios on future benefits can also be modeled.

i-Tree Species Selector is a free-standing utility designed to help urban foresters select the most appropriate tree species based on environmental function and geographic area.

i-Tree Storm helps you to assess widespread community damage in a simple, credible, and efficient manner immediately after a severe storm. It is adaptable to various community types and sizes and provides information on the time and funds needed to mitigate storm damage.

i-Tree Design (beta) is a simple online tool that provides a platform for assessments of individual trees at the parcel level. This tool links to Google Maps and allows you to see how tree selection, tree size, and placement around your home effects energy use and other benefits. This beta tool is the first stage in development of more sophisticated options that will be available in future versions.

i-Tree Canopy offers a quick and easy way to produce a statistically valid estimate of land cover types (e.g., tree cover) using aerial images available in Google Maps. The data can be used by urban forest managers to estimate tree canopy cover, set canopy goals, and track success; and to estimate inputs for use in i-Tree Hydro and elsewhere where land cover data are needed.

All beta programs are still in development, therefore feedback is particularly appreciated.

Disclaimer

The use of trade, firm, or corporation names in this publication is solely for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable. The software distributed under the label "i-Tree Software Suite v. 4.0" is provided without warranty of any kind. Its use is governed by the End User License Agreement (EULA) to which the user agrees before installation.

Feedback

The i-Tree Development Team actively seeks feedback on any component of the project: the software suite itself, the manuals, or the process of development, dissemination, support, and refinement. Please send comments through any of the means listed on the i-Tree support page: http://www.itreetools.org/support/.

Acknowledgments

i-Tree

Components of the i-Tree software suite have been developed over the last few decades by the USDA Forest Service and numerous cooperators. Support for the development and release of i-Tree v. 4.0 has come from USDA Forest Service Research, State and Private Forestry, and their cooperators through the i-Tree Cooperative Partnership of Davey Tree Expert Company, the Arbor Day Foundation, Society of Municipal Arborists, the International Society of Arboriculture, and Casey Trees.

i-Tree Eco

i-Tree Eco is an adaptation of the Urban Forest Effects (UFORE) model, which was cooperatively developed by US Forest Service Northern Research Station (NRS), the USDA State and Private Forestry's Urban and Community Forestry Program and Northeastern Area, the Davey Tree Expert Company, and SUNY College of Environmental Science and Forestry. The UFORE model was conceived and developed by David J. Nowak and Daniel E. Crane (USFS, NRS) and Patrick McHale (SUNY-ESF). The UFORE software was designed and developed by Daniel E. Crane and its graphical user interface (GUI) by Lianghu Tian and Mike Binkley (The Davey Institute).

Many individuals contributed to the design and development process of the UFORE application including Mike Binkley (The Davey Institute), Jaewon Choi (SUNY-ESF), Daniel E. Crane (NRS), Greg Ina (The Davey Institute), Robert E. Hoehn (NRS), Jerry Bond and Christopher J. Luley (Urban Forestry LLC), Patrick McHale (SUNY-ESF), David J. Nowak (NRS), Jack C. Stevens (NRS), Lianghu Tian (The Davey Institute), and Jeffrey T. Walton (Paul Smiths College).

Revisions for i-Tree Eco versions were carried out by members of The Davey Institute, including Lianghu Tian, Michael Kerr, Al Zelaya, Scott Maco, and Mike Binkley based on input and newly available research from NRS and feedback from i-Tree users. The manual was edited and designed by Kelaine Vargas.

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Introduction

Eco was developed to help managers and researchers quantify urban forest structure and functions based on standard inputs of field, meteorological, and pollution data. The model currently calculates the following parameters based on local measurements:

Urban forest structure, including species composition, tree cover, tree density, tree health (crown dieback, tree damage), leaf area, leaf biomass, and information on shrubs and ground cover types.

Hourly pollution removal by the urban forest for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter (PM10). The model accounts for potential negative effects of trees on air quality due to BVOC emissions.

Effect of trees on building energy use and related reductions in carbon dioxide emissions.

Total carbon stored and net carbon sequestered annually by trees.

Susceptibility to gypsy moth, Asian longhorned beetle, and emerald ash borer.

Exotic species composition.

Eco makes use of user-collected field data. For large-scale areas (entire cities or neighborhoods), a random sample of fixed area plots is analyzed. For smaller-scale sites, a complete inventory option is available that will provide information on urban forest structure, pollution removal, carbon sequestration and storage, and resource value. Model outputs are given for the entire population and, for smaller scale projects making use of complete inventories, results are also provided for individual trees.

International urban foresters have shown increasing interest in pursuing Eco projects. The i-Tree Team is currently working with cooperators to improve functionality of the model outside the U.S. as time and limited resources will permit. Currently certain limitations apply to international projects both in terms of functionality and required inputs. These limitations are outlined in Appendix 5.

Eco v. 4.0 offers two particularly significant upgrades over earlier versions. First, U.S. projects that make use of standard weather and air quality data will no longer need to be sent to the Forest Service for processing. An automated system is now available that completes data analysis within one day. Second, updates have been made to the air quality model, including improved leaf area index simulations, weather and air pollution data processing and interpolation, updated monetary values for reduced pollutant levels, and improved charts and tables that now display yearly, monthly, or hourly results. Due to these changes, users can expect more refined calculations of air pollution effects when compared with earlier versions of Eco.

For more information on the methodology that underlies Eco and the specific model updates, visit www.itreetools.org > Resources > Archives under Eco.

About This Manual

This manual provides all the information needed to conduct an Eco project. We start with installing the software and move on to the four project phases:

Phase I: Getting started. In this section, we talk about decisions that need to be made right at the outset, such as the boundaries of the study area and whether your inventory will be a random sample of fixed plots or a complete inventory of the site. During Phase I, you'll create a sample of plots to be inventories if necessary. The final step includes gathering general data that you'll need to have ready, such as air quality data and aerial imagery for the optional mapping tool.

Phase II: Getting started with the software. In this section, we run the Eco software and use it to configure a project, create inventorying materials, and set-up the PDA application for those who will be using this tool to collect data. In the last step, we describe how to map the field plots so you know where to start.

Phase III: Out in the field. This section is where all the hard work gets done, beginning with setting up the plots. Most importantly, we cover what data fields you need to collect, how to do so, and how to enter the data, either onto the paper forms or into the PDA. Phase III ends with a description of how to perform quality assurance checks to make sure your field teams are being as accurate as possible.

Phase IV: Back at your desk: Running Eco. In this section, we describe how to transfer data from the paper forms or PDA to the desktop, how to submit the data for processing and how to retrieve the results. This section covers all of the available reports and describes how to save, export, and print your results.

Appendices: These six sections provide information on generating random plots for stratified (Appendix 1) or unstratified (Appendix 2) samples, describe how to format and import existing tree data into Eco for use in a complete inventory analysis (Appendix 3), clarify pest detection protocol data collection (Appendix 4), describe limitations for projects undertaken internationally (Appendix 5) and present the paper data collection forms for printing (Appendix 6).

Installation

System Requirements

Requirements for desktop/laptop computers

Minimum hardware:

- Pentium or compatible 1600 Mhz or faster processor
- 512 MB of available RAM
- Hard drive with at least 500 MB free space
- Monitor resolution of 1024 x 768 or greater

Software:

- Windows XP service pack 2 or higher OS (including Windows 7)
- Microsoft Excel
- Microsoft Data Access Component (MDAC) 2.8 or higher (included in i-Tree installation)
- .NET 2.0 framework (included in i-Tree installation)
- Adobe PDF Reader 9.0
- For PDA users, ActiveSync 4.5 or higher for windows XP or Mobile Device Center 6.0 or above for Vista and Windows 7 (included in i-Tree installation)
- Crystal Report 2008 Runtime (included in i-Tree installation)

Requirements for field data collection devices

Several smart phones and PDA devices can be used with i-Tree applications. Devices with the following base specifications are recommended for optimal performance and compatibility with i-Tree applications:

- Windows Mobile 5.0–6.5 operating system (OS 7 is currently *not* compatible)
- 240 × 320 screen resolution

For an updated list of compatible devices, see the *System Requirements and Installation Document* at www.itreetools.org > Resources > Manuals and Workbooks.

> NOTE: i-Tree applications are developed to run on a .NET 2.0 framework which is included in the i-Tree installation package. Owing to the variability across devices and manufacturers, users may occasionally find inconsistencies running i-Tree applications on some devices.

Installation

To install Eco:

1 Visit www.itreetools.org to download the software or insert the i-Tree Installation CD into your CD-ROM drive.

2 Follow the on-screen instructions to run i-Tree setup.exe. This may take several minutes depending on which files need to be installed.

3 Follow the Installation Wizard instructions to complete the installation (default location recommended).

You can check for the latest updates at any time by clicking **Help** > **Check for Updates**.

Exploring Eco with the Sample Project

Now that you've installed Eco, you would probably like to see a little of what the software can do. To allow you to explore the program, we've included two sample projects: a plot-based sample project and a complete inventory project (in which all trees in a small area of inventoried).

1 You can begin by opening Eco using your computer's **Start** menu > **(All) Programs** > **i-Tree** > **i-Tree Eco**.

2 You have two sample project options, available under **File** > **Open Sample Project**: a plot-based sample project and a complete inventory project.

Plot-based sample project

Under **Edit > Enter or Edit Data**, you can see a list of the plots. Clicking **Edit Plot** brings up a window showing all the inventory fields that were collected for one plot. The charts and tables as well as the written report and mapping feature can be accessed from the tool bar under **Reports** or under **View > Project Window**. From the **Tools** menu, you can launch the PDA utility and explore some of the options there.

Complete inventory project

Under **Edit > Edit or Enter Data**, you can see a list of the inventory records. Selecting a tree and clicking **Edit Tree** brings up a window showing all the inventory data for that tree. The tables can be accessed under **Reports** or under **View > Project Window**. From the **Tools** menu, you can launch the PDA utility and explore some of the options there.

We will, of course, explain all of these functions and more in greater detail, but for now feel free to explore and see what's available.

Phase I: Getting Started

Early Decisions to Be Made

Before you get started with Eco there are several decisions that must be made. In this section, we'll describe some of the pluses and minuses of each option to help you choose.

> NOTE: i-Tree Eco users have developed a number of documents to help others with many aspects of Eco project planning and management. These are an excellent resource and can be found at www.itreetools.org under Resources > Archives > i-Tree Eco Project Planning & Management Resources.

What are the boundaries of your study area?

An Eco analysis can be done for an entire city, a neighborhood, a park, or even a backyard.

Will your inventory be a complete inventory of the entire study area or a series of sample plots?

A typical Eco project involves inventorying a series of sample plots distributed across a city, a large university campus, or other broad, diverse landscape. Occasionally, however, some users have opted for an Eco analysis of small, discrete areas, such as a residential parcel or a commercial property. In this case, a complete inventory of all trees on the site makes more sense. Keep in mind, however, that data collection on each tree is intensive, and sites with many trees will be very time consuming. Also, reporting for complete inventories is limited and does not include information on energy conservation, air pollution contributions by shrubs, or available planting space.

Will you format and import an existing complete inventory?

Users interested in analyzing an existing inventory now have the option to format their existing complete inventory data into a compatible Microsoft Access database and import into an i-Tree Eco project for analysis. You will need to create a new complete inventory Eco project as detailed in Phase II and refer to the steps in Appendix 4 to format and import data into an Eco project. The import option is not available for sample (plot-based) project data at this time.

What kinds of field data will you collect?

For sample inventories, certain information is required, while other variables are optional. Each variable collected adds depth to the analysis but also adds to the cost of the project. There are four optional data categories for sample inventory analyses:

Plantable space: If you would like to estimate the available planting space for your area, you will need to collect information on the fraction of each plot that is plantable.

Energy: If you would like to assess the effects your urban forest is having on energy consumption, you will need to collect information related to nearby buildings (distance and direction from trees).

Shrub: If you would like to know the effects your study area's shrubs are having on air pollution, you will need to collect information on the species, height, and cover of the shrubs within the plots.

Hydro: i-Tree Hydro is a new module in the i-Tree suite that offers the ability to assess the effects of urban tree cover and impervious surfaces on hourly stream flow and water quality for a defined watershed. If you plan to conduct an analysis of your watershed using Hydro, you will be asked to supply data regarding the average percentage of impervious surface and shrub cover under the driplines of trees in your area. As this information can be hard to come by, we have made it possible to collect these data during an Eco project. Keep in mind, however, that the project boundary of your Eco analysis should overlap or be the same as the watershed you will study in Hydro for this to be valuable.

Will you collect information on pests?

The i-Tree Pest Detection protocol (http://www.itreetools.org/iped/index.php) can now be used for sample and complete Eco inventory projects. This optional module allows you to document signs and symptoms of tree pests and diseases as part of your Eco project. Note, however, that although the data collection features are already active, the reporting functionality is not yet. The ability to run Pest Detection reports will be available soon in a future update.

> NOTE: The Pest Detection protocol is independent of the existing Eco pest susceptibility reports for emerald ash borer, gypsy moth, and Asia long-horned beetle. The existing reports do not reflect field-collected data about *actual* risks and harm, but rather calculate the damage that a *potential* outbreak could have. These reports will continue to be fully functional.

To conduct your inventory, will you use (a) the i-Tree PDA tool, (b) paper forms, or (c) a non-i-Tree inventory platform?

The Eco software package includes a PDA application for use in conducting inventories that works seamlessly with the desktop application. It is customizable for your city's inventory needs, easy to use, and results in a database that is properly formatted for Eco and can be uploaded with a single click. The PDA application works with a variety of handheld devices, including PDAs, smart phones, Trimble dataloggers, etc. running Windows Mobile 5.0–6.5 operating system.

If your community lacks funding to support the use of PDAs or you simply prefer to use an alternate method, that's no problem. Inventories can be conducted using paper forms, proprietary inventory tools, spreadsheets, etc. An inventory form is included to make inventorying simpler, and the desktop Eco application includes a user-friendly input form to simplify the data entry process. You should review the section Phase III: Out in the Field: Collecting Data to help with planning.

Creating a Sample

If you are conducting a sample inventory of a large-scale study area, the most important step in planning is to create the random sample of the plots. There are several decisions to be made before you begin. The following sections are provided to help you understand elements of designing a sample such as stratification options, determining the number of plots needed and a method of randomly distributing plots. As Eco projects can differ greatly, these are only guidelines and may not always be applicable to your project. Users are advised to consult with a statistician regarding their project sample design if they have very specific needs or concerns.

Your sample design decisions should be based on your desired project goals (i.e., the questions you are trying to answer), the available resources to manage and complete the project, and the desired precision of the model estimates. For example, a stratified sample design with many plots may allow for comparison between land use types or neighborhoods and for greater precision of the model estimates. However, there will be associated project considerations such as the additional resources that will be needed to create maps, obtain permission to access properties, travel to plots, and collect field data. Conversely, a simple unstratified random sample will not allow for comparison of subunits but may provide sufficient information to achieve the project objectives.

A technical article is available at www.itreetools.org under Resources > Archives that provides more detail on the effects of sample design options on project precision and estimates. See "Effect of Plot and Sample Size on Timing and Precision of Urban Forest Assessments" under the Eco resources section of this page.

Will you stratify your sample?

For some studies, stratifying (sub-dividing) the study area into smaller units can help clarify differences across the study area. For example, you might stratify your city into land-cover classes so that you can compare the urban forest effects in industrial areas with those in residential areas. Ultimately, the decision to stratify should be based on your current and future project objectives and your available resources.

No stratification (simple random sample): In a study with no stratification, plots are laid out randomly across the study area. This is a simpler method and offers the advantage of true randomness. True randomness, however, might not provide you with a true picture of your urban forest. Consider, for example, an extreme case of a city that is divided into

two land uses: single-family residential (10% of total area) and industrial (90% of total area), with all of the trees in the residential district. A true random sample would place 10% of plots in residential areas and 90% of plots in the industrial area and would result in an incorrect picture of the urban forest. Because in most cities, the trees themselves are not distributed randomly across land uses or neighborhoods, stratified sampling can offer a more accurate picture of the urban forest. If you decide to stratify your study, you can either pre-stratify or post-stratify.

Pre-stratification: With pre-stratification, the study area is divided into smaller classes (or *strata*) prior to determining the plots. The number of plots in each stratum is based on which areas are believed to have the greatest variability or are of greatest interest. Often the majority of the plots are distributed within residential and forest/vacant land uses, as these areas tend to have the greatest density of trees. One disadvantage of stratification is that it might make future studies that revisit the same plots difficult if land uses change over time.

Post-stratification: With post-stratification, plots are distributed randomly throughout the study area and strata boundaries are flexible and can be determined or modified after data collection or in the future. Post-stratification allows you to analyze your data into multiple schemes. For example, you can use the same plots and field data to compare your results by land use types and then change the stratification to allow for analysis by political boundaries, neighborhoods, or management units as desired. Post-stratification allows you to manage the stratification boundary definitions to analyze change over time if your project will be re-measured in the future. For example, a land use category that is agricultural in an initial study may be developed in the future and reclassified as residential or commercial. Although post-stratification allows for greater flexibility, one disadvantage is that estimates may not be as accurate as a pre-stratified project where plot quantity is predetermined based on existing land types and desired objectives.

Stratification limitations: If you decide to stratify your sampling, be sure not to choose too many categories or strata. The number of strata used in an Eco project is typically between 5 and 10 (for an analysis with 200 total plots) and can not exceed 14. Too many categories can lead to analysis problems, as too few plots may fall in some strata. Each stratum should have at least 20 plots.

How many plots will you inventory and how big will they be?

The number of plots to be inventoried must be determined. As a general rule, 200 plots (1/10 acre each) in a stratified random sample (with at least 20 plots per stratum) will yield a standard error of about 10% for an estimate for the entire city. As the number of plots increases, the standard error decreases and you can be more confident in the estimate for the population. The graph below provides a rough estimate of how the standard error of the total number of trees in a city changes based on the number of plots sampled. Note how for the first 100 plots, the standard error drops more rapidly than for the second 100 plots, although the standard error continues to drop with increased sample size.
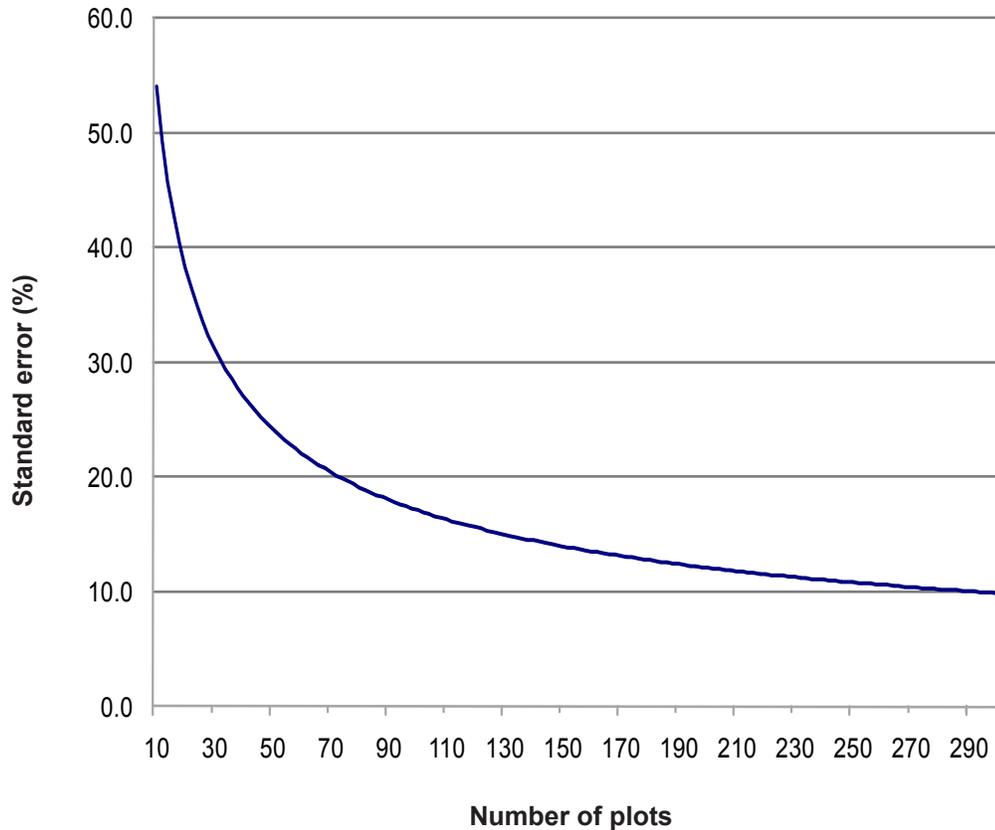
Keep in mind, however, that as the number of plots increases, so does the time and cost of field data collection. A crew of two people can typically measure 200 plots within one summer for a city with about 20% tree cover. The actual number of plots to be measured differs based on many factors, including the size of the city and tree cover.

> NOTE: We recommend adding an extra 5–10% to your total number of plots to use as replacements where a plot is inaccessible.

The standard plot size for an Eco analysis is a 0.1 acre circular plot with radius of 37.2 ft. If necessary, smaller or larger plots can be used, for instance, if you are analyzing a small area in which 0.1 acre plots would overlap.

What kind of randomization method will you use?

There are many ways that you can randomly distribute plots throughout your study area, whether you are working with a stratified or unstratified sample. Again, your decision should be based on the objectives of your study and the resources available to create the layout. Some Eco users collaborate with local universities or government agencies for assistance to create random plot layouts for their projects if they do not have the skills or resources. The three most common randomization methods are the following:

- Random: plots are laid randomly across the study area
- Grid: plots are laid on a fixed grid (equidistance between plots)
- Randomized grid: plots are laid randomly within evenly spaced grid cells

Random: Plots are laid randomly throughout the entire study area or randomly within individual predetermined strata boundaries if you select to pre-stratify your project. This type of random plot distribution is typically created with the aid of a GIS system.

Random

Grid: Random plots can also be created by laying out a fixed grid of points equidistant over the project area. This can be done manually on a map or by using a GIS. Once the grid points have been laid out, they are numbered, and specific plots are chosen using a random number generator, which can be found online or within software tools such as Excel.

An advantage of the grid method is that it can be produced without a GIS. A potential disadvantage, however, may occur if the grid unintentionally coincides with an existing city street grid. Thus, many plots may fall on similar land uses, which may not be desirable.

Grid

Randomized grid: In this method, an evenly spaced grid is laid over the study area. Then, plot points are selected randomly within each cell, which allows for a more even distribution of points throughout your study area with a greater degree of randomness than using a fixed grid. This method would most likely require use of a GIS to complete.

One advantage of the randomized grid is that it allows for multiple post-stratification schemes because plots are more evenly distributed.

Randomized grid

Creating the sample

You can use any method you like, including paper maps and pencil, as long as it follows random sampling conventions.

Appendices I and 2 in this manual provide detailed instructions for creating a completely random sample (stratified or unstratified) using ESRI's ArcGIS. The end result will be three files to load into Eco during project set up to create a plot list for your project configuration.
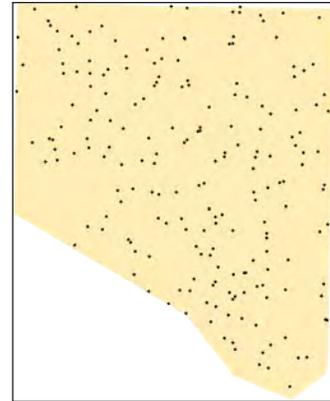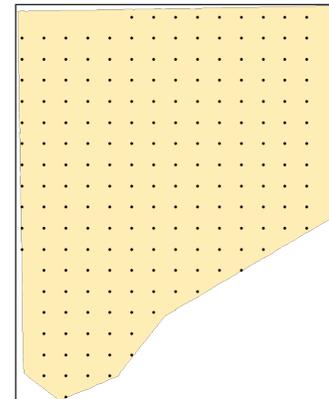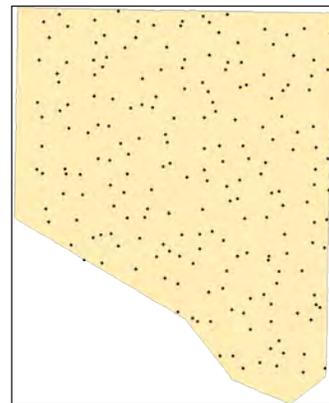
i-Tree Eco makes use of a set of default air quality (for the year 2000) and weather data (for years 1995–2005). Users outside the U.S. or users who wish to analyze more local data or data for other years will need to follow the process described below.

> NOTE: One significant upgrade in Eco v. 4 is that most projects are now processed automatically and results are returned in the same day. Providing custom air quality or weather data will necessitate custom processing by the US Forest Service and will slow processing time significantly.

Air quality data

Users in the United States do not need to provide air quality data for an Eco analysis, unless they wish to submit local data or data from a year other than 2000. Users outside the U.S. or users with local data should submit their hourly air pollution data for a complete year in Microsoft Excel format with column names and data as shown in the table below.

Pollution data should be sent to i-Tree support at info@itreetools.org as an email attachment referencing the associated Eco project. The data should be submitted at the same time the project is submitted for analysis.

| Column	Column name	Format	Description
A	Year	Number	The year the data were recorded
B	Month	Number	The month the data were recorded (1–12)
C	Spname	Text	Name of pollutant; must be CO, NO_2, O_3, PM_{10}, SO_2
D	Cityname	Text	The name of the city where the pollution monitor is located
E	Addr	Text	The address of the pollution monitor (cannot exceed 5 characters including spaces)
F	Units	Number	1 indicates $\mu g/m^3$; 7 indicates ppm
G	Quantity	Number	The concentration of the pollutant in ppm for CO, NO_2, O_3, SO_2; and in $\mu g/m^3$ for PM_{10}
H	Day	Number	The day the data were recorded (1–31)
I	Hour	Number	The hour the data were recorded (1–24)

Weather data

Hourly weather data are necessary to analyze air pollution removal by the urban forest and are available within Eco for most cities around the world for the years 1995–2005. If you wish to provide your own weather data, more information and formatting requirements are provided at www.itreetools.org under Resources.

Gathering Map Data

If you chose to stratify your sample, Eco offers the option of visualizing your results spatially by making use of the 2001 National Land Cover Dataset (NLCD), which is distributed by the Multi-Resolution Land Characteristics Consortium (MRLC; www.mrlc.gov). With Eco's Maps option, results of your analysis related to carbon storage, carbon sequestration, structural information, pollution removal, canopy cover, available planting space, and tree density are mapped directly onto NLCD images. This option does not require GIS knowledge or software. It does, however, have some limitations as described below.

> NOTE: The Maps option is only suited to stratified samples and projects within the continental United States. In addition, if your project data are not stratified by NLCD land cover classes, you will need to use a cross-walk tool within Eco to match your strata to NLCD cover classes. Due to limitations of NLCD imagery, canopy cover estimates in NLCD maps will likely differ from i-Tree Eco estimates. Therefore, the total effects displayed in the maps may be underestimated and are only meant for visualization purposes. For unstratified samples and for greater functionality working with the NLCD images, users are advised to use the i-Tree Vue application.

To make use of the Maps option, you'll need to procure three images for your study area from the NLCD datasets: land cover, percent impervious cover, and percent tree canopy.

MRLC Consortium Viewer

The MRLC Consortium Viewer is the gateway to obtaining the necessary images. To get started:

1 Turn off any pop-up window blockers in your browser, go to http://gisdata.usgs.net/website/MRLC, and review the user instructions.

2 Click **Launch MRLC Consortium Viewer** to begin.

3 Use the **Zoom** tool to focus the window tightly on your study area.

4 You can use the categories under **Display**, such as **Places**, **Transportation**, **Boundaries**, and **Hydrography**, to help you clarify your boundaries. Click the

green arrow to the left of the category to view the options and then **check the boxes** to show the information on the map.

5   Once you have focused on your study area, click the **Download** tab on the right, click the **arrow** next to Land Cover and select only these layers:

     NLCD 2001 Land Cover
     NLCD 2001 Canopy (Tree Cover)
     NLCD 2001 Impervious Surface

6   Use the rectangular **Download** tool from the toolbar group on the left to draw a box around the final download area on the map. Be careful not to drag the tool beyond the map edges as this causes a reset of the viewer.

7   A pop-up window will appear. Make sure that all three datasets are present in the download window because the three images must be downloaded at the same time with the exact same extents. For each layer, click **Download** and the **Save File** window will appear.

8   Click **Save** and navigate to the location where you want the folder stored and change the default name to Land_cover, Canopy, or Impervious_Surface as appropriate.

9   Unzip each folder into your preferred location. Make a note of where the folders are stored; you'll need this for Phase II.

With your sample created, your general data collected, and your maps downloaded if desired, you're ready to move on to Phase II and get started with Eco!

Phase II: Getting Started with Eco

Once you've decided which fields to collect during your inventory and created a random sample if appropriate, it's time to get started with the software.

To begin working with Eco, click your computer's **Start** menu > **(All) Programs** > **i-Tree** > **Eco**.

Creating a New Project

To start a new project:

1 Click **File** > **New project**. The **Save i-Tree Eco Project** window will appear. Navigate to the location where you want to save the project, give it a name, and click **Save**.

2 The **Creating a New Project** window will appear. It asks you for the location of four required databases (Species, Location, Input, and Report) and three optional images (Land Cover, Impervious Cover, and Tree Cover) to be used for mapping results.

   a The first two blanks are filled in automatically and should be left as they are.

   b The Input and Report databases are unique to a given project. Click **Create** and navigate to the location where you want to create each file. In the **File Name** field, supply a name (e.g., MyTown_2011_Input and MyTown_2011_Report), and click **Save**.

   c If you decided to use the Maps option to visualize your results on aerial imagery and have obtained the necessary images from the NLCD, enter the locations of the files in the next three blanks. For each (Land Cover, Impervious Cover, Tree Cover), click **Browse** and navigate to the appropriate folder you unzipped earlier. Select the .tif image within that folder.

You can return to this window to make changes later by clicking **File** > **Update Project**. If you have already started data collection, however, avoid making changes that would affect the quality or integrity of the data.

Creating/configuring inventories

Once all four tables and three image files (if desired) have been entered:

1 Click **Configure Input**. The **Creating/Configuring Inventories** window will open.

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2 Create a name for your location in the **Location Name** field and choose **nation, state, county**, and **place** from the drop-down menus. [Note: If the community that includes your study area extends across more than one county, you may have to try all relevant county names before the community name appears in the menu.]

3 To select a Weather Station ID (available for Eco v. 4 projects in the U.S. only)

  a Click **Select** next to the Weather Station ID box. The Select a Weather Station dialog box will appear with a red cross indicating your approximate location based on the information entered above and green markers indicating nearby weather stations offering hourly weather data. The Map Type can be changed between Normal, Satellite and Hybrid images as desired.

  b **Go to Location** can be used to move the red cross hairs to a specific geographic location. Zoom and Pan functions can be operated by manipulating the mouse as specified in the directions at the lower right of the screen or by moving the zoom slide bar.

  c Click on the green marker nearest your project location. Data may not always be readily available within your city and the nearest location will have to be used unless you have access to other local resources to acquire and submit properly formatted weather data.

  d Once a weather station is selected, the details will be populated in the ID number and station name fields. Click **OK** to proceed with configuration steps.

4 Give the series a name to identify the exact nature of the project, e.g., "ParkTrees" or "City," to distinguish it from other Eco projects done at the same time in the same place, if necessary. Series should be used sparingly. Their advantage is that they can allow for more efficient data management, although there are some risks associated with possible overrides of data. However, series can not be compared against each other within one project, but must be submitted separately. It is therefore generally better to group data into separate Eco projects with their own file names when such grouping is necessary.

5 If you plan to reinventory your plots in the future, check the box marked **Data collected permanent?** This option is only valid for sample inventories.

6 Indicate whether you will be collecting a complete inventory (Inventory - 100% census) or sampling with random field plots.

  a For sample inventories, select the sampling method from the drop-down box: If you stratified your sample, select **Stratified Random Sample**. If your sample was unstratified and plots were completely randomized, select

Simple Random Sample. If your sample was unstratified and you used the fixed grid or randomized grid methods to randomize the plots, select accordingly. This is for information only and does not affect analysis.

7 Type in the year of the inventory and choose between English and metric units.

8 Check the **Pest Detection Included** box if you decided in Phase I: Getting Started: Early Decisions to use the i-Tree Pest Detection protocol as part of your project.

9 When you are finished, click **Add to Database**.

If you are conducting a sample inventory, in the next step you'll define your plots and map land uses.

1 Click **Define Plots**. This function creates the proper number of empty rows in the database.

2 You can choose between **Manually Create** and **Load from Files**.

  a If you created a sample using one of the methods in the Appendices working with ArcGIS 9.2 or 9.3 and the iTree.mxd toolbar, you will have created three Eco-ready files (the plot list report text file, the strata area report text file, and the GIS projection file). To incorporate these, select **Load from Files**. Click the **button** to the right of each file type, and navigate to each of the files. Set your plot size (usually 0.1 acre with a radius of 37.2 ft, but other sizes are acceptable) and click **OK** to load plots into the database and then **Exit** to close the window.

  b If you used an alternate method (such as paper maps and pencils), select **Manually Create**. Enter your desired Plot Size (usually 0.1 acre).

  c In either case, if you are using metric units, please enter your plot size with five decimal places for the most accurate conversion (e.g., 0.04047 ha for 0.1 acre plots or 0.02023 ha for 0.05 acre plots).

  d Click the **Manage Map Landuse** button to launch the screen.

Managing map land use

In the following steps, you will give i-Tree Eco more information about your stratification classes (or nonstratification if this is the case), the total area of land each represents, and the number of plots associated with each. Please note that although the name of this function relates to land uses, it applies to all kinds of stratification (by neighborhood, management zone, city council district).

Simple random samples: If your project is a simple random sample (unstratified), you will only need to define one map land use or stratum for the entire project.

1. Click **Add New** and in the boxes that appear at the bottom, assign a numerical Land Use ID number ("1"), a Land Use Abbreviation ("CEnt"), Land Use Description ("Entire City") and Land Use Size (total study area). Click **Submit Change** and then **Exit**.

2. Back in the Define Plots window, place your cursor in the **Plots To Be Added** box and enter the number of plots you will inventory. Click **OK** and then click **Yes** to confirm.

Stratified projects: If you did not use the method in the Appendices to stratify your project, follow the steps below to manually create multiple land uses/other strata with associated plots.

1. From the Define Plots dialog screen, enter in a plot size and click the **Manage Map Landuse** button.

2. Click **Add New** and enter your first land use or other stratification category into the fields below. Assign a Land Use ID number ("10"), Abbreviation ("Res" or "FQ"), Description ("Residential" or "French Quarter"), and Land Use Size (total area of residential land or of the French Quarter neighborhood). Click **Submit Change** to populate table.

3. Repeat the sequence for each additional category. Remember, the size of the individual categories created must add up to the total project area.

4. Click **Exit** when complete.

5. Once the categories have been defined, you must create plots for each land use using the Define Plots dialog screen. For each category listed in the Define Plot screen, place your cursor in the corresponding row under the Plots to be Added column and enter the number of plots for that category. Select **OK** to populate. Values will appear in the Existing Plots column.

   Note: Plots will be numbered in the order they are created. For example if your first map land use was Residential with 100 plots and your second was Commercial with 25 plots, plots 1–100 will be initially assigned as residential and plots 101–126 will be assigned as commercial. The map land use assignments for a plot can be changed from the manual data entry form when field data are entered.

6. Click **Exit** to close the dialog box when complete.

Merging map land uses: One final feature of Managing Map Land Uses is the ability to combine two existing land uses into one category using the **Merge** button. Land use areas will be combined and plots will be combined into the land use category specified.

This feature would also be useful for reassigning a land use category for subsequent

projects. For example, if your original project contained an agriculture category and that land has since been developed, you could merge the plots within the Agriculture class into a Residential or Commercial class. Remember, if you merge Map Land Use classes of an existing project after receiving your results, you will need to resubmit the merged data to update the analysis. Note, also, that once two categories are merged, they can't be unmerged.

Creating Field Data Collection Materials

Your final step is to create the field data collection materials you will need. You can choose to collect data on paper forms or on PDAs.

1 To create paper forms for a sample inventory, click on the **Print** button next to **Sampled Paper Collection**. These forms are also available in Appendix 6 or from the tool bar under **Tools.**

2 To create paper forms for a complete inventory, click on the **Print** button next to **Inventory Paper Collection**. These forms are also available in Appendix 6 or from the tool bar under **Tools**.

We'll cover each aspect of how data collection relates to the forms in Phase IV below, but for now take a moment to familiarize yourself with them. The sections on the form conform to the main categories of data collection. For sample inventories, this includes plot information (address, GPS coordinates, sketch), permanent reference data for locating the site in the future, land use and cover data, ground cover, shrubs, and trees. For complete inventories, this includes general location information, tree characteristics, and land use type.

> NOTE: If you have decided to conduct your inventory on paper or with a method other than a PDA, skip ahead to Mapping Field Plots.

To use the PDA application to conduct your data collection, click **Launch PDA Program Generator**.

Configuring PDA for Data Collection

When you are ready to begin working with the PDA, connect it to your computer. Your computer must recognize your PDA. If it does not do so automatically, follow the instructions that came with the device to achieve this.

Check status and install necessary components

If you are still following along with the directions above, the i-Tree Eco PDA Utility window should be open on your screen. If not, from within the Eco desktop application, click **Tools > PDA Utility**.

1. Your first step should be to see what software needs to be loaded on the PDA. To do so, click **Check PDA Status**. If any components are missing, they will be shown in red and an **Install** button will appear.

2. Click **Install** to add the necessary components and follow the instructions on the screen and on the PDA.

Setting the project definitions

Once the PDA is properly set up:

1. Click the **Project Definition** tab in the PDA Utility interface. Each of the steps represented by the buttons shown on this screen must be executed. Some may be repeated later without any harm. However, once the project is set up, changes to the project definition are usually not made.

2. **Add/Edit/Delete Survey Team Information**: This button brings up a screen that allows you to edit survey team names that will appear on the PDA during log-in.

3. **Import Plot List from Field Input Database for Project** (sample inventories only): For projects involving a sample inventory, the list of available plots must be imported so they can be selected from the list on the PDA. Clicking this button brings up a screen that lists all plots created above in the Creating/Configuring Inventories: Define Plots window.

   a. Click the button at the bottom labeled **Import All Plots from Field Input Database**. As plots are completed, they will disappear from the lower box of uncompleted plots so you can follow the progress of your project.

   [NOTE: The plot list should only be imported once onto each PDA during the course of a project!]

4. **Add/Edit/Delete Additional Ground Cover Types** (sample inventories only): This button brings up a screen that allows you to edit the ground cover types to be included in the data collection. Ten come preloaded and the ID numbers 1–49 are reserved. You may enter up to 50 more ground cover types using the ID numbers 50–99.

Setting the project options

When you have completed each of the Project Definition tasks, click the **Project Options** tab to move on. The pre-defined items on the left are as you set them under Creating/Configuring Inventories and can only be changed there.

1. Under **Field-Defined Items** on the right, check the **boxes** next to each option (plantable space, energy, shrub cover, and hydro) you decided to measure during Phase I: Early Decisions.

2 Click **Update Config File** when you are finished.

Applying the new configuration settings to the PDA

Click the **PDA** tab to begin applying the new settings to the PDA. With the PDA connected to your computer and ActiveSync or Windows Mobile Device Center running:

1 Click **Send Configuration to PDA**.

   [NOTE: Defining and sending project configuration data is typically done only once at the start of the project. This procedure will automatically clear the PDA of any existing field data.]

2 Once the project data have been sent to the PDA, click **Exit** on the PDA Desktop interface.

3 If necessary, click **Exit** to close the **Creating/Configuring Inventories** window and click **OK** to leave the **Creating New Project** window.

Mapping Field Plots

The final step before data collection can begin is to determine the physical location of the plots. If the random plots were created in a GIS using the Random Plots Workbooks in the Appendices or another method, the plot shapefile can be overlaid on digital aerial photos of the study area to aid crews in locating plots and plot centers on the ground. In addition, detailed plot maps can be very useful in aiding crews in estimating plot cover percentages. Examples of plot maps can be found at www.itreetools.org under Resources > Archives > Eco Project Planning & Management Resources. If digital photos are not available or if the plots were created manually, they can be located on a digital land use or road map or on paper maps. Plot centers and plot boundaries should be identified.

With your plots plotted and your PDA configured or forms printed, you are ready for field data collection!

Phase III: Out in the Field

Plot Establishment

Sample inventorying begins with plot establishment. (If you're conducting a complete inventory you can skip to the next section.) Get permission to access the property if necessary (from resident or property owner).

Locate the plot center and plot boundaries using the aerial photographs and/or maps you created during Phase II. If the plot is sloped, measure slope with clinometer and adjust plot width accordingly. Adjusted plot radius can be read from the following table:

Slope %	5	10	12	15	17	20	22	25	27	30
Slope angle	2.9	5.7	6.8	8.5	9.7	11.3	12.4	14.0	15.1	16.7
Adj. radius (1/10 acre plot)	37.3	37.3	37.4	37.4	37.5	37.6	37.7	37.8	37.9	38.0
Adj. radius (1/6 acre plot)	48.1	48.2	48.2	48.3	48.4	48.5	48.6	48.8	48.9	49.1

In some cases, the plot *center* may fall in an inaccessible location, such as the middle of a building or highway. In this case, do not choose an alternate plot, but instead follow the instructions for Inaccessible Plot Centers to select a Tree Measurement Point (TMP) to use for subsequent data collection.

Adding a replacement plot

If you are completely unable to enter the plot or to collect data from afar, select an alternate plot. If you have a list of alternate plots, select the first plot from the list for that land use. For grid sampling schemes, the plot should be located in the same grid and land use as the non-accessible plot. Do not skip around the alternate list; go in sequence.

If you did not create extra plots during project configuration, you can manually add a new plot to the database when you are back at your desk by selecting **Edit** > **Enter or Edit Data** > **Add Plot**. The General Plot tab will then open up to a newly created plot which was added to your existing set. Plot data can then be entered manually into the form.

Inaccessible plot centers

In some cases, your plot center might fall in a location that is inaccessible, such as within a building or in the middle of a highway. The following describes how to determine plot boundaries and location of trees when plot centers are inaccessible (note that the numbers in the example only apply to 0.1 acre plots) (Fig. 1).

Determine '*a*' by estimating the approximate location of the true plot center from the aerial photo or map. Then calculate '*b*' by subtracting '*a*' from the plot radius (e.g., 37.2 ft. for a 0.1 acre plot). Then '*b*' is the distance from the plot boundary to the building wall.

To outline the general plot boundary walk parallel to the building for 26.2 ft (y_1), then perpendicular to the building for 11 ft (x_1). This would represent a point along the boundary approximately 45˚ from the start. If you then walk 11 ft (y_2) parallel to the building's edge, and 26.2 ft (x_2) perpendicular, the next plot boundary would be reached; representing a point 90˚ along a circle from your starting point.

To locate the trees that are in-plot more easily, the crew should first determine the plot boundaries as described above, and then pick a point from which distance and direction can easily be measured to serve as the Tree Measurement Point (TMP). In the figure, a corner of the building has been chosen as the TMP (the TMP should be recorded in the notes, e.g., northwest corner of building).

Remember to only record trees that are within the radius of the true plot center. Trees *c*, *d*, and *f* are all within the true plot boundary and must be inventoried. Tree *e*, on the other hand, is within 37.2 ft of the TMP, but not of the actual plot center. Therefore, it lies outside the plot boundary and is not tallied.
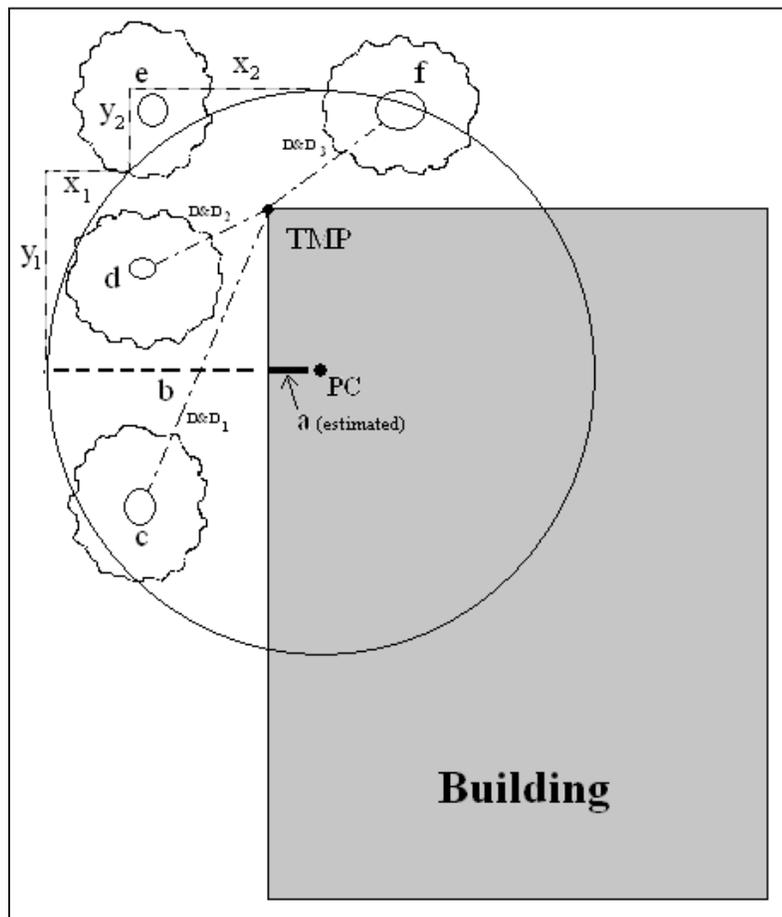
Fig. 1. Determining a Tree Measurement Point and plot boundaries

With the plot center, plot boundaries, and if necessary, a TMP, determined, you are ready to begin data collection. In the following sections, each data field is described in detail along with information on how to enter data on paper forms or using the PDA.

Survey information

Date: Optional. Date of data collection.

>Paper (sample and complete): Enter under **DATE**.

>PDA (sample and complete): Date is entered at the beginning of an inventory session under **Login**.

Crew: Optional. Name or number of crew conducting inventory.

>Paper (sample and complete): Enter under **CREW**.

>PDA (sample and complete): Name is entered at the beginning of an inventory session under **Login**.

Tree ID start no.: PDA only. A starting number for Tree IDs can be set for each PDA under **Login** so that duplicate numbers are not assigned.

Plot information

Plot ID: Required for sample inventories. Plot ID must be a unique identifier.

>Paper (sample): Enter a unique number under **PLOT ID** at the top of both pages.

>Paper (complete): NA

>PDA (sample): In the main **Plots** menu, select the Plot ID from the drop-down menu of all generated plots.

>PDA (complete): NA

Plot address: Required for permanent plots. Street address and any notes for locating plots in areas without street addresses.

>Paper (sample): Enter under **Plot address**.

>Paper (complete): Enter under **Location/Address**.

>PDA (sample): Enter under **Plots** > **Address**.

>PDA (complete): Enter under **Trees** > **Address**.

Stake: PDA (sample) only. If the location of permanent plots has been marked by a permanent identifier, check this **box**.

GPS Coordinates: Optional. GPS coordinates help if revisiting the site is necessary, although GPS accuracy can vary greatly, especially under trees.

> Paper (sample): Record latitude and longitude under **GPS COOR**.
>
> Paper (complete): Record latitude and longitude under **X Coord**. and **Y Coord**.
>
> PDA (sample and complete): NA

Photo: Optional. Use this to keep track of photo and memory card number if photos are taken.

> Paper (sample and complete): Record under **PHOTO ID**.
>
> PDA (sample): Record under **Plots** > **Photo**.
>
> PDA (complete): Record under **Trees** > **Add** > **Photo**.

Plot sketch: Optional. Draw a sketch of plot. Note distance and direction from plot center to fixed objects; sketch fixed objects in relation to plot center.

> Paper (sample): Sketch in empty space at the top of page 1.
>
> Paper (complete): Sketch on the back of the form.
>
> PDA (sample and complete): NA

Plot contact info: Optional. If available, record contact person's name and phone number. For residential land uses, do not ask for this information, but if name is on mailbox, record it. Owner vs renter status is useful if it comes up in conversation.

> Paper (sample): Record name and phone number under **Plot contact info**.
>
> Plot (complete): NA
>
> PDA (sample): Record under **Plots** > **Comment**.
>
> PDA (complete): NA

Percent measured: Required for sample inventories. The amount of the plot that the field crew is able to access and measure, either directly or by estimation. This allows for data collection for a partial plot. For example, if 10% of the plot is obscured from view behind a building or a tall stockade fence on land that you could not get permission to access, you would record 90%. (Safety concerns may also be a factor in accessing portions of the plot.) However, if you were able to look over a fence and estimate tree, shrub and ground covers and estimate DBH and other measurements for trees present on plot behind the fence, you would record 100%.

NOTE: For *stratified projects*, this category can serve an additional purpose in the unusual case that your plot falls across more than one of your designated strata. The plot center may be located within the appropriate land use but the plot boundaries may extend into a different land use with very different vegetation characteristics. In this case, you can collect data only on the portion of the plot that is within the designated land use and use

the percent measured field to document the adjustment. For example: If a plot center that is associated with the commercial land use strata has a plot boundary that includes some nearby forested land, you can specify the percent measured for vegetation within the commercial area of the plot and avoid having trees from the forest land use factored in the commercial land use.

Paper (sample): Record under **Percent measured**.

Paper (complete): NA

PDA (sample): Record under **Plots** > **% Measured**.

PDA (complete): NA

Tree cover: Required for sample inventories. The amount of the plot covered by tree canopy (in percent). You can imagine this as the area of the plot that would be shaded by trees when the sun is directly overhead, ranging from 0 to 100%. Tree cover can come from trees located outside the plot, so plots not containing trees can have tree cover. [HINT: Aerial images used as plot maps can be very helpful for determining tree cover percentages.] Record 0%, 100%, or mid-points of 5% intervals (3, 8, 13, 18, etc.).

Paper (sample): Enter under **PLOT TREE COVER (%)**.

Paper (complete): NA

PDA (sample): Enter under **Plots** > **% Tree cover**. If there are no trees present, check the **box** next to **No Trees on Plot**.

PDA (complete): NA.

Shrub cover: Required for sample inventories. The amount of the plot covered by shrub canopy (in percent). You can imagine this as the area of the plot that would be shaded by shrubs when the sun is directly overhead, ranging from 0 to 100%. Don't double-count multiple layers of shrubs. Record 0%, 100%, or mid-points of 5% intervals (3, 8, 13, 18...).

Paper (sample): Enter under **SHRUB COVER (%)**.

Paper (complete): NA

PDA (sample): Enter under **Plots** > **% Shrub**. If there are no shrubs present, check the **box** next to **No Shrubs on Plot**.

PDA (complete): NA

Plantable space: Optional. If you decided during Phase I: Getting Started: Early Decisions to measure the plantable space, estimate the amount of the plot area that is plantable for trees [i.e., plantable soil that is not under tree canopy or other overhead restrictions and where tree planting/establishment would not be prohibited due to land use (e.g., footpath, baseball field, etc.)]. Planting underneath utility wires is permitted. Record 0%, 100%, or mid-points of 5% intervals (3, 8, 13, 18, etc.). [HINT: A more accurate measurement can be obtained by using the sum of the following ground covers (collected below) as a starting point to evaluate plantable space: soil, duff/mulch, herb/ivy, maintained grass and

unmaintained grass.] As the definition for plantable space is somewhat subjective, project managers should make an effort to clearly define what counts as plantable space during crew training.

> Paper (sample): Enter under **PLANTABLE SPACE (%)**.
>
> Paper (complete): NA
>
> PDA (sample): Enter under **Plots** > **% Plantable**.
>
> PDA (complete): NA

Reference objects

Required for sample inventories. Identify at least one landmark visible when standing at plot center. Permanent plots require two, and two are recommended in all cases where the plot center is difficult to locate or identify. Reference objects do not have to be located within the plot. If you selected a TMP earlier because your plot center was inaccessible, it should be used as one of your reference objects.

Try to use objects that are likely to be present 5 to 15 years from now (e.g., stop signs, telephone poles, permanent structures, sidewalks/driveways). If the plot falls in a forested area and there are no man-made or permanent objects within sight, select two unique or "witness" trees (striking species or large DBH) that you expect to be present on the plot in the future. Photo(s) of reference objects are helpful. Describe the reference object very specifically (e.g., telephone pole 5 ft from left edge of driveway, when facing the house). Measure the distance and direction (1°–360°) *to* each reference object *from* the plot center.

> Paper (sample): Record the description, direction, and distance for one or two reference objects.
>
> Paper (complete): NA
>
> PDA (sample): From the **Reference Object** window, click **Add** and select an object type from the drop down list. Enter a distance and direction and click **Save**. Repeat if necessary for a second object. Click **Exit** when complete.
>
> PDA (complete): NA

Tree Measurement Point (TMP): If the plot center was inaccessible, you should select one of your reference points to serve as TMP.

> Paper (sample): Circle **Y** or **N** under **Tree Measurement Point** to identify a Reference Object as a TMP.
>
> Paper (complete): NA
>
> PDA (sample): In the **Reference Object** window, enter TMP in the **Comment** field of the object serving as the TMP.
>
> PDA (complete): NA

Land use

Actual land use: Required for sample inventories. Land use should be determined by the inventory team based on impressions out in the field (i.e., not from land use maps). This field describes how the land is being used, which is not necessarily the same as the ownership of the land.

NOTE: Eco uses these values to make adjustments to the model based on the differences in tree growth and valuation characteristics associated with predefined actual land uses. For example, a tree located in a Transportation plot will grow at a different rate than a similar tree that is located within a Golf Course or Residential plot. The actual land use categories can not be modified and *are not used to stratify your study*. Therefore, you will not receive a comparison of your project data based on the actual land use fields. Remember, you can use the Manage Map Land Use option to stratify your study.

The following land use types are included:

Residential (R): Freestanding structures serving one to four families each.

Multi-family residential (M): Structures containing more than four residential units.

[Note: A block of attached one- to four-family structures would be considered multi-family residential. A residential complex consisting of many separate one- to four-family structures and related greenspace would be also considered multi-family residential.]

Commercial/Industrial (C): In addition to standard commercial and industrial land uses, this category includes outdoor storage/staging areas as well as parking lots in downtown areas that are not connected with an institutional or residential use.

Park (P): Parks include undeveloped (unmaintained) as well as developed areas.

Cemetery (E): Includes any small unmaintained areas within cemetery grounds.

Golf Course (G): Self-explanatory.

Agriculture (A): Cropland, pasture, orchards, vineyards, nurseries, farmsteads and related buildings, feed lots, rangeland, timberland/plantations that show evidence of management activity for a specific crop or tree production are included.

Vacant (V): This category includes land with no clear intended use. Abandoned buildings and vacant structures should be classified based on their original intended use.

Institutional (I): Schools, hospitals/medical complexes, colleges, religious buildings, government buildings, etc.

[Note: If a parcel contains large unmaintained areas, possibly for expansion or other reasons, treat the area as Vacant. However, small forested islands in a maintained landscape would be considered Institutional.]

Utility (U): Power-generating facilities, sewage treatment facilities, covered and uncovered reservoirs, and empty stormwater runoff retention areas, flood control channels, conduits.

Water/wetland (W): Streams, rivers, lakes, and other water bodies (natural or man-made). Small pools and fountains should be classified based on the adjacent land use.

Transportation (T): Includes limited access roadways and related greenspaces (such as interstate highways with on and off ramps, sometimes fenced); railroad stations, tracks and yards; shipyards; airports; etc. If plot falls on any other type of road, or associated median strip, classify according to nearest adjacent land use.

Other (O): Land uses that do not fall into one of the categories listed above. This designation should be used very sparingly as it provides very little useful information for the model. Clarify with comments in Notes.

[NOTE: For mixed-use buildings, land use is based on the dominant use, i.e., the use that receives the majority of the foot traffic. It might not always occupy the majority of space in the building. For example, a building with commercial use of the first floor and apartments on upper floors would be classified as Commercial/Industrial.]

> Paper (sample): Enter codes for up to four land use types under **ACTUAL LAND USE**.
>
> Paper (complete): NA. Note that you will be asked later to identify the land use in which each tree is located.
>
> PDA (sample): In the **Land Use** window, click **Add** and select a land use from the drop-down menu. Enter a percentage as described below.
>
> PDA (complete): NA. Note that you will be asked later to identify the land use in which each tree is located.

Percent in each land use: Required for sample inventories. For plots that include only one land use, this value is 100%. For plots that include two or more land uses, estimate what percentage of the plot each land use occupies. For example, a plot that falls on the property line between a house and a convenience store might be 40% residential and 60% commercial/industrial. Land use differences must be clearly identifiable on the plot with a clear change in human use of the land, not just its cover or ownership.

> Paper (sample): Enter the percent for each land use type under **PERCENT IN**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Land Use** window, after you've selected a land use type, enter a percentage in **% of Plot**. Click **Save**. Add additional land uses until the Total % = 100. Then click **Exit**.
>
> PDA (complete): NA

Ground cover

Required for sample inventories. Within the plot, various materials will cover the ground (trees and shrubs are considered separately; tree stems as a ground cover are ignored). The crew should note the percentage of the plot ground area that is covered by the following materials:

Building (%BLDG)

Cement (%CMNT)

Tar (%TAR): Blacktop/asphalt

Rock (%ROCK): Pervious rock surfaces such as gravel, brick, or flagstone walkways or patios (without mortar). This category includes sand in playgrounds or added as topping to existing soil. Large solid rock outcrops should be listed as cement.

Bare soil (%SOIL): Includes naturally occurring sand.

Duff/mulch (%DUFF/MULCH): Loose organic material, leaf litter.

Herbs (%HERB/IVY): Herbaceous ground cover, other than grass, including agricultural crops.

Grass (%MAIN.GRASS)

Unmaintained grass (%UNMAIN.GRASS)

Water (%H20): Includes pools.

Estimate the percentage of each ground cover type to the nearest 5% unless cover is minimal. If trace amounts are present, 1, 2, 3%, etc. is acceptable. The sum of the proportions must add to 100% per plot. Use the following chart as a guide when estimating 1 and 5% increments of cover. (Some examples for comparison: a queen size mattress covers 35 sq. ft.; a full-size SUV covers 90 sq. ft.).

Percent of 0.1 acre site	Area (sq ft)	Diameter of circle (ft)
1%	44	7.5
5%	218	16.5
10%	437	23.6
25%	1,091	37.3
50%	2,183	52.7
75%	3,274	64.6
100%	4,365	74.5

Paper (sample): Enter the percentage of each ground cover under the appropriate category (given above in parentheses).

Paper (complete): NA

PDA (sample): In the **Ground Cover** window, click **Add** and select a ground cover from the drop-down menu. Enter a percentage in the **% of Plot** field and click **Save**. Continue adding ground covers until Total % = 100, then click **Exit**.

PDA (complete): NA

Shrub information

Optional for sample inventories; not available for complete inventories. You should complete this section if you decided to collect information on shrubs during the Phase I: Getting Started: Early Decisions.

For sample inventories, during Plot Information data collection, you were required to enter the percentage of the plot that was covered by shrubs. This phase focuses just on that area. For inventory purposes, shrubs should be grouped into masses of the same species and approximate height. For instance, if your plot includes five azaleas of similar heights in different areas, you can group them together and enter them as one group. A tree with DBH < 1 inch is considered a shrub. Record a maximum of twelve shrub groups. If there are more than twelve, record measurements for the first eleven, then lump the remaining shrubs into the twelfth group.

Paper (sample): For each shrub group, enter data for the four fields below under the **SHRUB** heading.

Paper (complete): NA

PDA (sample): In the **Shrubs** window, click **Add** to add a new shrub group and complete the four fields below.

PDA (complete): NA

Shrub species: Identify the shrub species. If this is not possible, the plant must be identified by its genus at a minimum; if genus is not known, then collect a sample for identification.

Paper (sample): Enter species name or species code under **SHRUBS** > **SPECIES**. Visit the i-Tree website, www.itreetools.org > Resources, for PDF and Excel spreadsheet of species code list.

Paper (complete): NA

PDA (sample): In the **Shrubs** window, after clicking **Add,** select a species from the drop-down list. You can switch among botanical name, common name, and species code using the drop-down menu at the top right. You can also search by typing in the **Species Search** box.

PDA (complete): NA

Shrub height: Measure the height of the shrub group to the nearest 0.1 ft/m. Height of shrub groups of a particular species will likely differ across the plot. An average height

may be used and different shrub masses grouped together where variation in height is relatively small.

> Paper (sample): Enter under **SHRUBS** > **HEIGHT**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Shrubs** window, enter under **Height**.
>
> PDA (complete): NA

Percent of total shrub area: Measure the percent of the total shrub area (i.e., not the total plot area) represented by this species/height combination. The total for all the shrub groups recorded on the plot must equal 100%. Where there are two or more layers of different shrub species, record the percent area of the entire tallest shrub mass, but only the area of the shorter shrub mass that is not shaded (overtopped) by the taller shrub, i.e., visualize the area of the shrub masses from a birds-eye view, and report the percent of the shrub masses as seen from above.

> Paper (sample): Enter under **SHRUBS** > **% AREA**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Shrubs** window, enter under **% Area**.
>
> PDA (complete): NA

Percent of the shrub mass that is missing: Visualize the shrub mass of this species/ height group as a volume (height x ground area) and record the percent of the volume that is missing, i.e., not occupied by leaves. The shrub mass leaves are assumed to start at the ground. The intent of this variable is to adjust height and area measurements to reveal actual volume of leaves and to allow you to account for voids in vegetation and inaccuracies in simple height x area estimates (e.g., height of mass might not be uniform). Allow for natural arrangement or spacing of leaves; however, you should investigate the interior of the shrub mass to better estimate the missing portions. In the past, crews have underestimated the mass missing by not accounting for the interior.

Percent Missing should be recorded as 0% or as mid-points of 5% intervals (3, 8, 13, etc.).

> Paper (sample): Enter under **SHRUBS** > **% MISSING**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Shrubs** window, enter under **% Missing**. Click **Save** to save that group, and click **Add** to continue adding shrub groups until the Total = 100%.
>
> PDA (complete): NA

Tree information

Data collection for living and dead trees starts with the tree farthest to the north and proceeds in a clockwise direction. If your plot center is inaccessible and you have

designated a TMP (see Inaccessible Plot Centers for more information), use it for measuring distance and direction, but remember that the plot itself does not shift to have the TMP as the center—only measure trees within the true plot boundaries based on the true plot center. All trees with DBH ≥ 1 inch should be recorded if at least half of their trunk lies within the plot.

NOTE: *What is a tree?* At different stages of its life, a tree can be classified as ground cover, shrub, or tree in the Eco model. The following excerpt is adapted from the journal article "A Ground-Based Method of Assessing Urban Forest Structure and Ecosystem Services" (available at www.itreetools.org under Resources > Archives) and may help Eco users distinguish between available field options.

Typically, shrubs are defined as woody material with a dbh less than 2.54 cm (1 in), whereas trees have a dbh greater than or equal to 2.54 cm (1 in). Woody plants that are not 30.5 cm (12 in) in height (e.g., seedlings) are considered herbaceous cover.

Trees and shrubs can also be differentiated by species (i.e., certain species are always trees or always shrubs) or with a different dbh minimum threshold. For example, in densely forested areas, increasing the minimum dbh to 12.7 cm (5 in) can substantially reduce the field work by decreasing the number of trees measured, but less information on trees will be attained.

NOTE: Flagging or chalking each tree as it is measured will help keep track of trees and prevent missing or double-entering a tree. Do not leave permanent marks (paint or scribe marks) on trees.

Tree ID: Required. Each tree in a plot requires a unique ID.

Paper (sample and complete): Enter under **TREE ID**. Begin with 1 and assign sequentially.

PDA (sample): From the **Trees** window, click **Add**. A Tree ID is generated automatically and you now have access to four additional tabbed windows: Address, Detail, Stems, and Bldg. Each will be used below.

PDA (complete): From the **Trees** window, click **Add**. A Tree ID is generated automatically based on the Start ID number entered during Log In. You now have access to three additional tabbed windows: Address, Detail, and Stems. Each will be used below.

Direction from plot center: Required. Direction from plot center to the tree in compass degrees/azimuths (e.g., north = 360°; east = 90°; south = 180°). If plot center

is inaccessible, measure direction from TMP. Make sure that TMP info is recorded in Reference Object sections of paper forms or on PDA.

> Paper (sample): Enter azimuth in degrees under **DR**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Address** window, use compass circle to define.
>
> PDA (complete): NA.

Distance to plot center: Required. Shortest distance (in ft or m) from plot center to edge of trunk at DBH, measured parallel to the ground. In heavily wooded plots, accuracy is critical to allow trees to be found in the future. If plot center is inaccessible, measure distance from TMP. Make sure that TMP info is recorded in Reference Object section of paper forms or on PDA.

> Paper (sample): Enter shortest distance to tree under **DS**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Address** window, enter under **Distance to Plot Ctr**.
>
> PDA (complete): NA

Land Use: Required for sample inventories. Record the land use in which the tree is located.

> Paper (sample and complete): Use land use codes defined above and enter under **LAND USE**.
>
> PDA (sample): In the **Address** window, select the land use from the drop-down list. Only land uses you identified for the specific plot will be included.
>
> PDA (complete): In the **Address** window, select the land use from the drop-down list.

Species: Required. If the species can not be identified, take and number a sample, record in notebook as Plot # XXX unknown #1, etc. If using PDA, record as UNKN#1, UNKN#2, etc. Each time that same unknown is encountered on the plot, it should be recorded with the same number. Sequentially number unknowns in notebook and attempt to identify later. After samples have been identified at the office, go back and enter correct species code on paper form or in PDA. If after all references guides have been checked and identification of individual species is still difficult (e.g., due to hybridization), then record genus if possible. For dead trees, when species or genus cannot be determined, record as Dead tree unknown hardwood or Dead tree unknown softwood.

> Paper (sample and complete): Enter under **TREE SPECIES**. If you wish to use species codes, you'll find a PDF and an Excel spreadsheet of the species code list on the i-Tree website, www.itreetools.org under Resources.
>
> PDA (sample): In the **Detail** window, select a species from the drop-down list. You

can switch among botanical name, common name, and species code using the **View/Search By** list. You can also search by typing in the **Species Search** box.

PDA (complete): In the **Detail** window, select a species from the drop-down list. You can switch among botanical name, common name, and species code using the **View/Search By** list. You can also search by typing in the **Species Search** box.

Tree site: Optional. Record whether tree is a street tree or not (S or N).

Paper (sample and complete): Enter **S** or **N** under **TREE SITE**.

PDA (sample): In the **Detail** window, select **S** or **N** from the drop-down menu under **Site**.

PDA (complete): In the **Detail** window, select **S** or **N** from the drop-down menu under **Site**.

Dead: PDA only. Checking this box will fill in all default options for dead trees automatically.

Paper (sample and complete): NA

PDA (sample): In the **Detail** window, check the **box** next to **Dead** if the tree is dead.

PDA (complete): In the **Detail** window, check the **box** next to **Dead** if the tree is dead.

Status: The eight possible statuses of a tree are shown below. In an initial inventory of a project area, all trees will be identified as Planted (P), Ingrowth (I), or Unknown (U). In future inventories of the same plot, new trees will be identified as P, I, or U. Trees that were present during a previous inventory should be identified with the other status codes.

During initial inventories or when inventorying new trees in subsequent inventories, please make a concerted effort to determine whether trees have been planted [(P) Planted] or have self-seeded [(I) Ingrowth] as that information will be more valuable for future reporting and enhancements of the Eco model. Although it is not recommended, you can choose (U) Unknown if you are unable to establish whether a tree was planted or self-seeded.

P: Planted—the tree was planted intentionally

I: Ingrowth—the tree self-seeded

U: Unknown—planted vs. ingrowth can not be determined

During subsequent inventories of plots, use the following codes to define the current status of trees that existed in the previous inventory.

N: No change in status—this tree was present in a previous inventory and is present today

H: Removed for hazard/health problem—the tree has been removed since the

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previous inventory for health or safety reasons

C: Removed but healthy—a healthy tree was removed by the property owner

L: Removed owing to land use change—the tree was removed due to land use change (e.g., development of site)

R: Removed, unknown—tree removed for unknown reason

[NOTE: The model will not include calculations for trees with a "removed status" of H, C, L or R.]

Paper (sample and complete): Enter the status code under **STAT**.

PDA (sample): In the **Detail** window, select the **Status** from the drop-down menu.

PDA (complete): In the **Detail** window, select the **Status** from the drop-down menu.

Total tree height: Required. Measure the height to top (alive or dead) of tree (to nearest ft or m) (Fig. 2). For standing dead trees, downed living trees, or severely leaning trees, height is considered the distance along the main stem from ground to tree top. (Do not include dead trees that are lying on the ground.)

Paper (sample): Enter tree height under **HEIGHT** > **TOT**.

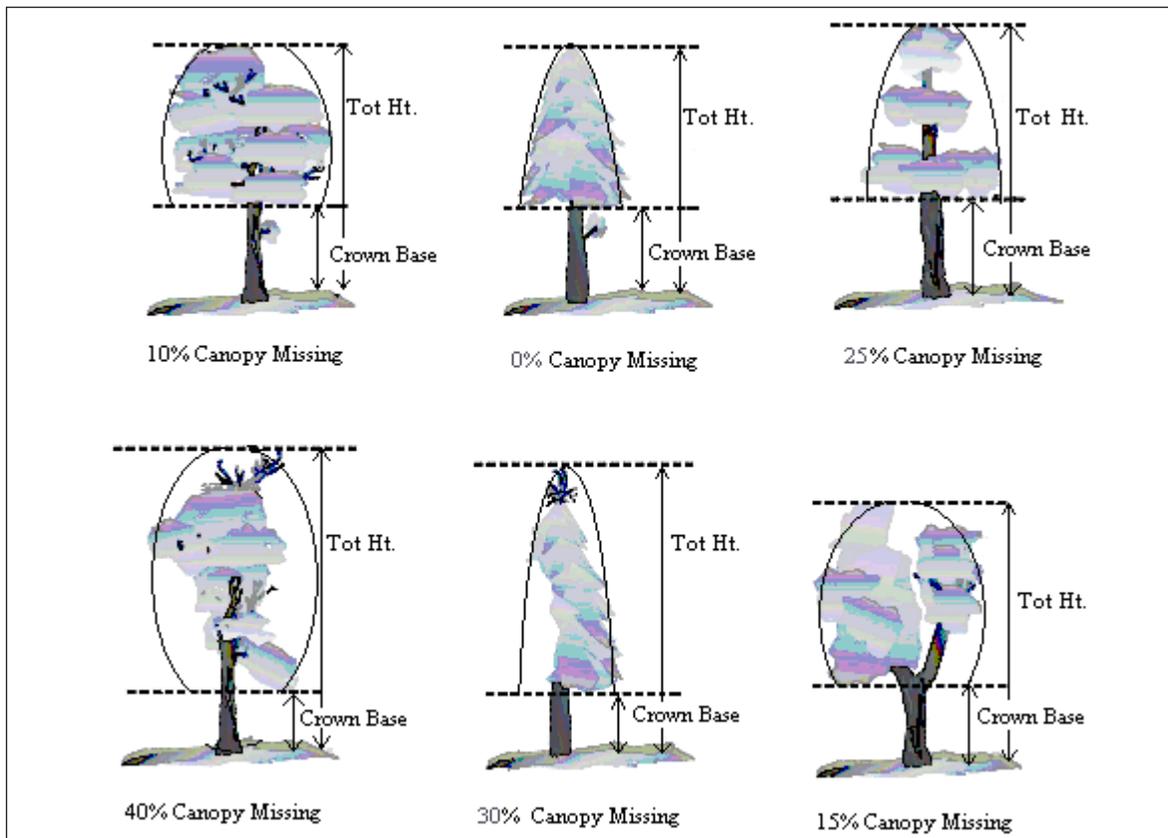Paper (complete): Enter tree height under **Height** > **Total Height**.

Fig. 2. Illustration of how to measure height to crown base and percent canopy missing.

PDA (sample): In the **Detail** window, enter under **Tot Hgt**.

PDA (complete): In the **Detail** window, enter under **Tot Hgt**.

Height to live top: This height will be the same as total tree height unless the tree is alive but the top of the crown is dead. This variable cannot be greater than total tree height. Record to the nearest foot or meter.

Paper (sample and complete): Enter under **HEIGHT** > **LIVE TOP**.

PDA (sample and complete): In the **Detail** window, enter under **Live Top**.

Height to crown base: Required. Measure height to base of live crown (to nearest ft or m). The live crown base is the point on the main trunk perpendicular to the lowest live foliage on the last branch that is included in the live crown. The live crown base is determined by the live foliage and not by the point where a branch intersects with the main bole (Fig. 2). (Record dead trees as -1. PDA will fill in default value of -1 if Dead box was checked.)

Paper (sample and complete): Enter under **HEIGHT** > **CROWN BASE**.

PDA (sample and complete): In the **Detail** window, enter under **Crn Base**.

Crown width: Required. Measure crown width (to nearest ft or m) in two directions: north-south and east-west or as safety considerations or physical obstructions allow. If tree is downed or leaning, take width measurements perpendicular to the tree bole. (Record dead trees as -1. PDA will fill in default value of -1 if Dead box was checked.)

Paper (sample): Enter under **CROWN WIDTH** > **N-S** and **E-W**.

Paper (complete): Enter under **Crown Attributes** > **Width N-S** and **Width E-W**.

PDA (sample and complete): In the **Detail** window, enter under **Crn E/W** and **Crn N/S**.

Percent canopy missing: Required. Percent of the crown volume that is not occupied by branches and leaves. Missing canopy should be measured by two people standing at perpendicular angles to the tree (Fig. 3). Visualize the expected "typical crown outline" as a symmetrical silhouette created by the live crown width, total height, and height to base of live crown measurements. It is assumed to be symmetrical around the center point of the measured width of the tree and filled with leaves as if it were a healthy tree in excellent condition.

Now estimate the percent foliage that is absent due to pruning, dieback, defoliation, uneven crown, or dwarf or sparse leaves. Do not include normal interior crown voids due to leaf shading. Take into account the natural crown shape for the particular species (Fig. 2).

Be sure to base your estimate of percent canopy missing on the crown that you have measured. For example, one-third of the crown may have been removed for power line

VIEWING THE CROWN

1/2 to 1 tree length away

grade level or upslope

90°

crew members 90 degrees to each other
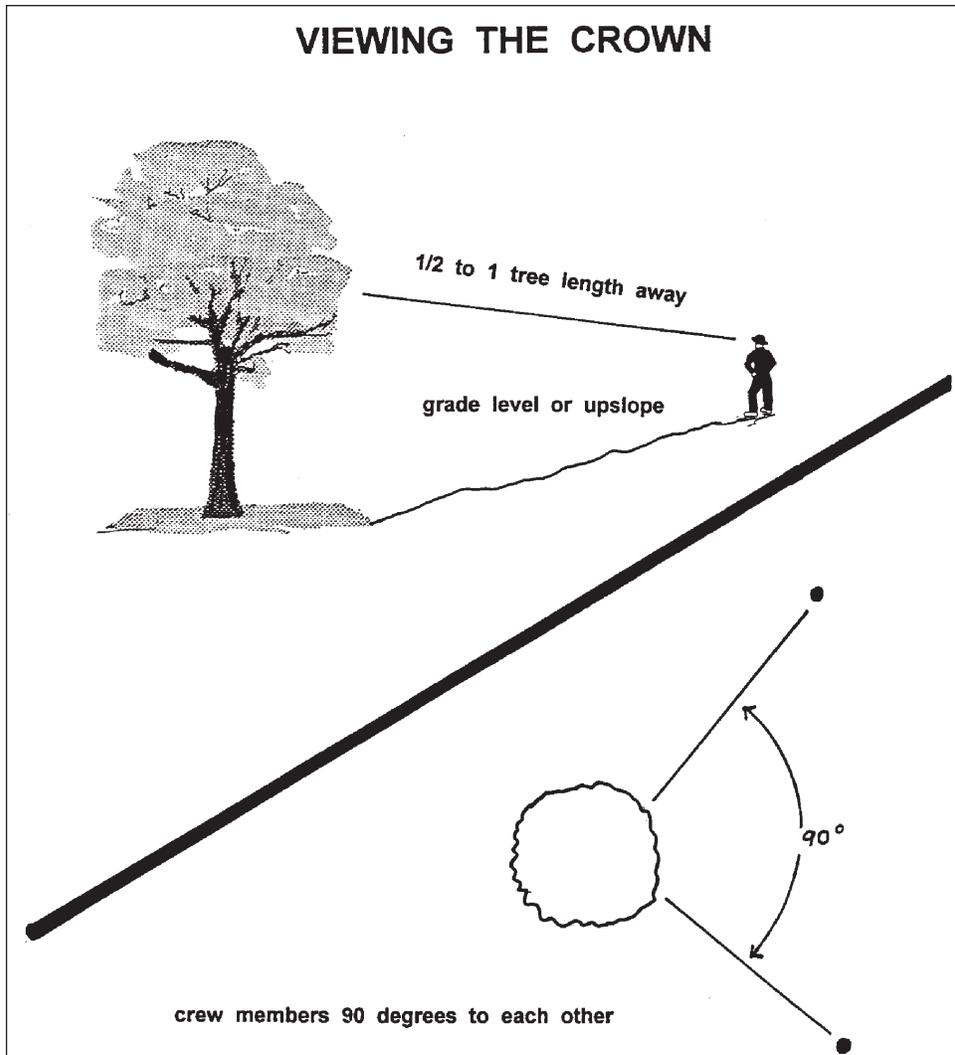
Fig. 3 How to position yourself to measure the crown.

clearance or the canopy could be very lopsided due to presence of a neighboring tree. However, the crown that remains could have a 0% missing value, if it is full. If the two observers disagree in their estimates, follow the guidelines listed below under Crown Rating Precautions.

Record percent canopy missing as 0%, 100% or mid-points of 5% intervals (3, 8, 13, 18, etc.). (Record as 100% for dead trees. PDA has a fixed value of 100 if Dead box was checked.)

> Paper (sample): Enter under **% MISS**.

> Paper (complete): Enter under **Crown Attributes** > **% Missing**.

> PDA (sample and complete): In the **Detail** window, select a value from the drop-down menu for **Crn Miss**.

Crown rating precautions

Crews must be especially careful when making evaluations under certain conditions and follow the procedures below.

Distance from the tree: Attempt to stay at least 1/2 to 1 tree length from the tree being evaluated. Some ratings change with proximity to the tree. In some situations, it is impossible to satisfy this step, but do the best you can in each case. All evaluations are made at grade (same elevation as base of the tree) or up slope from the tree. This may not be possible in all cases but never get in the habit of evaluating trees from the down slope side.

View of the crown: Two crew members should stand at angles to each other to evaluate trees, striving to obtain the best view of the crown. The ideal positions are 90 degrees apart on flat terrain (Fig. 3). Don't evaluate the tree from the same position or at 180 degrees unless no other option exists. In heavily canopied areas, getting a good perspective of the crown becomes difficult. Overlapping branches, background trees, and lack of a good viewing area can cause problems when rating some trees. Crews need to move laterally to search for a good view. Take special care when rating such trees.

Climatic conditions: Cloudy or overcast skies, fog, rain, and poor sun angles may affect estimates. Crown diameters may be affected but to a lesser degree than other crown indicators. Crown dieback may be underestimated because it is difficult to see dead twigs or to differentiate defoliated twigs from dead twigs. Be especially careful during poor lighting conditions. Move around a tree to get another view, even if the view appears adequate at a specific location.

Heavy defoliation: During heavy defoliation, crown dieback may be overestimated. The use of binoculars may help in separating dead twigs from defoliated twigs.

Trees with epicormic branches or sprigs: Trees that are densely covered in epicormic sprouts are not considered special cases in field data collection. There are two methods for handling this situation. The first choice is not to consider epicormic sprouts as part of the live crown base (if located under the actual branches crown base). The foliage the epicormics do produce for the tree would be considered for the percent canopy missing, proportionately decreasing the amount of percent canopy missing.

EXAMPLE: A tree has epicormic sprouts extending to four feet from the ground, but its live crown base is measured at eight feet high. The crew estimates the percent canopy missing at 15%, but also estimates the additional four feet of epicormic sprouts to contain approximately 5% of canopy cover. The percent canopy missing would then be recorded as 10%. All of the percentages would be based on the crown measurements (crown widths, total height, and crown base height).

The second way would be to lower the crown base measurement to the lowest epicormic sprout, and then that point would be used to estimate the percent canopy missing of the tree. More times then not this method will increase the percent canopy missing.

Either way of handling epicormic branches will work with Eco, but in the field, it is helpful to be consistent. Use one method or the other for most, if not all, of the cases when encountering epicormic sprouts.

If a tree's canopy consists only of epicormic sprouts, or if they are located above the crown base, then they will be considered the canopy. Measure them as if they were the crown.

Resolving measurement differences: If the crown measurement estimates from two crew members do not match, arrive at the final value by:

- Taking an average, if the numbers differ by 10% (2 classes) or less.

- Changing positions, if the numbers differ by 15% or more and attempt to narrow the range to 10% or less.

- Averaging the two estimates for those trees that actually have different ratings from the two viewing areas (ratings of 30 and 70 would be recorded as 50)

Crown dieback: Required. Percent dieback in crown area. This dieback does not include normal, natural branch dieback, i.e., self-pruning due to crown competition or shading in the lower portion of the crown. However, branch dieback on side(s) and top of crown area due to shading from a building or another tree would be included. For more information, see the Forest Inventory and Analysis National Core Field Guide.
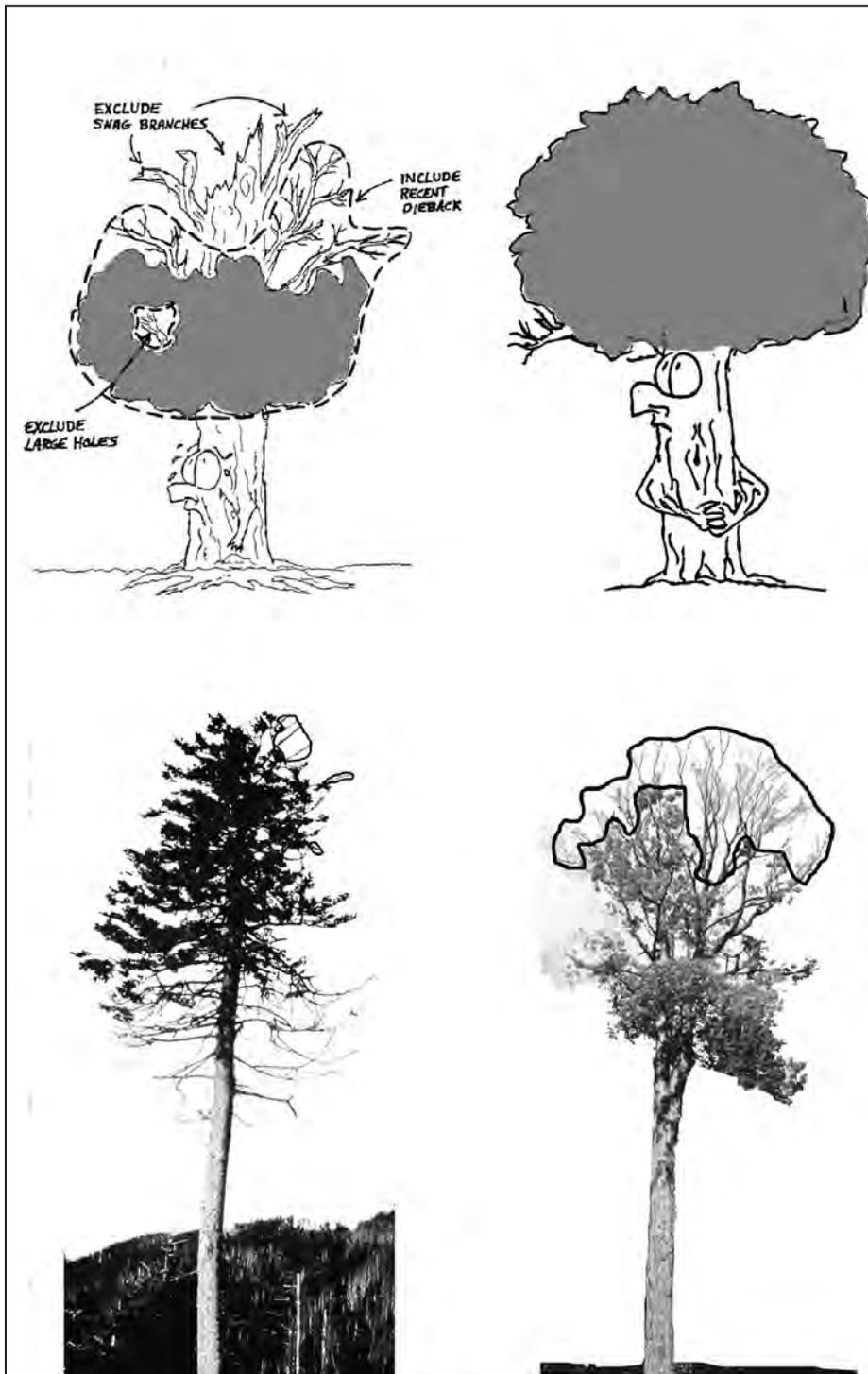

Fig. 4. Dieback rating examples.

Estimate crown dieback as a percentage of the live crown area, including the dieback area. Assume the perimeter of the crown is a two-dimensional outline from branch tip to branch tip, excluding snag branches and large holes or gaps in the crown (Fig. 4). Crown dieback is obtained by two people (Fig. 3) using binoculars. You should be conscious of lighting conditions and how light affects the day's observations, taking extra time under limited-light conditions.

Each individual should mentally draw a two-dimensional crown outline, block in the dieback and estimate the dieback area. If the two observers disagree in their estimates, follow the guidelines listed under Crown Rating Precautions.

Record crown dieback as 0%, 100% or mid-points of 5% intervals (3, 8, 13, 18, etc.). (Record as 100% for dead trees. PDA has a fixed value of 100 if Dead box is checked.)

>Paper (sample): Enter under **DB**.
>
>Paper (complete): Enter under **Crown Attributes** > **% Dieback**.
>
>PDA (sample and complete): In the **Detail** window, select a value from the drop-down menu for **Dieback**.

Crown light exposure: Required. Number of sides of the tree receiving sunlight from above (maximum of five). Top of tree is counted as one side. Divide the crown vertically into four equal sides. Count the number of sides that would receive direct light if the sun were directly above the tree (Fig. 5). One-third of the live crown must be receiving full light in order for a side to qualify. A sliver of a side receiving light does not qualify. Use the following codes:

Figure 1. Crown Light Exposure
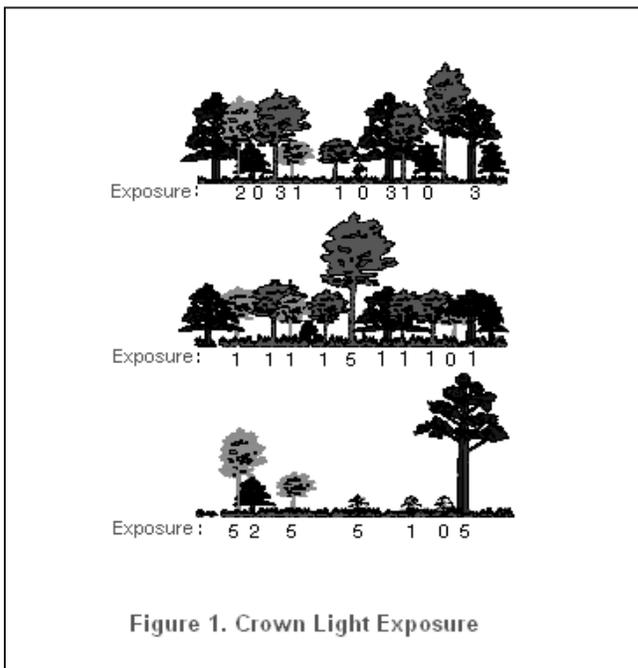
Fig. 5: Crown light exposure

-1: Dead trees.

0: The tree receives no full light because it is shaded by trees, vines, or other vegetation.

1: The tree receives full light from the top or 1 side.

2: The tree receives full light from the top and 1 side (or 2 sides without the top).

3: The tree receives full light from the top and 2 sides (or 3 sides but not top).

4: The tree receives full light from the top and 3 sides.

5: The tree receives full light from the top and 4 sides.

Paper (sample and complete): Enter under **CLE**.

PDA (sample and complete): In the **Detail** window, enter under **CLE**.

Percent impervious surface under the tree: If you decided to collect information related to hydrology during Phase I: Getting Started: Early Decisions, this field is required. Estimate the percent of the area beneath the dripline of the tree that is impervious. If the tree crown crosses out of the plot boundary, the entire area beneath the tree is still considered. Record 0%, 100% or mid-points of 5% intervals (3, 8, 13, 18, etc.).

Paper (sample): Enter under **% IMP**.

Paper (complete): NA

PDA (sample): In the **Detail** window, select a value from the drop-down menu for **%Imperv**.

PDA (complete): NA

Percent shrub cover under the tree: If you decided to collect information related to hydrology during Phase I: Getting Started: Early Decisions, this field is required. Estimate the percent of the area beneath the drip line that is occupied by shrubs. If the tree crown crosses out of the plot boundary, the entire area beneath the tree is still considered. Record 0%, 100% or mid-points of 5% intervals (3, 8, 13, 18, etc.).

Paper (sample): Enter under **% SHRUB**.

Paper (complete): NA

PDA (sample): In the **Detail** window, select a value from the menu for **%Shrub**.

PDA (complete): NA

DBH: Required. Record the tree's DBH on the uphill side of the tree to the nearest 0.1 inch/cm. For trees with irregular DBHs (Fig. 6):

Forked (multi-stemmed) tree: If the point of pith separation is above ground (Fig. 7), the plant is considered to be one tree. Measure the DBH of up to six stems separately. If the tree has more than six stems with DBH ≥1 inch, lower the measurement height to 1 ft above the ground and record the diameter of up to six stems (selecting the largest and ignoring any others). If the pith union is below ground, each stem is considered a separate tree (included bark down to ground is a good indicator that pith union is below ground).
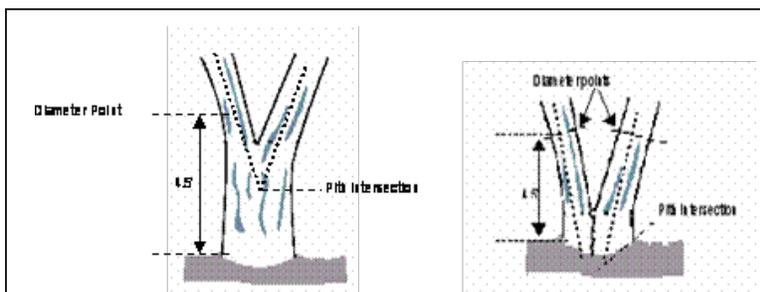
Fig. 7. Measuring DBH in forked (multistemmed) trees.
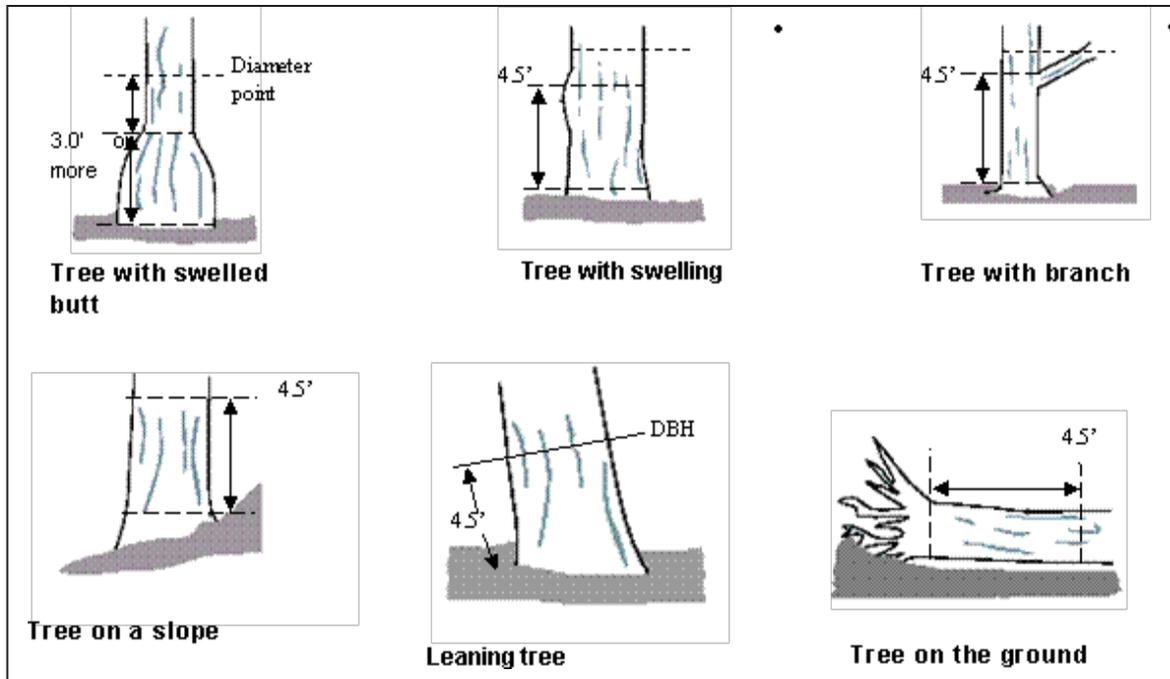
Fig. 6. Measuring irregular DBHs.

Root sprouts: Any root sprouts with DBH ≥1 inch should be measured as separate trees. Root sprouts with DBH < 1 inch can be ignored.

Tree with butt-swell or bottleneck: Measure these trees 1.5 ft. above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 ft. or more above the ground.

Tree with irregularities at DBH: On trees with swellings, bumps, depressions, branches at DBH height, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

Tree on slope: Measure diameter at 4.5 ft. from the ground along the bole on the uphill side of the tree.

Leaning tree: Measure diameter at 4.5 ft. from the ground along the bole. The 4.5 ft. distance is measured along the underside face of the bole.

Live windthrown tree: Measure from the top of the root collar along the length to 4.5 ft.

Paper (sample): For normal conditions, enter under **DBH** > column **1**. Use columns 2–6 if necessary.

Paper (complete): For normal conditions, enter under **DBH1**. Use DBH2–DBH6 if necessary.

PDA (sample and complete): DBH entry fields are accessed under the **Stems** tab. Click **Add** to begin entering DBHs. The stem ID will be generated automatically. Enter a value under **Diameter**.

DBH measurement height: If DBH was not measured at 4.5 ft, measure the height where DBH was taken.

> Paper (sample and complete): Enter under **HT DBH**.
>
> PDA (sample and complete): In the **Stems** window, a value of 4.5 is generated automatically. Correct if necessary.

DBH measured: PDA only. Whenever possible DBH should actually be measured, but if necessary it can be estimated visually. If DBH was measured check this box on the PDA.

> Paper (sample and complete): NA
>
> PDA (sample and complete): In the **Stems** window, if direct measurements were made, check the **box** next to **DBH Measured**.

Direction to building: If you decided to collect information related to energy effects during Phase I: Getting Started: Early Decisions, this field is required. For trees (≥20 ft. tall) that are located within 60 ft. of space-conditioned residential buildings that are three stories or fewer in height (two stories and an attic), record the direction (azimuth in degrees) from the tree to the closest part of the building. For multi-family dwellings, treat all the units in the building as a single building. The building does not have to be located on the plot. The energy analyses are currently set to run for typical building types and climate zones of the United States. Up to three buildings can be recorded using the paper forms; an unlimited number of buildings can be recorded with the PDA. Standing dead trees that meet the above conditions should be included.

> Paper (sample): Enter the direction to the three closest buildings under **TREES NEAR BUILDINGS** > **D1/D2/D3**.
>
> Paper (complete): NA
>
> PDA (sample): Building-related fields are accessed under the **Bldg** tab. Click **Add** to add the first building. The Bldg ID will be filled in automatically. Enter a value under **Direction**.
>
> PDA (complete): NA

Shortest distance to building: If you decided to collect information related to energy effects during Phase I, this field is required. For buildings recorded above, measure the shortest distance from the tree to the closest part of the building (in m or ft). Standing dead trees that meet the above conditions should be included.

> Paper (sample): Enter the distance to the three closest buildings under **TREES NEAR BUILDINGS** > **S1/S2/S3**.
>
> Paper (complete): NA
>
> PDA (sample): In the **Bldg** window, add a value under **Distance** and click **Save** to save that building. Add additional buildings if necessary.
>
> PDA (complete): NA

Pest detection: If you decided during Phase I to collect pest information according to the Pest Detection Protocol, these fields are required. Once Pest is selected on the PDA or Desktop, the initial pest detection window requires that you first choose yes or no to activate the individual Tree Stress, Foliage/Twigs, and Branches/Bole categories. If you select "yes" for any of these options, you will need to further characterize the signs and symptoms within the activated categories.

For detailed field data descriptions of the Pest Detection collection protocol, refer to the Pest Detection manual under Resources > Manuals and Workbooks at www.itreetools.org or the online Wiki Pest Detection Resources site (wiki.bugwood.org/IPED).

If you identified any signs or symptoms under any of the three categories, you will need to select a Primary Pest if known. If you are unsure, select Unknown as the protocol is not meant to be a diagnostic tool but a systematic method to evaluate and document pest and disease sign and symptoms.

If no signs or symptoms of pest or disease presence were indicated, select **None**.

> Paper (sample or complete): If you are interested in using a paper form for pest detection data collection, you can modify the Excel spreadsheet template found at www.itreetools.org under Resources > Archives > Pest Detection section.   Data can be entered manually in Eco by selecting the Pest button on the Tree Info tab of the data entry form.

> PDA (sample or complete): In the **Pest** window, select a radio button to further document pest and disease sign and symptoms as described in the Pest Detection manual.

Finishing Up the Plot or Site

For complete inventories, continue entering trees until all trees on the site have been inventoried. Check thoroughly to be sure all required fields are complete and all entries are reasonable.

For sample inventories, continue entering trees until all trees on plot have been accounted for. It is the responsibility of each crew to complete all variables before leaving the sample plot. Before leaving the plot, check thoroughly to be sure all required fields are complete and all entries are reasonable. For PDA users, once all trees have been entered, click **Exit/Done** and check the **box** on the **Plots** window next to **Mark Completed**. You're ready to move on to the next plot.

Quality Assurance Plan

This Quality Assurance (QA) Plan was designed specifically for i-Tree Eco data collection using either volunteer or professionally trained field crews. Although originally intended for sample inventories, it can be modified for complete inventories.

It is important to implement QA procedures to ensure accurate data. By setting standards and monitoring fieldwork, one can prevent or at least detect and correct errors and eliminate the repetition of most errors. Quality assurance procedures used in data collection should be documented for future project management reference especially if you plan to repeat your project in the future. Although Quality Assurance information and procedures are not included in the Eco reporting, it is an essential part of a project to ensure consistency of collected data and model results for your project.

After the initial training period, periodic inspections should be made of every crew's fieldwork. Inspections are the most important mechanism for assuring quality data. The number of errors detected will determine the frequency of inspections.

Definitions

Quality Assurance: Quality Assurance (QA) is a procedure to ensure that the field data are collected accurately. QA involves a series of hot and cold checks of the field plots.

Hot Check: Trainer works with the crew as they conduct measurements on the plot to ensure that they have mastered the measurement techniques. Hot checks are normally done as part of the training process. Trainer observes crews during data collection and checks their measurements while the crew is at the plot. Hot checks are informal, allowing for one-on-one interaction between the trainer and the trainee. Errors encountered during hot checks are corrected.

Cold Check: Cold checks are done at regular intervals throughout the field season. An inspector or alternate crew member revisits a plot after it has been completed. The original crew is not present, and critical measurements are checked. Plots should be selected at random so field crews do not know which plots will have a cold check. Errors encountered during cold checks are corrected.

QA timing

After the initial field training, a series of hot and cold checks should be completed on approximately 5% of the plots, with more cold than hot checks (e.g., 70% cold and 30% hot). Every crew should be hot and cold checked. It is important to perform several QA checks early in the data collection process, but occasional checks should be performed throughout the field season.

Week 1 and Week 2: Hot checks are conducted on a variety of plot types (wooded, residential, etc.)

Weeks 3–7: Cold checks are conducted on a variety of plot types (e.g., plots with low/no tree cover, plots with a few trees, and plots with high number of trees). For plots with <5 trees, verify that all trees on the plot were measured, verify species identification is correct, re-measure DBH and total height, and verify building interaction for all trees. For plots with >5 trees, verify that all trees on the plot were measured and verify species identification

is correct for all trees. Then for 5 randomly selected trees, re-measure DBH and total HEIGHT, and verify building interaction. Use the paper data collection forms during QA for each plot selected, with remeasurements recorded for the selected trees.

Variables to remeasure

The variables in the table below should be remeasured and recorded on a QA tree data form (see below for data collection suggestions). Measurement quality objectives (MQOs) are also listed. MQOs are objective, quantitative statements describing the tolerable level of error (deviation between true and measured value) for a given measurement. They are the objective standards against which data quality is measured. An MQO for a measurement generally consists of a maximum acceptable error size and the percent of the time that measurement error must be less than or equal to the maximum error. When measurements can be repeated with uniform results by several individuals, it is proper to set close tolerance limits that define acceptable data.

For variables that require subjective evaluation, tolerance limits should reflect the degree of subjectivity. Attributes with greater subjectivity should have broader tolerance limits.

Variable	Measurement unit	MQO
Land use	Land use	No errors, 99% of the time
Plot tree cover	5% classes	Within two 5% classes, 95% of the time
Tree count		
< 25 trees on plot	Presence/absence	No errors, 90% of the time
≥ 25 trees on plot	Presence/absence	Within 3% of total, 99% of the time
Tree species (or genus if species cannot be determined)	Species	No errors, 95% of the time
DBH		
Tree with 1–10 inch DBH	0.1 inch	Within 0.1 inch, 95% of the time
Tree with > 10 inch DBH	0.1 inch	Within 3%, 95% of the time
Tree total height	1 ft	Within 10%, 95% of the time
Building interaction	No. of buildings	No errors, 95% of the time

For all other measurements at the plot and tree level, make sure all items have been measured/recorded by the crew and that values are reasonable. There is no need to remeasure anything else unless a problem is obvious.

Highlight measurements where tolerances have been exceeded. Keep notes on accuracy of the other data collected. If major problems are encountered, document what you did to fix them (e.g., if one species is consistently being incorrectly identified, state that you re-trained the crew, went back to previously completed plots, and fixed them).

Documentation as to how the problem was fixed is critical.

NOTE: For any stray errors, talk with the crew to determine why errors occurred. Determine if these few errors are symptomatic of a bigger problem. If you recognize a trend and the problems are consistent from plot to plot, corrective action needs to take place: retrain the crews, fix the data sheets, and/or go back to the affected plots and re-measure the necessary items. The key, critical items to focus on are species identification and number of trees on the plot. Trends in diameter measurement are important to note. (Is the crew consistently measuring too high or too low?)

QA forms

There is not a specific data sheet designed for QA purposes as each project will have its own needs. You can create a form to use or another system for checking measurements. One option is to use the basic Eco data collection sheets. You can also print out existing plot data in PDF format. To do, from the tool bar in Eco, select **Edit** > **Enter or Edit Data**. Click **Print Plot** and from the window that opens, choose the plots you want to print and click **Display**.

Currently, there is not a way to send collected data from sample projects back to a handheld device once it has been transferred to the desktop. Therefore, PDA users are limited to manual QA procedures.

Phase IV: Back at Your Desk: Running Eco

Transferring Data to the Desktop

Once field data have been collected, they need to be transferred to the desktop and sent for processing.

Opening an existing project

To open the project you created during Phase II, open the Eco desktop application from your computer's **Start** menu.

1 Click **File** > **Open Project** and navigate to the location where you saved it.

2 Click **Open** to open the project.

Paper forms

1 Click **Edit** > **Enter or Edit Data** to enter data collected on paper and the Paper Data Entry window will open.

2 For sample inventories, the list of plots will appear.

    a Highlight the PlotID corresponding to the plot ID on the paper form and click **Edit Plot**. Enter the data for each plot, matching the data entry form with the paper form.

    b Click **Save** when you are finished with each plot.

    c If you need to add additional plots beyond those included in the list, click **Add Plot** and complete the form.

3 For complete inventories, click **Add Tree** to begin entering data.

    a Enter the data for each tree, matching the data entry form with the paper form.

    b Click **Save** when you are finished with each tree.

    c Click **Edit Tree** or **Delete Tree** to make changes or remove a tree entry.

PDAs

You must exit the Eco application on the PDA before uploading the data.

For sample inventories:

1 To exit from the Plots menu, select **Exit** from the drop-down menu at the bottom and click **Go**.

2 On the main menu click **Exit**.

For complete inventories:

1 To exit from the Trees menu, click **Exit/Done**.

2 From the main menu, click **Exit**.

To continue on your desktop:

1 Click **Tools** > **PDA Utility** and the PDA interface will open with the PDA tab active.

2 With the PDA connected to your computer, ActiveSync working, and the Eco PDA application not running, click **Check PDA Status**.

3 Then click **Retrieve Data from PDA**.

4 Click **OK** to clean completed plots from the PDA.

Making changes

If you would like to edit or enter any new inventory data:

1 Click **Edit** > **Enter or Edit Data**. The inventory list will open.

2 Highlight the PlotID or TreeID you would like to edit, click the **Edit Plot or Edit Tree** button and make any changes necessary.

3 Click **Save Edits** when you are finished.

4 For sample inventories, if you need to add additional plots beyond those included in the list, click **Add Plot** and complete the form.

5 For complete inventories, click **Add Tree** to add a new record and complete the form.

Rechecking Data in the Field for Complete Inventory Projects

On some occasions, you may find that you need to return to the field to recheck inventory entries, for example, to perform Quality Assurance checks. In this case, you can select records to be transferred *from* the desktop *to* the PDA, so you know which trees or plots to return to. Currently, this option is only available for complete inventory projects.

On your desktop:

1 Click **Tools** > **PDA Utility** and the PDA interface will open with the PDA tab active.

2 With the PDA connected to your computer, ActiveSync working, and the Eco PDA application not running, click **Check PDA Status**.

3 Click the button labeled **Select Recorded Tree Data to Send to PDA**. The inventory list will appear.

4 Check the box next to the appropriate records and click **OK**.

Your records should now appear in the PDA.

Submitting Data for Processing

Eco v. 4 includes a significant upgrade: data are now processed automatically through an online system and results are returned the same day.

> NOTE: International projects and projects with custom weather or air quality data will still be processed manually by the US Forest Service Northern Research Station in Syracuse. Submit them as described below and then please email info@itreetools.org to inform us that your project needs special handling.

To begin data transfer:

1 Click **Tools** > **Submit Data for Processing**.

2 The Contact Information dialog box will open. Fill in the boxes, being particularly careful with your email address. The Comments box is only for use by international users, who should provide the total size of their study area for cross reference here.

3 When you have filled in and checked all the information, click **OK**. If you receive a dialog box informing you of errors or issues to resolve, make the necessary corrections and resubmit.

4 You will receive an auto-generated email from info@itreetools.org to let you know that your data have been received for analysis. Please check your spam folders if you do not receive the email.

Downloading Results

When your data have been processed, you will be notified by email that the results are ready to download. A file name will be supplied in the email. If you do not receive your results within 24 hours, please contact info@itreetools.org.

1 Open the Eco program and then open your project.

2 Click **Tools** > **Load Results.**

3 In the **File** window, enter the name of the file from the email notification you received. The recommended method is to copy the file name from the email, then paste it into this dialog box to avoid errors.

4 Click **OK**. Eco will automatically download your results from the server and place them in the correct database location on your computer.

Reporting Results

There are two ways to view the results of your Eco analysis: using the **Reports** menu on the tool bar or by clicking **View** on the tool bar and selecting **View Project Window**. This opens an outline on the left. Click on each **plus sign** to reveal the options below. The same charts and tables are available under both Reports and View, but the View Project Window additionally allows you to see fine-scale detail regarding each plot, under the **Input** section.

Keep in mind that each chart and table may include several pages. To switch between English and metric units, select the appropriate button above the chart or table.

Available charts for sample projects (plot-based)

- Tree density by land use
- Number of trees by land use
- Leaf area by land use
- Leaf area density by land use
- Origin of live trees, percent by land use
- Carbon storage by land use
- Carbon storage density by land use
- Annual carbon sequestration by land use
- Annual carbon sequestration density by land use
- Monthly pollutant removal by trees and shrubs
- Hourly pollutant removal by trees and shrubs (dynamic graph of several pollutant-related characteristics)

Available tables for sample projects (plot-based)

- Percent of tree species population by land use and DBH

- Percent of tree species population by DBH

- Percent of condition for trees by land use

- Percent of DBH and condition classes for trees by land use

- Percent of trees by condition class

- Origin of live trees, percent by land use

- Susceptibility of trees to gypsy moth by land use

- Susceptibility of trees to Asian longhorned beetle by land use

- Susceptibility of trees to emerald ash borer by land use

- Percent of predicted land use in actual land use

- Species richness, Shannon/Wiener Diversity Index

- Percent ground cover by land use

- Total estimates for trees by species

- Total estimates for trees by land use

- Leaf area and biomass for trees by DBH and land use

- Leaf area and biomass for shrubs by land use

- Leaf area and biomass for trees and shrubs by land use

- Per area estimates for trees

- Most important species

- Energy effects from trees

- Pollutant removal

Available tables for complete inventory projects (100% census)

- Individual tree pollution effects

- Individual tree characteristics

Model processing results

The new automated system generates a data sheet with information about processing that may be helpful for troubleshooting errors. The final page of the file provides definitions of the error messages and suggestions for resolving them.

Printing and exporting results

1 To print: With the desired chart or table open, click the **Print** icon above it.

2 To export, first select the desired format (PDF, RTF, or CSV) from the drop-down menu above the chart or table and then click **Export**.

Written report

Eco will automatically generate a written summary report of your results (approximately 15 pages). This option is only available for sample inventories. To view the report:

1 Click **Reports** > **Written Report**.

2 An initial dialog box will ask the population of your city. You can find the information at www.census.gov/popest/cities/cities.html.

3 The report will open in the project window and can be printed by clicking the **Print** icon or exported in PDF or RTF (which can be edited using any word processing program such as Microsoft Word) format.

Pack Project

The Pack Project option allows you to create a zip folder that includes all the necessary database and project files to transfer your Eco project from one computer to another or to share the project with another user. To begin the process:

1 Click **File** > **Pack Project** and type a name for the zip file that will be created.

The file will include the Eco project file, input database, output (estimation) database, and NLCD image files if available. To unpack the project on the new computer:

1 Extract the files into one folder to simplify file management.

2 Select the Eco project file and double-click to open.

3 You will be prompted to select the input database and the estimation database for the project. In each case, navigate to the folder with the extracted files and select the appropriate database.

4 Reconnect the NLCD files (if available) by selecting **File** > **Update Project**. Then navigate to the folder where the extracted files are located and select the cover, impervious, and canopy images as directed.

5 Save the project.

Maps

With Eco's Maps option, results of your analysis related to carbon storage, carbon sequestration, structural information, pollution removal, canopy cover, available planting space, and tree density are mapped directly onto NLCD satellite imagery, allowing you to visualize the information spatially.

NOTE: The Maps option is only available if you conducted a stratified sample inventory. Also, due to limited data availability, the Maps option is currently only available for projects in the continental United States.

NOTE: The three NLCD datasets (land cover, tree canopy, impervious cover) MUST have been downloaded at the same time so they have the exact same extents. If these images are downloaded separately they will not align correctly and all subsequent output processing will be invalidated.

Keep in mind that there are several relevant limitations to the data: (1) Thin, linear features such as bridges can be overwhelmed by the spectral response of the surrounding surface material, particularly water. In some cases this will produce data artifacts where portions of a bridge span may not register as impervious cover. (2) Impervious cover and tree canopy are not necessarily mutually exclusive as tree canopy may exist over top of impervious cover. You should be aware that both of these limitations will impact subsequent map calculations and thus display. (3) If land use classes in your Eco analysis are not NLCD land cover classes, then the extrapolation of effects to the cover maps will be approximations based on the assumptions that the average results from the Eco land use per unit canopy fit the NLCD classes as assigned by the user with the cross-walker. (4) Because the canopy cover from the NLCD maps likely differs somewhat from the canopy cover estimates from Eco, the total effects as illustrated by the maps will be off in proportion to the differences in the cover estimates. For example, if NLCD estimates 20% tree cover, and UFORE estimates 40%, then the total estimate as portrayed on the map will be underestimated by 50% (20/40).

You should already have collected the necessary map data, but if not, return to Phase I: Getting Started: Gathering Map Data. Then incorporate the maps in the project by entering their locations under **File** > **Update Project**.

To begin working with the Maps tool, click **Reports** > **Maps**.

Land cover cross walk

The first window that appears asks you to match NLCD land cover classes with your classification scheme. NLCD land cover classification categories are listed on the left. In the drop-down boxes on the right, the land cover classes that you defined when you created your sample using ArcGIS will be listed. You must match each of your land cover to the most appropriate NLCD category. For example, if you have a "Wetlands" category, you would use this for both "Woody Wetland" and "Herbaceous Wetland."

It is important to appropriately match land cover categories in this step. Subsequent map calculations performed on the NLCD image data are inherently dependent upon this step. Inappropriate match-ups between categories will skew the output image results.

When you are finished, click **OK**.

Map outputs

The map results window consists of four sub-windows: the downloaded NLCD Land Cover, Tree Canopy, and Impervious Cover imagery, as well as the chosen map Output. Under the **Output Options** drop-down menu at the bottom right, you can view the maps for carbon storage, carbon sequestration, structural information, pollution removal, canopy cover, available planting space, and tree density.

Map controls

The following controls can be used to manipulate the Maps results window:

Imagery Window: Click and drag with mouse to pan the images

Maximize / Restore Image Window: Enlarge a single window

Zoom Level of Image Windows: Select desired zoom from drop-down or enter value

Full Extent: Zoom to full extent of map images

Scroll Bars: Toggle image window scrolling on or off

Legends: Toggle map legends on and off

Save Output: Once processing is complete, select a location to save the output image

Reset Output: Clear the processing selection and reset the output image

Output Options: Select the desired output result

Faster Output: By default the output image is turned off during processing for faster processing. Unchecking this box results in a real-time update of the output image at a much slower pace.

The windows pan and zoom in unison. The output maps can be saved as TIFF images and brought into GIS programs for further mapping or inserted into other documents.

Map usage notes

Output processing time is system dependent. On slower machines, processing may take several minutes. The output processing progress is shown by a progress bar at the bottom of the screen. Occasionally, this progress bar will appear to stall due to other system activity on your computer. You should NOT exit the program at this point. Instead, wait a few more minutes for the processing to complete.

Appendix 1: Random Plots Workbook: Stratified Sample

These instructions are designed to help users of all skill levels create a random sample of i-Tree Eco plots, plot centers, and the associated Eco-required data within your defined study area. ESRI ArcGIS v9.x software is used (the instructions are compatible with ArcGIS v. 8 with some modifications). Sample plots are stratified by land cover type (not by land-use data collected in the field). For purposes of example, 2001 USGS National Land Cover Database (NLCD) data are employed as strata.

These instructions are composed of four basic steps:

1 Prepare project area data

2 Prepare strata (land cover types)

3 Generate sample plots

4 Create Eco-ready output

When you are finished, you will have created the following:

- Projected area-of-interest (AOI) map layer composed of a single (multi-part) *polygon.*

- Projected land cover map layer conforming to the AOI boundaries and composed of singular, multi-part land cover *polygons* with Eco-required fields added and populated.

- Random sample plots *point* map layer with Eco-required fields added and populated. (The points are the plot centers.)

- Sample plot areas *polygon* map layer. (The polygons are the plots.)

- Eco-ready strata area report text file.

- Eco-ready plot list report text file.

- Eco-ready PRJ file.

Tips

- These instructions require use of a few simple i-Tree tools within the iTree.mxd ArcMap project file that can be downloaded from the i-Tree website at www. itreetools.org under Resources.

- Advanced GIS users can primarily follow the bulleted overviews with special attention to the detailed instructions in areas such as field names and types.

- Obtain projection/coordinate system and map unit information from the map data provider.

- Final map units must be either feet or meters.

- AOI examples are large polygons such as city boundary, park areas, or a management zone(s).

- ESRI shapefiles, coverages, or geodatabases can be used; shapefiles are easiest.

- Practice good file management using folders to hold copies of original data, folders to hold output, employing logical file naming, etc.

- Save the iTree.mxd project periodically through all steps.

- Temporarily turn off any web browser pop-up blockers.

- Decide in advance the number of plots for each stratum.

Common tools

Open Project	ArcToolbox	Add Data	Properties	

Project Area Data Preparation

Overview

- Obtain a GIS map layer representing the area-of-interest (AOI) polygon(s) for your project area.

- Launch the ArcMap application of ArcGIS at the ArcView, ArcEditor, or ArcInfo level.

- Open and save the iTree.mxd project with a *new* name at your preferred location.

- Load the AOI map layer into the view.

- Define the projection/coordinate system of the AOI.

- Reproject the AOI to a system using feet or meters if needed.

- Dissolve the AOI into a single polygon (single, multi-part polygon if more than one polygon).

Results

- Projected AOI map layer composed of a single (possibly multi-part) polygon.

Detailed instructions

1 Obtain an area-of-interest (AOI) polygon from your GIS Dept or an online resource. Several options can be found here: http://www.esri.com/data/free-data/index.html.

2 Download the i-Tree.mxd file from www.itreetools.org and save it to your computer.

3 Launch ESRI's ArcMap application at the ArcView (or ArcEditor or ArcInfo) level.

4 Click the **Open** icon button to browse for the iTree.mxd. The iTree.mxd project file contains a custom toolbar for random sample generation and UFORE report output.
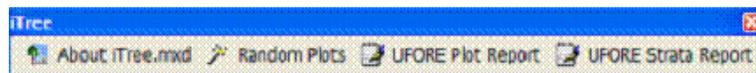
5 Save a copy of the iTree.mxd project *with a new name* at a new location via the **File** > **Save As** menu.
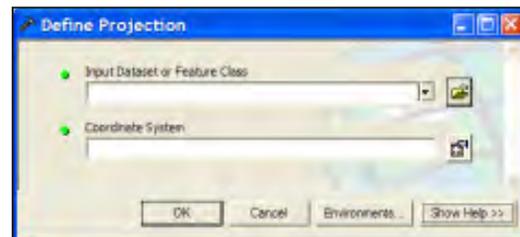
6 Open ArcToolbox.

7 Use the **Add Data** button to navigate to and load the AOI polygon map layer to the current view. An "Unknown Spatial Reference" message may appear; click **OK** to move past it.

8 If necessary, use ArcToolbox to define the projection of the AOI map layer according to your data provider's specifications. (If a projection is already defined, skip to Step 9):

 a Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Define Projection**.

 b Complete the **Data Projection** form.

 For **Input Dataset**, choose the AOI map layer from the drop-down list. For Coordinate System, click the **Properties** button to the right.

 In the **Spatial Reference Properties** window that appears, click **Select** and choose the coordinate system indicated by your data provider.

9 If necessary, use ArcToolbox to reproject your AOI map layer to a system using feet or meters, ideally selecting a projection system already in use by your organization

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or a commonly used system such as State Plane or UTM in the United States:

  a Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Feature** > **Project.**

  b Complete the **Project** form.

For **Input Dataset**, select the AOI map layer from the drop-down menu.

Input Coordinate System should be grayed out based on your work in the previous step.

For **Output Dataset or Feature Class**, use the **Browse** button to the right and navigate to a suitable location to save the output file and give it a name.

For **Output Coordinate System**, click the **Properties** button to the right, and in the **Spatial Reference Properties** window that appears, click the **Select** button and navigate to the proper coordinate system.

For **Geographic Transformation**, select the first choice in the drop-down list if prompted with an "Undefined Geographic Transformation" message. Click **OK** when you've completed all the boxes.

10 If your AOI has more than one polygon, use **ArcToolbox** to dissolve them:

  a Navigate to **ArcToolbox** > **Data Management Tools** > **Generalization** > **Dissolve.**

  b Complete the **Dissolve** window.

For **Input Features**, select the **AOI map layer** from the drop-down list.

For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and give the file a name.

For **Dissolve Field**, check the data field attribute value that unifies the AOI. Example: a "Name" field containing the city name of an AOI, even across physically separate city sections.

Leave the **Statistics** field blank.

Ensure the **Create Multipart Features** box is checked. Click **OK** to finish.

Results

Area-of-interest (AOI) *polygon* **map layer**

- Verify AOI map layer is loaded into the map view. It may be necessary to **right-click** the new AOI layer and select **Zoom to Layer**.

- It should have one record present in its table. **Right-click** the new AOI layer name in the map layers list and choose **Open Attribute Table**.
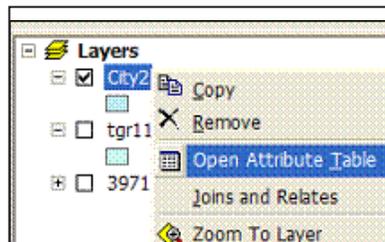
The AOI polygon map layer is now ready to be used to clip the strata layer.

Overview

- Obtain a land cover GIS map layer encompassing the AOI polygon(s) for the project area.

- Convert the land cover data to polygons, if needed.

- Dissolve the land cover polygons into single, multi-part polygons for each land cover category.

- Define the projection/coordinate system of the land cover data if needed.

- Reproject the land cover data to a system using feet or meters if needed.

- Clip the land cover data to the AOI area.

- Select each land cover category and give it a plain text name.

- Add Eco-required fields and calculate appropriate values for them.

Results

- Projected, clipped land cover map layer composed of multi-part polygons with Eco-required fields added and populated.

- NLCD canopy and impervious surface layers for use later with the i-Tree software suite.

Detailed instructions

1 Obtain an area-of-interest (AOI) polygon from your GIS Department or an online resource such as the Multi-Resolution Land Characteristics Consortium (MRLC) (http://gisdata.usgs.net/website/MRLC/viewer.htm).
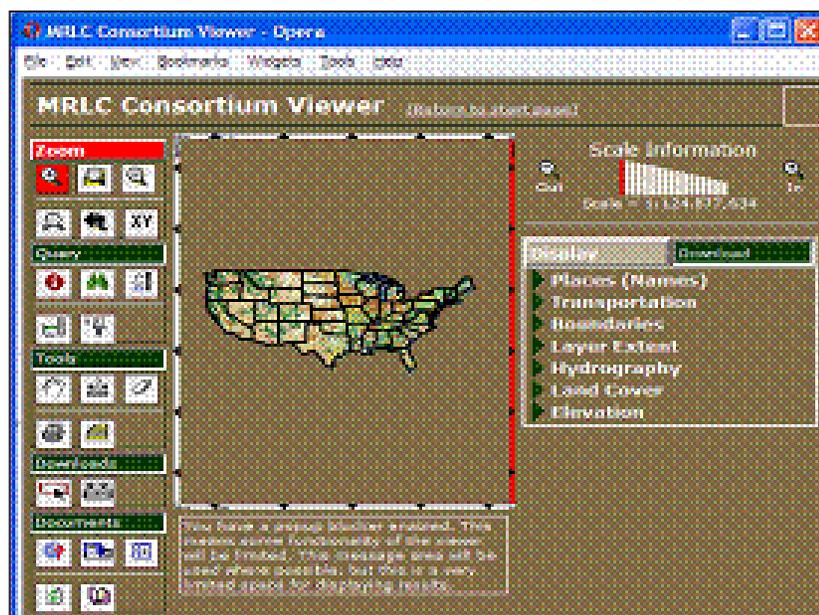
a Zoom and pan to your AOI, making sure you cover the entire AOI, plus a bit more.

b Click on the **Download** tab at right, and make sure only **Land Cover**, **Canopy**, and **Impervious for 2001** are checked. [Note: (1) Downloading Canopy and Impervious now will enable you to use them later in Eco's Maps function. All three must be downloaded at the same time. (2) Although data from 2006 are becoming available, they cannot yet be used in Eco.]

c Use the **Download** tool to delineate a square area on the map for download and in the resulting pop-up window, click **Download** to download and save each of the three layers. Delineating and downloading all three layers during the same online mapping session ensures each layer covers the same exact area and each layer aligns correctly with the rest.
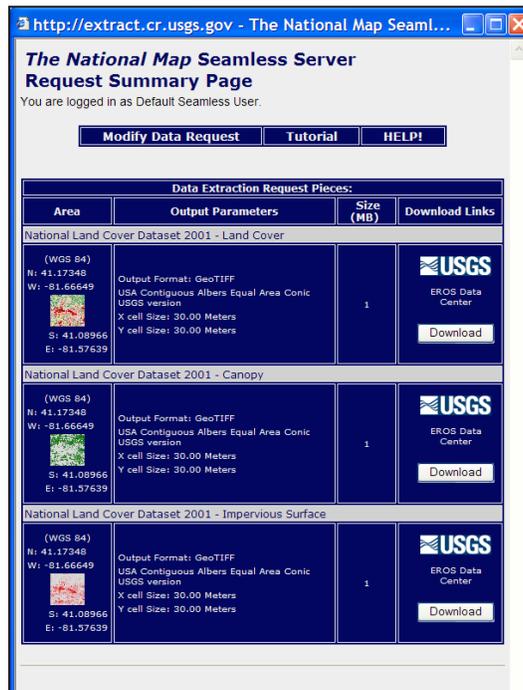
NOTE: The download files consist of raster (image) data. Each file is composed of pixels, and each pixel contains information such as land cover type. A metadata file describing the layers' Entity and Attribute information is included as well. The names of the land cover categories can be found within.

d Unzip the compressed files to your desired location.

e The download files are named numerically. Load each into ArcMap to determine which file is the land cover layer. Canopy and impervious layers can be removed from the view.

f Right-click the land cover layer and click **Zoom to layer** as it is most likely in a different projection/coordinate system.

2 Use ArcToolbox to convert the land cover raster data to polygons:

a Navigate to **ArcToolbox** > **Conversion Tools** > **From Raster** > **Raster to Polygon.**

b Fill out the **Raster to Polygon** form.

For **Input Raster**, choose your land cover map layer from the drop-down menu.

For **Field**, select the field containing the land cover values (refer to metadata documentation if necessary).
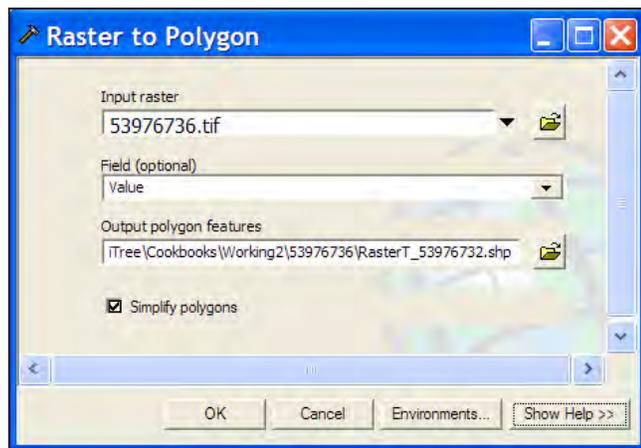
Under **Output Polygon Features**, use the **Browse** button to locate a suitable location and create a filename for the resulting polygon map layer.

The **Simplify polygons** box should be **UNCHECKED**.

Click **OK**.

3 Use **ArcToolbox** to dissolve the land cover polygon(s):

a Navigate to **ArcToolbox** > **Data Management Tools** > **Generalization** > **Dissolve.**

b Fill out the **Dissolve** form.

Under **Input Features**, choose the land cover polygon map layer from the drop-down list.
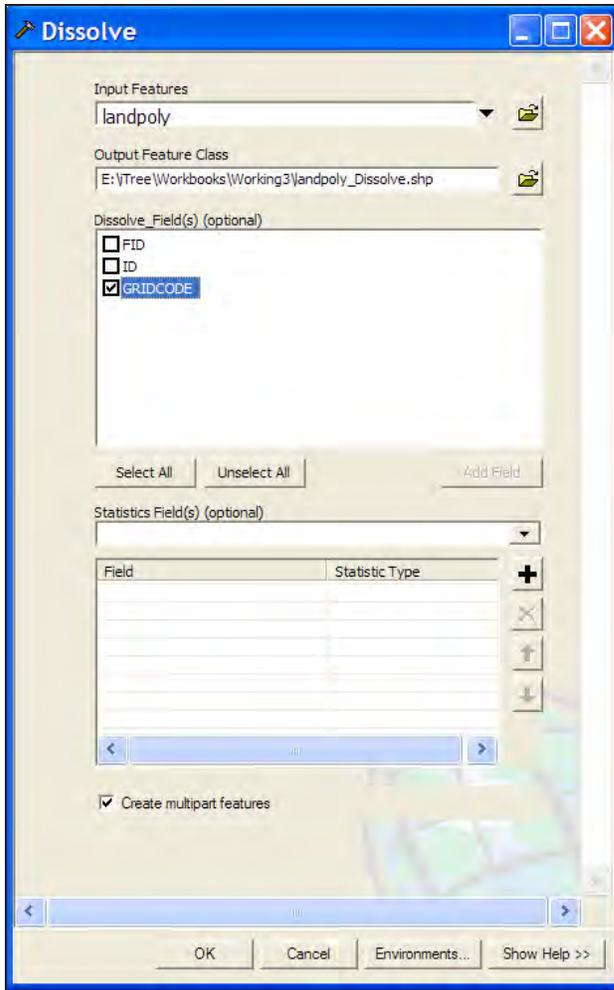
For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and create a file name for the resulting map layer.

Under **Dissolve_Field(s)**, check the GRIDCODE data field (whose attribute value holds the Land Cover values).

Leave the **Statistics Field(s)** blank.

The box next to **Create Multipart Features** should be checked.

Click **OK**.

4 If needed, use ArcToolbox to define the projection of the dissolved land cover polygon map layer according to your data provider's specifications:

   a Downloaded NLCD data have their projection pre-defined by the MRLC. If your projection is already defined, you can skip to step 5.

```
Projection: Albers
False_Easting: 0.000000
False_Northing: 0.000000
Central_Meridian: -96.000000
Standard_Parallel_1: 29.500000
Standard_Parallel_2: 45.500000
Latitude_Of_Origin: 37.500000
Linear Unit: Meter (1.000000)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.017453292519943295)
Prime Meridian: Greenwich (0.000000000000000000)
```

```
Datum: D_North_American_1983
  Spheroid: GRS_1980
    Semimajor Axis: 6378137.000000000000000000
    Semiminor Axis: 6356752.314140356100000000
    Inverse Flattening: 298.257222101000020000
```

b If the projection is NOT pre-defined, navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Define Projection**.

Fill out the **Define Projection** form:

Under **Input Dataset**, choose the land cover polygon map layer from the drop-down list.

For **Coordinate System**, click the **Properties** button at right, and in the **Spatial Reference Properties** window that appears, click the **Select** button and navigate to the proper coordinate system. The proper coordinate system is determined by your data provider.

5 Use ArcToolbox to project the dissolved land cover polygon data. For consistency in placing sample plots, project the land cover data to the projection/coordinate system chosen above for the AOI data:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Feature** > **Project.**

b Fill out the **Project** form.

Under **Input Dataset**, choose the dissolved land cover polygon map layer from the drop-down list.

The **Input Coordinate System** should be grayed out with the NLCD Albers projection system.

Under **Output Dataset or Feature Class**, use the **Browse** button to navigate to a suitable location and

choose a file name for the resulting map layer.

Under **Output Coordinate System**, lick the **Properties** button at right and in the **Spatial Reference Properties** window, click the **Select** button and navigate to the coordinate system employing either feet or meters as previously selected for the AOI.

If you are prompted with an "Undefined Geographic Transformation" message, select the first choice in the drop-down menu under Geographic Transformation.

Click **OK**.

Right-click the projected land cover map layer and select **Zoom to layer**.

6   Use ArcToolbox to clip the dissolved land cover polygon map layer by the AOI map layer:

   a   Navigate to **ArcToolbox** > **Analysis Tools** > **Extract** > **Clip.**

   b   Complete the **Clip** form.
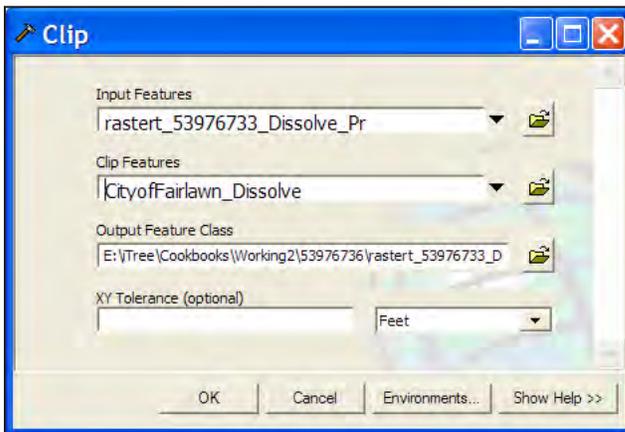
Under **Input Features**, select the projected and dissolved land cover polygon map layer from the drop-down list.

Under **Clip Features**, choose the projected and dissolved AOI map layer from the drop-down list.

Under **Output Features**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.

Leave the **XY Tolerance** field and the **units** field blank.

Click **OK**.

7   If necessary, use the **Add Data** button to navigate to and load the clipped land cover polygon map layer to the current view. The land cover map layer should now conform to the project area boundaries.

8   Use ArcToolbox to add Eco-required fields to the clipped land cover map layer:
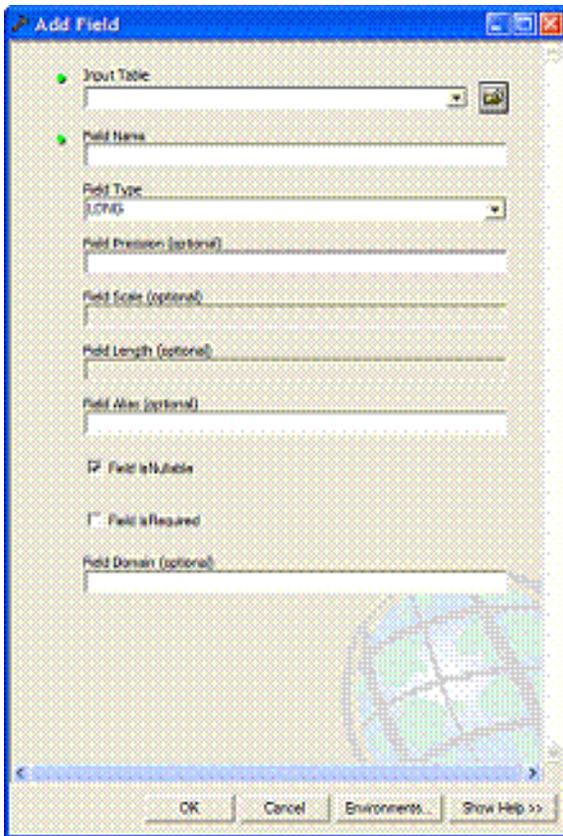
a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Add Field.**

b Complete the **Add Field** form. [For experienced users, fields can be added via the ArcMap table view as well.]

Under **Input Table**, select the clipped land cover map layer from the drop-down list.

For **Field Name**, enter: Strat_ID
For **Field Type**, select LONG from the drop-down list.

Skip the following fields:

Field Precision
Field Scale
Field Length
Field Alias
Field is Nullible
Field is Required
Field Domain

Click **OK.**

c Repeat the steps above as follows for these four additional fields:

> **Field Name**: GRID_TXT
> **Field Text**: Select **TEXT**.
>
> **Field Name**: Strata
> **Field Text**: Select **TEXT**.
>
> **Field Name**: Strat_Area
> **Field Text**: Select **DOUBLE**.
>
> **Field Name**: No_Plots1
> **Field Text**: Select **LONG**.

9 Use regular Selection Queries and ArcToolbox to calculate text values that are equivalent to the land cover categories for the clipped land cover map layer:

> **a** Examine the metadata documentation file that you downloaded with the NLCD Land Cover data.
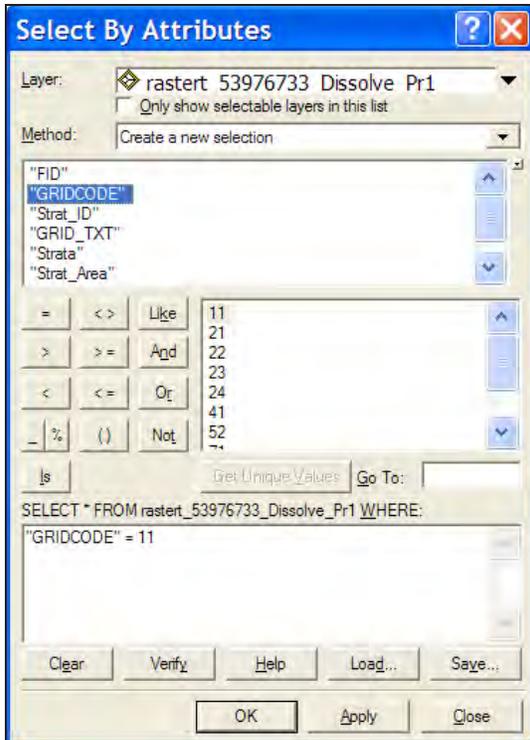
Each GRIDCODE value corresponds to one land cover category.

Use the GRIDCODEs to decipher the land cover data.

b In the tool bar, choose **Selection** > **Select by Attributes**.

c Complete the **Select by Attributes** form.

For **Layer**, select your processed land cover map layer.

For **Method**, select **Create a new selection**.

To add the necessary "equations" to the **SELECT * FROM** box at the bottom:

1. Double-click the **"GRIDCODE"** field name from the list above.
2. Click the **equals** button.
3. Click the **Get Unique Values** button.
4. Double-click the first land cover GRIDCODE value in the list.
A properly formatted query will look like this: "GRIDCODE"=11.

Click **Apply**.
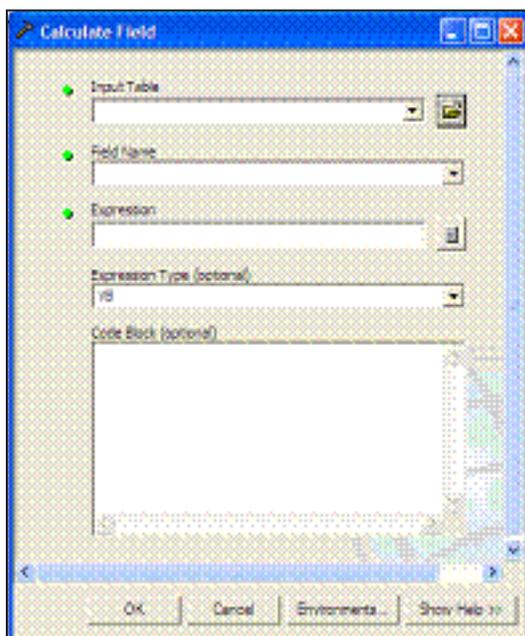
d With the features in this first land cover category selected, use ArcToolbox to give the land cover category a text name.

Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Calculate Field.**

Complete the **Calculate Field** window.

Under **Input Table,** select the processed land cover polygon map layer from the drop-down list.

For **Field Name**, select **GRID_TXT** from the drop-down list.

Under **Expression**, enter an appropriate name to describe the land cover type, for example: "Developed High Intensity" (including quotes!)

Skip **Expression Type**.
Skip **Code Block**.

Click **OK**.

Open the table and verify that only the selected feature records were populated with the appropriate land cover category text. (Right-click the land cover polygon map layer in the map layers list and select **Open Attribute Table**.)

e Repeat step 9a-d for each land cover category present in the land cover polygon map layer.

f From the **Selection** menu, choose **Clear Selected Features** to unselect the last land cover features.

10 Use ArcToolbox to calculate values for the Eco-specific fields added to the clipped land cover map layer:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Calculate Field.**

b Fill out the **Calculate Field** form [For experienced users, the Field Calculator could be used via the ArcMap table view. Also, later versions of ArcGIS have a Calculate Geometry option available via a right-click on the field name in the table.]

For **Input Table,** select the processed land cover polygon map layer from the drop-down list.
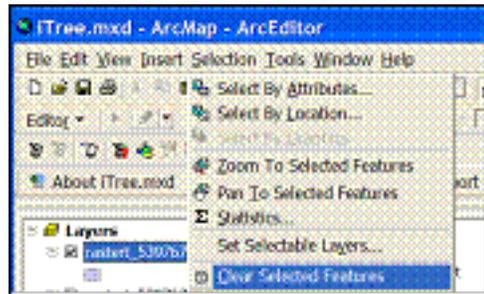
For **Field Name**, select **Strat_ID**.
For **Expression**, enter: [FID]+1
Skip **Expression Type** (default is typically VB).
Skip **Code Block**.
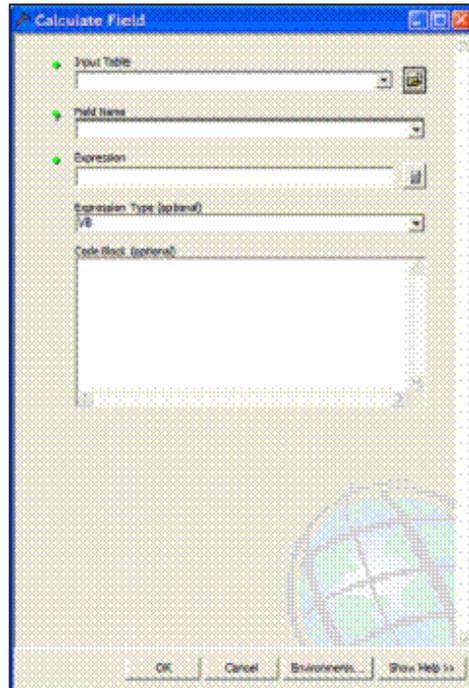
Click **OK**.

c Repeat for the **Strata** field.

For **Field Name**, select **Strata**.
For **Expression**, enter: [GRID_TXT]

d Repeat for the **Strat_Area** field

For **Field Name**, select **Strat_Area**.
For **Expression**, enter: Output
For **Expression Type**, select **VB.**
Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output as double
Dim pArea as Iarea
Set pArea = [shape]
Output = pArea.area
```

Results

Converted, dissolved, projected, and clipped polygon land cover map layer with Eco-required fields added and populated.

- It should align with and conform to the project area boundaries.

- It should have ONE record representing EACH land cover category present in its table. (Right-click the land cover polygon map layer name in the map layers list, and choose **Open Attribute Table**).
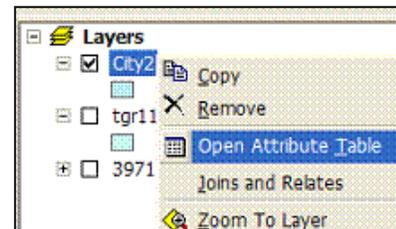
The land cover polygon map layer is now ready to be used for plot generation.

Overview

- Select each land cover category and run the Random Plots tool from the i-Tree toolbar for each land cover category.

- Merge the resulting random plots data together.

- Define the projection of the merged random plots data.

- Spatially join the land cover data to the random plots data.

- Add Fields to the random plots data.

- Calculate field values for random plots data.

- Buffer the random plots point data to form plot areas.

Results

Random sample plots *point* map layer with Eco-required fields added/populated.

Detailed instructions

1 Use regular selection queries and the **Random Plots** tool to select an individual land cover category and add the number of desired plots to it:

    a From the **Selection** menu, choose **Select by Attributes**.

    b Fill out the **Select by Attributes** form.

    Under **Layer**, ensure that the processed land cover map layer is selected.

    For **Method**, select **Create a new selection**.

    To add the necessary "equations" to the SELECT * FROM box:

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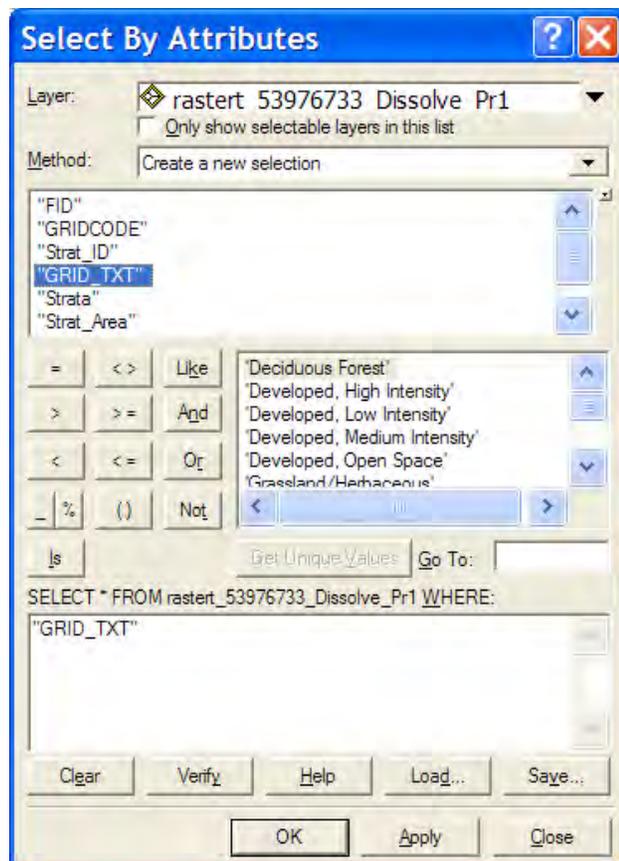
Double-click the **"GRID_TXT"** field name from the list above.
Click the **equals** button.
Click the **Get Unique Values** button.
Double-click the first land cover GRID_TXT value in the list.

A properly formatted query will look like this: "GRID_TXT"='Developed, High Intensity'.

Click **Apply**.

c Click to select the processed land cover map layer in the map layers list and then click the **Random Plots** tool in the i-Tree toolbar.
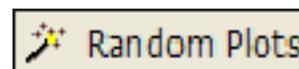
d Enter the desired number of sample plots for this land cover in the **Random Point Generator** window.

NOTE: The number of plots per land cover is determined by the area of the land cover in relation to the entire study area. For example, if the given land cover represents 20% of the study area, 20% of the total number of plots should fall in that land cover. A minimum of 20 plots per stratum is recommended.
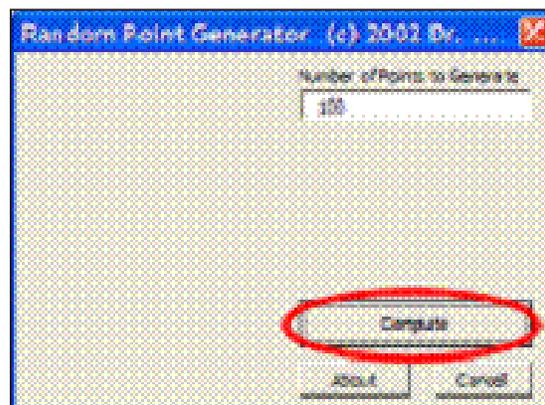
e Click **Compute** and then select a location and file name for the sample plots point map layer to be created. Sample plots will be created for each land cover category as a separate map layer file. Choose a name for each file that reflects the category as they will eventually be merged together into one sample plots layer, e.g., plots_Developed_HighIntensity.

f Repeat Step 1a-e for each land cover category.

g Click **Close** to exit the **Random Point Generator** window.

h From the **Selection** menu, choose **Clear Selected Features** to unselect the last land cover features.
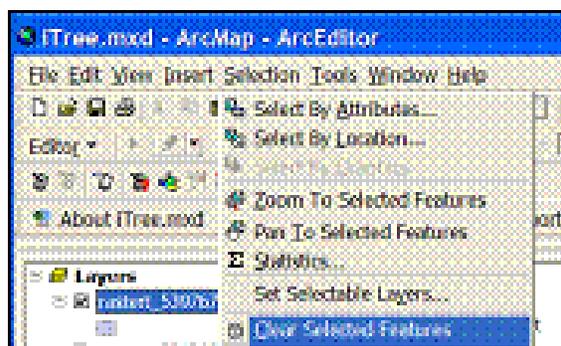
2 Use ArcToolBox to merge the individual land cover category plot map layer files together:

    a Navigate to **ArcToolbox** > **Data Management Tools** > **General** > **Merge** and complete the **Merge** form.
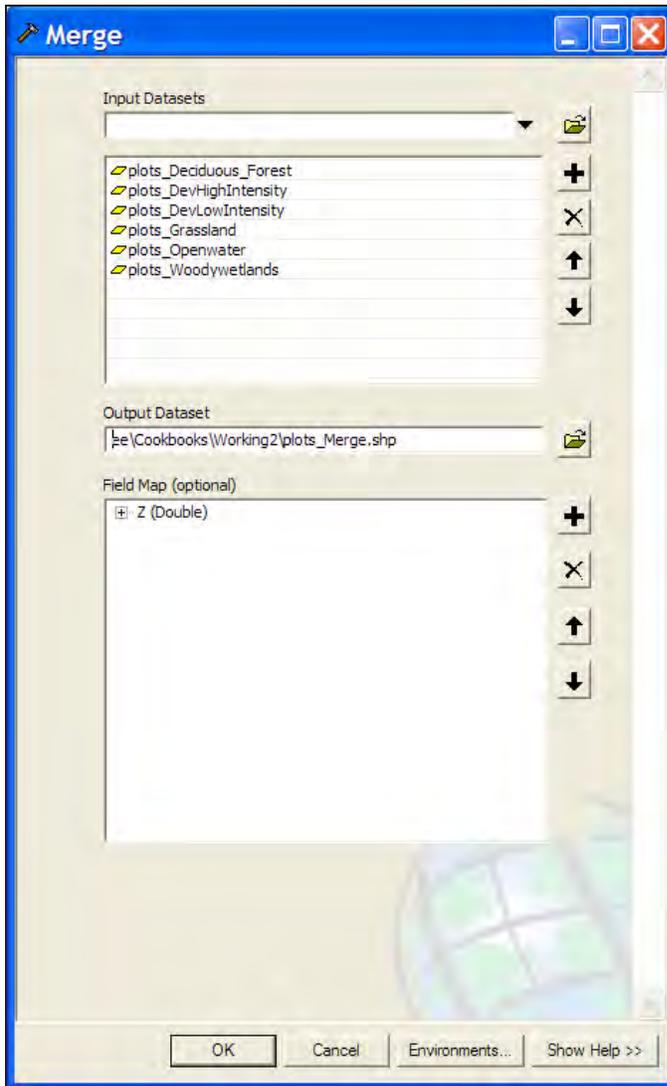
From the drop-down list under **Input Datasets**, select each land cover plot layer, one at a time.

For **Output Database**, click the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer, e.g., SamplePlots_Merge.

Skip the **Field Map** option.

Click **OK**.

3 Use **ArcToolbox** to define the projection of the merged sample plots point map layer according to your data provider's specifications:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Define Projection.**

b Complete the **Define Projection** form**.**

For **Input Dataset**, choose the merged sample plots point map layer from the drop-down list.

For **Coordinate System**, click the **Properties** button at right and in the **Spatial Reference Properties** window, click the **Select** button and navigate to the proper coordinate system. The proper coordinate system is the one you selected for the AOI map layer.

4 Perform a spatial join between the merged sample plots point map layer and the land cover polygon map layer:
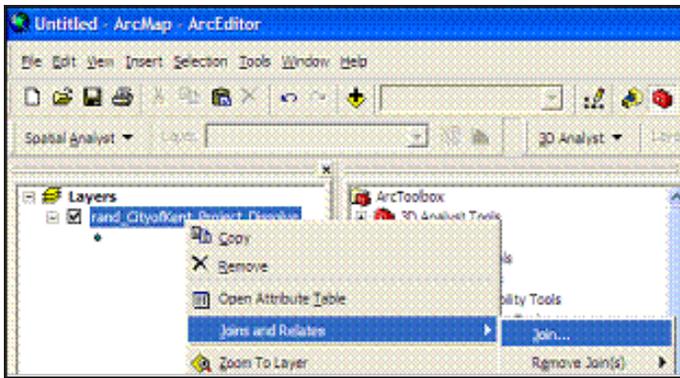
a This step assigns land cover types to the sample plot points.

b Right-click the merged sample plots layer and select **Joins and Relates** > **Join.**
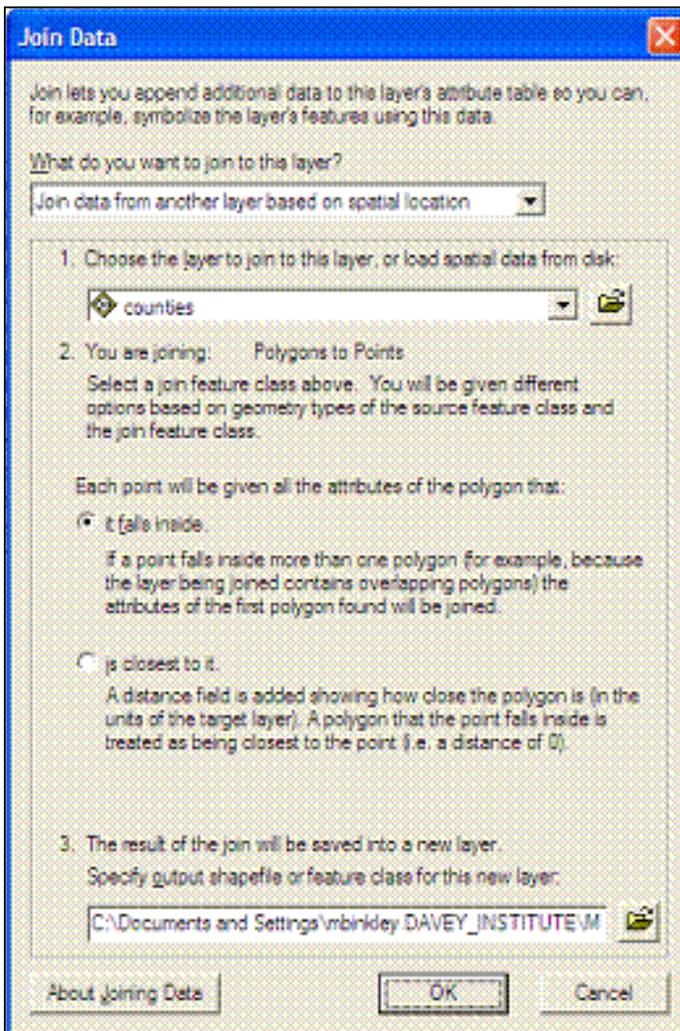
c Complete the **Join Data** form.

Under **What do you want to join to this layer?** select **Join data from another layer based on spatial location**.

Under **Choose the layer to join to this layer…** select the land cover polygon layer.

Under **Each point will be given all the attributes of the polygon that:** click the button next to **it falls inside**.

Under **The result of the join will be saved into a new layer,** use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.

Click **OK**.

5 Use **ArcToolbox** to add Eco-required fields to the spatially joined sample plots point map layer:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Add Field.**

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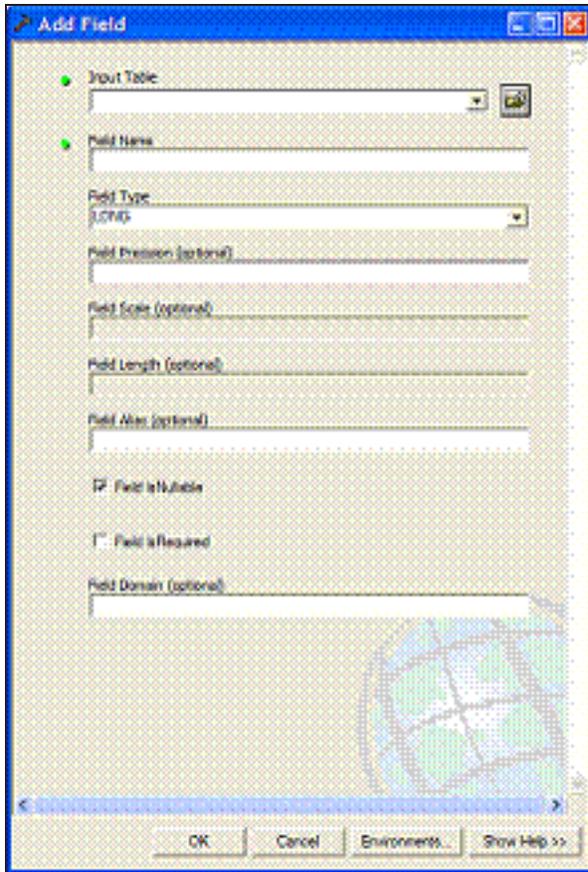
b Complete the Add Field form. [For experienced users, fields can be added via the ArcMap table view as well.]

For **Input Table**, select the spatially joined sample plots point map layer from the drop-down list.

For **Field Name**, enter: **ID**

For **Field Type**, select LONG from the drop-down list.

Skip the following fields:

Field Precision
Field Scale
Field Length
Field Alias
Field is Nullible
Field is Required
Field Domain

Click **OK.**

c Repeat the steps above as follows for these five additional fields:

> **Field Name**: **LCCode**
> **Field Text**: Select **SHORT**.
>
> **Field Name**: **X_Coord**
> **Field Text**: Select **DOUBLE**.
>
> **Field Name**: **Y_Coord**
> **Field Text**: Select **DOUBLE**.
>
> **Field Name**: **LCType**
> **Field Text**: Select **TEXT**.
>
> **Field Name**: **MapUnits**
> **Field Text**: Select **TEXT**.

6 Use **ArcToolbox** to calculate values for the Eco-specific fields added to the spatially joined sample plots point map layer in step 2:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Calculate Field.**

b Complete the **Calculate Field** form.

For **Input Table**, select the sample plots point map layer from the drop-down list.

For **Field Name**, select **ID.**
For **Expression**, enter: `[FID]+1`
Skip **Expression Type.**
Skip **Code Block.**

Click **OK**.

c Repeat for the **LCCode** field.
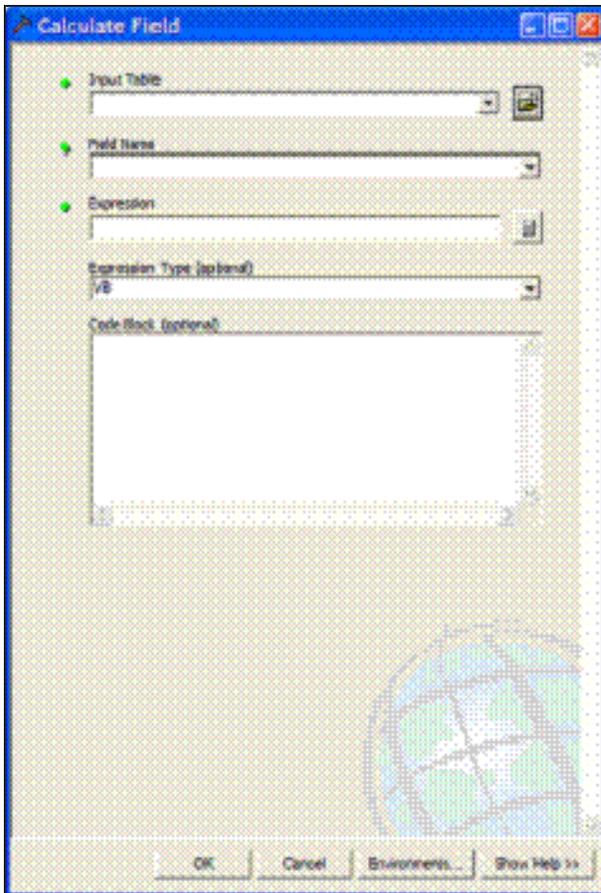
For **Field Name**, select **LCCode.**
For **Expression**, enter: `[Strat_ID]`

d Repeat for the **X_Coord** field.

For **Field Name**, select **X_Coord.**
For **Expression**, enter: `Output`
For **Expression Type**, select **VB.**

Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output As Double
Dim pPoint As IPoint
Set pPoint = [Shape]
Output = pPoint.X
```

e Repeat for the **Y_Coord** field.

For **Field Name**, select **Y_Coord.**
For **Expression**, enter: `Output`
For **Expression Type**, select **VB.**
Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output As Double
Dim pPoint As IPoint
Set pPoint = [Shape]
Output = pPoint.Y
```

f Repeat for the **MapUnits** field.

For **Field Name**, select **MapUnits**.
For **Expression**, enter either:

`"Foot_US"` (including quotes!) if your map units are in feet.
OR
`"Meters"` (including quotes!) if your map units are in meters.

g Verify the attributes have been correctly modified in the sample plots point map layer.

Right-click the new, sample plots point map layer in the map layers list, and choose **Open Attribute Table**.

Scan through the fields and their values to verify they are correct.

Note that no projection system is assigned to the plots layer. If desired, it can be defined using steps similar to those for defining the AOI projection system above.

7 Use ArcToolbox to buffer the spatially joined sample plots point map layer. This step creates the plot of your desired size around the plot centers:

a Navigate to **ArcToolbox** > **Analysis Tools** > **Proximity** > **Buffer.**

b Complete the **Buffer** form.

Under **Input Features**, select the spatially joined sample plots point map layer from the drop-down list.

For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.

For **Distance**, in the **Linear Unit** box, enter the distance value from the table below, based on your desired plot size. [The distance is the radius of the plot.]
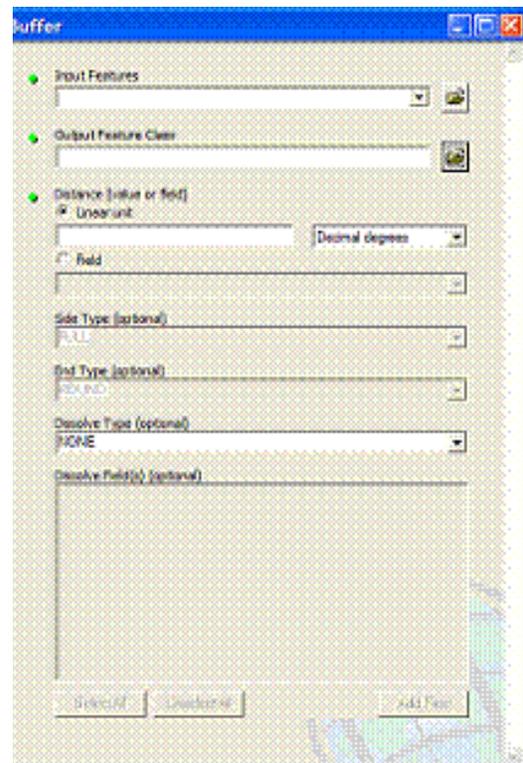
For plot size:	Enter:

	For plot size:	Enter:
Map units in feet	1/5 acre	52.66
	1/10 acre	37.24
	1/20 acre	26.33
	1/100 acre	11.78
Map units in meters	1/5 hectare	25.23
	1/10 hectare	17.84
	1/20 hectare	12.62
	1/100 hectare	5.64

Skip the following entries:

Side Type
End Type
Dissolve Type
Dissolve Field(s)

c   The buffered sample points layer is added to the map view automatically; zoom in to examine individual plot areas.

Results

Sample plots *point* map layer

- User-defined number of plots randomly spread throughout each stratum (land cover)
- Plot points assigned with land cover categories
- Eco-required fields added and populated

Sample plot areas *polygon* map layer

Overview

- Run the UFORE Plot List Report tool.
- Run the UFORE Strata Area Report tool.

Results

- Eco-ready Plot List report text file.
- Eco-ready Strata Area report text file.
- Eco-ready PRJ file.

Detailed instructions

1 Select the spatially joined sample plots point map layer in the map layers list and click the UFORE Plot Report tool in the i-Tree toolbar to create the Plot Report:

    a Respond to the questions to confirm your map units.

    b In the next window, navigate to a suitable location and choose a file name for the Plot Report.

    c If the report is completed correctly, the **UFORE Plot Report completed** box will appear.

    d If a field is missing or incorrectly named, an error message will appear. Even though the output will be completed, you must correct the mistake by returning to the previous instructions.

    e Once the mistake is corrected, repeat these steps to output a new, corrected Plot Report.

2 Select the processed land cover polygon layer in the map layers list and click the **UFORE Strata Report** tool in the i-Tree toolbar to create the Strata report:

    a Respond to the questions to confirm your map units.

b In the next window, navigate to a suitable location and choose a file name for the Strata Report.

c If the report is completed correctly, the **UFORE Strata Report completed** box will appear.

d If a field is missing or incorrectly named, an error message will appear. Even though the output will be completed, you must correct the mistake by returning to the previous instructions.

e Once the mistake is corrected, repeat these steps to output a new, corrected Strata Report.

Results

Three Eco-ready reports:

- Plot listing
- Strata listing
- PRJ file (automatically created in the Define Projection/Reprojection steps above as part of the AOI Shapefile)

Appendix 2: Random Plots Workbook: Unstratified Sample

These instructions are designed to help users of all skill levels create random i-Tree Eco sample plots, plot centers, and the associated Eco-required data within your defined study area. ESRI ArcGIS v9.x software is used (the instructions are compatible with ArcGIS v. 8 with some modifications). These instructions comprise three basic steps.

1 Prepare project area data.

2 Generate sample plots.

3 Create Eco-ready output.

When you are finished, you will have created the following:

- Projected area-of-interest (AOI) map layer composed of a single (multi-part) *polygon.*
- Random sample plots *point* map layer with Eco-required fields added and populated. (The points are the plot centers.)
- Sample plot areas *polygon* map layer. (The polygons are the plots.)
- Eco-ready strata area report text file.
- Eco-ready plot list report text file.
- Eco-ready PRJ file.

Tips

- These instructions require use of a few simple i-Tree tools within the iTree.mxd ArcMap project file that can be downloaded from the i-Tree website at www. itreetools.org under Resources.
- Advanced GIS users can primarily follow the bulleted overviews with special attention to the detailed instructions in areas such as field names and types.
- Obtain projection/coordinate system and map unit information from the map data provider.
- Final map units must be either feet or meters.
- AOI examples are large polygons such as city boundary, park areas, or a management zone(s).
- ESRI shapefiles, coverages, or geodatabases can be used; shapefiles are easiest.

- Practice good file management using folders to hold copies of original data, folders to hold output, employing logical file naming, etc.

- Save the iTree.mxd project periodically through all steps.

- Temporarily turn off any web browser pop-up blockers.

Common tools

📂	Open Project	🧰	ArcToolbox	➕	Add Data	📋	Properties	

Project Area Data Preparation

Overview

- Obtain a GIS map layer representing the area-of-interest (AOI) polygon(s) for your project area.

- Launch the ArcMap application of ArcGIS at the ArcView, ArcEditor, or ArcInfo level.

- Open and save the iTree.mxd project with a *new* name at your preferred location.

- Load the AOI map layer into the view.

- Define the projection/coordinate system of the AOI.

- Reproject the AOI to a system using feet or meters if needed.

- Dissolve the AOI into a single polygon (single, multi-part polygon if more than one polygon).

- Add Eco-required fields and calculate appropriate values for them.

Results

Projected AOI map layer composed of a single (possibly multi-part) polygon with Eco-required fields added and populated.

Detailed instructions

1 Obtain an area-of-interest (AOI) polygon from your GIS Department or an online resource such as ESRI's Geography Network (www.geographynetwork.com/).

2 Download the i-Tree.mxd file from www.itreetools.org and save it to your computer.

3 Launch ESRI's ArcMap application at the ArcView (or ArcEditor or ArcInfo) level.

4 Click the **Open** icon button to browse for the iTree.mxd. The iTree.mxd project file contains a custom toolbar for random sample generation and UFORE report output:
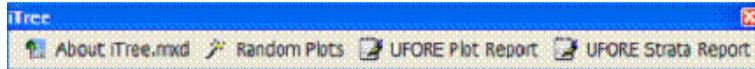
5 Save a copy of the iTree.mxd project *with a new name* at a new location via the **File** > **Save As** menu.

6 Open ArcToolbox.

7 Use the **Add Data** button to navigate to and load the AOI polygon map layer to the current view. An "Unknown Spatial Reference" message may appear; click **OK** to move past it.

8 Use ArcToolbox to define the projection of the AOI map layer according to your data provider's specifications. (If a projection is already defined, skip to Step 9):

    a Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Define Projection**.

    b Complete the **Data Projection** form.

        For **Input Dataset**, choose the AOI map layer from the drop-down list.

        For Coordinate System, click the **Properties** button to the right. In the **Spatial Reference Properties** window that appears, click **Select** and choose the coordinate system indicated by your data provider.

9   If necessary, use ArcToolbox to reproject your AOI map layer to a system using feet or meters, ideally selecting a projection system already in use by your organization or a commonly used system such as State Plane or UTM in the United States:

   a   Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Feature** > **Project.**

   b   Complete the **Project** form.

      For **Input Dataset**, select the AOI map layer from the drop-down menu.

      Input Coordinate System should be grayed out based on your work in the previous step.

      For **Output Dataset or Feature Class**, use the **Browse** button to the right and navigate to a suitable location to save the output file and give it a name.

For **Output Coordinate System**, click the **Properties** button to the right, and in the **Spatial Reference Properties** window that appears, click the **Select** button and navigate to the proper coordinate system.

For **Geographic Transformation**, select the first choice in the drop-down list if prompted with an "Undefined Geographic Transformation" message. Click **OK** when you've completed all the boxes.

10 If your AOI has more than one polygon, use **ArcToolbox** to dissolve them:

    a Navigate to **ArcToolbox** > **Data Management Tools** > **Generalization** >
       Dissolve.

    b Complete the **Dissolve** window.

       For **Input Features**, select the **AOI map layer** from the list.

       For **Output Feature Class**, use the **Browse** button to navigate to a suitable
       location and give the file a name.

       For **Dissolve Field**, check the data field attribute value that unifies the AOI.
       Example: a "Name" field containing the city name of an AOI, even across
       physically separate city sections.

       Leave the **Statistics** field blank.

       Ensure the **Create Multipart Features** box is checked. Click **OK** to finish.
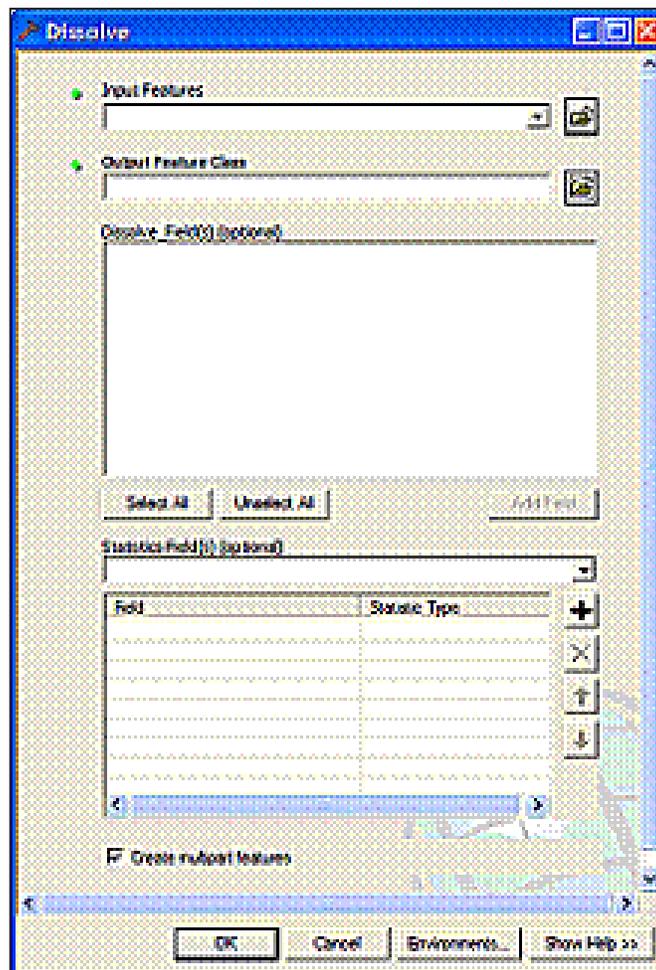
11 Use ArcToolbox to add Eco-required fields to the projected, dissolved AOI map layer. [For experienced users, fields can be added via the ArcMap table view as well.]
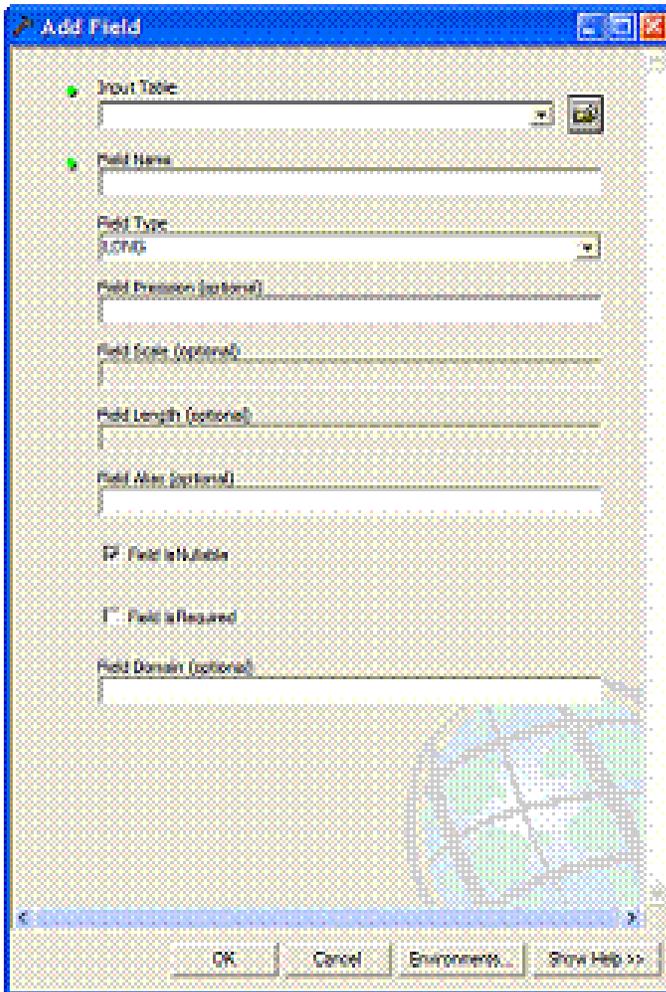
a **Management Tools** > **Fields** > **Add Field.**

b Complete the **Add Field** form.

Under **Input Table**, select the clipped land cover map layer from the dropdown list.

For **Field Name**, enter: Strat_ID
For **Field Type**, select LONG from the drop-down list.

Skip the following fields:

Field Precision
Field Scale
Field Length
Field Alias
Field is Nullible
Field is Required
Field Domain

Click **OK.**

c Repeat the steps above as follows for these THREE additional fields:

Field Name: Strata
Field Text: Select **TEXT**.

Field Name: Strat_Area
Field Text: Select **DOUBLE**.

Field Name: No_Plots1
Field Text: Select **LONG**.

12 Use ArcToolbox to calculate values for the Eco-specific fields added to the projected, dissolved AOI map layer. [For experienced users, the Field Calculator can be used via the ArcMap table view. Also, later versions of ArcGIS have a Calculate Geometry option available via a right-click on the field name in the table.]
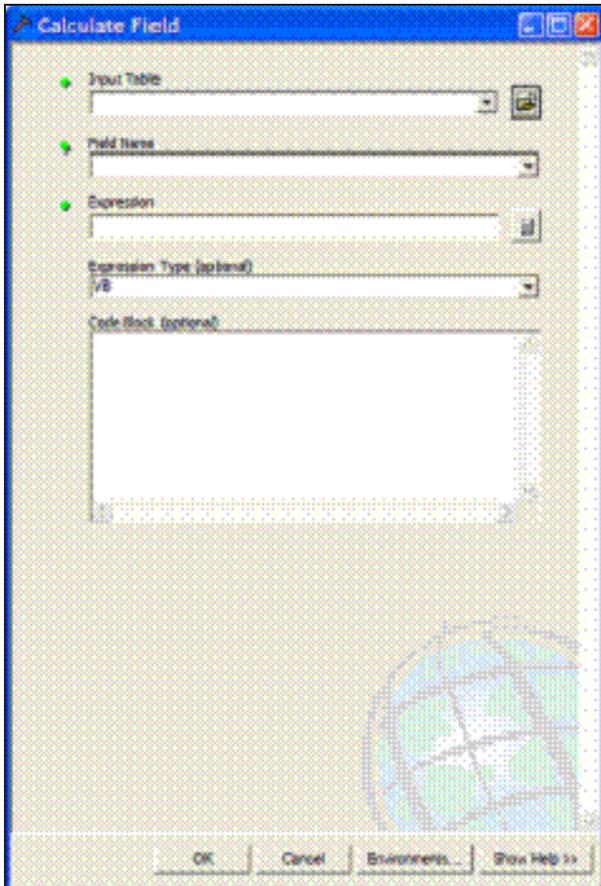
a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Calculate Field.**

b Fill out the **Calculate Field** form
For **Input Table,** select the AOI polygon map layer from the drop-down list.

For **Field Name**, select **Strat_ID**.
For **Expression**, enter: `1`
Skip **Expression Type** (default is typically VB).
Skip **Code Block**.Click **OK**.

c Repeat for the **Strata** field.

For **Field Name**, select **Strata**.
For **Expression**, enter: `"Single Strata"` (including quotes!)

d Repeat for the **Strat_Area** field.

For **Field Name**, select **Strat_Area.**
For **Expression**, enter: `Output`
For **Expression Type**, select **VB.**

Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output as double
Dim pArea as Iarea
Set pArea = [shape]
Output = pArea.area
```

e Repeat for the **No_Plots1** field

For **Field Name**, select **No_Plots1**.
For **Expression**, enter: `XX` where XX is the total number of plots to be generated.

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Results

Area-of-interest (AOI) *polygon* map layer with Eco-required fields added and populated.

- Verify AOI map layer is loaded into the map view. It may be necessary to **right-click** the new AOI layer and select **Zoom to Layer**.

- It should have one record present in its table. **Right-click** the new AOI layer name in the map layers list and choose **Open Attribute Table**.
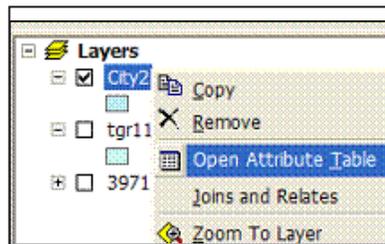
The AOI polygon map layer is now ready to be used for plot generation.

Overview

- Run the Random Plots tool from the i-Tree toolbar.

- Add fields to the random plots data.

- Calculate field values for random plots data.

- Buffer the random plots point data to form plot areas.

Results

- Random sample plots *point* map layer with Eco-required fields added/populated.

- Sample plot areas polygon map layer.

_____

Detailed instructions

1 Click to select the AOI polygon layer in the map layers list and then click the **Random Plots** tool in the i-Tree toolbar:

> **a** Enter the desired number of sample plots in the **Random Point Generator** window.
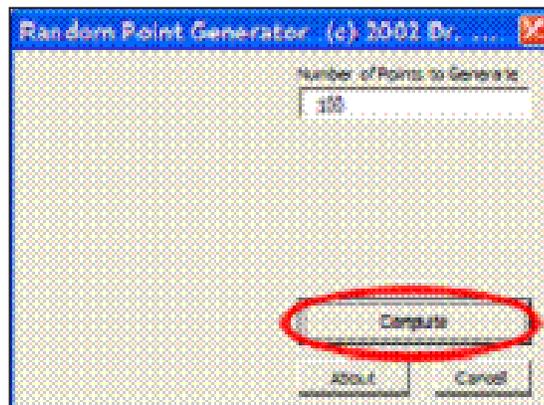
> **b** Click **Compute** and then select a location and file name for the sample plots point map layer to be created.

> **c** Click **Close** to exit the **Random Point Generator** window.

2 Use **ArcToolbox** to add Eco-required fields to the newly created sample plots point map layer:
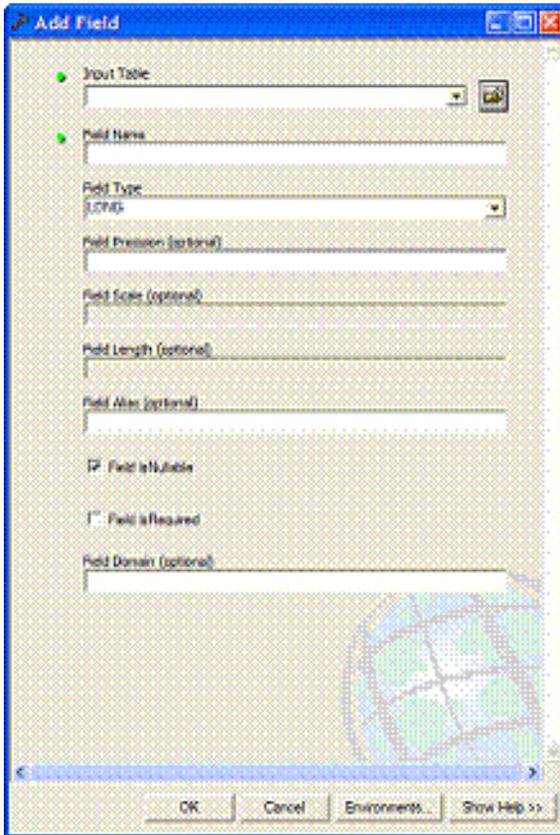
a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Add Field.** [For experienced users, fields can be added via the ArcMap table view as well.]

b Complete the Add Field form.

For **Input Table**, select the sample plots point map layer from the dropdown list.

For **Field Name**, enter: ID
For **Field Type**, select LONG from the drop-down list.

Skip the following fields:

Field Precision
Field Scale
Field Length
Field Alias
Field is Nullible
Field is Required
Field Domain

Click **OK.**

c Repeat the steps above as follows for these five additional fields:

Field Name: LCCode
Field Text: Select **SHORT**.

Field Name: X_Coord
Field Text: Select **DOUBLE**.

Field Name: Y_Coord
Field Text: Select **DOUBLE**.

Field Name: LCType
Field Text: Select **TEXT**.

Field Name: MapUnits
Field Text: Select **TEXT**.

3 Use **ArcToolbox** to calculate values for the Eco-specific fields added to the spatially joined sample plots point map layer in step 2:

a Navigate to **ArcToolbox** > **Data Management Tools** > **Fields** > **Calculate Field.**

b Complete the **Calculate Field** form.

For **Input Table**, select the sample plots point map layer from the dropdown list.

For **Field Name**, select **ID**.
For **Expression**, enter: [FID]+1
Skip **Expression Type.**
Skip **Code Block**.

Click **OK**.

c Repeat for the **LCCode** field.
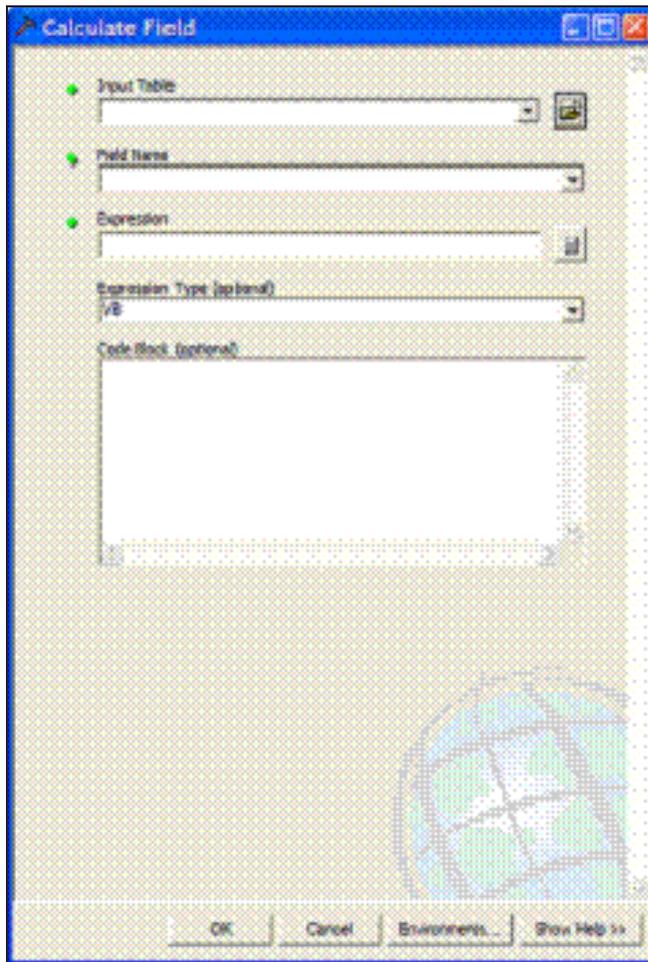
For **Field Name**, select **LCCode**.
For **Expression**, enter: 1

d Repeat for the **X_Coord** field

For **Field Name**, select **X_Coord** .
For **Expression**, enter: Output
For **Expression Type**, select **VB.**

Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output As Double
Dim pPoint As IPoint
Set pPoint = [Shape]
Output = pPoint.X
```

Repeat for the **Y_Coord** field

For **Field Name**, select **Y_Coord**.
For **Expression**, enter: Output
For **Expression Type**, select **VB.**

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Under **Code Block**, enter this code (hint – copy and paste from here):

```
Dim Output As Double
Dim pPoint As IPoint
Set pPoint = [Shape]
Output = pPoint.Y
```

e Repeat for the **LCType** field.

For **Field Name**, select **LCType**.
For **Expression**, enter: "Single Strata" (including quotes!)

f Repeat for the **MapUnits** field.

For **Field Name**, select **MapUnits**.
For **Expression**, enter either:

"Foot_US" (including quotes!) if your map units are in feet.
OR
"Meters" (including quotes!) if your map units are in meters.

g Verify the attributes have been correctly modified in the sample plots point map layer.

Right-click the new, sample plots point map layer in the map layers list, and choose **Open Attribute Table**.

Scan through the fields and their values to verify they are correct.

Note that no projection system is assigned to the plots layer. If desired, it can be defined using steps similar to those for defining the AOI projection system above.

4 Use ArcToolbox to buffer the spatially joined sample plots point map layer. This step creates the plot of your desired size around the plot centers.

a Navigate to **ArcToolbox** > **Analysis Tools** > **Proximity** > **Buffer.**

b Complete the **Buffer** form.

Under **Input Features**, select the sample plots point map layer from the drop-down list.

For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.
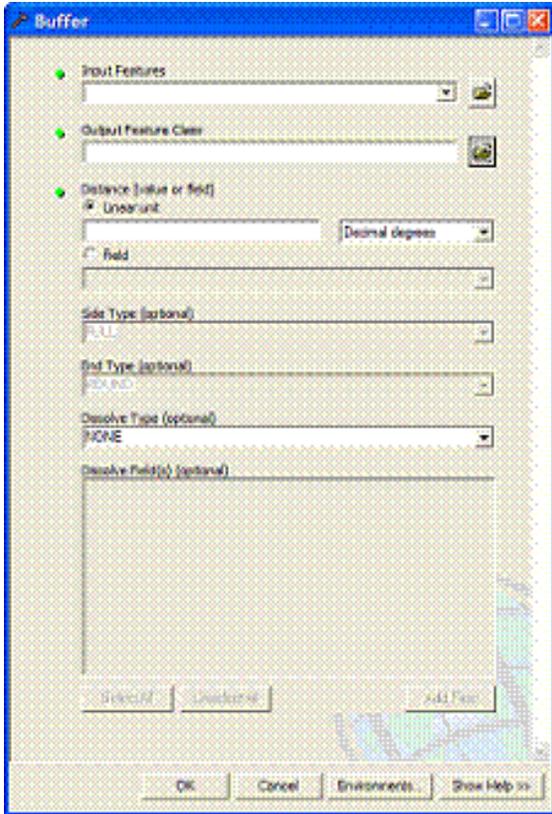
For **Distance**, in the **Linear Unit** box, enter the distance value from the table below, based on your desired plot size. [The distance is the radius of the plot].

Skip the following entries:

Side Type
End Type
Dissolve Type
Dissolve Field(s)

c The buffered sample points layer is added to the map view automatically; zoom in to examine individual plot areas.

	For plot size:	Enter:
Map units in feet	1/5 acre	52.66
	1/10 acre	37.24
	1/20 acre	26.33
	1/100 acre	11.78
Map units in meters	1/5 hectare	25.23
	1/10 hectare	17.84
	1/20 hectare	12.62
	1/100 hectare	5.64

Results

Sample plots *point* map layer

- User-defined number of plots randomly spread throughout the AOI
- Eco-required fields added and populated

Sample plot areas *polygon* map layer

Overview

- Run the UFORE Plot List Report tool.
- Run the UFORE Strata Area Report tool.

Results

- Eco-ready Plot List report text file
- Eco-ready Strata Area report text file
- Eco-ready PRJ file

Detailed Instructions

1 Select the sample plots point map layer in the map layers list and click the UFORE Plot Report tool in the i-Tree toolbar to create the Plot Report.

    a Respond to the questions to confirm your map units.

    b In the next window, navigate to a suitable location and choose a file name for the Plot Report.

    c If the report is completed correctly, the **UFORE Plot Report completed** box will appear.

    d If a field is missing or incorrectly named, an error message will appear. Even though the output will be completed, you must correct the mistake by returning to the previous instructions.

    e Once the mistake is corrected, repeat these steps to output a new, corrected Plot Report.

2 Select the AOI polygon layer in the map layers list and click the **UFORE Strata Report** tool in the i-Tree toolbar to create the Strata report.

    a Respond to the questions to confirm your map units.

    b In the next window, navigate to a suitable location and choose a file name

for the Strata Report.

c If the report is completed correctly, the **UFORE Strata Report completed** box will appear.

d If a field is missing or incorrectly named, an error message will appear. Even though the output will be completed, you must correct the mistake by returning to the previous instructions.

e Once the mistake is corrected, repeat these steps to output a new, corrected Strata Report.

Results

Three Eco-ready reports:

- **Plot listing**
- **Strata listing**
- **PRJ file (automatically created in the Define Projection/Reprojection steps above as part of the AOI Shapefile)**

Appendix 3: Importing Existing Inventory Data

This Appendix provides more detailed information on formatting and importing existing tree data into an Eco complete inventory project for analysis.

General Rules for Data Input

If you are working with an existing data set for a complete inventory Eco project and would like to import it into Eco rather than entering the data using Eco's Paper Data Entry window, your data must be formatted to conform to the Eco inventory requirements before importing. The end result will be a Microsoft Access database file that includes a table containing your inventory data. The Access database file can have any name (*.mdb) but the table must be called `FullInventoryTrees.`

To import data from Microsoft Access into an Eco complete inventory project, you need to know the following:

1 Some inventory fields **must** be included in the Access database, whether or not you have data for those fields (see the yellow rows in Table 3.1). Other fields are optional. For example, every database must include a field for PhotoID, even if you don't have information on Photo ID. You will simply leave the relevant entries blank.

2 The pest detection fields, in contrast, should only be present in the database if you carried out the pest detection protocol.

3 For some fields, *data* are required. For example, every tree must have a species code, but it need not have a DBH2. If you chose to carry out the Pest Detection protocol and included these fields in your database, all data are required.

4 Eco has certain rules that serve as data integrity checks and all values must fall within the accepted limits. These limits are given in Table 3.1. The import function will not import trees that do not have required data or if the data do not adhere to validation rules.

5 Database field names and field types must match the format specified in Table 3.1 in the field name column.

Table 3.1. Required and optional fields and required and optional data for importing an existing tree inventory into Eco for a complete inventory analysis. The table within Access must be named `FullInventoryTrees`. Yellow highlighting indicates required fields.

Field name	MS Access field type	Notes on data
TreeID	Integer OR Long	Data required. Must be >0 without duplication.
Date	Date/Time	Data required.
Crew	Text (100 chars)	Data optional.
X	Double	Data optional. GPS coordinate longitude.
Y	Double	Data optional. GPS coordinate latitude.
PhotoID	Text (100 chars)	Data optional.
TreeAddress	Text (100 chars)	Data optional.
STAT	Text (1 char)	Data required. Tree status, must be P, I, U for initial inventory. Can be N, P, I, U, R, H, C, L for re-inventory.
Species	Text (8 chars)	Data required. Must be species code or genus code.
FieldLandUse	Text (1 char)	Data required. Must be A, C, E, G, I, M, O, P, R, T, U, V, W.
DBHHT	Single OR Double	Data required. Must be -1 for a removed tree. Otherwise, must be between 0 and 6.
DBH1	Single OR Double	Data required. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.
DBH2	Single OR Double	Data optional. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.
DBH3	Single OR Double	Data optional. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.

Field name	MS Access field type	Notes on data
DBH4	Single OR Double	Data optional. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.
DBH5	Single OR Double	Data optional. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.
DBH6	Single OR Double	Data optional. Must be -1 for a removed tree. Otherwise, must be between 0.5 and 200.
TOTHT	Single OR Double	Data required. Height to top of tree. Must be -1 for a removed tree, otherwise must be between 0 and 450.
LiveTop	Single OR Double	Data required. Height to top of live crown. Must be -1 for a removed tree, otherwise must be less than TOTHT and between 0 and 450.
CrownBase	Single OR Double	Data required. Height to base of crown. Must be -1 for a removed tree, otherwise must be less than LiveTop and between 0 and 450.
CrownWidthNS	Single OR Double	Data required. Crown width (north-south). Must be -1 for a removed tree, otherwise must be between 0 and 300.
CrownWidthEW	Single OR Double	Data required. Crown width (east-west). Must be -1 for a removed tree, otherwise must be between 0 and 300.
PercentCrownMissing	Integer OR Long	Data required. Percent of crown silhouette missing. Must be -1 for a removed tree, otherwise must be between 0 and 100.

Field name	MS Access field type	Notes on data
CrownDieback	Integer OR Long	Data required. Percent crown dieback. Must be -1 for a removed tree, otherwise must be between 0 and 100.
CLE	Integer OR Long	Data required. Crown light exposure. Must be -1, 0, 1, 2, 3, 4, 5.
TreeSite	Text (1 char)	Data required. Location of the tree. Must be N or S.
Comments	Text (255 chars)	Data optional.
PestPest	Long	Data required. Pest ID.
PestTSDieback	Integer OR Long	Data required. Tree dieback for tree stress.
PestTSEpiSprout	Integer OR Long	Data required. Tree epicormic sprouts for tree stress.
PestTSWiltFoli	Integer OR Long	Data required. Tree wilted foliage for tree stress.
PestTSEnvStress	Integer OR Long	Data required. Tree environmental stress.
PestTSHumStress	Integer OR Long	Data required. Tree human-caused stress.
PestTSNotes	Text (255 chars)	Data required. Tree stress notes. Can be zero length string.
PestFTChewFoli	Integer OR Long	Data required. Defoliation for foliage/twigs.
PestFTDiscFoli	Integer OR Long	Data required. Discolored foliage for foliage/twigs.
PestFTAbnFoli	Integer OR Long	Data required. Abnormal foliage for foliage/twigs.

Field name	MS Access field type	Notes on data
PestFTInsectSigns	Integer OR Long	Data required. Insect signs for foliage/twigs
PestFTFoliAffect	Integer OR Long	Data required. Percent foliage affected for foliage/twigs.
PestFTNotes	Text (255 chars)	Data required. Foliage/twigs notes.
PestBBInsectSigns	Integer OR Long	Data required. Insect signs for branch/bole.
PestBBInsectPres	Integer OR Long	Data required. Insect presence for branch/bole.
PestBBDiseaseSigns	Integer OR Long	Data required. Disease signs for branches/bole.
PestBBProbLoc	Integer OR Long	Data required. Problem location for branches/bole.
PestBBAbnGrowth	Integer OR Long	Data required. Loose bark for branches/bole.
PestBBNotes	Text (255 chars)	Data required. Branches/bole notes.

NOTE: There are two options for formatting a compatible inventory. Within Eco, you can create a template that is already properly formatted and that allows for data validation. You can copy your data into this template manually or using Access's Get External Data option. Alternatively, you can use this Appendix to create a table from scratch.

Creating a Template Within Eco

To create a template database within Eco:

1 Select **File** > **Import Data Inventory** to open the Importing dialog function. The source data table definitions used within Microsoft Access will appear in the main tab.

2 Select **Create Template Database** and navigate to a location on your computer where you would like to create the template and assign a filename. Click **Open** and you will be asked to confirm database creation.

3 Navigate to the import template database created in the prior step and open in Microsoft Access. You should have a Table called FullInventoryTrees.

4 Populate the FullInventoryTrees table template with your data by either manually entering the data or using Access's Get External Data option, which can be found in Access under File > Get External Data > Import. Follow the Wizard steps to import your data.

Using the Complete Inventory Import Function

Once you have populated your data into the FullInventoryTrees table of the template database or a database that you created and formatted on your own, you can then import into an existing Eco inventory project. With your Eco complete inventory project open:

1 Select **File** > **Import Data Inventory** from the main menu to open the Import dialog function.

2 Select **Browse** to locate the template Access database with the FullInventoryTrees table.

3 Click the **Import** button.

4 A window will appear with the following tabs:

    a **Results** tab: The number of imported trees will be reported as well as whether any were skipped or overwritten if duplicate Tree ID numbers were present.

    b **Overwriting** tab: If you import a database that contains records with identical TreeID numbers, the overwriting tab will be activated and you will need to select records to overwrite or de-select to leave existing records in the input database. Click **Proceed** will complete the process.

    c **Error** tab: Import errors are shown here and importing will not be permitted until errors are resolved. You will need to address these errors in the Access database itself. Once addressed, save and close your Access database first and then repeat the Eco Import process.

5 Close the Import dialog box and save the project to continue. Imported records can be viewed or modified as needed by selecting **Edit** > **Edit or Enter Data** from the main menu. See Submitting Data for Processing section to proceed.

Appendix 4: Pest Protocol

If you conducted the Pest Detection protocol, but did not use the PDA application, you can use the following tables to format your data to import into Eco. You can find more information on the protocol at www.itreetools.org under Resources > Archives, on the Pest Detection webpage at www.itreetools.org/iped/index.php, and the online Wiki PED resources site (wiki.bugwood.org/IPED).

Table 4.1. The pest fields, their categories, and the respective values.

Field name	Category	Value
PestBBAbnGrowth	None	0
	Loose bark only	5
	Rhizomorphs present	7
	Mycelial fans or pads present	8
	Insect boring or galleries causing loose bark	9
	Other	6
PestBBDiseaseSigns	None	0
	Decay	9
	Conks	1
	Fleshy mushrooms	2
	Cankers	3
	Bleeding/slime flux	4
	Resinosis/gummosis	7
	Woody galls or burls	10
	Other	8
PestBBInsectPres	None	0
	Caterpillars	1
	Beetles	2
	Aphids	3
	Scale	4
	Carpenter ants	5
	Other insects	6

Table 4.1, continued.

Field name	Category	Value
PestBBInsectSigns	None	0
	Frass only	1
	Sawdust	2
	Pitch/resin exudation	3
	D-shaped exit holes	4
	Pencil round or oval exit holes (>=2mm)	5
	Shot holes (<2mm)	6
	Other holes	7
PestBBProbLoc	None	0
	Branches	1
	Bole and/or root collar	2
	Both	3
PestBBNotes	Text; up to 255 characters	
PestFTAbnFoli	None	0
	Foliage/twigs distorted (including galls)	2
	Witches' brooms present	6
	Other	5
PestFTChewFoli	None	0
	Defoliation, >10% of foliage but not pervasive	1
	Defoliation, pervasive throughout the crown	4
	Leaf mining, >10% but not pervasive	2
	Leaf mining, pervasive throughout the crown	5
	Chewing of the mid-rib only (any level)	3

Table 4.1, continued.

Field name	Category	Value
PestFTDiscFoli	None	0
	Mottling, spots, or blotches (any color)	1
	Marginal scorching (browning) of leaves	2
	Interveinal scorching (browning) of leaves	3
	White coating	4
	Black coating often sticky	10
	Complete browning/bronzing of leaves or needles	5
	Complete yellowing of leaves or needles	6
	Stippling	7
	Yellow/orange pustules	8
	Other	9
PestFTFoliAffect	None	0
	>10%; <30%	2
	>30% but not the whole crown	3
	Whole crown affected	4
PestFTInsectSigns	None	0
	Caterpillars/sawflies feeding throughout the crown	1
	Beetles feeding throughout the crown	3
	Aphids/white cotton pervasive throughout the crown	4
	Bags pervasive throughout the crown	5
	Scales pervasive throughout the crown	6
	Tents/webbing on more than one branch	7
	Other	8
PestFTNotes	Text; up to 255 characters	
PestTSDieback	None	0
	Twig dieback upper/outer crown (>10%), but not pervasive	2
	Pervasive twig dieback throughout the crown	3

Table 4.1, continued.

Field name	Category	Value
PestTSEnvStress	None	0
	Frost cracks	8
	Lightning strike	1
	Hail injury	2
	Sunscald	3
	Broken branches	4
	Flooding	5
	Drought/poor soil	6
	Other	7
PestTSEpiSprout	No	0
	Yes	1
PestTSHumStress	None	0
	Topping/Poor pruning	1
	Poor or restricted planting/mulching	2
	Wounding of woody tissues	3
	Salt/Chemicals	4
	Other	5
PestTSWiltFoli	None	0
	Wilt, whole crown	1
	Wilt, partial crown	2
PestNTNotes	Text; up to 255 characters	
PestPest	See Table 3.	

Table 4.2. Pest IDs to be entered under field PestPest in the database. The pest list is dynamic and is frequently updated by forest health pest experts. You should update your software frequently using the option under the **Help** menu to ensure that you are using the most current pest list available.

Common name	Scientific name	Value
- Unknown -	- Unknown -	-1
- None -	- None -	0
Ash yellows phytoplasma	*Candidatus Phytoplasma fraxini*	906
Asian gypsy moth	*Lymantria dispar*	10911
Asian longhorned beetle	*Anoplophora glabripennis*	2178
Bacterial leaf scorch	*Xylella fastidiosa*	647
Balsam woolly adelgid	*Adelges piceae*	288
Bark beetle	*Hylurgops palliatus*	9357
Beach bark disease	*Nectria coccinea*	569
Blue stain	*Ophiostoma piceae*	4065
Bronze birch borer	*Agrilus anxius*	352
Brown root rot	*Phellinus noxius*	525
Brown spruce longhorn beetle	*Tetropium fuscum*	4117
Butternut canker	*Sirococcus clavigignenti-juglandacearum*	578
Citrus greening	*Candidatus Liberibacter asiaticus*	4695
City longhorned beetle	*Aeolesthes sarta*	4013
Dogwood anthraconose	*Discula destructiva*	670
Dutch elm disease	*Ophiostoma ulmi*	643
Dutch elm disease	*Ophiostoma novo-ulmi*	19386
Eastern larch beetle	*Dendroctonus simplex*	31
Egyptian cotton leafworm	*Spodoptera littoralia*	5010
Elm phloem necrosis phytoplasma	*Phytoplasma*	11269
Emerald ash borer	*Agrilus planipennis*	7171
European oak bark beetle	*Scolytus intricatus*	4086

Table 4.2, continued.

Common name	Scientific name	Value
European oak leaf roller	*TOrtrix viridana*	9319
False coddling moth	*Thaumatotibia leucotreta*	4989
Forest tent caterpillar	*Malacosoma disstria*	172
Giant woodwasp	*Urocerus gigas*	4097
Goldenhaired bark beetle	*Hylurgus ligniperda*	885
Goldspotted oak borer	*Agrilus coxalis*	56246
Great spruce bark beetle	*Dendroctonus micans*	4038
Gymnopus fungus	*Gymnopus fusipes*	22250
Gypsy moth	*Lymantria dispar*	165
Hemlock woolly adelgid	*Adelges tsugae*	289
Jack pine budworm	*Choristoneura pinus*	117
Japanese pine sawyer beetle	*Monochamus alternatus*	4532
Larch engraver beetle	*Ips subelongatus*	4140
Large brown trunk beetle	*Hylobius abietis*	4119
Laurel wilt	*Raffaelea lauricola*	20929
Leptographium root rot	*Leptographium truncatum*	4057
Light brown apple moth	*Epiphyas postvittana*	4954
Mediterranean pine engraver beetle	*Orthotomicus erosus*	4071
Oak ambrosia beetle	*Platypus quercivorus*	10989
Oak splendour beetle	*Agrilus biguttatus*	4101
Oak wilt	*Ceratocystis fagacearum*	642
Phytophthora root rot	*Phytophthora quercina*	10986
Pine shoot beetle	*Tomicus destruens*	10996
Pine-tree lappet	*Dendrolimus pini*	7053
Raffaela fungus	*Raffaelea quercivora*	22299
Rosy gypsy moth	*Lymantria mathura*	4601

Table 4.2, continued.

Common name	Scientific name	Value
Sakhalin pine sawyer	*Monochamus saltuarius*	4060
Siberian silk moth	*Dendrolimus superans*	12200
Sirex woodwasp	*Sirex noctilio*	4093
Small white-marmorated long-horned	*Monochamus sutor*	4113
Southern pine beetle	*Dendroctonus frontalis*	24
Spruce budworm	*Choristoneura fumiferana*	114
Sudden oak death	*Phytophthora ramorum*	4603
Summer fruit tortrix	*Adoxophyes orana*	4937
Thousand cankers disease	*Geosmithia morbida*	56599
Tremex wasp	*Tremex fuscicornis*	10997
White pine blister	*Cronartium ribicola*	722
White satin moth	*Leucoma salicis*	162

Appendix 5: International Limitations

The following information is provided to summarize international limitations and data requirements for users considering using i-Tree Eco outside the United States. This information is a supplement to the i-Tree Eco manual and other documentation which primarily provide details for use of the Eco model within the United States. The i-Tree Team is currently working with cooperators to improve functionality of the model outside the U.S. as time and limited resources will permit.

Processing time

Processing time for international Eco projects can range from 2 to 6 months after field data are submitted for analysis. This is due to additional formatting time required by the Forest Service to make adjustments to the model to accept and analyze international data. Processing time can vary depending on the current backlog and the amount of data integrity issues needing resolution.

Species list limitations

International Eco users may find that certain trees are not available in the Eco species database. A methodology for integrating new species along with necessary characteristics into the Eco species database has not yet been developed. You are instead advised to choose a substitute tree/shrub species from the list that has similar characteristics in terms of size, structure and leaf type. A unique substitution should be made for each tree not available on the list because reporting (charts and tables) will be generated with the substitute species; you may then edit the reports to reflect the true tree species. The USDA Plants Database and other resources may help users in this process. Please submit your species substitution list to the Forest Service for reference when submitting project data.

Air pollution data

Users outside of the United States will need to supply a full year of local hourly pollution data in the specified format. See Gathering General Data in Phase I for more information.

Weather data

The Forest Service uses weather data that are available for international cities from the National Climatic Data Center. Therefore, most international users will not need to supply this information. However, in some instances, international weather data may be incomplete or unavailable and international users will need to find and submit local weather data in the required format. Reference weather data and formatting documents are available at www.itreetools.org under Resources.

Energy effects

This model component is designed for US climate types, building types, energy use and emission factors. As such, this model component is limited in international applications, except for possibly Lower Canada. Previous international users have requested that their data be analyzed using the values of U.S. cities with similar climates. However, the model estimates are highly uncertain in these instances and the Forest Service will not estimate economic values in these cases. Users should consider international energy effect limitations carefully before deciding to collect tree-building interaction data.

Structural value

The Eco model uses the Council of Tree and Landscape Appraisers (CTLA) formula methodology to determine the structural value of trees within the United States. The Eco model currently does not have the data needed to generate amenity values using other accepted international methods for determining tree values. Therefore, structural values are not estimated for international Eco projects.

Carbon valuation

The model estimates monetary values associated with carbon storage and sequestration by multiplying carbon values by $22.8/tonne of carbon. This is based on the estimated social costs of carbon dioxide emissions for 2001 to 2010 from the literature. Carbon valuation is not estimated for international projects. See Frankenhauser 1994 in the UFORE methods paper for details.

Pollution removal valuation

The monetary value of pollution removal by trees is estimated using the median externality values for the United States for each pollutant analyzed. Recently, the values were adjusted to 2007 values, based on the producer's price index, and are now in dollars per tonne. International literature and other resources are currently being evaluated to decide how to update pollution valuation numbers in the future.

Charts and tables

Certain charts and tables may not be available to international Eco users because of limitations in the Eco databases needed to generate values for cities outside the U.S. The Forest Service can provide raw data output files which are used to generate the Eco charts and tables as a substitute in some instances.

Appendix 6: Data Collection Forms

The following pages include the data collection forms for complete and sample inventories. For sample inventories, you'll need to print one copy per plot.

i-Tree Eco Data Collection Sheet for Inventory Option

Project Name: _____ **Location/Address:** _____

Tree ID	Date	Crew	X Coord.	Y Coord.	Photo ID	Status (NR)	Tree Species	Land Use	HT DBH	DBH1	DBH2	DBH3	DBH4	DBH5	DBH6	Total Height	Live Top	Crown Base	Width N-S	Width E-W	% Missing	%Die Back	CLE	Tree Site

Column group headings: Location/Address — Height — Crown Attributes

PLOT ID=	DATE=	CREW=	GPS COOR		PHOTO ID=
			X		
			Y		

PLOT SKETCH AND NOTES FOR PLOT RELOCATION

(Note distance and direction from plot center to fixed objects; sketch fixed objects in relation to plot center)

Plot address=   Plot contact info:
Notes: Name and
Title:_____

                                                       Phone

#_____

LOCATING REFERENCE OBJECTS/LANDMARKS (Identify at least 1 object)
Measure Reference Object (1) description_____
Distance to Reference Object (1)_____
Direction to Reference Object (1)_____
Measured Reference Object (2) description_____
Distance to Reference Object (2) _____
Direction to Reference Object (2)_____
Tree Measurement Point (TMP): Reference Object (1) used Y/N
                    Reference Object (2) used Y/N
Measurement Unit: M/E

Percent Measured_____

ACTUAL LAND USE=	PERCENT IN=	PLOT TREE COVER (%)=	SHRUB COVER (%)=	PLANTABLE SPACE (%)=
ACTUAL LAND USE=	PERCENT IN=			
ACTUAL LAND USE=	PERCENT IN=			
ACTUAL LAND USE=	PERCENT IN=			

GROUND COVER	%BLDG	%CMNT	%TAR	%ROCK	%SOIL	%DUFF/ MULCH	%HERB/ IVY	%MAIN. GRASS	%UNMAIN GRASS	%H2O

S H R U B S	SPECIES	HEIGHT	% AREA	% MISSING	SPECIES	HEIGHT	% AREA	% MISSING	SPECIES	HEIGHT	% AREA	% MISSING

PLOT ID=

TREE ID	STAT	DR	DS	TREE SPECIES	LAND USE	HT DBH	DBH 1	2	3	4	5	6	HEIGHT TOT	LIVE TOP	CROWN BASE	CROWN WIDTH N-S	E-W	% MISS	DB	% IMP	% SHRUB	CLE	TREES NEAR BUILDINGS D1	S1	D2	S2	D3	S3	TREE SITE