AWS User Manual

Adaptive Web Sampling – ArcPad Applet Manual

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Weed & Invasive Plant Ecology & Management Group

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Prepared for Distribution with Adaptive Web Sampling ArcPad Applet

Abstract

It has been estimated approximately 275,000 acres of Army training and testing land currently have use restrictions related to non-indigenous plant species (NIS). The most cost effective and feasible strategy to address any new and recently established NIS populations is "early detection and rapid response" (EDRR). Conventional sampling designs can be inefficient and costly to implement, however, when used to sample populations that typify early phases of invasion.

Adaptive sampling designs, alternatives to conventional sampling, were specifically developed to take advantage of the rarity and clustered nature of many biological populations. One class of adaptive sample designs is adaptive web. These designs can provide a balance between increasing sampling in the immediate proximity of an already detected patch and sampling further away from the detected patch looking for more distant satellite patches. This balance makes adaptive web sampling well suited for mapping NIS in the early invasion phases when populations are rare and clustered within a management area.

This manual describes an adaptive web sampling design 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's (Redlands, CA) ArcPad® mobile geographical information software (GIS) for field application. ArcPad is designed to integrate with ESRI's desktop GIS technology, ArcGIS®, and this software is required.

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Preface

This study was conducted for the Department of the Army, Office of the Director of Environmental Programs under 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 use restrictions 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.

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 established needs. Military bases do have vehicle wash stations to clean vehicles travelling within and between sites. While this approach can reduce the number of plant propagules on a vehicle, it does not totally remove the risk. 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 the landscape (Davies and Sheley 2007). There is frequently a lag 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, necessitating some type of sampling to be performed. Conventional sampling designs can be inefficient and costly to implement, however, when used to sample sparsely and/or small, patchily distributed populations that typify early phases of invasion. In order 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 sampling designs are an alternative to conventional sampling specifically developed to concentrate sampling effort in 'hot spots' or areas with a high probability of finding the target species of interest. 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 the amount of time spent sampling and travelling between sampling unit locations.

One class of adaptive sample designs is adaptive web. This class of designs focuses on sampling populations in networks or ones that exhibit spatial structure. Like all adaptive sampling designs, designs in this class adjust sampling intensity during the sampling process to allocate more effort in areas that are most promising. Designs in the class, however, are more flexible than other adaptive designs, because how much sampling effort is allocated to adaptive selection is not constant and can depend on local factors. Any remaining effort can be allocated to sampling units selected at random from within the population or sampling frame. Consider, for example, a simple adaptive cluster design implemented using a grid. The grid is composed of square cells of fixed dimension and once a target species is located in a cell, the two neighboring cells directly to the right and left and above and below the cell containing the target species are adaptively sampled. Adaptive sampling continues in this manner - adding all four neighboring cells - until no more target species are located. Now, consider an adaptive web sampling design with a basic adaptive sampling unit selection algorithm proposed by Thompson (2006) implemented over the same grid. The selection algorithm is as follows: when a target species is located in a cell, with probability $p = .9$ a neighboring cell is sampled, while with a probability $1 - p = .01$, a cell is selected at random from within the grid to sample. Sampling continues in this way until no more target species are located within any of the cells chosen to sample. Only ninety percent of the neighboring cells get sampled with this adaptive web, as opposed to one hundred percent with the adaptive cluster design. Thus, when sampling for NIS, adaptive web designs can provide a balance between increasing sampling in the immediate proximity of an already detected patch and sampling further away from the detected patch looking for more distant satellite patches. It is this balance between sampling near and far from an existing patch that makes the designs well suited for mapping NIS in the early phases of invasion when the populations are rare and clustered within a management area.

1.2 Objectives

This manual describes an adaptive web sampling design (AWS) and a user friendly 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®, a 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 objective of the sampling design and ArcPad application described in this manual is to assist Army land managers wanting to employ an EDRR NIS management strategy in detecting and mapping the locations of NIS populations, a crucial first step in the strategy. In addition, because the ArcPad is fully integrated with ArcGIS and requires a geodatabase, the geodatabase can become part of a longer-term NIS monitoring program to assist Army land managers in planning, budgeting, prioritizing, and later tracking the effectiveness of NIS management control actions.

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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 Adaptive web sampling design

A sampling design specifies the rules for which sampling units of the population are included in the sample during a survey. In conventional sampling designs, all the sampling units in the sample can be specified prior to conducting a survey. In adaptive sampling designs, some sampling units in the sample are specified prior to conducting a survey, while others are added to the sample during the survey. Sampling units get selected and added to the sample during the survey when some inclusion criterion is met. For the AWS the inclusion criterion is the presence of one or more plants of the target NIS.

The AWS is a two-stage sequential design, similar to Thompson (1991) and Salehi and Smith (2005), where a set of secondary sampling units are selected, once a target NIS is found within the primary sampling unit. The secondary sampling unit is a square polygon of fixed area referred to as a cell. The primary sampling unit, referred to as a transect, consists of a group of X-number of contiguous cells, where X is an integer greater than zero. The AWS implements the simple adaptive web strategy suggested by Thompson (2006) over a spatial network. In this strategy, the nodes of the networks are cells and the links between nodes are defined by adjacency, i.e., each cell is linked to its (at most eight) adjacent neighbors. When a NIS is detected in a cell only some, not all, of the cell's neighboring cells are added to the sample (i.e. the link between the cells is chosen or followed). Whether or not a neighboring cell gets added to the sample is determined probabilistically with probability p. When, with probability $1 - p$, a neighboring cell is not chosen to be added to the sample, another cell, within a predefined area, is randomly chosen in its place. A predefined area from which random cells can be selected is associated with each transect and is called the survey grid. The survey grid consists of the group of cells formed by adding an equal number of cells to the right and left of each transect cell. For example, if a transect consists of 10 cells and 3 cells are added to the right and left of each transect cell, then the survey grid would be a group of 70 cells.

In the AWS, the probability, p, a link between adjacent cells is chosen once a plant is detected reflects the biology of the NIS and is a function of both the type of spatial pattern exhibited by the plants in the cell and the variability of the local environment surrounding the cell. More specifically, let $cell_i$ be any secondary sampling unit, p_i be the probability a link from $cell_i$ to one of its neighboring cells is followed once a plant is detected in a $cell_i$, then the value of p_i associated with $cell_i$ is as follows;

$p_i = P_{sp}$, if $pattern_i$ = individual scattered plants;

$p_i = LHV_i / 9$, if $pattern_i$ = discrete patches; or,

$p_i = LHV_i / 9$, if $pattern_i$ = interconnected patches,

where:

P_{sp} = a constant that is fixed per survey and is set prior to conducting a survey.
$pattern_i$ = the spatial distribution pattern of the plants in $cell_i$,
LHV_i = local variability of the environment surrounding $cell_i$ (described below).

The local variability of the environment surrounding a cell is a measure of local environmental heterogeneity. It needs to be calculated for each cell in the survey area prior to conducting a survey using the ArcGIS spatial analyst's variety focal function and a GIS data layer of some environmental variable, such as terrain aspect. The variety focal function calculates, for each cell in the layer, the number of different values of the environmental variable found in a nine cell neighborhood centered at the cell. If the environmental variable is terrain aspect, for example, then the focal function would calculate the number of different aspect values in the nine cell neighborhood surrounding a cell, see Figure 1. Possible environmental variables include slope, elevation, aspect, annual radiation, and distance to rights-of-way.

Carrying out an adaptive cluster sampling design with all eight neighboring cells being adaptively sampled upon detection of a NIS in a cell is possible if P_{sp} is set to one and LHV_i is set to nine for all cells. With $LHV_i = 9$ for all cells and $P_{sp} =1$, the probability of following a link between cells is always one and thus, all links are followed once a NIS is found.

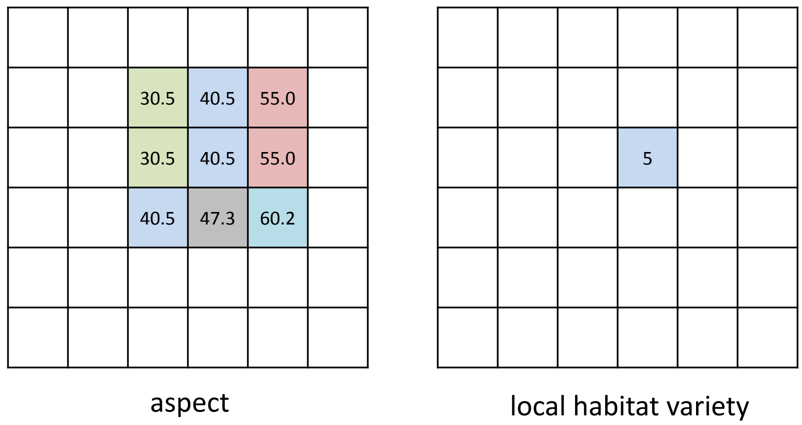


Figure 1. GIS raster layers of aspect (left) and the local habitat variety in aspect (right) that would be derived from using the focal function in ArcGIS.

2.2 Adaptive web sampling ArcPad application

The AWS 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 hence, 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 AWS. 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 Applet implements the AWS, and provide definitions of important terms necessary to understand the implementation, see Table 1. The AWS and Applet were developed to survey for only one target NIS at a time.

The Applet guides the person performing the sampling, surveyor, through the process of conducting a survey using the AWS 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., when to stop adaptively sampling. Lastly, once a target species has been found, the Applet performs the selection algorithm discussed in Section 2.1 to choose additional cells to be surveyed adaptively; referred to as an adaptive sampling session. It updates and displays the sampling status of the all cells in the survey grid using the color scheme in Table 2 to aid the surveyor in navigation.

Table 1. Important Applet terminology and definitions.

Term	Description
Sampling Status or Scode	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.
Plot Point	In the Applet, a **surveyGrid** feature is called a plot. The **Plot Point**, is a point feature that indicates the starting location of survey. It should be GPS captured in the first cell of the initial sample set.
P_{sp}	The fix probability of visiting a link between two neighboring cells, once a target species is found and the patch pattern is 'individual scattered plants.'
Initial Sampling Set	The primary sampling unit. It consists of a group of X-number of contiguous cells, where X is an integer greater than zero. It is also referred to as a transect.
Adaptive Sampling Session	Refers to the time spent and cells surveyed once a target species has been detected in one of the initial sample set cells.
Cell	The secondary sampling unit. It is square polygon of fixed size.
Smax	Abbreviation for 'sample maximum,' it is the maximum number of cells to sample in conjunction with each initial sample set or transect.
Amax	Abbreviation for 'maximum number of cells to sample in an adaptive sampling session'.
Survey Grid	A survey grid is a feature in the **surveyGrid** feature class. It consists of a fixed number of cells to the right and left of a transect, as well as the cells making up the transect itself. During an adaptive sampling session, the Applet selects cells to randomly sample from those cells in the survey grid not already sampled. It is required by the Applet.

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

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

Being an ArcPad application, the Applet can update features stored in a GIS geodatabase as well as create new features. To begin a survey, the surveyor creates a Plot Point. The Applet then displays a form allowing the surveyor to set the required AWS variables: $\mathbf{P_{sp}}$, **Smax**, and **Amax**, and enter the names of the surveyors and target species. In addition, they can choose from two available options: **Allow Random Additions** and **Constrain Random Additions**. These options pertain to the selection algorithm used once a NIS is detected. Choosing the first option and not the second tells the Applet to implement the selection algorithm as described in Section 2.1. If the first option is not chosen, then no cells within the survey grid will be randomly selected when a link between neighboring cells is not selected to be followed. Choosing both options tells the Applet to implement the selection algorithm as described in Section 2.1, but limit the selection of any randomly chosen cells to just those cells either to the right or to the left of the current occupied cell, i.e., those cells in the same survey grid row as the occupied cell.

Once the variables and options have been entered the surveyor can proceed with surveying cells from the initial sample set that are clearly displayed. After surveying each cell, the Applet's updating tools can be used change the sampling status of the cell. Each time a cell is updated, the display is updated as well. When a target plant is found, the Applet will require the surveyor to input values for the percent cover, density, and spatial pattern of the plants in cell. Based on the data entered, the Applet will select and display additional cells to survey during an adaptive session. The selection process takes place on a cell by cell basis from among the cells not already surveyed. The Applet will also display labels indicating the order in which the cells selected for sampling should be surveyed.

Surveying adaptively in this manner continues until: (1) all cells selected by the Applet are surveyed, (2) Amax is reached, (3) Smax is reached, or (4) all the cells in the survey grid have been surveyed. When Amax or Smax is reached, the Applet alerts the surveyor with a pop-up window. If Amax is reached, the surveyor returns to sampling cells in the initial sample set. The surveyor continues surveying in this manner until all the cells in the initial sample set are surveyed or Smax is reached, whichever occurs first.

3 Approach

This chapter describes the process necessary for a successful field session using the AWS 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 customized ArcGIS tool 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

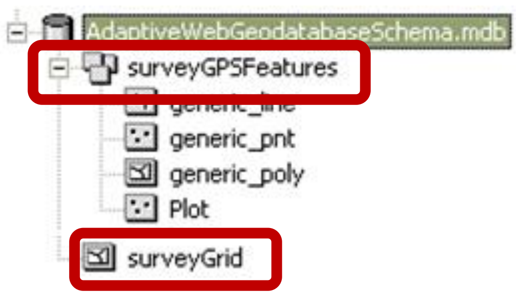
- Open ArcCatalog and in the table of contents navigate to the geodatabase titled AdaptiveWebGeodatabaseSchema.mdb you received with the Applet files
- Copy the geodatabase to your current working directory
  - This manual will use the name AdapativeWebGeodatabaseSchema.mdb for all examples. If you choose to rename your copy of the database 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



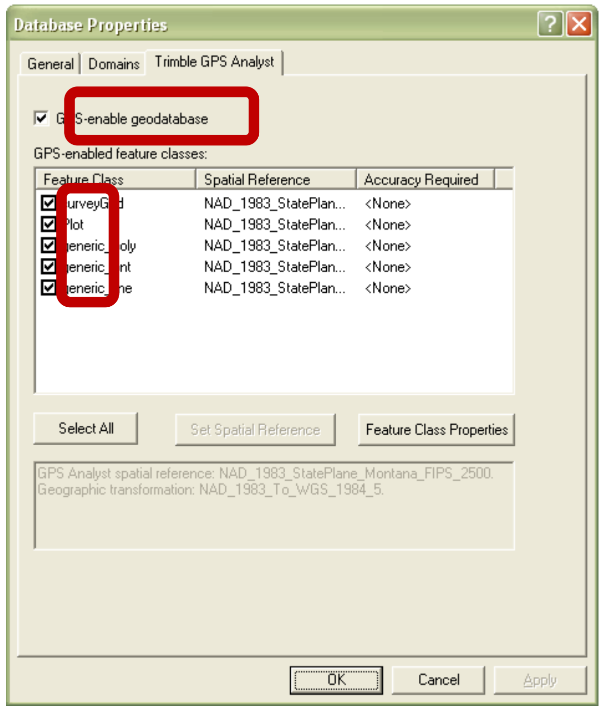
- Select the feature dataset **surveyGPSFeatures**. Set the coordinate system by right-clicking your mouse over the dataset and selecting **Properties**
- Click the **XY Coodinate System** tab and select the coordinate system you prefer to use with your GIS data
- Click **OK.** This sets the spatial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

Step 3. GPS-enable the geodatabase

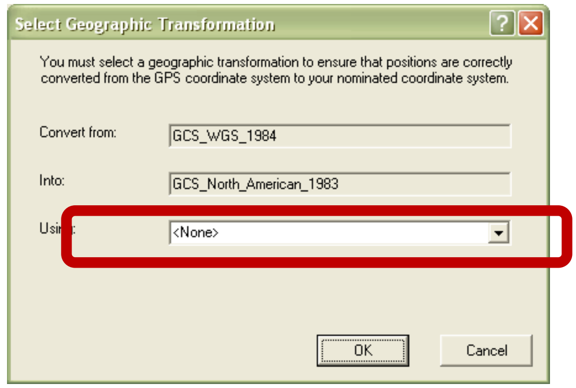
GPS-enabling the geodatabase allows data to be checked out for editing in ArcPad.
Note: The **Trimble GPS Analyst** extension must be activated in Arc before the database can be enabled. To enable the geodatabase take the following steps:

- Right click on the AdaptiveWebGeodatabaseSchema.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 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 by, when you start to add features to feature classes in the geodatabase, 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 class **surveyGrid** because 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

The Applet requires a populated **surveyGrid** feature class to function properly. A tool for use in ArcMap has been provided with the Applet to simplify the creation of the **surveyGrid** features. The **Survey Grid Builder** tool uses a transect line feature to create a set of equal area polygons, i.e., a **surveyGrid** feature, see Figure 2. 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. A feature class of transect lines is required for input into the tool. These transects can be created via any process you chose, but the feature class **MUST** be in the same coordinate system as the features in your geodatabase. The **Survey Grid Builder** tool will build a **surveyGrid** feature corresponding to each transect, hence including several line features in a single feature class will save time and effort in the construction of the **surveyGrid** features.

Before proceeding, you should create transect line features to use with the tool. 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 that extends beyond the **surveyGrid** feature. 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 extending beyond the **surveyGrid** feature, see Figure 2. To avoid confusion in the field, it is best to ensure all transect lengths are multiples of cell size.

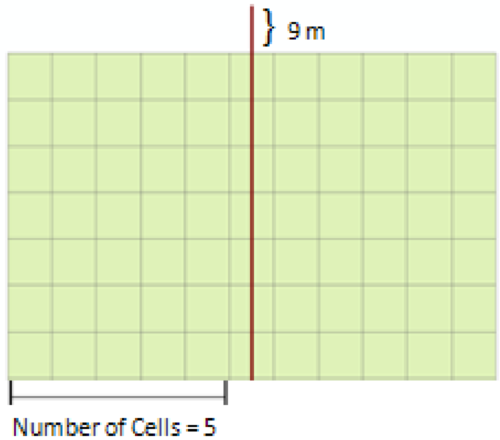


Figure 2. A surveyGrid feature created with a transect length that is not a multiple of cell size

Step 1. Add the tool to ArcMap

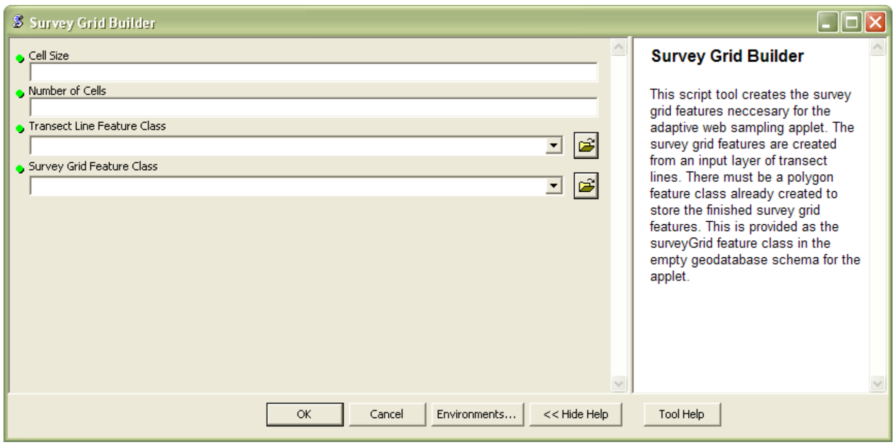
- Locate the folder supplied with the Applet called AdaptiveSamplingTools. This folder contains the toolbox, tool and source script for the tool.
- Optional: Copy this folder and all of its contents to a secure location for future use.
- Open ArcMap
- Right click in the ArcToolBox window and click **Add Toolbox…**
- Navigate to the file Adaptive Sampling Tools folder provided with the Applet
- Select **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 to create the surveyGrid features.

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 **surveyGrid** feature surrounding each transect line. All but the number of cells has been discussed previously. The number of cells variable defines the width of a **surveyGrid** feature; it represents the number of cells to the right or to the left of the group of 'center' cells that the transect line bisects, see Figure 1. A **surveyGrid** feature width is given by the following formula:

Survey Grid Width = (2*Number of Cells)*Cell Size + Cell Size



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

- Add the AdapativeWebGeodatabaseSchema.mdb and your transect line layer to ArcMap
  - This will make the **surveyGrid** feature and line layer available in the drop down menus in the tool.
- Double click the **Survey Grid Builder** script tool in the **Adaptive Sampling Tools** Toolbox
- 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 take several minutes or longer to build all of the **surveyGrid** features.

Step 3. Attribute the cells in each of the surveyGrid features.

The possible **Scode** and **Status** values for the survey grid cells are shown below. Open the **surveyGrid** attribute table. Notice the **Survey Grid Builder** tool has populated all the survey grid cells with a **Scode** of 2 and the **Status** field with **Not Sampled**. It is, therefore, only necessary to assign values of -1 to the desired initial sample set, which is the set of cell intersecting your transect lines. You will also notice the **Survey Grid Builder** tool has attributed the fields **col** and **row,** therefore, the only other field you need to attribute for each cell is **LHV**. Updated the **Scode, Status** and **LHV** fields can be done using any method – such as an edit session – but must be done for the Applet to function correctly.

Table 3. Values for Scode and Status for each cell in a surveyGrid feature.

Scode	Status
-9	Not Sampleable
-1	Initial Sample Set
0	Sampled/Absent
1	Sampled/Present
2	Not Sampled
3	Need to Sample

A finished **surveyGrid** feature is shown in Figure 3, along with a roads layer. The initial sample set is shown in purple. Your data should look similar when finished.

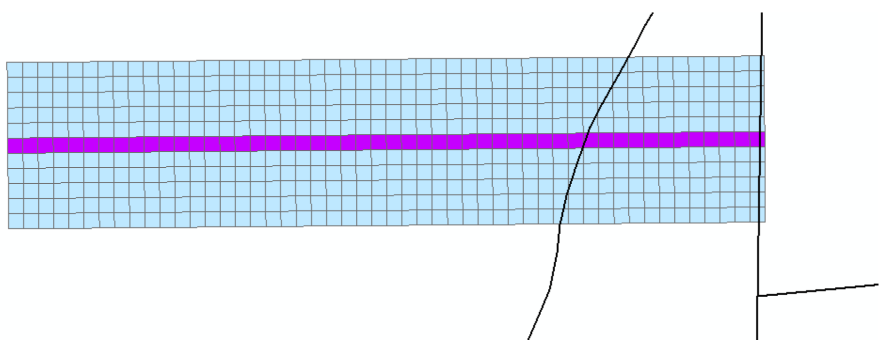


Figure 3. Finished surveyGrid feature. Cells belonging to initial sample set are shown in purple; remaining cells shown in blue (Applet display colors). The black lines are roads.

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 background 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

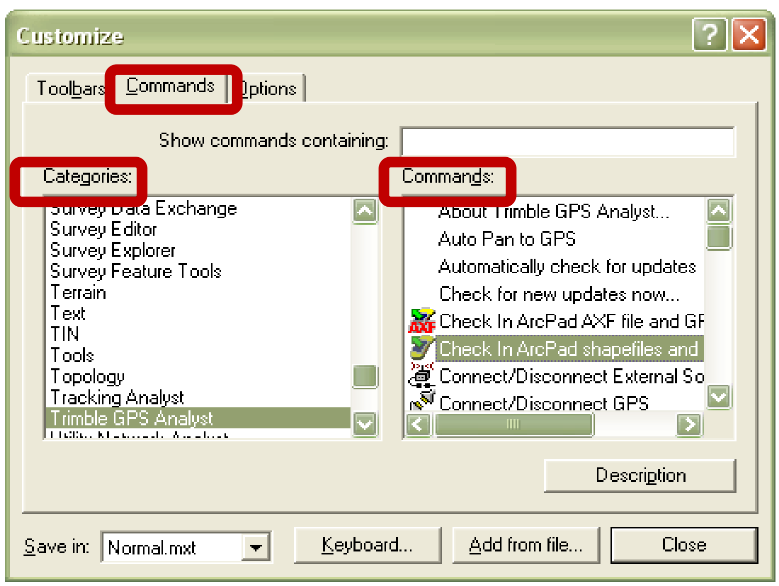
This section will guide you through the process of checking out data from your GPS-enabled geodatabase and transferring it to a GPS device for use in the field. Here you will check out all of the feature classes required by the Applet to function, as well as any layers useful for navigation or reference as background layers. This manual assumes that you have received the proper program files for installation of the Applet on your GPS unit and that 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 that 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.

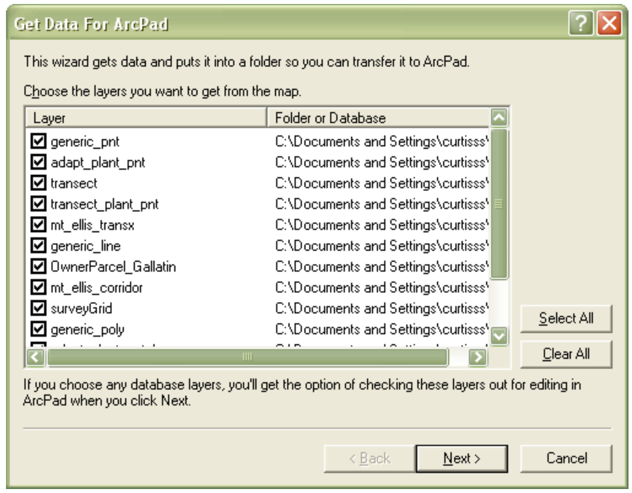
Step 3. Check out data

- Open the Arc Map .mxd containing your geodatabase that you saved in Step 2 of Section 3.1.3

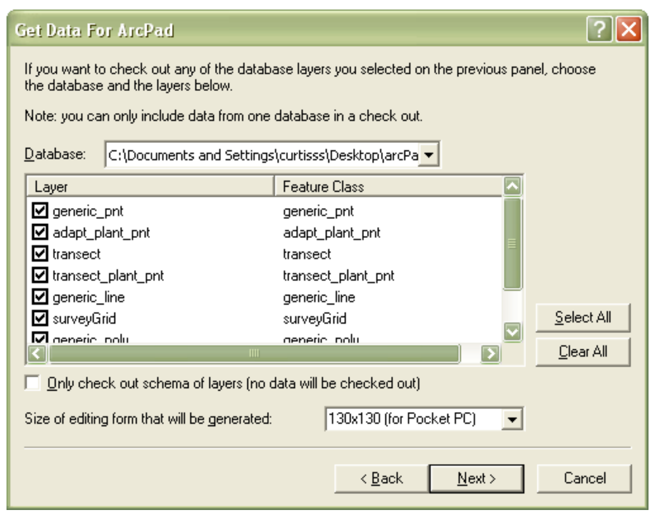
- Zoom to the extent of the data you wish to check out
  - It is **strongly recommended** that you set the extent to a single survey grid feature and only check out one survey grid per check out session. By doing so, ArcPad will run much faster. ArcGIS allows multiple check outs from a geodatabase and 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 that you wish to display in ArcPad including background files and click **Next**:



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

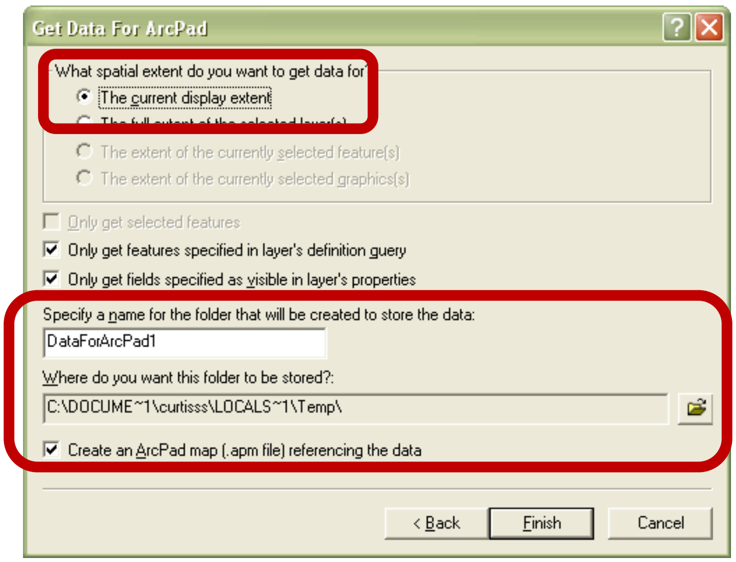


- Verify that the radio button, next to **The Current Display Extent** is selected. This button is located under the question **What spatial extent do you want to get data for?**
  - This limits the amount of information that will be transferred onto the GPS unit.

- Specify a name and a location on your desktop to save the checked out data

- Verify that the **Create an ArcPad Map** checkbox is selected

- Click **Finish**

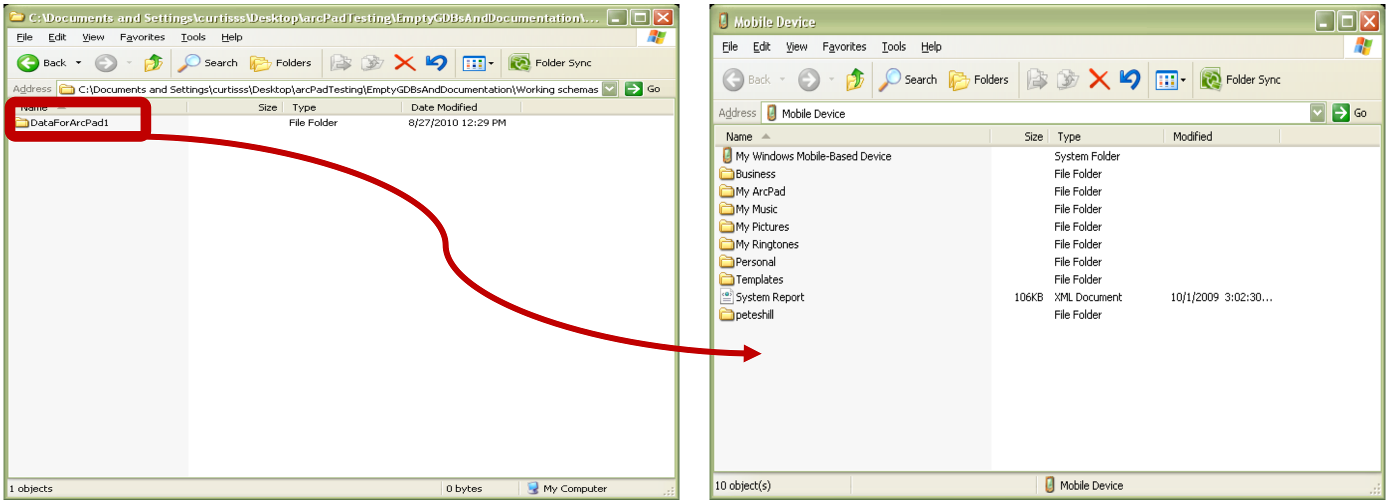


Step 4. Transfer checked out data to the GPS unit.

- 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 that contains the Applet files
- Copy the AdaptiveSampling.config file onto your computer and update the necessary fields:
    1. Fill in all pick lists with the desired possible values.
    2. Verify that 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. In the AdaptiveSampling.config file the two layers important for the Applet to function are PlotLayer and GridLayer. For example, by default the GridLayer= surveyGrid. If, however, your sur-

veyGrid, for example, is named mySurveyGrid, then the variable GridLayer should be set equal to mySurveyGrid. 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.

- Replace the AdaptiveSampling.config file in the Applet file with the updated file

3.3 Conduct a Survey

3.3.1 Survey Steps

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. This section will guide you through the process of carrying out a survey using the AWS Applet. 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.

Step 1. Move to the first cell in the initial sample set and record a start point using the **Capture Plot Point** button (the Applet refers to a **surveyGrid** feature as a plot). Enter or choose values for **Target Species**, **Surveyor1**, **Surveyor2**, **Smax, Amax,** and $\mathbf{P_{sp}}$. Also, check the box next to **Allow Random Additions**, if want to the Applet to choose and display random cells to survey when appropriate; and if you want these random selections to be constrained to just the right or left of the cell containing the target species, check the box next to **Constrain Random Additions**. The remaining steps assume random selections are requested and are not constrained to the left or right of an occupied cell.

Step 2. Move to each of the cells in the initial sample set looking for the target plant species; starting with the one where you recorded the start **Plot Point** in Step 1. If the target species is not found within a cell or for some reason you are unable to survey the cell, use the **Update Grid Cell** button to update its sampled **Status** to **Sampled/Absent** or **Not Sampleable**, respectively. If the target species is found within a cell, use the **Update Grid Cell** button to update its sampled status to **Sampled/Present.** In this case, you will also need to fill in values for the **Per.Cover**, **Patch Density**,

and Patch Pattern. Click **OK**. The Applet will chose and display the cells you need to sample adaptively. These cells will be displayed orange with "0" labels, see Figure 4. An adaptive sampling session has now started and the Applet will keep track of the number of cells sampled adaptively.

Step 3. Continue sampling the cells labeled "0" looking for more target plants and using the **Update Grid Cell** button to update each cell's sampling **Status**. Whenever a cell's **Status** is updated to **Sampled/Present,** the Applet will choose additional cells to sample adaptively and will label each new set of cells associated with an occupied cell with a consecutive integer 1,2...4 etc. corresponding to the order the occupied cells were encountered. You should, but are not required to, sample all cells in the order they are labeled.

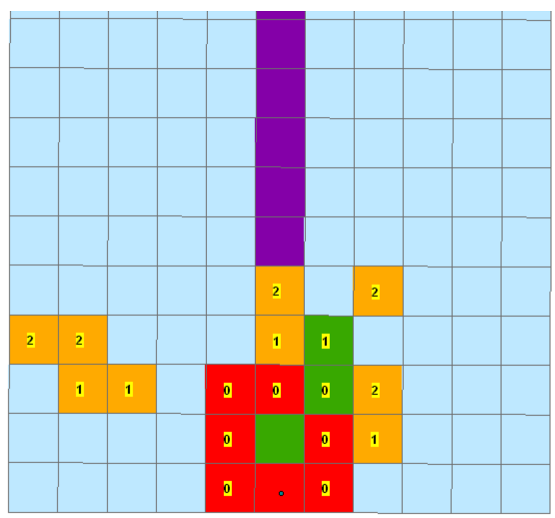


Figure 4. Applet display during sampling. This illustration shows the way in which the Applet will generate successively labeled levels of adaptive cells for each presence encountered. The first presence along the initial sample set generates '0' cells, the next '1' cells and on until the adaptive limit is reached or no more plants are found. Here sampling began with an absence in the initial sample set and the second cell was sampled as a presence, initiating adaptive sampling.

Step 4. Continue with the adaptive sampling session until either the maximum number of cells sampled adaptively, **Amax**, is reached or you have run out of cells to adaptively sample, i.e. orange cells. In the first instance**,** the Applet will display a window informing you **Amax**

has been reached and asking you if you wish to continue. Select **No**. The Applet will automatically reset the counter for number of cells sampled adaptively to zero and erase the labels and change the color of the cells that were not yet sampled back to blue. In the second instance, you will have to use the **Reset Counter** button, as described below, to achieve the same effect.

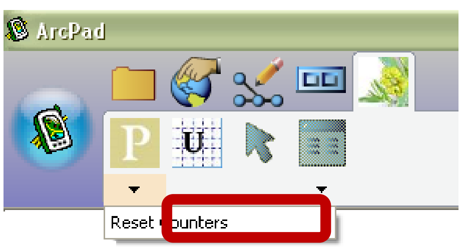
Step 5. After sampling all of the adaptive cells, move back to the next cell in the initial sample set.

Step 6. Continue with Steps 2-5 until all the cells in the initial sample set has been sampled or the maximum number of cells to be sampled within the **surveyGrid** feature, **Smax**, has been reached. For correcting possible errors made during the sampling process, see below.

Step 7. Save and close your ArcPad map and move to the next **surveyGrid** feature.

3.3.2 Resetting the Applet's counters

1) *Running out of cells to sample adaptively*. If during an adaptive sampling session all of the additional cells chosen by the Applet are sampled before **Amax** is reached, the counter that keeps track of the number of cells sampled adaptively needs to be set to zero; to do this, access **Reset Counters** form from the menu under the **Capture Plot Point** button. Reset the **Amax counter** and the **Labels** to **0**, and **Weed Found** to **False**.



2) *Correcting a mistake*. During the course of a survey, if a cell is mistakenly updated with the wrong value and needs to be changed, the steps below must be followed to correct the mistakes and avoid discrepancies with the Applet's counters for **Amax** and

Smax. For additional help with the Applet's buttons see Appendix C or Appendix D.

There are two different updating mistakes that can be corrected while conducting a survey; either updating a cells sampling **Status** to **Sampled/Absent** when, in fact, there was a target species present, or updating a cell's sampling **Status** to **Sampled/Present** when there wasn't any target species present. However, because these mistakes can occur while sampling a cell in the initial sample set or while carrying out an adaptive sampling session, there are actually two cases to consider.

<u>Case 1. A mistake made while sampling an initial sample set cell.</u>
If you need to change a cell **Status** from **Sampled/Absent** to **Sampled/Present**, use the **Update Grid Cell** button and change the value from absent to present. The counters will automatically adjust for the error and no other steps are required.

If you need to change a cell **Status** from **Sampled/Present** to **Sampled/Absent**, use the **Update Grid Cell** button and change the value to **Sampled/Absent**. Once the cell is updated, access the **Reset Counters** form from the menu under the **Capture Plot Point** button and to reset the **Amax counter** to **0** and **Weed Found** to **False.** In this situation the Applet does not automatically correct the sampling **Status** of the cells it selected to be adaptively sampled. This must be done manually using the ArcPad edit tools. By changing the sampling **Status** back to **Not Sampled**, these cells become available to the selection process again.

<u>Case 2. A mistake made while sampling cells during an adaptive sampling session.</u>
If you need to change a cell from "**Sampled/Absent** to **Sampled/Present**, use the **Update Grid Cell** button and change the value to **Sampled/Present.** Also, access the **Reset Counters** form from the menu under the **Capture Plot Point** button and to decrease the **Amax counter** by one. Nothing else needs to be done.

If you need to change a cell **Status** from **Sampled/Present** to **Sampled/Absent**, use the **Update Grid Cell** button and change the value to **Sampled/Absent**. Nothing else needs to be done to avoid errors in the Applet's counters. In this situation the Applet does not automatically correct the sampling **Status** of the cells it selected to be adaptively sampled. This must be done manually using the ArcPad edit tools. By changing the sampling **Status** back to **Not Sampled**, these cells become available to the selection process again.

3.4 Check in Data from ArcPad

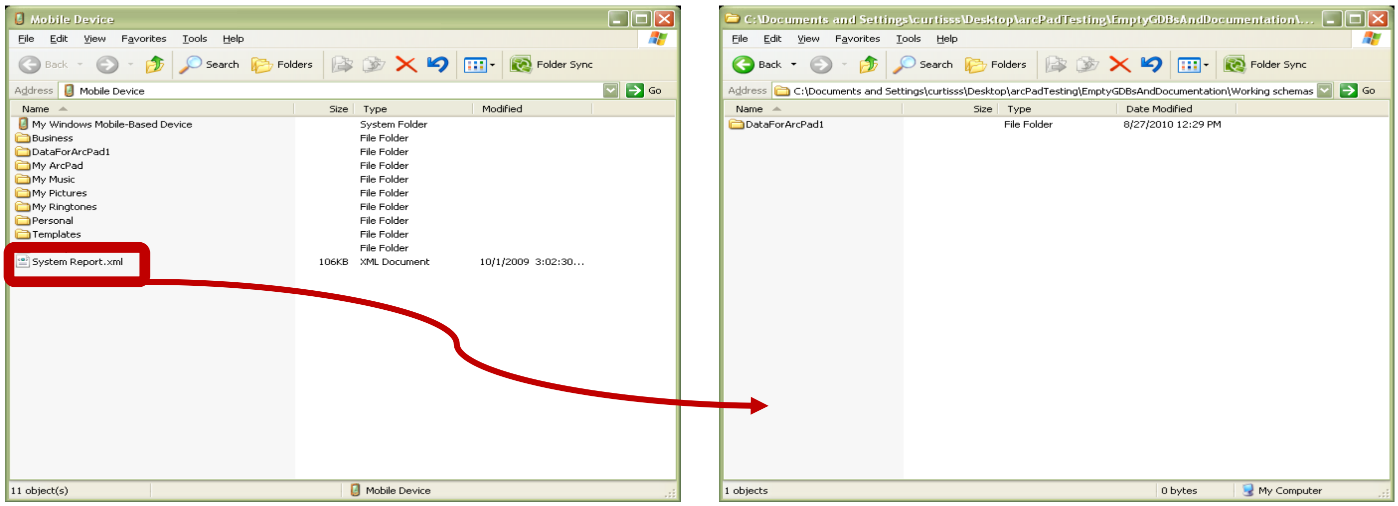
After completing a successful field session it is necessary to check your survey data back into the geodatabase. This section will guide you through the process of data check in. Once your data are successfully checked in they are ready for post-processing and then, for further analysis or other final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

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

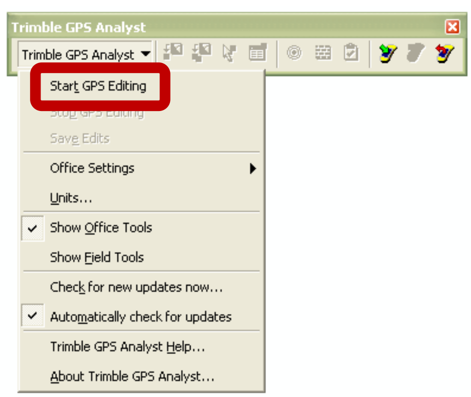
- ➢ Connect using the method you are accustomed to
  - A **Guest Partnership** is the recommended connection method.

Step 2. Check in data

- ➢ Transfer the data folder from the GPS back to the computer using Windows Explorer
  1. You want to replace the file that was 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 Arc Map 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 that need to be checked into your geodatabase. Select all the layers that 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 design

Personal Data Base Design

Geodatabase Name: l 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
Surveyor	coded	text	User Defined

Feature Dataset Name: surveyGPSFeatures

Feature Class Name	Geometry Type	Field Name	Data Type	Domain Name	Values
Plot	point	SURVEYOR1	text	Surveyor	*see domain*
		SURVEYOR2	text	Surveyor	*see domain*
		ID	text	none	*length=25*
		AVE_ACCURA	double	none	
		WORST_ACCU	double	none	
		TARGET_SPE	test	NIS_Species	*see domain*
		GPSDATE	date	none	
		TRANSECTID	text	none	length=30
		PLOTID	text	none	length=30
		COMMENTS	text	none	length=250
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	
		worst_accuracy	double	none	
		SHAPE_Length	double	none	
generic_poly	polygon	Comment	text	none	Length = 50
		ave_accuracy	double	none	
		worst_accuracy	double	none	
		SHAPE_Length	double	none	
		SHAPE_Area	double	none	
surveyGrid	polygon	Id	long integer	none	none
		Status	text	none	Length = 25
		scode	short integer	none	
		target_spe	text	none	Length = 35
		Percent_Co	long integer	none	
		Patch_Dens	text	none	Length = 10
		Patch_Patt	text	none	Length = 25
		Shape_Leng	double	none	
		LHV	short integer	none	
		PLOT_ID	text	none	Length = 25
		row	short integer	none	
		col	short integer	none	
		Label	text	none	Length = 10
		PlotCount	long integer	none	
		SHAPE_Length	double	none	
		SHAPE_Area	double	none	

Appendix B: Requirements and Installation

Requirements

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 recommended for use on Trimble GPS units

Installation

Configuration File

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

Surveyor1=Bruce,Leroy,Joe,Ted,Jeff *Defines pick list for surveyor 1*

Surveyor2=Bruce,Leroy,Joe,Ted,Jack *Defines pick list for surveyor 2*

TargetSpecies=Bromus tectorum,Cirsium arvense,Linaria dalmatica pratense*Defines pick list for target species*

Smax=10 *Defines maximum number of sampling units per plot*

Amax=4 *Defines maximum number of sampling units to sample adaptively*

Psp=.7 *Defines the constant probability of surveying one of the eight adjacent neighboring cells*

PlotLayer=plot *Defines the plot layer name for the applet to use*

GridLayer=surveyGrid *Defines the survey grid layer for the applet to use*

CurrentSurveyor1=Leroy *Defines current surveyor 1 in ArcPad – written by applet*

CurrentSurveyor2=Joe *Defines current surveyor in 2 ArcPad – written by applet*

CurrentPlotID=CobbleCreek *Defines current Grid plot ID – written by applet*

CurrentTargetSpecies=Cynoglossum officinal *Defines current target species – written by applet*

AllowRand=True *Defines if random selections are allowed by Applet*

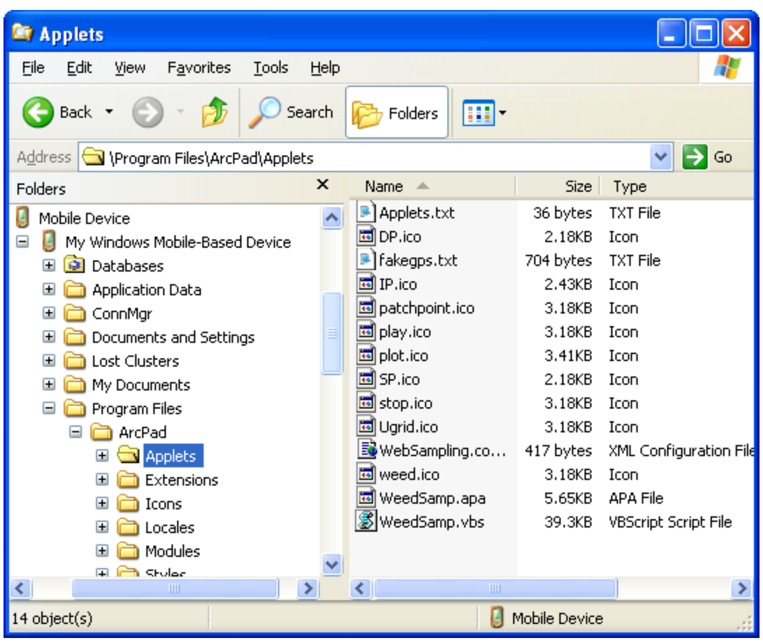
ConstRand=*Defines if random selections are constrained to current grid row.*

Gridsize=10 *Defines grid cell size*

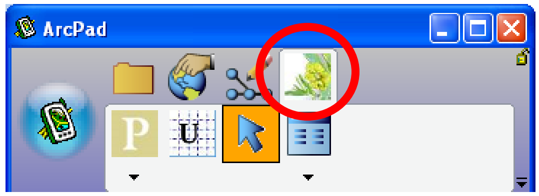
Fields in **bold** above are required values. The variables PlotLayer and GridLayer refer to shapefiles checked out from the geodatabase for use with the Applet. If you have renamed the feature class layers prior to checkout, you will have to modify the names here so that the Applet knows which layers to use for each variable. For example, using the above list the Applet will look GridLayer named surveyGrid. If, however, the survey grid feature dataset name was changed in the geodatabase to mySurveyGrid, then the variable GridLayer should be set to GridLayer=mySurveyGrid. TargetSpecies and Surveyors are pick lists for the Applet to use and must 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 that need to be changed and then copy it back to the unit, overwriting the old configuration file.

Applet

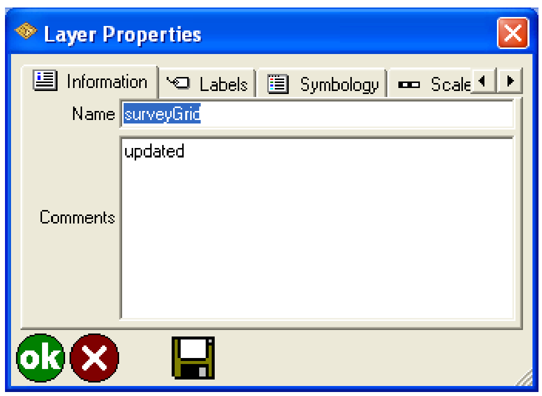
To install the Applet, copy all files contained in the Applets folder to the/Program Files/ArcPad/Applets folder on the mobile device. The Applet is installed by ArcPad on startup so if ArcPad is running on the device, you will need to restart ArcPad after the files are copied to the mobile device.



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



Note: When the Applet initially loads the configured data files, it writes new forms (apl files) for the application to use. To verify the files have been updated correctly, the word "updated" will appear in the comments section of layers properties in ArcPad. In the event these files need updated, clear the word "updated", save and close ArcPad and when the file is loaded again it will be updated.

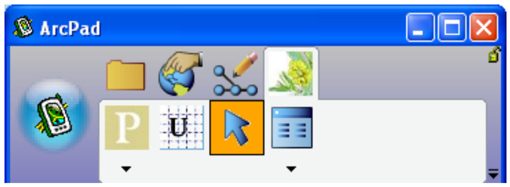


Appendix C: Applet Operation

In this appendix, the terms survey grid, plot and grid are used interchangeable and mean the same thing.

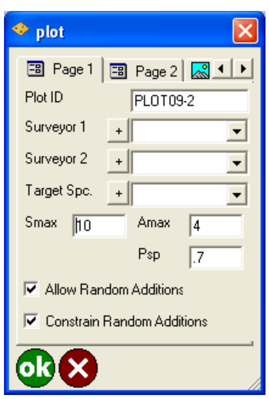
a. Starting the Applet

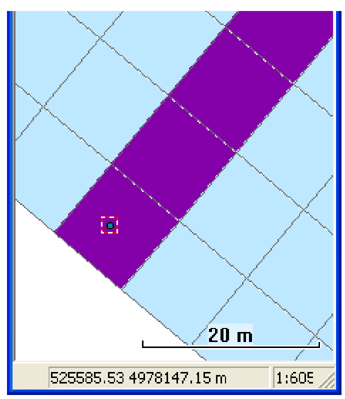
The Applet is automatically loaded by ArcPad when the application is started. A new tool bar will appear in when the Applet is properly installed.



b. Capture Plot Point

Plot Points are created to define start of transects, click the **Capture Plot Point button**  to create a starting point for a plot (right). If the GPS is active, the data collection form is shown (left). If the GPS isn't active a dialog will appear asking to turn it on.



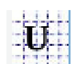


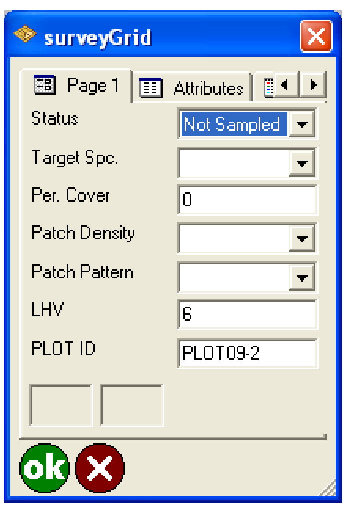
When creating a **Plot Point** the **Smax**, **Amax**, **Allow Random Additions** and **Constrain Random Additions** values are set for the current plot and stored until another **Plot Point** is created.

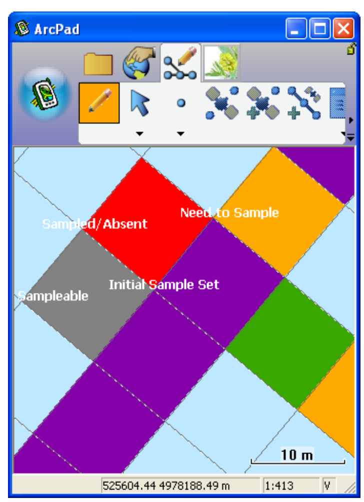
c. Reset Counters

The submenu under the create **Plot Point** button allows the user to reset the **Current Smax**, **Amax**, **Label** counters and the indicator for **Weeds Found**. This form is used if a surveyor finishes a plot before the Amax counter has been reached, or if a mistake is made in marking a grid cell.

d. Update Grid Cell

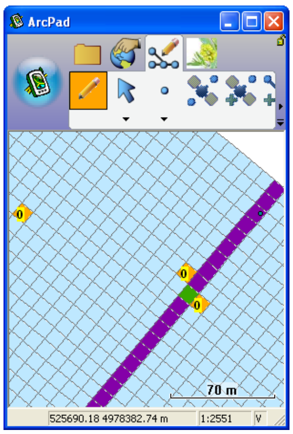
Update grid cell button  is used to update the current grid cell based upon the surveyor's current GPS location, with an active GPS location click this button to select the grid cell based on the current GPS location and display the survey grid form.

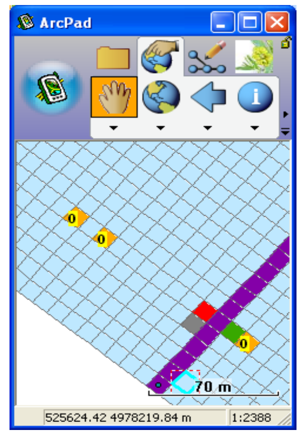




Updating the grid changes the color of the grid cell to visually indicate the status of the grid location. There are 5 different values for the grid cells; 0 = Sampled/Absent (red), 1 = Sampled/Present (green), 3 = Need to Sample (orange), 2 = Not Sampled (blue default value) and -9 = Not Sampleable.

When a cell is marked as Sampled/Present the additional values **Target Spc.**, **Per. Cover**, **Patch Density** and **Patch Pattern** are required values. Marking a cell as sampled present launches the random selection procedure to mark additional cells that need to be sampled (orange). Below are examples of what the selection procedure will produce if **Allow Random Additions** is checked (left) and if **Constrain Random Additions** is checked (right).





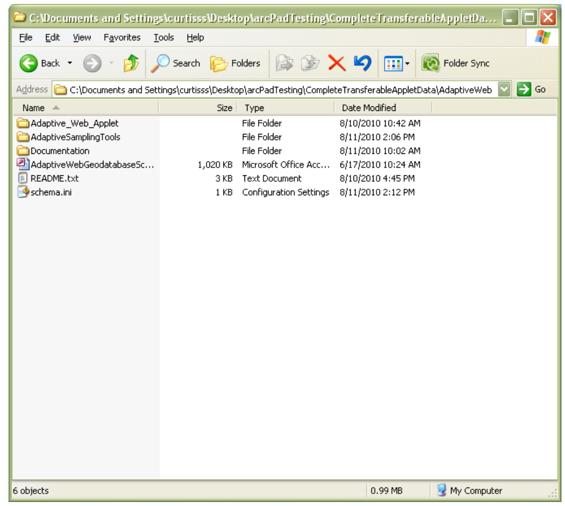
Appendix D: Applet Quick Reference

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

	Capture Plot Point	Create GPS point feature for plot start point.
Reset Counters	Show the Reset Counters form	Used to update label, Smax and Amax counters
	Update Grid Cell	Update Grid Cell based on GPS location.
	Select	ArcPad tool to select editable features
	Feature Properties	ArcPad tool to show feature attributes
	Delete Feature	ArcPad tool to delete selected feature

Appendix E: File Reference

The following files and folders, described below are included for use with the AWS Applet:



- A folder called AdaptiveSamplingTools
- A folder called Documentation
- A folder called Adaptive_Web_Applet
- An empty geodatabase schema in the correct format containing all required fields and attributes.

AdaptiveSamplingTools:

This folder contains an ESRI tool box file called Adaptive_Sampling_Tools.tbx as well as the script to be used for the construction of data in the geodatabase. To access the tool this script belongs 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 in which you have chosen to keep the .tbx file. This location can be within the AdaptiveWeb folder as provided, or at another location. Be sure to keep the PYTHON script file in the same folder as the .tbx file. If they are separated the tools stored path will not be correct and the tool will not work. Should this happen verify that the script path is correct. Once the toolbox is added to the toolbox window, the **Survey Grid Builder** tool will appear. Double click on this tool to access its functionality.

Documentation:

This folder contains all of the documentation that was provided with the Applet. It includes users' guides, tips, 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 goes step by step through the majority of processes required by the Applet. It is recommended that this documentation be read before using the Applet and kept available for future reference.

Adaptive_Web_Applet:

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

Applet2GeodatabaseSchema.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.