RTAC User Manual

Weed & Invasive Plant Ecology & Management Group

Montana State

Random Transect with Adaptive Cluster Sampling Design – ArcPad Applet Manual

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Prepared for Distribution with Random Transect with Adaptive Cluster Sampling ArcPad Applet

Abstract

Non-native invasive plant species (NIS) pose a significant threat to native biological diversity. Their management and control are mandated by Executive Order 13112 on all federal lands in the United States, including Army training lands.

"Early detection and rapid response" (EDRR) can be a cost effective and feasible strategy to address new and recently established NIS populations. Unfortunately, conventional sampling designs can be inefficient and costly to implement when used to sample sparsely and/or small, patchily distributed populations that typify early phases of invasion. Adaptive cluster sampling designs are an alternative to conventional sampling specifically developed to take advantage of the rarity and clustered nature of many biological populations. Widespread field applications of adaptive cluster sampling designs have been limited by the availability of tools to aid implementation in the field.

This manual describes an adaptive cluster sampling design called the Random Transect with Adaptive Cluster Sampling Design (RTAC) and a user-friendly global positioning system (GPS) interface developed to aid implementation of the sampling design in the field. The GPS user interface is a customized application developed for ESRI® (Redlands, CA) ArcPad®, mobile geographical information software (GIS) for field applications. ArcPad is designed to integrate with ESRI's desktop GIS technology, ArcGIS®, and use of the application is not possible without this software. The application should be used for the mapping of species that are rare on the landscape – as many NIS are at the early stages of invasion.

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Preface

This study was conducted for the Department of the Army, Office of the Director of Environmental Programs (ODEP) under Research, Development, Test & Evaluation Program Element A896, “Base Facility Environmental Quality”; Project 030F25, “Dynamic Adaptive Inventory and Mapping of Non-Native Invasive Plants on Army Installations.” The technical monitor was Steve Sekscienski.

The work was completed as part of a cooperative agreement between Montana State University and the US Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). The ERDC-CERL work was performed by the Ecosystem Processes Branch (CN-N) of the Installations Division (CN). At that time, William Meyer was Branch Chief, CN-N; Dr. John Bandy was Chief, CN; and Alan Anderson was Technical Director for Environmental Quality. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

1 Introduction

1.1 Background

It has been estimated that approximately 275,000 acres of Army training and testing land currently have restrictions on use related to non-indigenous plant species (NIS). NIS are introduced to areas by a variety of natural and anthropogenic means. Once established, some NIS can threaten the ecological integrity of native plant communities and alter important ecosystem-level properties, such as hydrology, disturbance regimes, nutrient cycling, and microbial processes (Vitousek et al. 1989; Mack et al. 1998; D' Antonio 2000; Zavaleta 2000; Brooks et al. 2004; Ehrenfeld 2003; Bais et al. 2006; Allan et al. 2010, Hickman et al. 2010). This potential threat has made the management of NIS on federal lands, including Army training lands, mandatory by Executive Order 13112, "Invasive Species."*

NIS populations can be extremely difficult and expensive to eradicate once established. A more economical and ecologically viable means of limiting NIS impacts is to prevent harmful, unwanted NIS from arriving in an area in the first place (Moody and Mack 1988; Davies and Sheley 2007). Unfortunately, NIS management strategies based on prevention have limited feasibility on Army training lands. Army land use is unique among federal land stewards. Military operations such as off-road maneuvers, moving equipment, material and personnel between sites, and driving considerable distances along unpaved roads, pose a high risk of transporting NIS propagules within and between sites. The high degree of vegetation and soil disturbance associated with training maneuvers also facilitates the establishment of NIS that are dependent upon or benefited by disturbance. Limiting access to areas infested by NIS as a means of preventing unintended transport of NIS propagules is also not viable, given that training land availability does not meet current established needs. Military bases do have vehicle wash stations to clean vehicles travelling within and between sites. Although this approach can reduce the number of plant propagules on a vehicle, it does not totally remove the risk of transfer. Thus, some new NIS populations are likely to establish as a result of vehicle movements. The most cost effective and feasible strategy to address any new and recently established NIS populations is "early detection and rapid response (EDRR)," i.e. treatment, while they are still infrequent on

* Issued by President Clinton on February 3, 1999, and published 64 FR6183, February 8, 1999.

the landscape (Davies and Sheley 2007). Frequently, there is lag time between introduction of NIS and the occurrence of rampant population growth and corresponding impacts (Hobbs and Humphries 1995). Treatment of small NIS populations during this lag phase can prevent widespread invasion and establishment. However, early treatment is dependent upon accurate detection and mapping (Dewey and Anderson 2004; Barnett et al. 2007).

Paradoxically, it is during the lag phase between introduction and rapid population growth that NIS can be the most challenging to detect and map. The large spatial extent of some managed areas, coupled with limited financial resources and competing priorities, can make it impossible to conduct a complete inventory and mapping effort needed to document NIS distributions. These restraints necessitate that some type of sampling to be performed. Conventional sampling designs, however, can be inefficient and costly to implement when used to sample sparsely and/or small, patchily distributed populations that typify early phases of invasion. To increase the number of patches detected using conventional sampling methods, sample size must be increased, but many sampling units will not contain individuals of interest (Morrison et al. 2008).

Adaptive cluster sampling is an alternative to conventional sampling specifically developed to take advantage of the rarity and clustered nature of many biological populations. The designs concentrate sampling effort in 'hot spots' or areas with a high probability of finding the target species of interest. In general, adaptive cluster sampling designs work by first deciding upon an initial sample set. For each sample unit within the initial sample set, if the value of the variable of interest satisfies a specified condition (e.g., target species present), then neighboring units are added to the sample set. The addition of sampling units continues until the specified condition is no longer met (e.g., target species is no longer found). By concentrating sampling effort where target species are most likely to be found (i.e. near other target species), the problem of visiting unoccupied sampling units is minimized. Adaptive sampling methods can, therefore, be more efficient at detecting sparsely dispersed NIS populations when efficiency is evaluated in terms of time spent sampling and travelling between sampling unit locations. Unfortunately, widespread field applications of adaptive cluster sampling designs have been limited by the availability of software and hardware tools to facilitate their use.

1.2 Objectives

This manual describes an adaptive cluster sampling design, called the Random Transect with Adaptive Cluster Sampling Design (RTAC), and a user-friendly Global Positioning System (GPS) interface developed to aid implementation of the sampling design in the field. The GPS user interface is a customized application for ArcPad®, a mobile geographical information software (GIS) for field applications developed by ESRI® (Redlands, CA). ArcPad is designed to integrate with ESRI's desktop GIS technology, ArcGIS®, and use of the application is not possible without this software. This application should be used for the mapping of species that are rare on the landscape – as many NIS are at the early stages of invasion.

The objective of the sampling design and ArcPad application described in this manual is to assist Army land managers who want to use an EDRR NIS management strategy to detect and map the locations of NIS populations. ArcPad is fully integrated with ArcGIS and requires a geodatabase that can also become part of a longer-term NIS monitoring program to assist Army land managers in planning, budgeting, prioritizing, and tracking the effectiveness of NIS management actions.

1.3 Method of technology transfer

The software, i.e. ArcPad GPS user interface, and all accompanying documentation are available to all users: military and non-military, interested in non-indigenous species management. The software and documentation is available through the Montana State University, Weed and Invasive Plant Ecology and Management Group's website. To download, go to http://ippf.msu.montana.edu/ and click on "Download Tools."

2 Background

2.1 Random transect with adaptive cluster sampling design

The RTAC is a combination, with slight modifications, of two sampling designs that have been previously used to survey NIS. Rew and colleagues (2006) and Huebner (2007) found stratified random targeted transects to be a reliable and efficient means of surveying NIS populations. In this type of design, the person conducting the survey walks from the start to the end of each transect recording the presence of a NIS along the way. Prather (2006) used an adaptive sampling design that consists of walking concentric circles around detected patches to search for additional patches. If an additional patch is detected, the process is repeated until a predefined maximum distance is reached. Sampling also stops when after walking a concentric ring no NIS are found, even if the predefined distance has not been reached.

The way in which the stratified random targeted transect and adaptive circle cluster designs are performed in the field allows information about the location of both occupied and unoccupied areas to be collected. Knowledge of areas where NIS are absent, as well as where they are present, is of considerable importance for management. These presence/absence data can be, and are used to elucidate the potential distribution of a NIS (Prather 2006) and can be used to create probability of occurrence maps (Rew et al. 2005) to guide future surveying and management efforts.

The RTAC combines features of the two previously described NIS sampling designs by having a surveyor traverse a transect from start to end, alternating between applying adaptive cluster sampling (referred to as an adaptive sampling session) and applying non-adaptive sampling (referred to as a transect sampling session). Patch density (stems per sq. meter), percent cover, and patch pattern (e.g., discrete patches or individual scattered plants) data are collected at each NIS patch intersected. Similar to the previously described NIS sampling designs, both presence and absence data are collected. A customized ArcPad application, known as an applet, was developed to guide surveyors through the RTAC while in the field. A description of how the RTAC is implemented in the applet is discussed below. A complete step-by-step guide to using the applet is provided in Chapter 3.

2.2 Random transect with adaptive cluster sampling ArcPad application

The RTAC ArcPad application, referred to from this point forward simply as the Applet, is a user-friendly ArcPad GPS interface written in Visual Basic Scripting language. It was developed and tested for ArcPad 8.0 on a Trimble GeoXT GPS device, but should run on any mobile device that supports ArcPad. The Applet requires certain GIS feature classes in a geodatabase, and therefore, requires ESRI ArcGIS. It functions as a navigation, GPS data collection, and decision support tool to guide a user through the process of conducting a survey using the RTAC. How the Applet actually works when loaded on a GPS unit and how to prepare the ArcGIS geodatabase required by the Applet are covered in detail in Chapter 3. The purpose of this section is to familiarize the user with how the Applet implements the RTAC, and provide definitions of important terms, see Table 1. Before proceeding you should read these definitions, and refer back to the table as necessary.

Table 1. Important Applet terminology and definitions.

Term	**Description**
Cell	The secondary sampling unit. It is square polygon of fixed size, referred to as the cell size. In the Applet's associated geodatabase, a cell is a polygon feature of the **surveyGrid** feature class.
Transect Line	A line feature in the **TransectLine** feature class in the Applet's associated geodatabase. The length of each transect line feature should be a multiple of cell size.
Transect Corridor	A rectangular polygon feature in the **Transect_Corridor** feature class in the Applet's associated geodatabase. Each transect corridor feature has width equal to cell size and length equal to the length of a transect. They are used to indicate, in the ArcPad display, the group of cells making up the primary sampling unit. The primary sampling unit consists of a group of X-number of contiguous cells, where X is an integer greater than zero. Each cell in the group bisects the transect line.

Survey Grid	A survey grid is not an ArcGIS raster, rather it is a term used to refer to a collection of (survey grid) cell features in the **surveyGrid** feature class in the Applet's associated geodatabase. The collection consists of a fixed number of cells to the right and left of a transect corridor, as well as the cells bisecting the transect line. Each cell in a survey grid has the same **Id** attribute value, and each survey grid has a unique id associated with it grid.
Sampling Status or Scode	Both are attributes of a survey grid cell. They are used by the Applet to keep track of which cells have been sampled or surveyed, and to determine the display color of each cell. Values and colors are in Table 2.
Transect Point	This is a point feature in the **transect** class in the Applet's associated geodatabase that shows the location of where a surveyor either started or ended the survey of a transect line. GPS capturing a start transect point allows the surveyor to set RTAC parameter values and other data before beginning a survey. GPS capturing an end transect point indicates the survey of the transect line is complete.
Transect Plant Point	A point feature in the **transect_plant_pnt** feature class in the Applet's associated geodatabase. These features indicate either the start or end of a large NIS patch or the middle of a small NIS patch intersecting a **Transect_Corridor** feature. These features are captured by the GPS unit during a transect sampling session.
Adaptive Plant Point	A point feature in the **adapt_plant_pnt** feature class in the Applet's associated geodatabase. These features represent small NIS patches that are not large enough to be represented as polygons in a geodatabase. These features are captured by the GPS unit during an adaptive sampling session.
Adaptive Plant Patch	A polygon feature in the **adapt_plant_patch** feature class in the Applet's associated geodatabase. These features represent NIS patches big enough to be represented as polygons in a geodatabase. These features are captured by the GPS unit during an adaptive sampling session.

Adaptive Sampling Session	Refers to the time spent surveying cells adaptively once a target species has been detected in a transect corridor when adaptive sampling is allowed.
Transect Sampling Session	Refers to the time spent surveying cells in the transect corridor. During this time only transect plant point features are captured and no adaptive sampling takes place.
Maximum Search Area	Abbreviation for 'maximum number of cells to search while delineating a NIS patch boundary.' In the Applet, this sampling design variable is abbreviated as Max Srch Dist. This variable can used to limit adaptive cluster sampling to only patches less than a predetermined size.
Maximum Survey Area	Abbreviation for 'the maximum number of cells to survey in an adaptive sampling session'. In the Applet, this sampling design variable is abbreviated as Max Sur Dist. This variable can be used to place a limit on the number of cells that need to be sampled during an adaptive sampling session.

In section 2.1, general descriptions of the two sampling designs making up the RTAC: stratified random transect and adaptive circle cluster, are given. The Applet implements both these designs as a grid based sampling scheme. Keeping this fact in mind will help make sense of the classes in the Applet's associated geodatabase and the reason behind some of their names. Another key characteristic of the Applet to keep in mind, relates to ArcPad. ArcPad does not have the capability to create or update ArcGIS raster datasets (grids). The Applet, therefore, even though it executes the RTAC as a grid based sampling scheme, does not do so using a raster dataset.

In place of a raster dataset, the Applet uses a collection of polygons, referred to as a survey grid; there is one survey grid per transect to be sampled. All the polygons in a survey grid have the same **Id** attribute value and are of equal size. These square polygons are referred to as cells and thus, their size (length and width) is referred to as cell size. The cell represents the secondary sampling unit in the Applet's grid based implementation of the RTAC. The primary sampling unit for the RTAC is a straight-line transect of fixed length. In the Applet, the primary sampling unit is also referred to as a transect, but because the RTAC is implemented as a grid based sampling scheme, an Applet transect is actually the group of cells that the transect line bisects. In the Applet's geodatabase, transect lines are features of the **TransectLine** feature class and the group of cells bisecting these features are displayed by the Applet using features in the **Transect_Corridor** feature class. The transect corridor features are polygons that buffer transect lines (features in the **Transect_Line** feature class) with a width equal to cell size. The Applet uses the transect corridor to visually indicate to the user which cells make up the Applet transect (i.e. the primary sampling unit) and need to be sampled.

Conducting a RTAC survey consists of sampling each cell delineated by a transect corridor and updating the (Sampling) **Status** of each cell, and consequently, the **Scode** as well. The Applet uses the **Scode** to display cells according to the color scheme in Table 2. Displaying the cells in different colors based on their sampling status helps the user navigate to cells that need to be sampled. While sampling the cells in a transect, the Applet user will alternate between implementing transect sampling and adaptive circle cluster sampling designs.

Table 2. Applet color scheme for displaying cells based on their sampling status.

Sampling Status	Scode	Display Color
Sampled/Absent	0	Red
Sampled/Present	1	Green
Not Sampled	2	Blue
To Be Sampled	3	Orange
Not Sampleable	-9	Grey

Sampling transect cells and implementing the transect sampling design is referred to as transect sampling session; similarly, sampling cells while implementing the adaptive circle cluster design is referred to as an adaptive sampling session. Transect sampling takes place for fixed distance equal to the maximum survey distance variable. Adaptive sampling takes place within a fixed area defined by the maximum survey distance once a target species is detected in a transect cell. A survey can start out with either sampling design. Alternating between sampling designs is not a requirement of the Applet, hence a user is free to implement either design during the entire survey.

During both types of sampling sessions, when a target NIS patch is detected in a transect cell, the Applet is used to create new geodatabase features: **transect_plant_pnt** , **adaptive_plant_pnt,** or **adaptive_plant_patch**. The features **adaptive_plant_pnt** and **adaptive_plant_patch** are created when NIS patches are detected during an adaptive sampling session. The only difference between the features is patch size. Adaptive plant point features represent NIS patches that are too small to be represented in the geogdatabase as polygons. The feature **transect_plant_pnt** is created during a transect sampling session. The transect plant point feature represents the start, middle, or end position of a NIS patch. If the patch is large, two such features are GPS captured: one at the patch start position and another at the end position. If the patch is small, only one such feature is GPS captured at the middle position of the patch. After a NIS feature of any type is GPS captured, the Applet displays forms with menus and pick-lists of predefined values for the feature's attributes; standardizing the NIS patch information collected.

During an adaptive sampling session, once a NIS patch is detected in a transect cell and the first GPS point captured, the Applet will display two squares (see Figure 3 in Chapter 3); one defining the maximum search area and the other defining the maximum survey area. The two areas provide the user with some practical guidelines to use to avoid excessive sampling effort. The smaller of the two areas – maximum search – defines the maximum area to search for satellite NIS patches associated with the NIS patch intersecting the transect. The maximum search are has length and width equal to the variable maximum search distance, and is centered on the first GPS point captured. After the adaptive plant feature has been captured, if its area exceeds the maximum search area, then adaptive circle cluster sampling should not be carried out. The underlying assumption being the adaptive design is most appropriate for clusters of small patches rather than a single large patch.

The larger of the two areas – maximum survey – defines the boundary where the sampling of cells should stop. After an adaptive feature has been captured, the Applet determines which cells need to be additionally sampled and changes their status, and thus their display color (see Table 2). Additional cells to be sampled are chosen based on the location of their centroids relative to the patch boundary; the centroids must be within the maximum search distance or boundary. The cells to be sampled adaptively should be thought of as sets of concentric 'rings' of cells formed around the patch. The Applet user circles around the NIS patch updating the **Status** of the cells in each ring, alternating between walking in a clockwise or counter-clockwise direction when circling. The direction to start with in the first ring is determined randomly by the Applet. As a means of controlling final sample size, any cells lying outside the maximum survey area should not be sampled. It should be noted, the user is free to ignore the built-in Applet guidelines, just like the built-in option of alternating between the two sampling designs mentioned previously.

The maximum search and survey area distance variables are set by the users at the start of a transect to be surveyed. When at the start position, the user should GPS capture a transect point feature whose **start_end** equals **start**, after which the Applet will display a menu requesting input values for sampling design variables and some additional information, for example the name of the target NIS (the Applet is designed to survey for only one NIS at a time). When the survey of a transect is complete, either because the last cell has been sampled or because surveying can no longer continue for some reason, another transect point feature is GPS captured whose **start_end** equals **end**. Gather required information at the beginning of surveying a transect and designating the location of where the survey ended is the sole purpose of the point features in the transect point feature class.

In summary, the Applet guides the person performing the sampling, surveyor, through the process of conducting a survey using the RTAC in three ways. First, it standardizes the information collected during a sampling session by providing menus, forms, and pick-lists of predefined values. Second, it has support tools and features that help the surveyor make key sampling design decisions, e.g., where to start and stop adaptively sampling. During an adaptive sampling session, once a target species has been found, the Applet selects and displays the additional cells that need to be surveyed adaptively. Lastly, it uses visual cues and displays the cells according to the sampling status to aid the surveyor in navigation.

3 Approach

This chapter describes the process necessary for a successful field session using the RTAC Applet. It will guide you through the entire process from the creation of the necessary data, to the incorporation of the final sampled data into the geodatabase for monitoring and analysis. It assumes that you have correctly installed the Applet and have all the materials provided with the Applet CD. If you have not installed the Applet see Appendix B.

3.1 Prepare GIS data for ArcPad

This section describes how to prepare the required data for the Applet and transfer it to the GPS unit for use in the field. There are two steps in the process of data creation: (1) create and GPS-enable a geodatabase and (2) create features in the geodatabase's feature classes. To simplify the geodatabase creation process an empty geodatabase schema is provided with the Applet. Also, there is a set of customized ArcGIS tools provided to help create and attribute the required features in the geodatabase. These were provided on the Applet installation CD.

3.1.1 Create and GPS-enable the GIS sampling design geodatabase

The following steps show you how to prepare the geodatabase required for use with the Applet. It is assumed you have a copy of the geodatabase schema provided with the Applet. In the event that you do not have this schema, a complete description of the geodatabase is included in chart form in Appendix A to allow you to generate a geodatabase with all necessary feature classes, fields and attributes. To build your data with the existing schema:

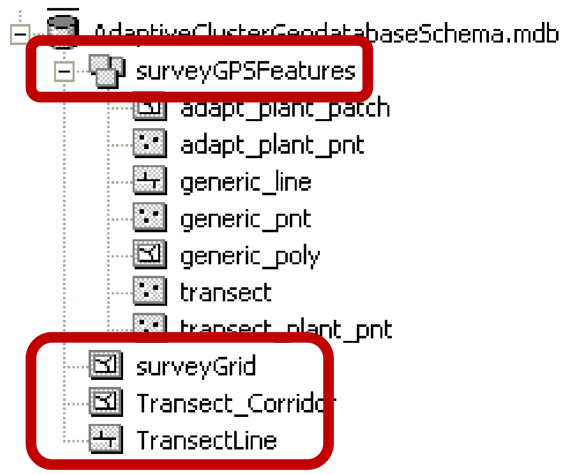
Step 1. Copy the schema to your working directory

- Open ArcCatalog and in the table of contents navigate to the geodatabase titled AdaptiveClusterGeodatabaseSchema.mdb you received with the Applet files
- Copy the geodatabase to your current working directory
  - This manual will use the name AdaptiveClusterGeodatabaseSchema.mdb for all examples. If you choose to rename your copy of the geodatabase you will need to substitute that name, where appropriate, in future steps.
- Optional- copy this original geodatabase and store it in a safe location as a template for future use.

Step 2. Define the geodatabase's spatial reference

Each feature's spatial reference must be defined to work with ArcPad. You can choose to set the spatial reference by individual feature class or you can define it by feature dataset

- In the ArcCatalog table of contents, expand the geodatabase

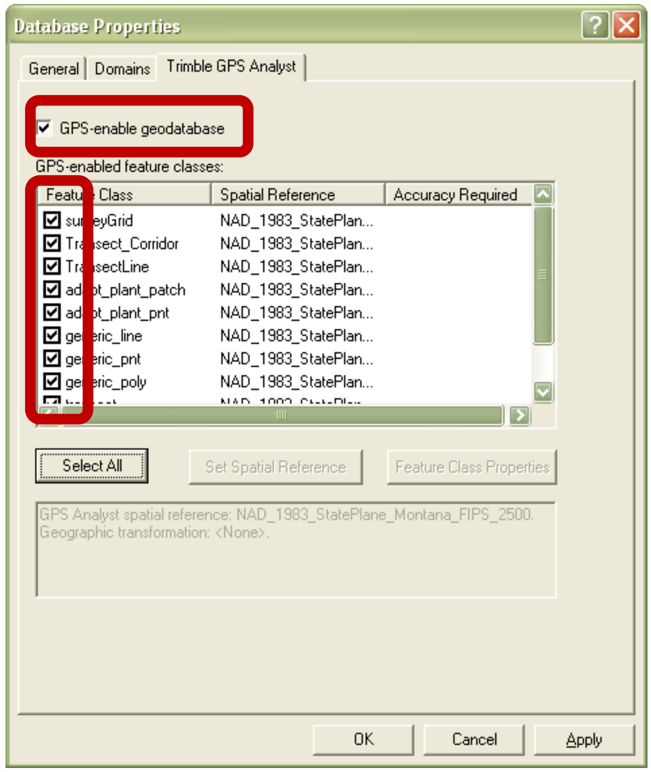


- Select the feature dataset **surveyGPSFeatures**. Set the coordinate system by right-clicking your mouse over the dataset and selecting **Properties**
- Click the **XY Coordinate System** tab and select the coordinate system you prefer to use with your GIS data
- Click **OK.** This sets the spatial reference for each feature class in the feature dataset
- Repeat this process again for the feature classes **surveyGrid**, **Transect_Corridor** and **TransectLine**

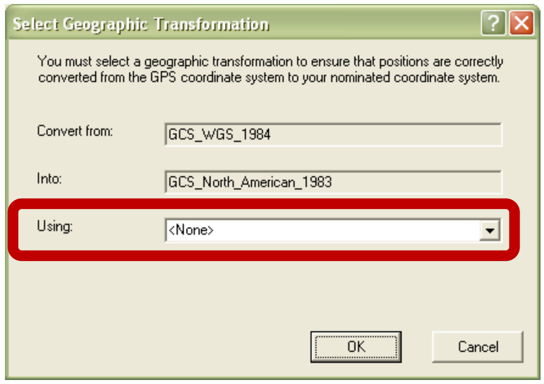
Step 3. GPS-enable the geodatabase

GPS-enabling the geodatabase allows data to be checked out for editing in ArcPad. **Note**: The Trimble GPS Analyst extension must be activated in Arc before the geodatabase can be enabled. To enable the geodatabase take the following steps:

- Right click on the AdaptiveClusterGeodatabaseSchema.mdb file in the ArcCatalog table of contents and select **Properties**
- Check the **GPS-enable geodatabase** button under the **Trimble GPS Analyst** tab
- Select all of the classes that you will be updating with the GPS:



- Click **OK**
- Select the appropriate transformation to convert your data from WGS_1984 into your chosen coordinate system and click **OK**.
    - All GPS data is collected in GCS_WGS_1984. If the coordinate system that you chose to use for your geodatabase is not GCS_WGS_1984, you will need to select a transformation method so that the data from the GPS can be correctly converted from GCS_WGS_1984 to your chosen coordinate system.
    - ESRI provides documentation of the many transformation methods with ArcMap so that you can choose the correct transformation for your area or consult a local GIS expert.



Note: At this point, ArcCatalog may display a warning indicating that the extents of the selected feature classes are outside the extent selected while GPS-enabling the geodatabase. This occurs because the geodatabase is empty. Click **OK** to this warning. In general, this will not cause a problem. However, you can prevent possible problems when you start to add features to feature classes in the geodatabase by first zooming the data frame in ArcMap into a reasonable extent and scale for your intended field session. Load background data into ArcMap to find the correct location in the empty geodatabase, if you are unsure of the location and extent of your field sites when you first start ArcMap.

Step 4. Set GPS accuracy fields

The geodatabase schema for the GPS feature classes includes the attribute fields **ave_accuracy** and **worst_accuracy**. These fields will record the GPS accuracies for each feature you GPS-capture while in the field. By default the geodatabase is set not to record these values in the table, hence, you need to follow these steps to activate these fields for this purpose:

- In the ArcCatalog table of contents, right click on any one of the feature classes under the **surveyGPSFeatures** dataset
- Select **Properties** and click on the **Trimble GPS Analyst** tab
- Use the drop down menus for **Store Average Estimated Accuracy** and **Store Worst Estimated Accuracy** to select the proper field in the geodatabase
- Click **OK**
- Repeat this process for each of the other feature classes under the **surveyGPSFeatures** dataset
    - This does not need to be done for the feature classes **surveyGrid** and **Transect_Corridor** be-

cause the features in this class will only be updated rather than created.

Your geodatabase is now GPS-enabled and ready for data preparation and check out

3.1.2 Create features in the geodatabase

This Applet requires two populated feature classes to function properly and one to aid in sample design implementation. These feature classes are **TransectLine**, **Transect_Corridor**, and **surveyGrid**. Tools for use in ArcMap have been provided with the Applet to simplify the creation of **Transect_Corridor** and **surveyGrid** features. A transect feature class that includes the transects to be surveyed must be provided as input to the tools prior to the creation of either of the remaining features classes. The transect lines themselves can be created via any process you choose, but should be created in the feature class **TransectLine** included in the empty geodatabase. The transect lines can be of any length, but the length of should be a multiple of the cell size, described below. In order for the tools to perform properly, each transect feature **MUST** have a unique ID.

Once the transect features in **TransectLine** have been created, you can use the **Corridor Builder** tool to generate features in the **Transect_Corridor** feature class and the **Survey Grid Builder** tool to generate features in the **surveyGrid** feature class. The **Survey Grid Builder** tool uses a transect line feature to create a set of equal area polygons, i.e. the survey grid, associated with each transect line, see Figure 1. The individual polygons, referred to as cells, are squares whose side lengths are referred to as cell size. For example, a cell size of 10 m would produce a cell whose length and width equal 10 m and area equal to 100 m^2. Each cell in a survey grid has the same **Id** value; this is how the Applet recognizes a set of cells as a survey grid. The **Corridor Builder** tool is similar to the **Survey Grid Builder** tool in that it creates a single rectangular polygon corresponding to the center column of cells in the **surveyGrid** feature class, i.e., those cells that the transect line features bisects. The tools will build a survey grid and transect corridor corresponding to each transect feature, hence including several transect line features in a single **TransectLine** feature class will save time and effort in the construction of the survey grids and transect corridor features.

Before proceeding, you should create transect line features to use with the tools. The tool will accept transects of any length. If a transect's length, however, is not a multiple of the cell size, there will be a length of transect and corridor that extends beyond the surveyGrid. For example, if you choose a cell size of 10 m and a transect has length 79 m, there will be a segment of the transect and corridor that extends beyond the **surveyGrid**. For example if you choose a cell size of 10 m and a transect has length of 79 m, there will be a 9 m section of the transect and corridor extending beyond the **surveyGrid**, see Figure 1. To avoid confusion in the field, it is best to ensure all transect lengths are multiples of cell size.

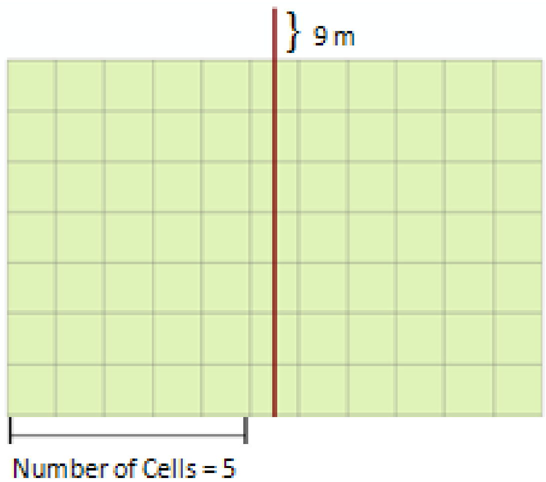


Figure 1. Example of a surveyGrid generated with the Survey Grid Builder tool. Brown lines represents the transect of length 79 m, and the green squares represent cells of size 10 m x 10 m. The transect extends beyond the surveyGrid, because the length of the transect is not divisible by the cell size.

Transect features should be created in the **TransectLine** feature class of the geodatabase provided with the Applet. To begin creating transect features add the AdaptiveClusterGeodatabaseSchema.mdb to an ArcMap session and create the transects in the correct feature class. If ArcCatalog brought up the warning mentioned previously when you GPS-enabled the geodatabase, ensure that the transects you create are in the correct location by adding background data and/or by checking the coordinates of the features. Once you have added the geodatabase to an ArcMap session and created transects, you can save the .mxd and use this map document in the following steps.

Step 1. Add the tools to ArcMap

- Locate the folder supplied with the Applet called AdaptiveSamplingTools. This folder contains the toolbox, tools and source scripts for each of the tools.
- Optional: Copy this folder and all of its contents to a secure location for future use.
- Open ArcMap.

- Right click in the ArcToolBox window and click **Add Toolbox**…
- Navigate to the file Adaptive Sampling Tools folder provided with the Applet.
- Select the **Adaptive_Sampling_Tools** toolbox and click Open.

The Adaptive Sampling Tools toolbox should now be added to the ArcToolBox

Step 2. Use the Survey Grid Builder tool to create the survey grids

The **Survey Grid Builder** tool uses the input variables **Cell Size**, **TransectLine Feature Class**, **Survey Grid Feature Class**, and **Number of Cells** to create a survey grid feature surrounding each transect line. All but the number of cells has been discussed previously. The number of cells variable defines the width, in number of cells, of a survey grid feature; it represents the number of cells to the right or to the left of the group of 'center' cells the transect line bisects, see Figure 2. A survey grid width, in map units, is given by the following formula:

SurveyWidth = (2*(Number of Cells))*(Cell Size) + (Cell Size)

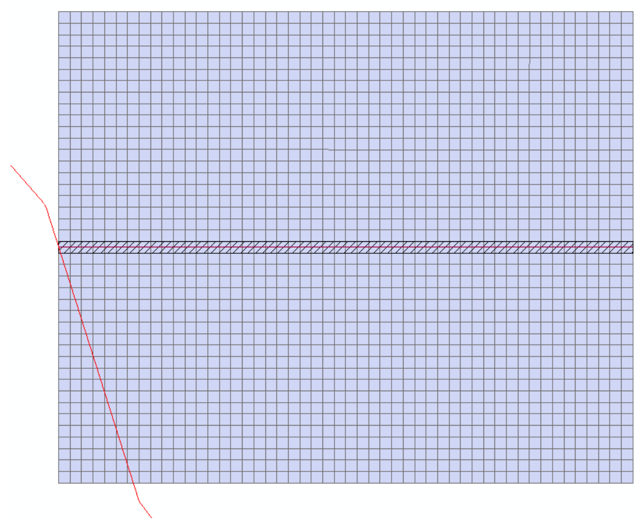
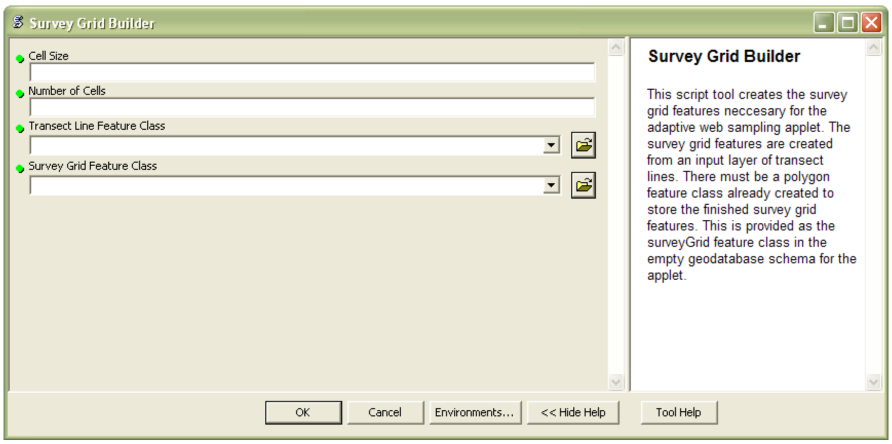


Figure 2. Example of the relation between a surveyGrid, transect, and transect corridor feature. Dash line represents transect corridor and orange line represents a road.

To create survey grid features in the **surveyGrid** feature class:

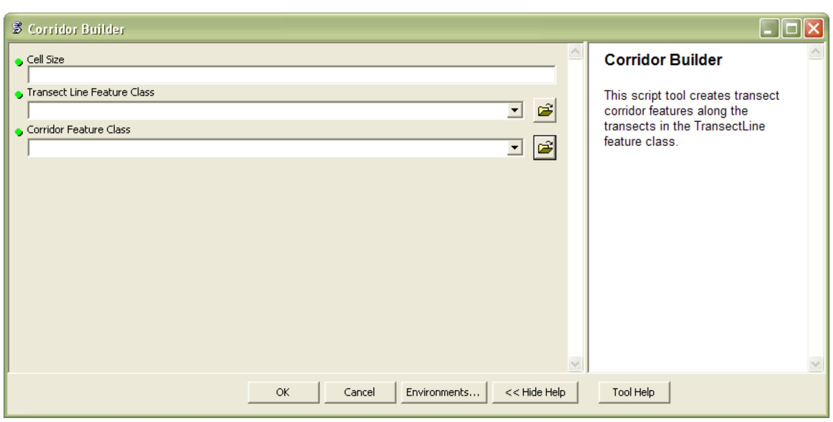
- Add the AdaptiveClusterGeodatabaseSchema.mdb to ArcMap if you have not already done so.

    - Create the transect line features in the **TransectLine** feature class if you have not already done so.
- Double click the **Survey Grid Builder** script tool in the **Adaptive Sampling Tools** ArcToolbox
- Fill in the values for the four tool variables
- Click **OK**
    - If you have a large number of transects or a small cell size the tool will take several minutes or longer to build all of the survey grids



Step 3. Use the Corridor Builder tool to create the transect corridors.

The **Corridor Builder** tool uses the input variables **Cell Size**, **Transect Line Feature Class** and **Corridor Feature Class** to create a corridor along each transect line.



Follow these steps to create the Transect Corridor:

- Double click the **Corridor Builder** script tool in the Adaptive Sampling Tools ArcToolbox
- Fill in the values for the three tool variables
- Click **OK**

A finished **surveyGrid,** transect and transect corridor are shown in Figure 2, along with a roads layer. The transect lines are shown in pink, the transect corridor in hatched symbology, and the **surveyGrid** cells in blue. Your data should look similar when finished.

3.1.3 Add additional reference data

Along with checking out data from the geodatabase, other GIS data can be copied out as background or reference data for use in ArcPad.

Step 1. Add any reference data needed to complete the survey

- This could include roads, streams or aerial photographs that will help you navigate while in the field.

Step 2. Save your ArcMap document

- You will use this .mxd to check out and check in geodatabase layers and copy out all other layers for use in ArcMap using the **Trimble GPS Analyst**.

Once you have built and attributed all of the features required, layers in your geodatabase are ready to be checked out for use in the field.

3.2 Check out data for ArcPad

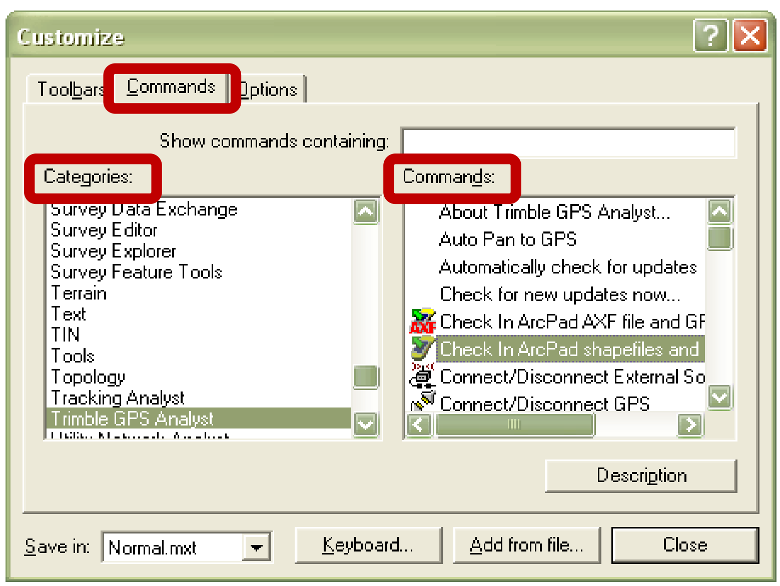
This section will guide you through the process of checking out data from your GPS-enabled geodatabase and transferring it to a GPS device for use in the field. Here you will check out all of the feature classes required by the Applet to function, as well as any layers useful for navigation or reference as background layers. This manual assumes you have received the proper program files for installation of the Applet on your GPS unit and the Applet is correctly installed on the unit. If the Applet is not currently installed on your GPS unit see Appendix B.

Step 1. Get the appropriate buttons

Before beginning the data checkout process, ensure the correct buttons are present on the **Trimble GPS Analyst** toolbar. The buttons required for this process are the (1) **Get Data for ArcPad** and (2) **Check in ArcPad Shapefiles and GPScorrect SSF** buttons.

If you do not find the buttons on the toolbar they must be added before beginning data checkout. To do this:

- Right click on the **Trimble GPS Analyst** toolbar
- Scroll through the list and click on **Customize**...
- Select the **Commands** tab
- Under the **Categories** heading select **Trimble GPS Analyst**
- Select the tools under the **Commands** heading and drag them onto the **Trimble GPS Analyst** toolbar
  - The **Check in ArcPad** button will be grey and unavailable on the toolbar until data has been checked out and a GPS Editing session has been started.
  - To avoid confusion, unnecessary buttons can be dragged off the toolbar if they are not needed.
- When you have added the necessary buttons click **Close**



Step 2. Connect the GPS unit to the computer using ActiveSync

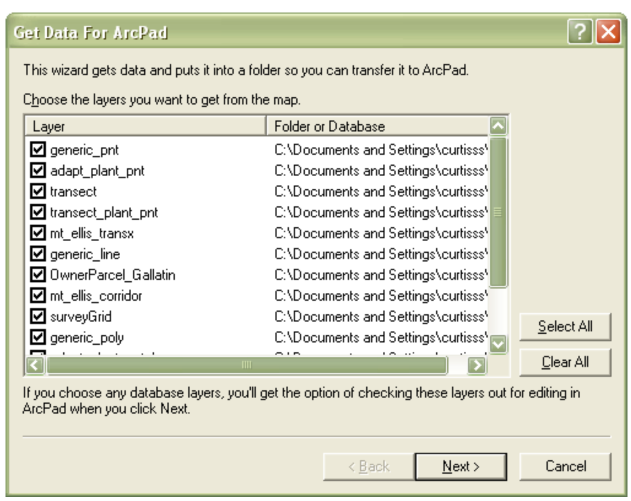
- Connect using the method you are accustomed to

- A Guest Partnership is the recommended connection method.

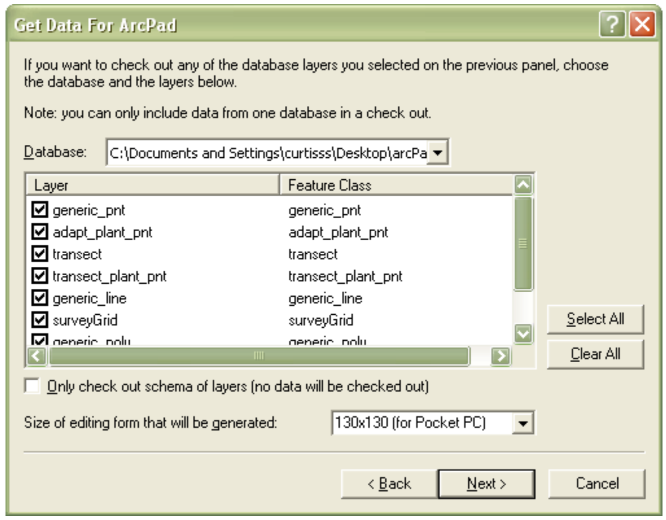
Step 3. Check out data

- Open the Arc Map .mxd containing your geodatabase you saved in Step 2 of Section 3.1.3
- Zoom to the extent of the data you wish to check out
    - It is **strongly recommended** you set the extent to a single survey grid feature and only check out one survey grid per check out session. By doing so, ArcPad will run much faster. ArcGIS allows multiple check outs from a geodatabase and you can load multiple check out sessions on your GPS units to use in ArcPad at one time. Hence, if you have several survey grid features in your **surveyGrid** class and check them out separately, it will not cause any problems in either ArcPad or your geodatabase.
    - It may be helpful to create a bookmark at each survey grid for future reference or checkout
- Click the **Get Data** icon to access the menu for data selection:

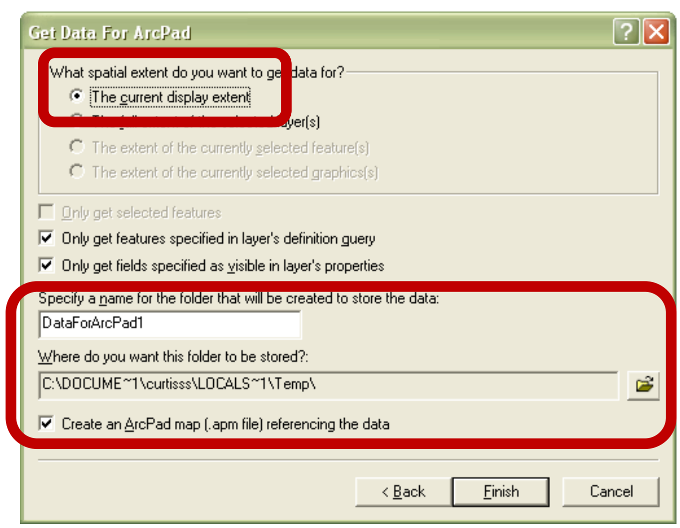
- Select all the layers you wish to display in ArcPad including background files and click **Next**:



- ➢ Select all the layers to check out for GPS editing in ArcPad and click **Next**:



- ➢ Verify the radio button, next to **The Current Display Extent** is selected. This button is located under the question **What spatial extent do you want to get data for?**
  - This limits the amount of information that will be transferred onto the GPS unit
- ➢ Specify a name and a location on your desktop to save the checked out data
- ➢ Verify the **Create an ArcPad Map** checkbox is selected
- ➢ Click **Finish**

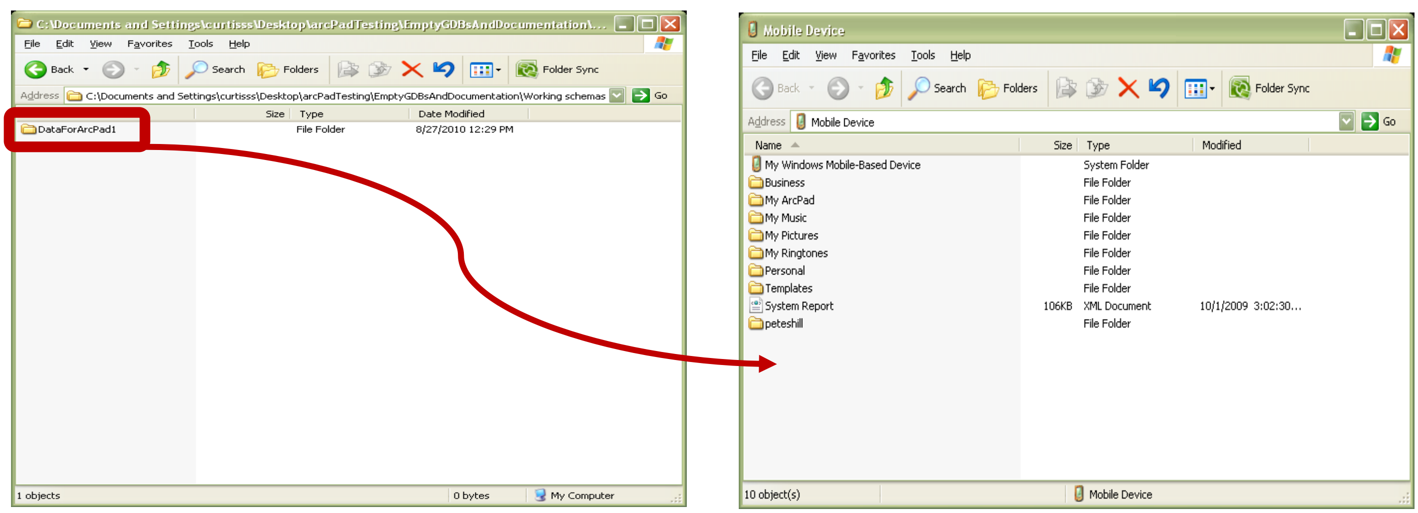


Step 4. Transfer checked out data to the GPS unit

- Open the folder where you specified during the check out process to have your data placed
  - Rename the ArcPad .apm file to a more descriptive name.

- Delete the .sbn and .sbx file extensions from the **surveyGrid** files
  - This allows ArcPad to run much faster and is **strongly recommended**.
  - Do not delete these files for any other layers, only the **surveyGrid**.

- Choose a location on the GPS unit and copy the data folder to the GPS using **Copy** and **Paste**.
  - It is recommended to copy your data to the Mobile Device Screen of your GPS unit or to the default path used by ArcPad.



Step 5. Customize the .config file

Before going into the field, you will want to customize the Applet's configuration file, AdaptiveSampling.config. The configuration file sets variables required by the Applet to the appropriate layer names in the user's geodatabase and specifies possible values for certain fields, such as targeted species or surveyor names. Specified values for certain fields will show up in the form of pick lists when the Applet is used. While still connected to the GPS unit with active sync:

- Use Windows Explorer to navigate to the folder in the Mobile Device window containing the Applet files
- Copy the AdaptiveSampling.config file onto your computer and update the necessary fields:
  - Fill in all pick lists with the desired possible values.
  - Verify the layers that were checked out from the geodatabase are properly specified in the AdaptiveSampling.config file and update the file names as necessary. If the feature class layer's names in the AdaptiveSampling.config file for the variables are not the same as the feature class layer names that were checked out from the geodatabase, the Applet will not function correctly. For example, by default the TransectLineLayer = TransectLine. If, however, the transect line layer named in your geodatabase was, for example, Transx in the geodatabase, then the variable TransectLineLayer should be set equal to Transx. If you used the schemas provided to create your geodatabase, no variables relating to the geodatabase should need to be changed. See Appendix B for more information
  - Verify the **drawmaxsurveyarea** field is set to **true**
- Replace the AdaptiveSampling.config file in the Applet file with the updated file.

3.3 Conduct a survey

After you have checked out your data and transferred them to your GPS unit, start ArcPad and make sure you can open the .apm file. You will want to take along a few small flags to stick in the ground at your field site; we have found these useful when marking patch boundaries and plant locations. This section will guide you through the process of carrying out a survey using the RTAC Applet described above. The steps assume you have opened the appropriate ArcPad map (.apm) containing the GIS data for data collection or update, activated the GPS receiver and verified the GPS status.

In general, you will traverse a transect from beginning to end looking for the target plant species within the transect corridor. Once a target species is found you will, depending on whether or not you are currently in an adaptive sampling section of the transect, either capture a transect plant point feature, or an adaptive plant point or patch feature. If you capture an adaptive plant feature, you will then begin implementing adaptive cluster sampling, i.e., walking in concentric circles centered at the adaptive plant feature looking for neighboring target species. In the Applet, the concentric circles consist of rings of cells. The specific process is presented as a series of steps below. The steps assume you will be starting with adaptive sampling, but you can start with either adaptive or non-adaptive, transect sampling. Also, the terms target plant species, target species and plant are used interchangeably, as the only plants of concern are the target plant species.

Step 1. Move to the transect start and record a start point using the **Capture Transect Point** button. Enter or choose values for **TransectID**, **Point Type**, **Target Species**, **Surveyor1**, **Surveyor2**, **Maximum Search Distance**, **and Maximum Survey Distance**.

Step 2. Move from cell to cell following the transect looking for the target species within in the transect corridor. If the target species is not found within a cell use the **Update Current Grid Cell** button to update its sampled status to **Sampled Absent**. Once a target species is found, look around to see if another plant(s) is within 10 meters of the current plant. **Note**: The Applet does not require you to use 10 meter as the cut-off distance defining separate patches. You are free to set your own distance criterion.

- If no additional plants are detected or if the plant patch is too small to be captured by the GPS as a polygon, use the **Capture Adaptive Plant Point** button to capture the plant feature.
- If additional plants are found, then use the **Capture Adaptive Plant Patch** button to capture the patch as a polygon feature. When you click on the **Capture Adaptive Plant Patch** button, the maximum adaptive survey area and maximum adaptive search area will be delineated by the GPS unit and shown on the screen, see Figure 3.
  - Only move along the patch perimeter that lies <u>within</u> the maximum survey area. Should the patch perimeter extend beyond the maximum survey area boundary, when you reach the maximum survey area boundary, just follow its boundary until it intersects the patch perimeter again, see Figure 4.

- Should the patch perimeter extend beyond the maximum search area boundary, the actual patch perimeter should be mapped, see Figure 5.

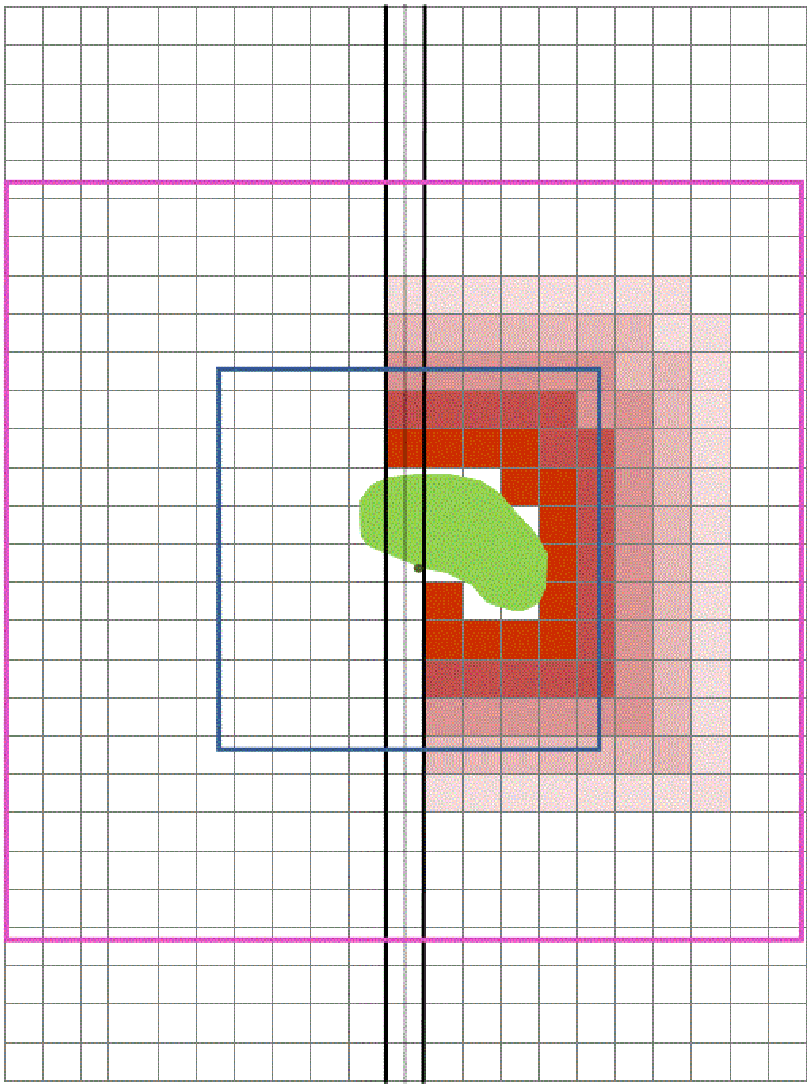


Figure 3. Example showing a target plant patch entirely within a maximum search and suvey area. The solid black lines represent the sides of the transect corridor and the dotted line the transect; the blue box delineates the maximum search area and pink box delineates the maximum survey area; and the first target species found in the transect is shown as a dark green dot and the patch it belongs to, as captured by the GPS, is shown in lime green. The concentric rings of cells to be adaptively sampled are shown in various shades of rose. The patch crosses both sides of the transect, hence the surveyor would adaptively sample only one side of the transect. In the illustration, the right-side was assumed to be randomly chosen.

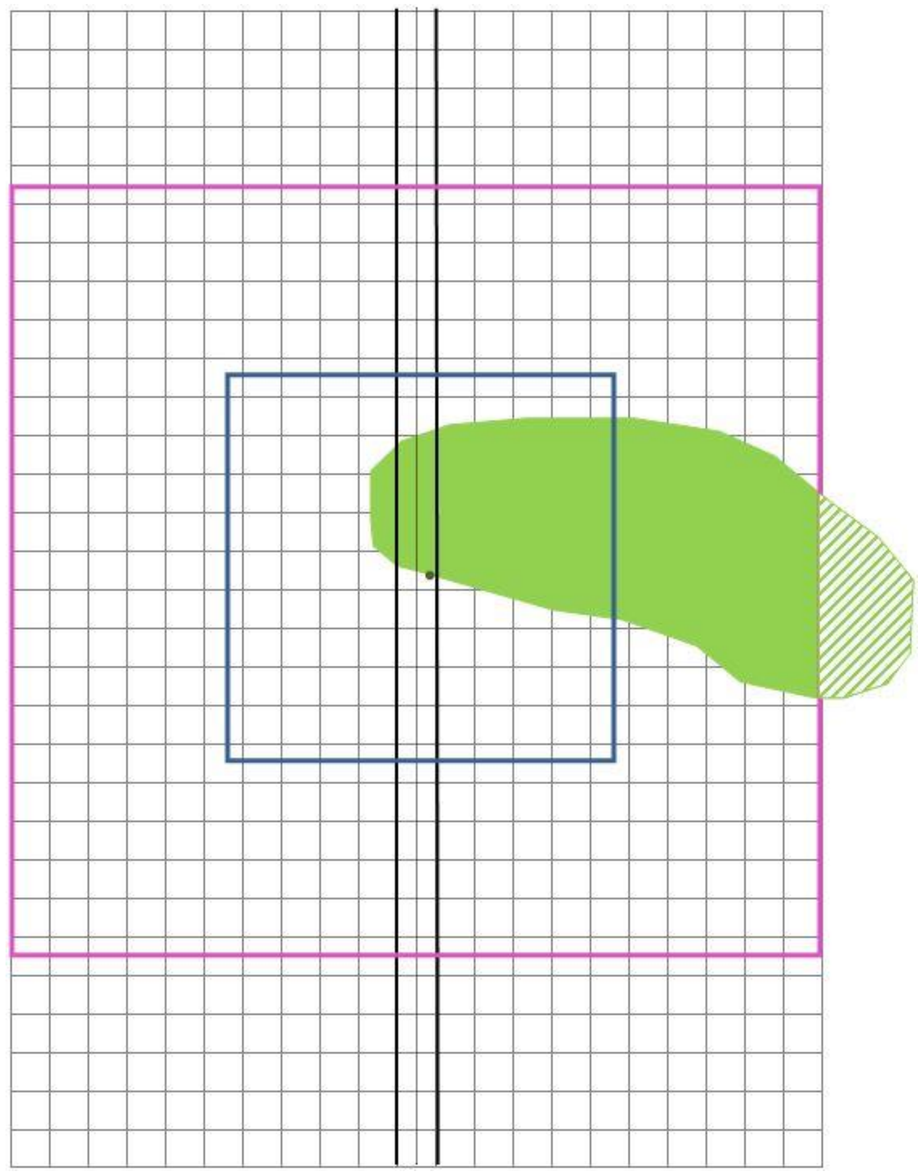


Figure 4. Example showing a target plant patch with a boundary lying outside both the maximum search and survey area. In this case, the patch is too large to carry out an adaptively sampling session. In addition, once the surveyors reach the maximum adaptive survey boundary, they would follow the survey area boundary, not the patch boundary itself, i.e. the striped patch area would not be captured with the GPS. All other lines, boxes, points and polygons represent the same survey features as in Figure 3.

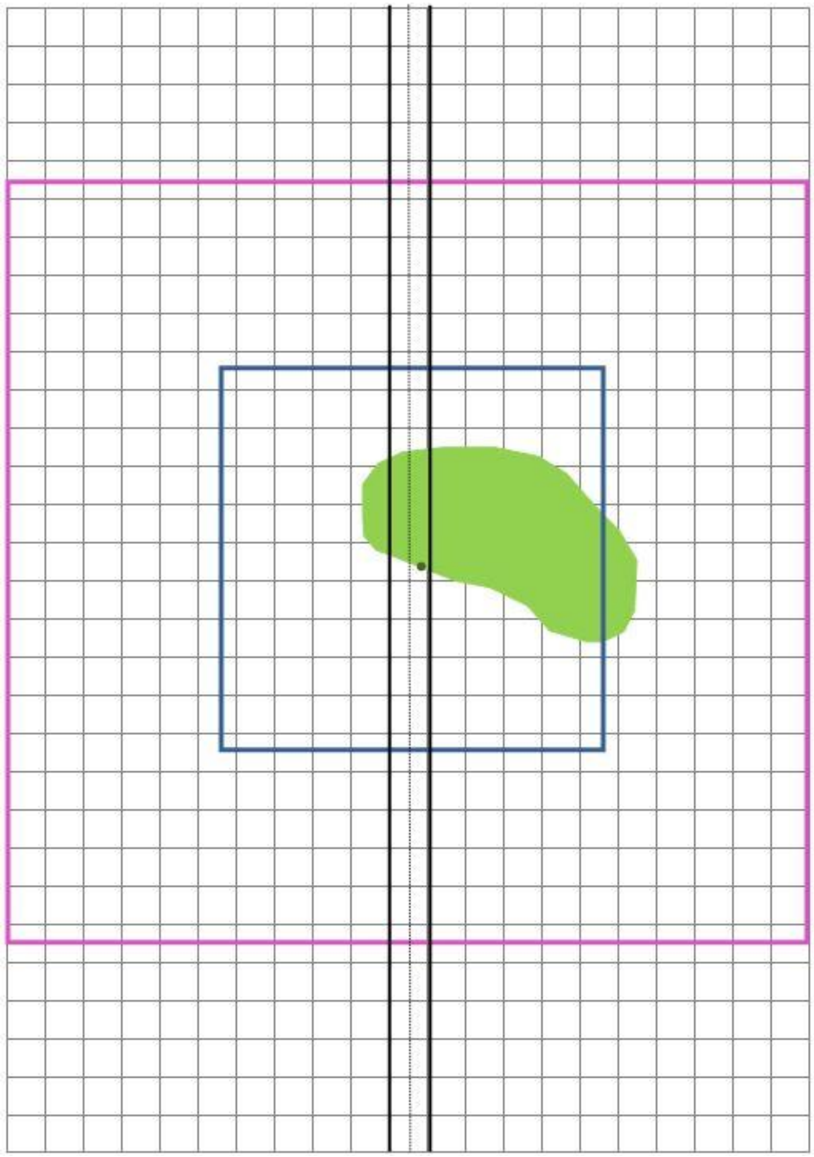


Figure 5. Example showing a target plant patch with a boundary lying outside the maximum search area, but within the maximum survey area. In this case, the patch falls outside the maximum adaptive search bounding box, hence an adaptive sampling session would not take place. Lines, boxes, points and polygons represent the same survey features as in Figure 3.

Step 3. Once the plant feature has been captured, a dialog box will appear. Enter values in the appropriate fields in the dialog for plant density, percent cover, and spatial pattern of individual plants within the patch. Click **OK**.

- The Applet will display the cells to be adaptively sampled. The cells to be sampled adaptively should be thought of as sets of concentric 'rings' of cells formed around the patch. The cells immediately adjacent to the patch form the first ring; the cells immediately adjacent to the first ring of cells form the second ring; and, so forth. The number of rings in the set corresponds to maximum search area divided by the cell size, see Figure 3.
- If the patch perimeter extends beyond the maximum search area, no adaptive sampling will take place for this patch, because of the patch's large size. **Click** the **Clear Max Survey Area** button, which clears the maximum search and survey areas, as well as the cells to be adaptively sampled. Go to Step 2.

Step 4. If the plant patch boundary falls within the maximum search area, begin an adaptive sampling session.

- If the patch intersects the transect centerline, only cells on the right or left side of the transect should be adaptively sampled. Whether the right or left side of the transect is sampled is determined randomly by the Applet by pressing the **Coin Toss** button, which will randomly indicate **Right/Clockwise** or **Left/Counterclockwise**. **Note**: Sampling one side of the transect is only a time-saving option, it does not have to be implemented.
- Begin adaptive sampling by using the **Coin Toss** button to determine whether to start circling the plant patch in a clockwise or counter clockwise direction. Start walking around the patch in the selected direction, stopping in each cell in the first ring of cells looking for more target species. If the target species is not found within a cell use the **Update Current Grid Cell** button to update its sampled status to **Sampled Absent**. If no target species are located in the first ring, begin walking the second ring of cells, but in the opposite direction.
- Continue moving around the patch alternating between clockwise and counter clockwise directions until all cells the Applet has displayed are sampled, i.e., the adaptive sampling session is complete. If at any time while circling a target species is found, go to Step 2. **Note**: Once a new patch or plant is located, the grid cells selected in Step 3 for the previous patch or plant and not yet sampled are not traversed, and those grid cells the Applet updated as **Need to Sample** will be set back to **Not Sampled**, and displayed accordingly.

Step 5. Once the adaptive sampling session is complete. **Click** the **Clear Max Survey Area** button, which clears the maximum search and survey areas, as well as any cells that did not need to be adaptively sampled.

- Move back to the transect corridor and move to the next grid cell along the transect corridor that has not yet been sampled.
- The **Draw Next Adaptive Search Unit** button should be pressed and an "X" indicating where the next adaptive sampling session can take place will appear, see Figure 6.

Step 6. Continue down the transect

- If a target plant is found after reaching the "X" that demarcates the beginning of the next adaptive sampling session, go to Step 2. See Figure 7.
- If a transect plant point starts before the '"X" that demarcates the next adaptive sampling set but finishes after the "X", an adaptive sampling session is not carried out. One will be carried out, however, on the text target species found, if any, see Figure 7.

Step 7. Move to the transect end and record a transect end point using the GPS.

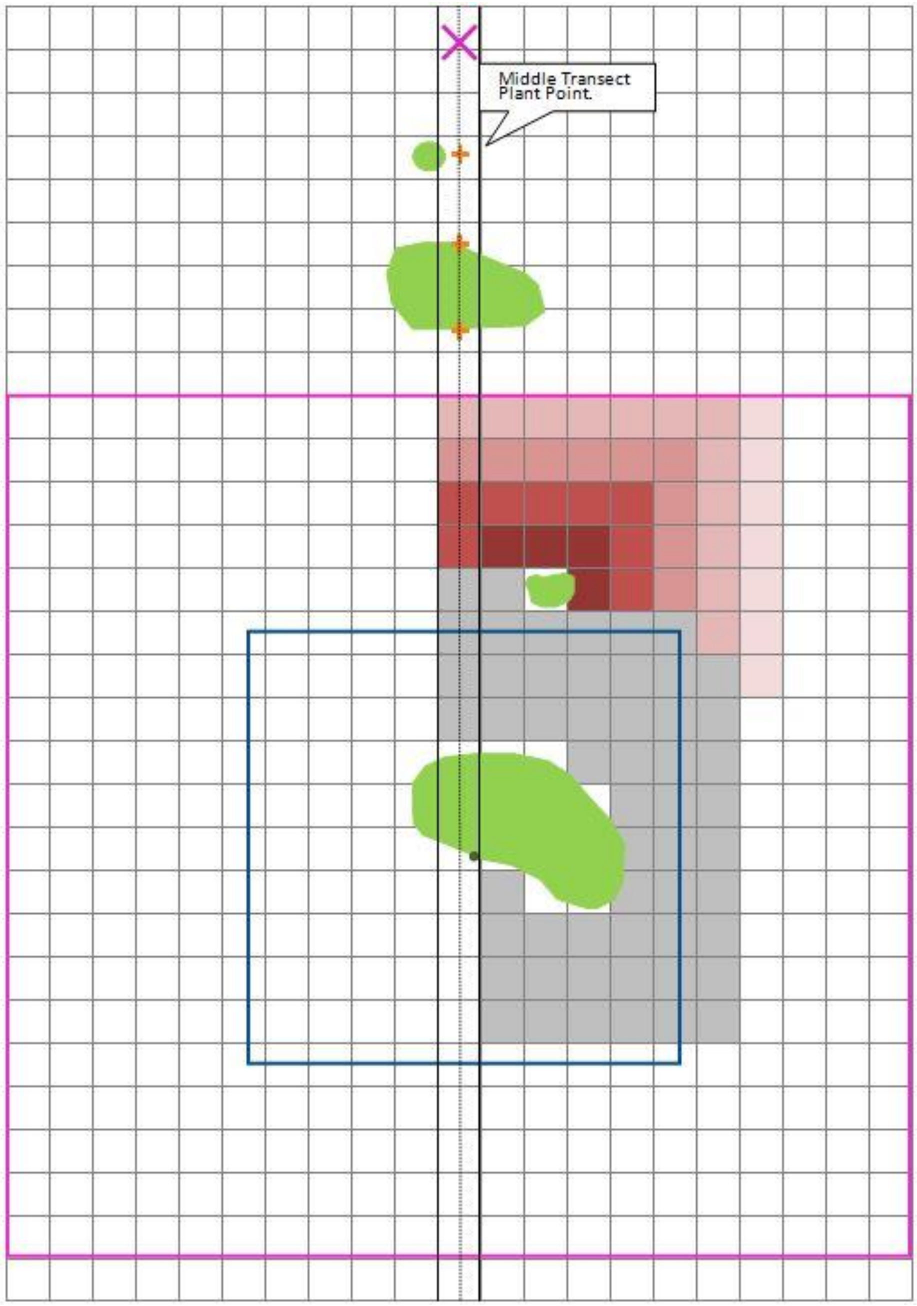


Figure 6. Example showing both adaptive and transect plant features captured during an adaptive sampling session and transect sampling session, respectively. Gray cells represent cells sampled adaptively relative to the first patch location and where no target species were found. The set of orange cells represent the concentric rings of cells that were surveyed relative to the second patch detected while surveying the cells associated with the first patch . The first transect plant patch is delineated by a start point and and end pint. The second transect plant patch is capture using a single Middle Transct Plant Point. The purple × indicates the location along the transect where the next adaptive sampling session could take place should another target species be detect. Lines, boxes, points and polygons represent the same survey features as in Figure 3.

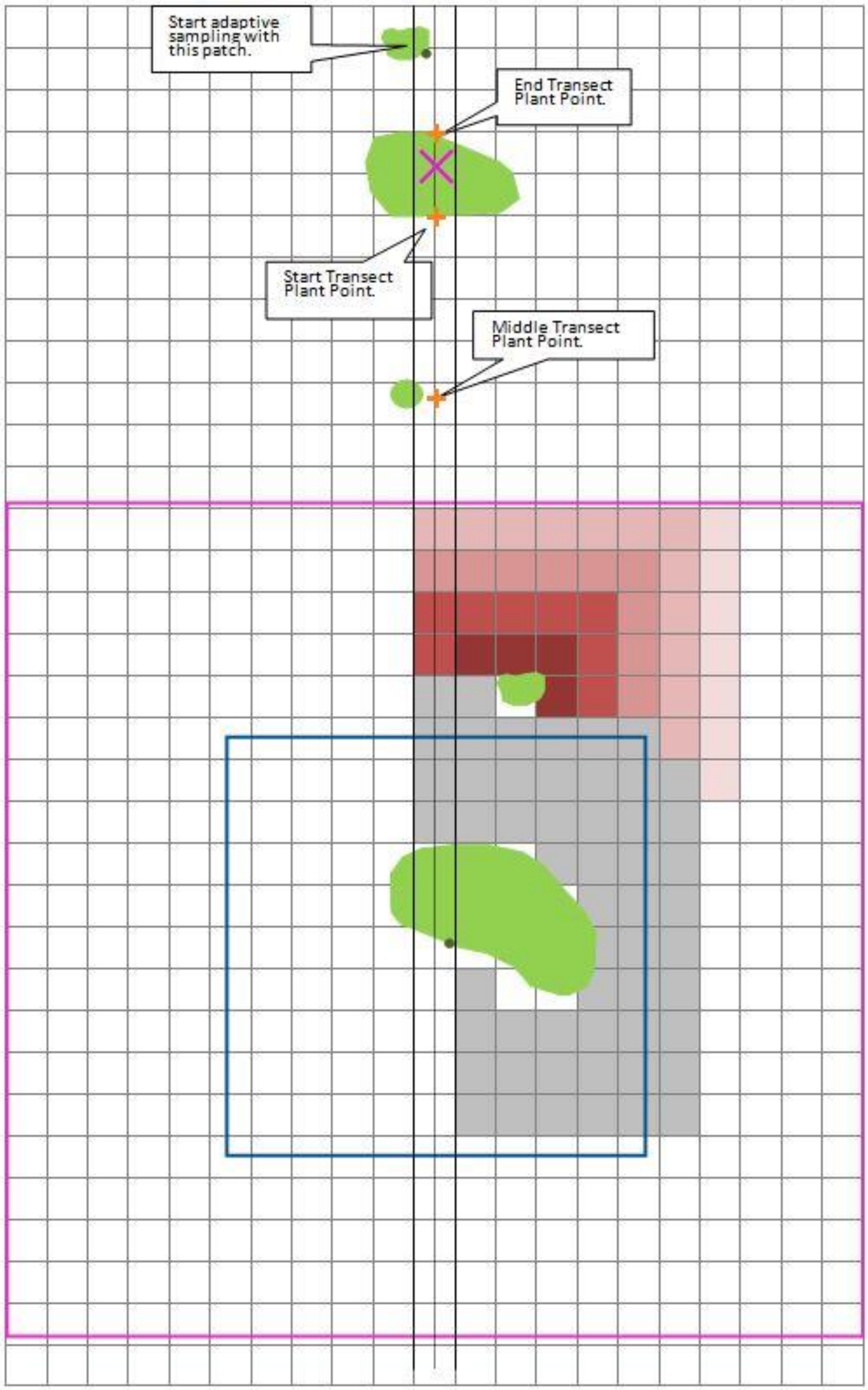


Figure 7. Example showing transect plant points starting before and finishing after 'next adaptive sampling unit' line. Survey features same as Figure 6.

3.4 Check in data from ArcPad

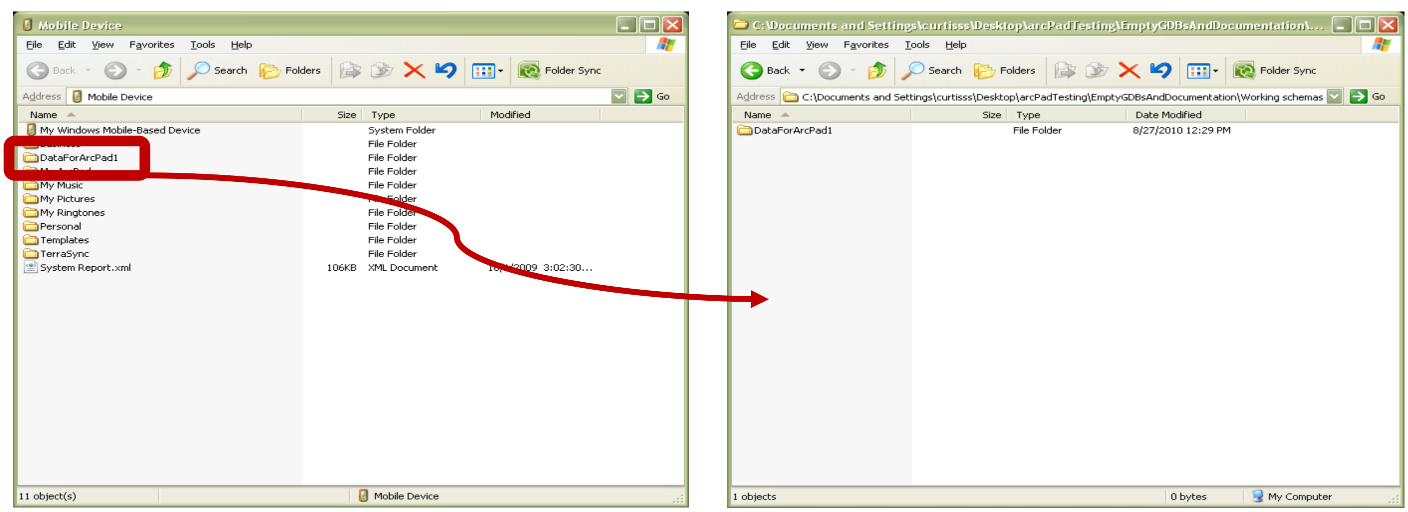
After completing a successful field session it is necessary to check your survey data back into the geodatabase. This section will guide you through the process of data check in. Once your data are successfully checked in they are ready for post-processing and then, for further analysis or other final uses. **Note**: Data check in and check out transactions are both PC specific, this means you must use the same computer to check out and check in the data.

Step 1. Connect the GPS unit to the computer using ActiveSync

- Connect using the method you are accustomed to
  - A **Guest Partnership** is the recommended connection method.

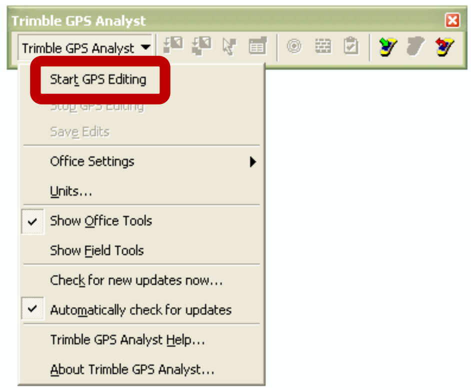
Step 2. Check in data

- Transfer the data folder from the GPS back to the computer using Windows Explorer
  - You want to replace the file originally checked out with the new updated file; by replacing the original folder the Trimble GPS Analyst will know where to find your updated information.



- Open ArcMap and the map document (.mxd) containing your geodatabase
- Start a GPS edit session by select **Start GPS Editing** under the **Trimble GPS Analyst** toolbar

- This will simultaneously start an ArcMap edit session.
- This also activates the **Check in ArcPad shapefiles and GPS correct SSF** button



- Use the **Check In Data** button to select the layers needed to be checked into your geodatabase. Select all the layers you checked out for editing.
- Click **OK** to begin the import process.

Once the import is finished you are ready to post process your data using the Trimble GPS Analyst toolbar.

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Appendix A: Geodatabase Schema

Geodatabase Name: User Defined

Geodatabase Domain:

Domain Name	Domain Type	Field Type	Values (If only one listed, then coded equals description).
NIS_Species	coded	text	User Defined
Percent_Cover	range	long integer	0-100
Patch_Density	coded	text	<0-1, 1-11, 12-32, 33-100, 101-316, 317-1000, >1000
Patch_Pattern	coded	text	ind/scattered plants, discrete patches, interconnected patches
Surveyor	coded	text	User Defined
StartEnd	coded	text	Start, End

Feature Dataset Name: surveyGPSFeatures

Feature Class Name	Geometry Type	Field Name	Data Type	Domain Name	Values
transect	point	start_end	text	StartEnd	*see domain*
		surveyor1	text	Surveyor	*see domain*
		surveyor2	text	Surveyor	*see domain*
		id	text	none	Length = 25
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		target_species	text	NIS_Species	see domain
		gpsdate	date	none	none
		TRANSECTID	text	none	Length=30
adapt_plant_pnt	point	target_species	text	NIS_Species	*see domain*
		Percent_Cover	long integer	Percent_Cover	*see domain*
		Patch_Density	text	Patch_Density	*see domain*
		Patch_Pattern	text	Patch_Pattern	*see domain*
		Comment	text	none	Length = 50
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		TRANSECTID	text	none	Length=30
adapt_plant_patch	polygon	target_species	text	NIS_Species	*see domain*
		Percent_Cover	long integer	Percent_Cover	*see domain*
		Patch_Density	text	Patch_Density	*see domain*
		Patch_Pattern	text	Patch_Pattern	*see domain*
		Comment	text	none	Length = 50
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		TRANSECTID	text	none	Length=30
		SHAPE_Length	double	none	none
		SHAPE_Area	double	none	none
transect_plant_pnt	point	target_species	text	NIS_Species	*see domain*
		Percent_Cover	long integer	Percent_Cover	*see domain*
		Patch_Density	text	Patch_Density	*see domain*
		Patch_Pattern	text	Patch_Pattern	*see domain*
		Comment	text	none	Length = 50
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		TRANSECTID	text	none	Length=30
		POSITION_	text	none	Length=15
		LENGTH	float	none	none
		WIDTH	float	none	none
generic_pnt	point	Comment	text	none	Length = 50
		ave_accuracy	double	none	
		worst_accuracy	double	none	
generic_line	line	Comment	text	none	Length = 50
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		SHAPE_Length	double	none	none
generic_poly	polygon	Comment	text	none	none
		ave_accuracy	double	none	none
		worst_accuracy	double	none	none
		SHAPE_Length	double	none	none
		SHAPE_Area	double	none	none
surveyGrid	polygon	Id	long integer	none	none
		Status	text	none	Length=25
		scode	short integer	none	none
		SHAPE_Length	double	none	none
		SHAPE_Area	double	none	none
Transect_Corridor	polygon	Id	long integer	none	none
		BUFF_DIST	long integer	none	none
		SHAPE_Length	double	none	none
		SHAPE_Area	double	none	none
TransectLine	line	Id	long integer	none	none
		Shape_Length	double	none	none

Appendix B: Requirements and Installation

a. Operating System and GPS unit

- ArcPad 7.1 or greater
- GPS unit with Windows Mobile 6 or greater installed
- This Applet was tested on and is recommended for use with Trimble GPS units

b. Configuration File

There is a configuration file supplied with the Applet called AdaptiveSampling.config. This is a customization file for the Applet that stores information required by the Applet and can be edited in a text editor before being uploaded to the device. An example configuration file follows:

Surveyor1=Bruce,Leroy,Joe,Ted,Jeff

Surveyor2=Bruce,Leroy,Joe,Ted,Jack

TargetSpecies=Bromus tectorum, Cirsium arvense, Cynoglossum officinalis, Linaria dalmatica, Phleum pratense,

MaximumSearchDistance=50

MaximumSurveyDistance=100

IntervalDistance=10

PlantPatchLayer=adapt_plant_patch

PatchPointLayer=adapt_plant_pnt

PlantPointLayer=transect_plant_pnt

GridLayer=surveyGrid

TransectLineLayer=TransectLine

TransectIDField=TransectID

TransectPointLayer=transect

CurrentSurveyor1=Leroy

CurrentSurveyor2=Ted

CurrentTransectID=55

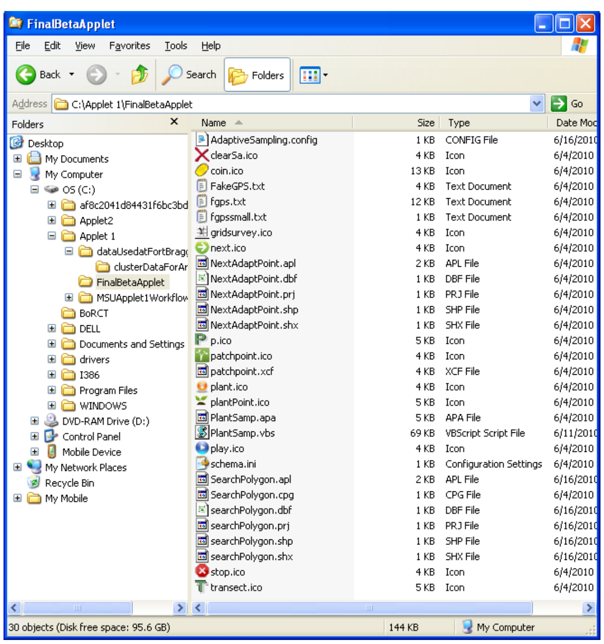
CurrentTargetSpecies=Cirsium arvense

drawnmaxsurveyarea=false

Variables in **bold** above are required values. The variables TransectLineLayer, TransectPointLayer, PlantPatchLayer, PatchPointLayer, PlantPointLayer, and GridLayer refer to the layers in the geodatabase checked out for use with the Applet. If you have renamed the feature class layers prior to checkout, you will have to modify the names here so that the Applet knows which layers to use for each variable. For example, using the above list the Applet will look for a TransectLineLayer named TransectLine. If, however, the transect line layer name was changed to, for example, Transx in the geodatabase then the variable TransectLineLayer should be set to TransectLineLayer=Transx. TargetSpecies and Surveyors are pick lists for the Applet to use and should be populated prior to using the Applet. This file should be updated before taking your data to a survey. Either change the configuration file before transferring it to the GPS unit or, once the files are all transferred to the unit, copy it to your computer, change the values you desire to change and then copy it back to the unit, overwriting the old configuration file.

c. Applet Installation

To install the Applet, copy all files contained in the Applets folder to the/Program Files/ArcPad/Applets folder on the mobile device. The Applet is installed by ArcPad on startup so if ArcPad is running on the device, you will need to restart ArcPad after the files are copied to the mobile device.



If the application is installed correctly a new tool bar will appear within ArcPad.

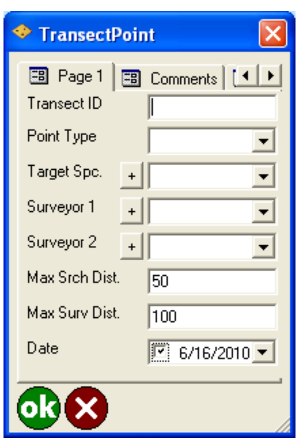
Appendix C: Applet Operation

a. Starting the Applet

The Applet is automatically loaded by ArcPad when the application is started. A new tool bar will appear in ArcPad when the Applet is properly installed.

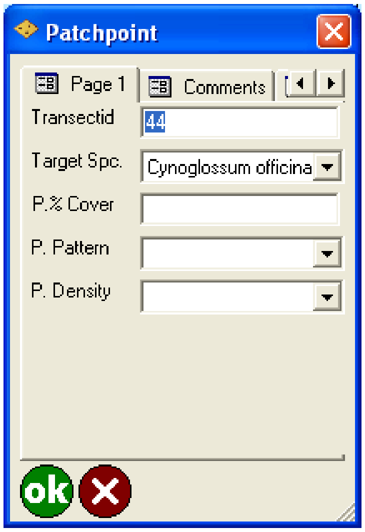
b. Capture Transect Point

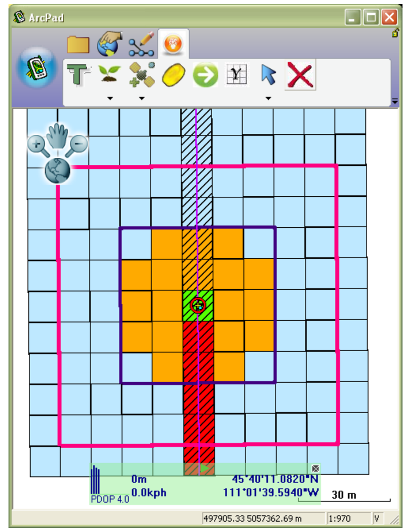
Transect points are created to define start and end points of a transect; click the **Capture Transect Point** button  to create a start or end point for the transect. If the GPS is active the data collection form is shown, if the GPS is not active a dialog window will appear asking you to turn it on. The data collection form for a transect point follows:



c. Capture Adaptive Plant Point

Adaptive plant points are used for capturing and attributing individual plants or small patches. Click the **Capture Adaptive Plant Point** button  to display the data collection form.

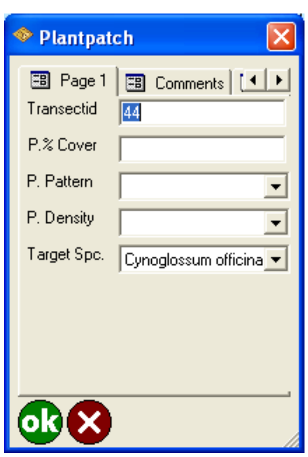


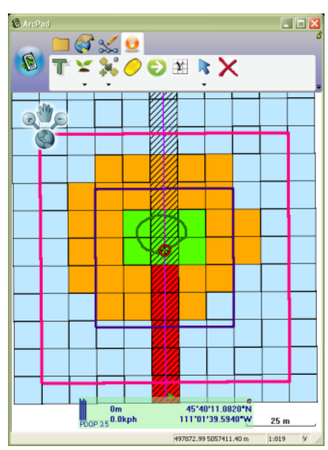


When an adaptive plant point is created, the maximum survey area and maximum search area delineated on the screen as shown above in pink and purple, the current grid cell is selected based on the plant point location and marked as surveyed/present (as shown above). Orange cells in the above example are marked as need to sample based on the search tolerances.

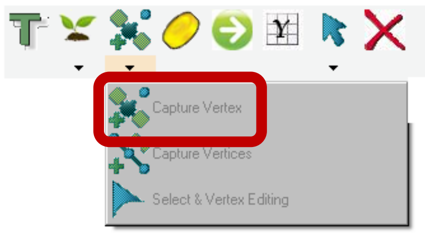
d. Capture Adaptive Plant Patch

Adaptive plant patches are used for capturing larger plant patch boundaries and their attributes. After clicking the **Capture Adaptive Plant Patch** button  use ArcPad tools to capture vertices. When finished the data collection form appears.

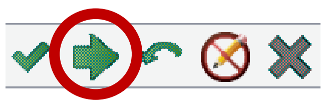




Use the **Capture Vertex** button to add vertices while walking the patch perimeter.



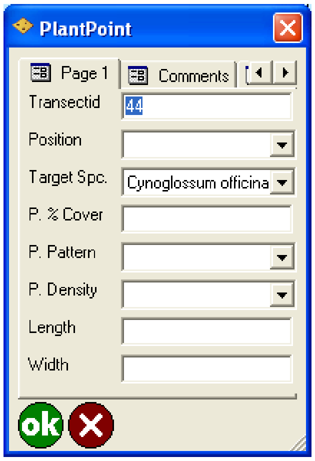
Once the patch has been mapped use the green arrow in the bottom left of the screen to finish and close the polygon.



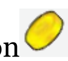
When an adaptive plant patch is created each grid cell within the polygon boundary is marked as sampled/present (green in the above screen shot), additional grid cells are selected based on the search tolerances and marked as need to sample (orange).

e. Capture Transect Plant Point

A transect plant point is used to mark plant features that do not require adaptive sampling, such as when between adaptive search areas. With a GPS position fix, click the **Capture Transect Plant Point** button  to mark the location and show the data collection form shown below. If the patch to be marked with a transect plant point is small enough, simply select **Middle** under the **Position** drop down menu and enter all the attribute values. If the patch is large, i.e. you can't see the opposing patch boundary, select **Start** under the **Position** drop down and enter a value of 0 for the length. Also, enter values for the other attributes. When you reach the opposing boundary, click the **Capture Transect Plant Point** button  again mark the end location of the patch and open the data collection form. This time select **End** under the **Position** drop down menu, enter a value of 0 for the length, and enter values for the remaining attributes. The start and end positions can be used later, within ArcGIS, to calculate the patch length.

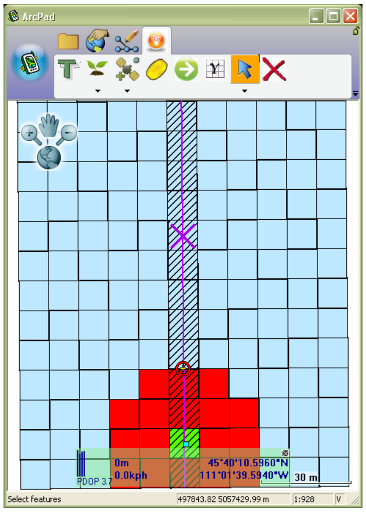


f. Coin Toss Button

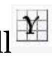
The **Coin Toss** button  is used before adaptively sampling grid cells to indicate the direction the user should begin sampling.

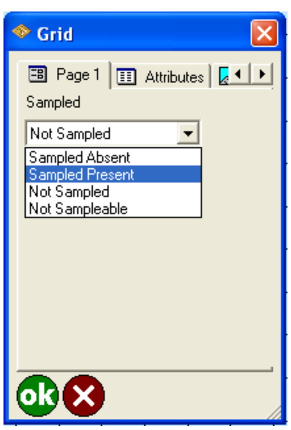
g. Draw Next Adaptive Search Area

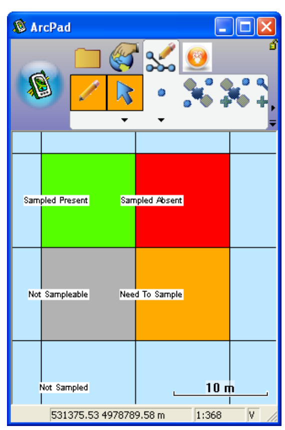
The Draw Next Adaptive Search Area **button**  **is used to draw the indicator for where to begin using adaptive sampling methods. At the start of a transect use the** Clear Max Survey Area **button and begin sampling along the transect. The maximum adaptive search area will automatically draw when an adaptive plant point or patch is recorded. After finishing an adaptive sampling session, the** Draw Next Adaptive Search Area **button should be pushed to draw the indicator for the next location to be adaptively sampled.**



h. Update Current Grid Cell

The Update Grid Cell  is used to sample grid cells based on the Current GPS location, cells are automatically selected from the current GPS location and a form is presented to update the grid attributes.





Updating the grid changes the color of the grid cell to visually indicate the status of the grid location. There are 5 different values for the grid cells, 0 = Sampled/Absent (red), 1 = Sampled/Present (green), 3 = Need to Sample (orange), 2 = Not Sampled (blue default value) and -9 = Not Sampleable.

i. Clear Max Survey Area

The **Clear Max Survey Area** button will delete the current maximum survey and maximum search areas displayed on the map. This tool also sets a flag to draw the maximum survey area next time an adaptive point feature is created.

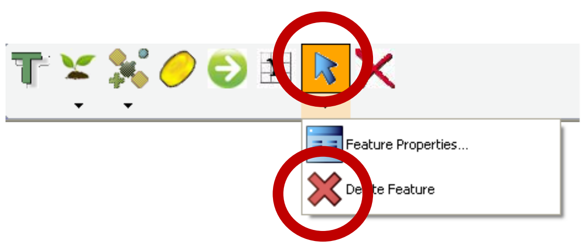
j. Editing Features in ArcPad

For various reasons the survey crew may find it necessary to change features while in the field. Examples of this may include instances where the survey crew finds they have missed a target plant or have misidentified a plant and included it in the survey. The following steps outline the proper methods to update and change features and/or previously sampled cells.

Changing Sampled Present to Sampled Absent

Transect Plant Point

Use the **Select** button on the Applet toolbar and select and then use the **Delete** button to delete the point. Once the point is deleted, use the **Update Current Grid Cell** button to change the cell where the Transect Plant Point was mistakenly captured from **Present** (green) to **Absent** (red).



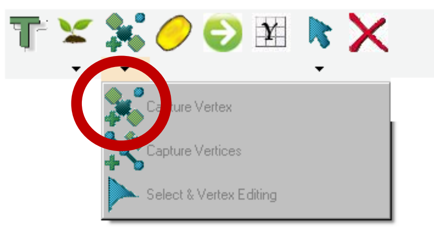
Adaptive Plant Point

Use the **Select** button under the Applet toolbar and select and delete the point. Once the point is deleted use the **Update Current Grid Cell** button to change the cell in which the Plant Point was gathered from present (green) to absent (red). The Applet will not automatically change the selected adaptive cells to Not Sampled but they do not need to be manually changed because at the next present location the Applet will select new adaptive cells and clear the mistaken ones.

Adaptive Plant Patch

Use the **Select and Vertex Edit** button to do one of two things:

- Erase the feature: When a complete feature is deleted, the adaptive cells will be updated when another presence is recorded. The cells automatically changed to present (green) within a polygon that is deleted must be manually reset to Not Sampled. If these cells are not manually changed they will be unavailable for future adaptive selection.
- Move vertices: Use the **Select** and **Vertex Edit** button and move the necessary vertices to show the actual patch boundary. The Applet will automatically update the adaptive cells.



Once the vertices are in the correct location, use the green checkmark in the lower left corner of the screen to accept the changes and finish the new polygon.

Changing Sampled Absent to Sampled Present

Transect Plant Point

In the cell mistakenly marked **Sampled Absent**, collect a Transect Plant Point using the **Capture Transect Plant Point** button . Fill in all the fields in the data collection form and continue sampling. The Applet will update the cell to **Sampled Present**.

Adaptive Plant Point

In the cell mistakenly marked **Sampled Absent**, collect an Adaptive Plant Point using the **Capture Adaptive Plant Point** button  . Fill in all the fields in the data collection form and continue sampling. The Applet will update the cell to **Sampled Present**, and will display the appropriate cells to adaptively sample.

Adaptive Plant Patch

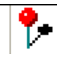
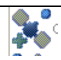
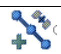
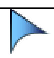
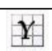
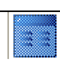
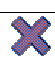
If no Adaptive Plant Patch feature has been captured, collect an Adaptive Plant Point using the **Adaptive Plant Patch** button. Fill in all the fields in the data collection form and continue sampling. The Applet will update the appropriate cells to **Sampled Present**, and choose the cells to adaptively sample and display them accordingly. .

If an Adaptive Plant Patch has been captured, but you would like to adjust the boundary of the patch, use the **Select** and **Vertex Edit** button to move vertices in an existing patch to reflect the true boundary of the patch. Once the vertices are in the correct location, use the green checkmark in the lower left corner of the screen to accept the changes and finish the new polygon.

The Applet will adjust the cells surrounding the new edited version of the Adaptive Plant Patch boundary appropriately.

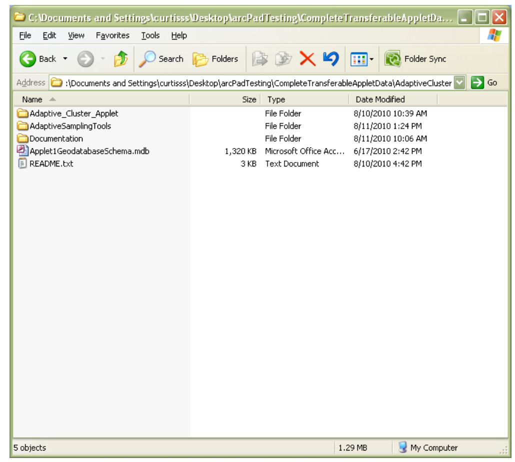
Appendix D: Applet Buttons Quick Reference

Table D1 Buttons on the Applet's main toolbar  **.**

	Capture Transect Point	Create GPS point feature for start/end transect
	Capture Adaptive Plant Point	Create GPS point feature for plant
	Capture Adaptive Plant Patch	Create GPS polygon feature for area
	Capture Transect Plant Point	Create GPS point feature for transect point
	Capture Vertex	ArcPad tool to capture vertex
	Capture Vertices	ArcPad tool to capture streaming vertices
	Select & Vertex Editing	ArcPad tool to edit polygon vertices
	Coin Toss	Tool to tell user which direction to survey
	Draw Next Adaptive Search Unit	Draw next available search unit based on current GPS location
	Update Current Grid Cell	Selects cell for updating based on current GPS position
	Select	ArcPad tool to select editable features
	Feature Properties	ArcPad tool to show feature attributes
	Delete Feature	ArcPad tool to delete selected feature
	Clear Max Survey Area	Clears (deletes) current maximum survey area
Help	Located under the Capture Transect Point button	Brings up the help menu for the Applet

Appendix E: File Reference

The following files and folders are included, as illustrated, for use with the RTAC method:



- Folder called AdaptiveSamplingTools
- Folder called Documentation
- Folder called Adaptive_Cluster_Applet
- Empty geodatabase schema in the correct format containing all required fields and attributes.

A brief description of each follows:

AdaptiveSamplingTools:

This folder contains an ArcGIS® tool box file called Adaptive_Sampling_Tools.tbx as well as two scripts to be used for the construction of data in the geodatabase. To access the tools these scripts belong to, open ArcMap and right click in the Toolbox window, choosing the menu Add Toolbox. Correctly define the location of the Adaptive_Sampling_Tools.tbx at the location where you have chosen to keep the .tbx file. This location can be within the AdaptiveCluster folder as provided, or at another location. Be sure to keep the PYTHON script files in the same folder as the .tbx file. If they are separated, the tools' stored paths will not be correct and the tools will not work. Should this happen verify the script paths are correct. Once the toolbox is added to the toolbox window, two script tools will appear: **Corridor Builder** and **Survey Grid Builder**. Double click on either of these tools to access their functionality.

Documentation:

This folder contains all of the documentation provided with the Applet. It includes users' guides and methods for the all of the processes that must be completed to utilize this method of sampling and to properly prepare data for use by the Applet. This documentation proceeds step by step through the majority of processes required by the Applet. It is recommended this documentation be read before using the Applet and kept available for future reference.

Adaptive_Cluster_Applet:

Contains all of the files required to run the Applet on the GPS unit. From this folder Copy/Paste the files into the /Program Files/ArcPad/Applets folder on the GPS unit.

Applet1GeodatabaseSchema.mdb:

This is the empty geodatabase that has been prepared for this Applet. It contains all of the correct layers, fields and attributes required for the Applet to function properly. It is recommended to make a backup of this .mdb before making any changes. If the original is lost, or for any reason it becomes necessary to build a new geodatabase, a table is included in the documentation provided illustrating the proper layout and required fields of the geodatabase.