

VSP 7.0: Remedial Investigations (RI) of UXO Prone Sites & Visual Sample Plan

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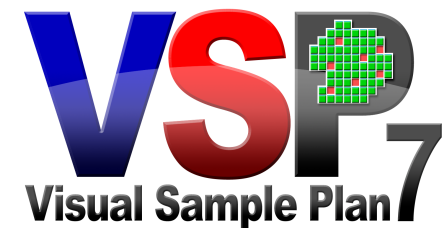
M2S2 Webinar
June 24, 2014



Outline



- I. VSP 7.0 Updates
- II. UXO Guide
- III. Remedial Investigation (RI) Focus
 - ◆ TOI Rate Estimation
 - ◆ Impact Area Discovery Updates (Formerly called Find Target Areas)
- IV. Grids vs. Transects
- V. Upcoming Classes
- VI. Things not to say as a VSP Expert
- VII. Conclusions & Conversations



Motivation: New VSP RI Tools & Structure



Remedial Investigations (RI) projects need more consistently applied sampling designs and tools

- ◆ Some inappropriate applications of non-RI VSP modules
- ◆ UXO Estimator and VSP were often awkwardly cobbled together (neither tool completely met needs)

Solution:

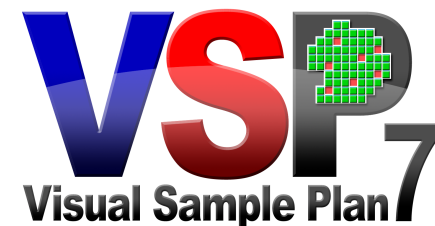
1. ESTCP established a VSP-RI advisory group
2. RI survey and data evaluation objectives were defined
3. Developed new VSP Modules for RI survey design and analysis to clearly address RI objectives

VSP 7.0



- Released March 2014
- New VSP-RI Additions Include
 - ◆ VSP UXO Expert Guide
 - ◆ VSP-RI Sampling Goal Menu Item
 - 3 primary survey design and analysis objectives
 - ◆ HTML-based Help Files (also available on vsp.pnnl.gov/help)
 - ◆ UXO-Estimator Replacement
- Other new Features added
 - ◆ Map tile servers connections
 - ◆ Improved graph views

VSP Users (Since 5.0 as of 4/3/14)		
USA	Sites	# Users
	EPA	1768
	DOE	1044
	States	1059
	Army	1511
	Navy	740
	Air Force	330
	Other DoD	106
	NRC	203
	Other	495
Total USA		7256
International		
	UK	529
	Canada	362
	Australia/NZ	217
	Brazil	133
	Spain	91
	Other/Unknown	1415
Total International		2747
Total Recent Unique Users		10003



VSP Workflow Guidance in Expert Mentor



Objective: Provide guidance to VSP users on which UXO related module to protect against misuse (>15 module options).

1. Developed decision objective flowchart that leads user to the appropriate VSP module
2. Created descriptive summaries for each VSP module
3. Incorporated work into the VSP-UXO Guide
4. Rolled out in VSP 7.0

Expert Guide (UXO)



File Map Edit **Sampling Goals** Tools Options Room View

- Compare Average to Fixed Threshold ...
- Compare Average to Reference Average ...
- Estimate the Mean
- Construct Confidence Interval on Mean
- Locate Hot Spots (Contiguous Areas of Contamination)
- Show That at Least Some High % of the Sampling Area is Acceptable
- Discover Unacceptable Areas With High Confidence ...
- Combined Average and Individual Measurement Criteria ...
- Detect a Trend
- Identify Sampling Redundancy
- Add Sampling Locations to Reduce Spatial Uncertainty ...
- Compare Proportion to Fixed Threshold ...
- Compare Proportion to Reference Proportion ...
- Construct Confidence Interval on Proportion ...
- Estimate the Proportion
- Establish Boundary of Contamination
- UXO Guide (beta)**
- Find Target Areas and Analyze Survey Results (UXO)
- Post Remediation Verification Sampling (UXO)
- Remedial Investigation (UXO)
- Sampling Within a Building
- Radiological Transect Surveying
- Item Sampling ...
- Non-Statistical Sampling Approach
- Last Design

Expert Guide Guide rev 1.2.2 / Data rev 1.3.6

VSP Process Workflow Guide

Introduction Finish

My site contains

- Areas with known or suspected target areas that need to be identified and delineated
- Areas where some TOI may be present and the TOI/acre needs to be estimated but target area discovery/delineation is not a design objective
- Areas that are believed to be free of TOI (presumptively clean) but additional confirmation is required
- Areas that have already undergone remediation and an additional survey is needed to demonstrate remediation effectiveness
- Areas where transect surveys have been performed and where anomalies were dug for some grids and I need an improved estimate of remediation efforts that may be required
- Areas where so many anomalies have been found that only a small subset can be dug
- Areas where anomaly classification technologies have been used and need to sample more to provide extra confidence

CANCEL BACK NEXT

VSP Modules

[Using the expert guide](#)

VSP Process Workflow Guide



My site contains

- Areas with known or suspected target areas that need to be identified and delineated
- Areas where some TOI may be present and the TOI/acre needs to be estimated but target area discovery/delineation is not a design objective
- Areas that are believed to be free of TOI (presumptively clean) but additional confirmation is required
- Areas that have already undergone remediation and an additional survey is needed to demonstrate remediation effectiveness
- Areas where transect surveys have been performed and where anomalies were dug for some grids and I need an improved estimate of remediation efforts that may be required
- Areas where so many anomalies have been found that only a small subset can be dug
- Areas where anomaly classification technologies have been used and need to sample more to provide extra confidence

VSP Modules

[CANCEL](#)[BACK](#)[NEXT](#)

Directs to Correct VSP Module



Expert Guide
Guide rev 1.2.2 / Data rev 1.3.6
X

VSP Process Workflow Guide

Introduction
Confidently Estimate TOI
Finish

Finished! Based on all the options selected, the recommended modules are highlighted in the right pane and featured in the list below. Click the links to open the VSP module.

Remedial Investigation Sampling Goal With No Priors

Design Driver

Need to develop a transect survey design to show that the rate or total number of unacceptable items (TOI) is less than a pre-specified level (i.e., UXO/acre < Z)

Data/Information Needs

- Definition of what constitutes a TOI
- Pre-specified "acceptable" TOI density and required confidence

Additional Information

- VSP determines the survey acreage required and transects placement.
- See VSP Online Help

Remedial Investigation Sampling Goal With Uninformed Prior

Design Driver

Need to estimate the unacceptable item rate (e.g., MEC/acre) or number of unacceptable items on my site and show that I am confident that the true rate or total number of unacceptable items is less than a pre-specified level (i.e., UXO/acre < Z)

CANCEL
BACK
NEXT

VSP Modules

RI Survey Objectives



- Three primary objectives identified

Takes user to impact area discovery module or to augment existing surveys module

Provides options for non-Bayesian and Bayesian approaches including UXO Estimator equivalent

Goes to presumptively clean survey module

The image shows a screenshot of a software dialog box titled "Remedial Investigation (UXO)". The dialog box contains the following text and controls:

I need to

- Develop a transect survey design where target areas are known and delineate target areas.
- I want to use existing transects or fix transects.
- Develop a transect survey design to show that the rate of contamination is at or below a pre-specified level (UXO/acre < Z), with no clear target areas and no known target areas that have some potential for contamination.
- Develop a transect or grid survey design for presumptively clean area(s) to show I'm X% confident that at least Y% of the area does not contain unacceptable items.

At the bottom of the dialog box are two buttons: "OK" and "Cancel".

TOI Rate Estimation



I want to estimate the unacceptable item rate (e.g., MEC/acre) or number of unacceptable items on my site and show that I am confident that it is no more than some value.

My site is acres

My sampling unit will be a by feet transect.

I want to demonstrate with % confidence that:

- the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per
- the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

Design	Survey Acreage
Non Bayesian	5.93 (87 transects)

You must survey 1.98% of the site (5.9322 acres) by taking approximately 87 transects (1000 by 3 feet) and have no unacceptable items found. If no unacceptable items are found, your best estimate of the true rate of unacceptable items is 0 per acre and you can be 95% confident that the true unacceptable item rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items on the entire 300 acre site.

If any unacceptable item is found, then you cannot conclude with 95% confidence that the true rate of unacceptable items is no larger than 0.5 per acre. If unacceptable items are encountered, you can go to the Post-Survey Analysis tab to estimate the unacceptable item rate and confidence interval.

If I want to have no more than a % chance of concluding that the true rate of unacceptable items (i.e., MEC/acre) is greater than 0.5 per acre, then the true rate of unacceptable items must be equal to or less than 0.04 per acre.

TOI Rate Estimation



RI TOI Estimation | **Transect Placement** | Costs | Post-Survey Analysis

I want to estimate the unacceptable item rate (e.g., MEC/acre) or number of unacceptable items on my site and show that I am confident that it is no more than

My site is acres

My sampling unit will be a by feet transect.

I want to demonstrate with % confidence that:

the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per

the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

I want to use an prior. (An uninformed prior is equivalent to UXO Estimator).

You must survey 1.96% of the site (5.8931 acres) by taking approximately 86 transects (1000 by 3 feet) to have no unacceptable items found. If no unacceptable items are found, your best estimate of the rate of unacceptable items is 0 per acre and you can be 95% confident that the true unacceptable item rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items on the entire 300 acres, assuming your prior information is correct.

Design	Survey Acreage
Non Bayesian	5.93 (87 transects)
Uninformed Bayesian	5.89 (86 transects) (UXO Estimator)

If any unacceptable item is found, then you cannot conclude with 95% confidence that the true rate of unacceptable items is no larger than .5 per acre. If unacceptable items are encountered, you can go to the Post-Survey Analysis tab to estimate the unacceptable item rate and confidence interval.

I want to estimate the unacceptable item rate (e.g., MEC/acre) or number of unacceptable items on my site and show that I am confident that it is no more than some value.

My site is acres

My sampling unit will be a by feet transect.

I want to demonstrate with % confidence that:

- the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per
- the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

I want to use an prior. (An uninformed prior is equivalent to UXO Estimator).

I am quite sure (with probability >) that the maximum number of unacceptable items on this site is no more than

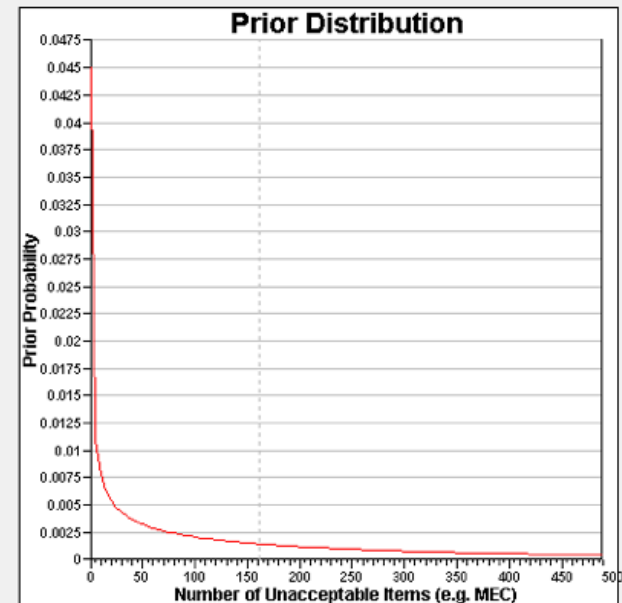
There is chance of having 162 or fewer unacceptable items than there is of having > 162 unacceptable

You must survey 1.07% of the site (3.1958 acres) by taking approximately 47 transects (1000 by 3 feet) and have no unacceptable items found. If no unacceptable items are found, your best estimate of the true rate of unacceptable items is 0 per acre and you can be 95% confident that the true unacceptable item rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items on the entire 300 acre site, assuming your prior information is correct.

If any unacceptable item is found, then you cannot conclude with 95% confidence that the true rate of unacceptable items is no larger than .5 per acre. If unacceptable items are encountered, you can go to the Post-Survey Analysis tab to estimate the unacceptable item rate and confidence interval.

TOI Rate Estimation

Design	Survey Acreage
Non Bayesian	5.93 (87 transects)
Uninformed Bayesian	5.89 (86 transects)
Informed Bayesian	3.19 (47 transects)



Log Y-Scale

I want to estimate the unacceptable item rate (e.g., MEC/acre) or number of unacceptable items on my site and show that I am confident that it is no more than some value.

My site is acres

My sampling unit will be a by feet transect.

TOI Rate Estimation

I want to demonstrate with % confidence that:

- the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per
- the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

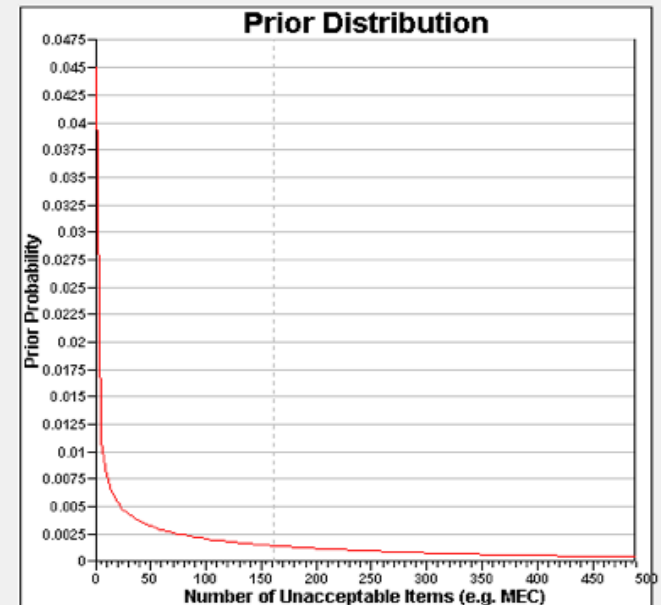
I want to use an prior. (An uninformed prior is equivalent to UXO Estimator).

I am quite sure (with probability >) that the maximum number of unacceptable items on this site is no more than

There is chance of having 162 or fewer unacceptable items than there is of having > 162 unacceptable

You must survey 1.98% of the site (5.9331 acres) by taking approximately 87 transects (1000 by 3 feet) and have no unacceptable items found. If no unacceptable items are found, your best estimate of the true rate of unacceptable items is 0 per acre and you can be 99% confident that the true unacceptable item rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items on the entire 300 acre site, assuming your prior information is correct.

If any unacceptable item is found, then you cannot conclude with 99% confidence that the true rate of unacceptable items is no larger than .5 per acre. If unacceptable items are encountered, you can go to the Post-Survey Analysis tab to estimate the unacceptable item rate and confidence interval.



Design	Survey Acreage	Confidence
Non Bayesian	5.93 (87 transects)	95
Uninformed Bayesian	5.89 (86 transects)	95
Informed Bayesian	3.19 (47 transects)	95
Informed Bayesian	5.93 (87 transects)	99

Log Y-Scale

Post-Survey Analysis



- Non-Bayesian
- Data analysis summaries provided in blue

RI TOI Estimation | Transect Placement | Costs | **Post-Survey Analysis**

My site is acres

My sampling unit was a by feet transect.

I surveyed:

- % of the site (coverage)
- 1000 by 3 foot transects
- a total of acres

and found unacceptable items.

I want to demonstrate that I am % confident that:

- the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per acre
- the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

Estimate:

Your best estimate of the unacceptable rate based on observing 1 unacceptable items and surveying 4.56 acres is 0.2193 per acre.

You can be at least 95% confident that the unacceptable item rate is no larger than 1.037 per acre and there are no more than 311 unacceptable items on your site.

You can be 66.7% confident that the unacceptable rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items.

If you want to show that you are 95% confident that the true rate of unacceptable items is no larger than 0.5 per acre and the total number of unacceptable items is no more than 150, given the fact that you have already encountered 1 unacceptable items, you will need to survey an additional 4.81 acres and find no additional unacceptable items.

Post-Survey Analysis



- Bayesian
- Data analysis summaries provided in blue
- Confidence bounds use priors

RI TOI Estimation | Transect Placement | Costs | **Post-Survey Analysis**

My site is acres

My sampling unit was a by feet transect.

I surveyed: % of the site (coverage)
 1000 by 3 foot transects
 a total of acres

and found unacceptable items.

I want to demonstrate that I am % confident that:

the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per acre
 the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

I want to use an prior. (An uninformed prior is equivalent to UXO Estimator).

I am quite sure (with probability >) that the maximum number of unacceptable items on this site is no more than

There is chance of having 162 or fewer unacceptable items than there is of having > 162 unacceptable

Your best estimate of the unacceptable rate based on observing 1 unacceptable items and surveying 4.56 acres is 0.2193 per acre.

You can be at least 95% confident that the unacceptable item rate is no larger than 0.89 per acre and there are no more than 267 unacceptable items on your site.

You can be 69% confident that the unacceptable rate is no larger than 0.5 per acre and there are no more than 150 unacceptable items.

If you want to show that you are 95% confident that the true rate of unacceptable items is no larger than 0.5 per acre and the total number of unacceptable items is no more than 150, given the fact that you have already encountered 1 unacceptable items, you will need to survey an additional 4.81 acres and find no additional unacceptable items.

Presumptively Clean



- Develop a transect or grid survey design for presumptively clean area(s) to show I'm X% confident that at least Y% of the area does not contain unacceptable items.

- Similar methodology to post remediation verification
- Requires the user to define a parcel size of concern

Presumptively Clean Verification | Transect Placement | Costs and Coverage

My site is acres

My transects will be by foot transect.

My parcel size of concern will be acres

With the expectation that no targets of interest (TOI) remain,
I want to survey enough area to state with % confidence that:

the percent of parcels that contain TOI ranges from 0% to no more than %.

the number of parcels that contain TOI ranges from 0 to no more than %.

Note that as the parcel size increases, the maximum number of allowed unacceptable parcels decreases and the required survey acreage increases. Parcel sizes that are too small will result in more allowed unacceptable parcels and too little survey acreage. Thus, clear justification for selecting parcel size should be provided (e.g. 1/4 acre home lot size).

I want to account for prior belief about likelihood of unacceptable items in my area.

Before any surveying takes place, I expect no more than (4.17%) of the 1200 total 0.25-acre parcels contain TOI.

You must survey approximately 1.83% of the site (5.50 acres) by surveying 80 (1000 by 3 foot) transects and find no TOI. If no TOI are found, your best estimate of the number of parcels that contain TOI on the site is 0 and you can be 90.00% confident that at least 95.00% of all 1200 parcels do not contain TOI and that there are no more than 60 parcels that may contain TOI.

If TOI are found, then you cannot conclude with 90.00% confidence that at least 95.00% of all 1200 parcels do not contain TOI and that there are no more than 60 parcels that may contain TOI.

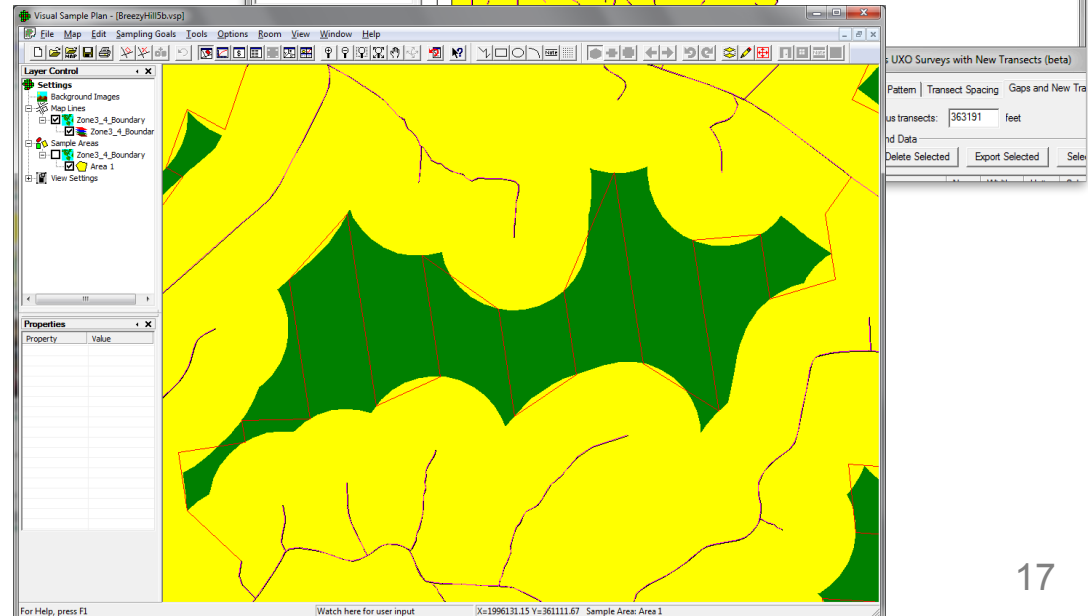
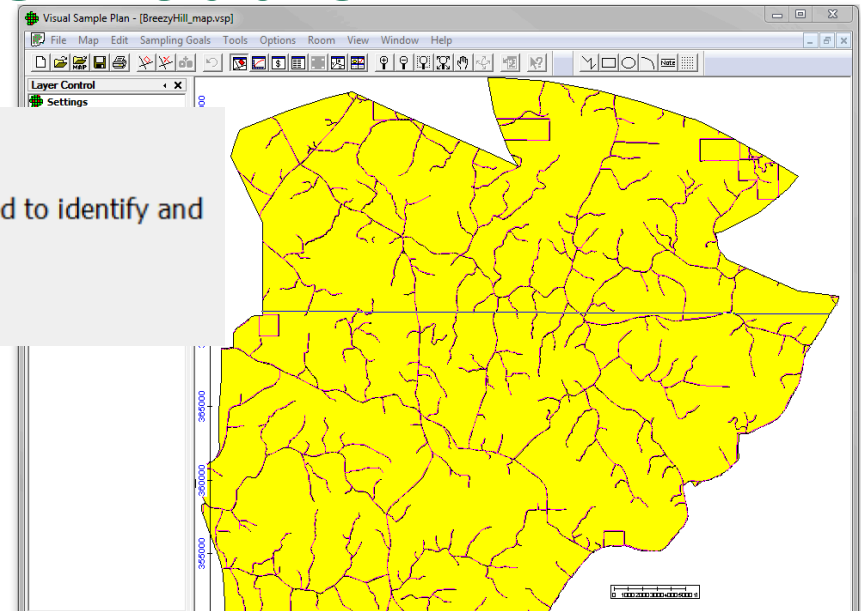
Augmented Transects Module

I need to

- Develop a transect survey design where target areas are known or suspected to identify and delineate target areas.

I want to use existing transects or fix transects.

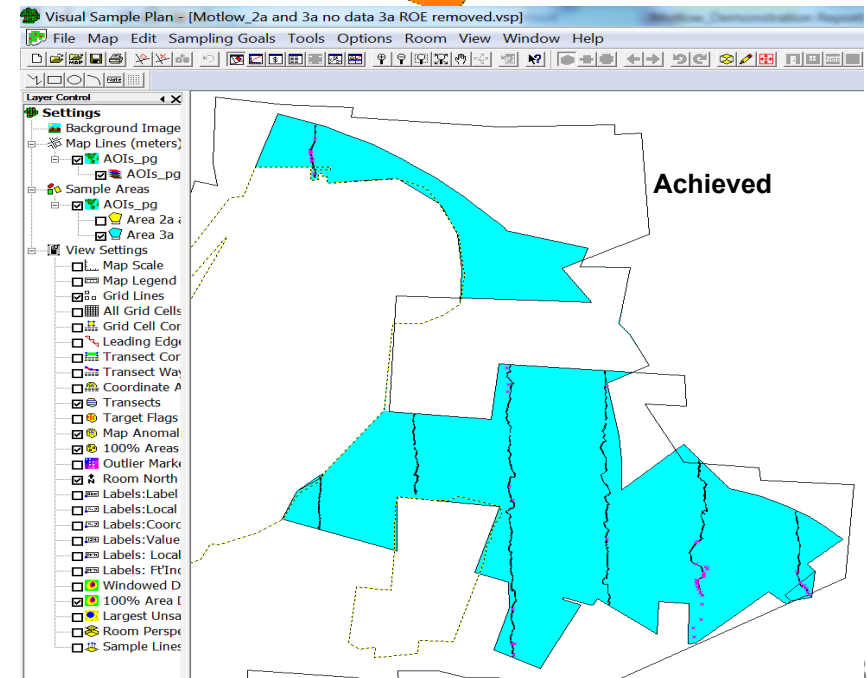
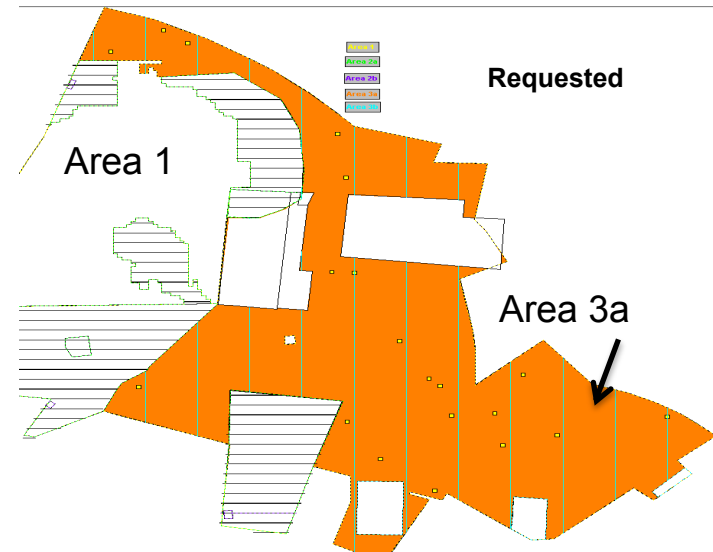
- ACOE funded new module for augmenting existing surveys to meet TA detection objective
- Successfully applied on Breezy Hill site
- Added as an option within VSP 7.0



Motlow: TOI/Acre Estimation



- Wanted to show 90% confident that $\text{TOI/Acre} < 0.5$
- Used uninformed prior (UXO Estimator equivalent)
- Requested 4.6 acres of transect surveys
- Made reasonable Bayesian prior design as well
- Cleanup of Area 1 where target areas were prevalent, <800 TOI found
- Cost limited demonstration to 2.7 acres of transect surveys
- No TOI found



Motlow Area 3a: TOI/Acre Analysis

Target of Interest (TOI) Estimation/Comparison

RI TOI Estimation | Transect Placement | Costs | Post-Survey Analysis

My site is acres

My sampling unit was a by feet transect.

I surveyed:

- % of the site (coverage)
- 10000 by 3.28 foot transects
- a total of acres

and found unacceptable items.

I want to demonstrate that I am % confident that:

- the true rate of unacceptable items (e.g., MEC/acre) in the site ranges from 0 to no more than per
- the true number of unacceptable items in the entire site ranges from 0 to no more than

I want to use a Bayesian method to account for prior knowledge about the likelihood of unacceptable items.

I want to use an prior. (An uninformed prior is equivalent to UXO Estimator).

I am quite sure (with probability >) that the maximum number of unacceptable items on this site is no more than

There is chance of having 499 or fewer unacceptable items than there is of having > 499 unacceptable

Your best estimate of the unacceptable rate based on observing 0 unacceptable items and surveying 2.7 acres is 0 per acre.

You can be at least 90% confident that the unacceptable item rate is no larger than 0.466 per acre and there are no more than 750 unacceptable items on your site.

You can be 91.6% confident that the unacceptable rate is no larger than 0.5 per acre and there are no more than 805 unacceptable items.

If quite sure (0.75 probability) that number of TOI < 1000..., can be 90% confident TOI/acre is < 0.47.

Grids vs. Transects

Grids vs. Transects



- Using Area 3a boundary, via simulation examined effect of grids vs. transects on actual achieved confidence for TOI/acre estimation
 - ◆ varied TOI clustering
 - ◆ varied survey unit dimensions

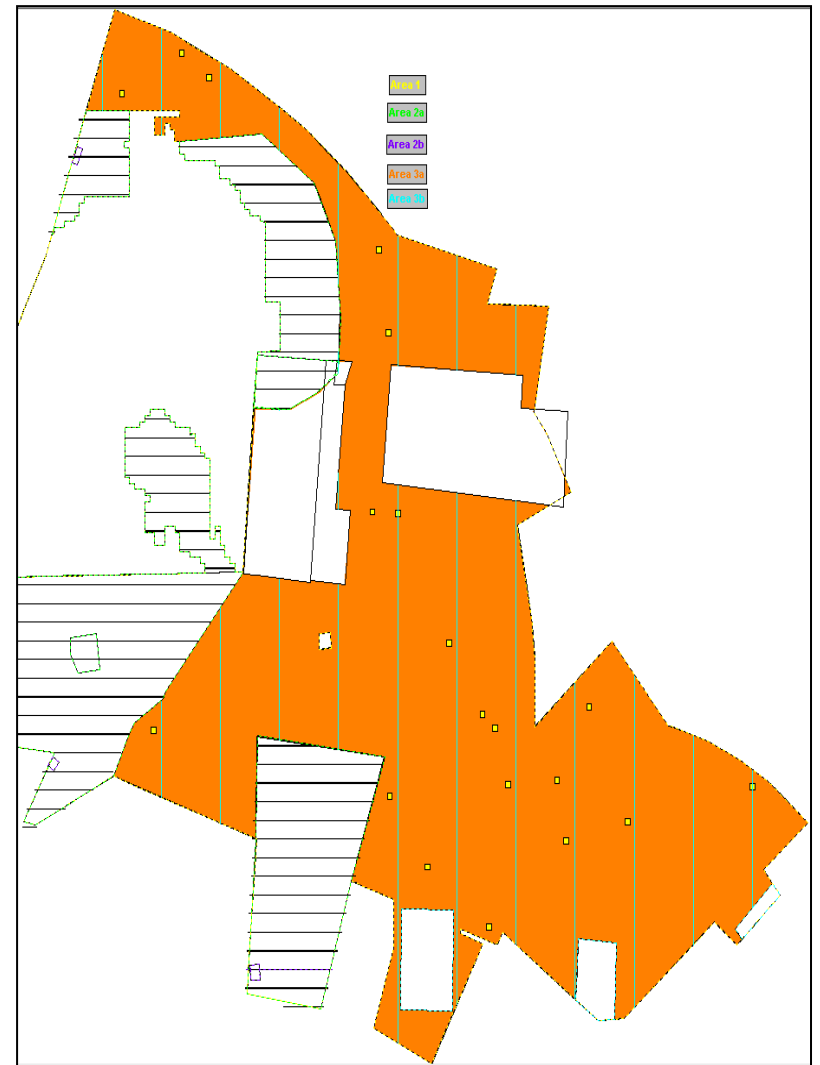
Sample Unit Dimensions (meters)

• *Transects*

- ◆ 1x50, 1x100, 1x500, & 1x1000
- ◆ 3x50, 3x100, 3x500, & 3x1000
- ◆ 6x50, 6x100, 6x500, & 6x1000

• *Grids*

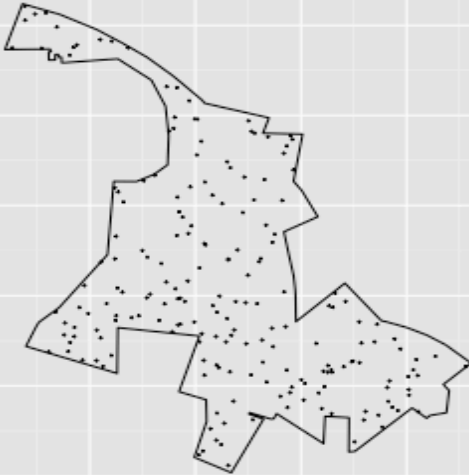
- ◆ 50x50, 50x100, & 100x100



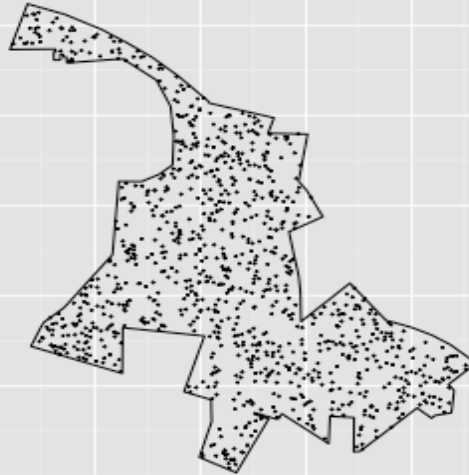
TOIs for 5 Rates per Acre



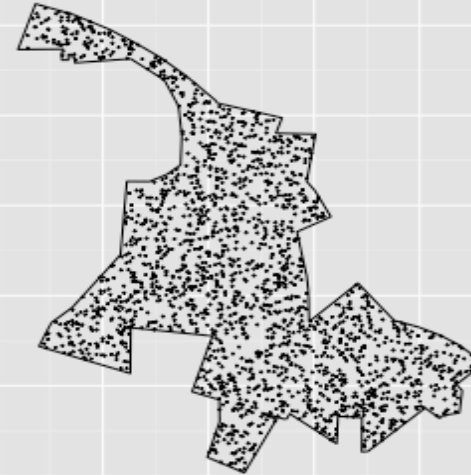
Uniformly distributed
with a rate of 0.1 per acre



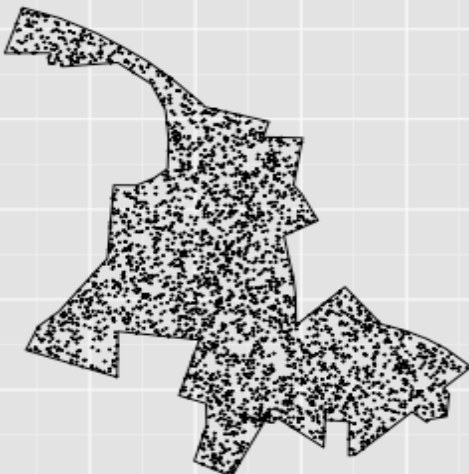
Uniformly distributed
with a rate of 0.5 per acre



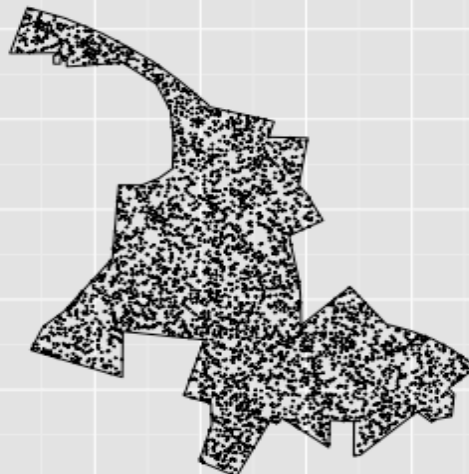
Uniformly distributed
with a rate of 1 per acre



Uniformly distributed
with a rate of 1.5 per acre



Uniformly distributed
with a rate of 2 per acre



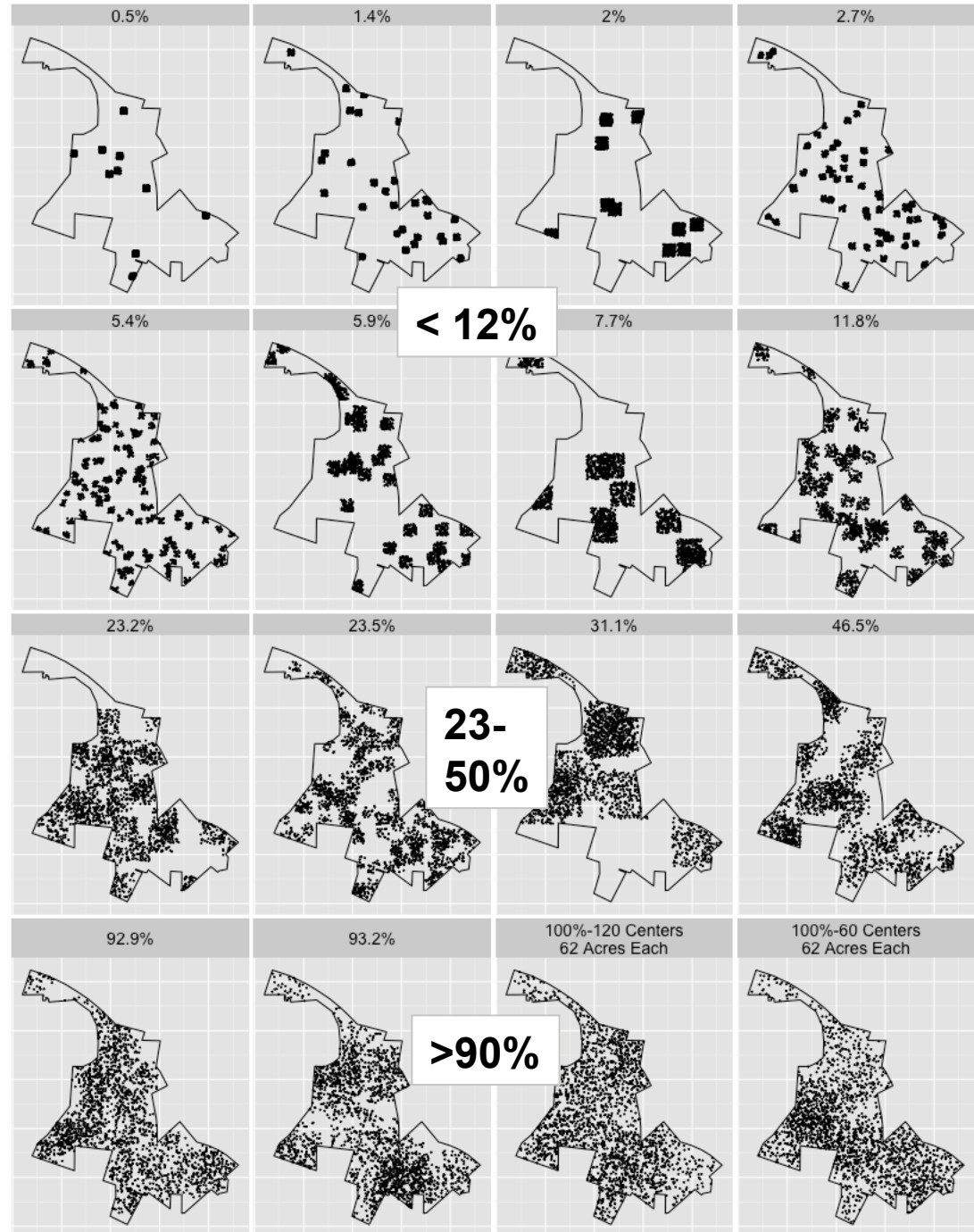
- The base case uniformly distributes TOI at five different rates
 - ◆ 0.1, 0.5, 1.0, 1.5, 2.0

All survey dimensions met objectives equally well as expected

Grids vs. Transects

- 16 different levels of clustering were used for Area 3a at 5 different rates

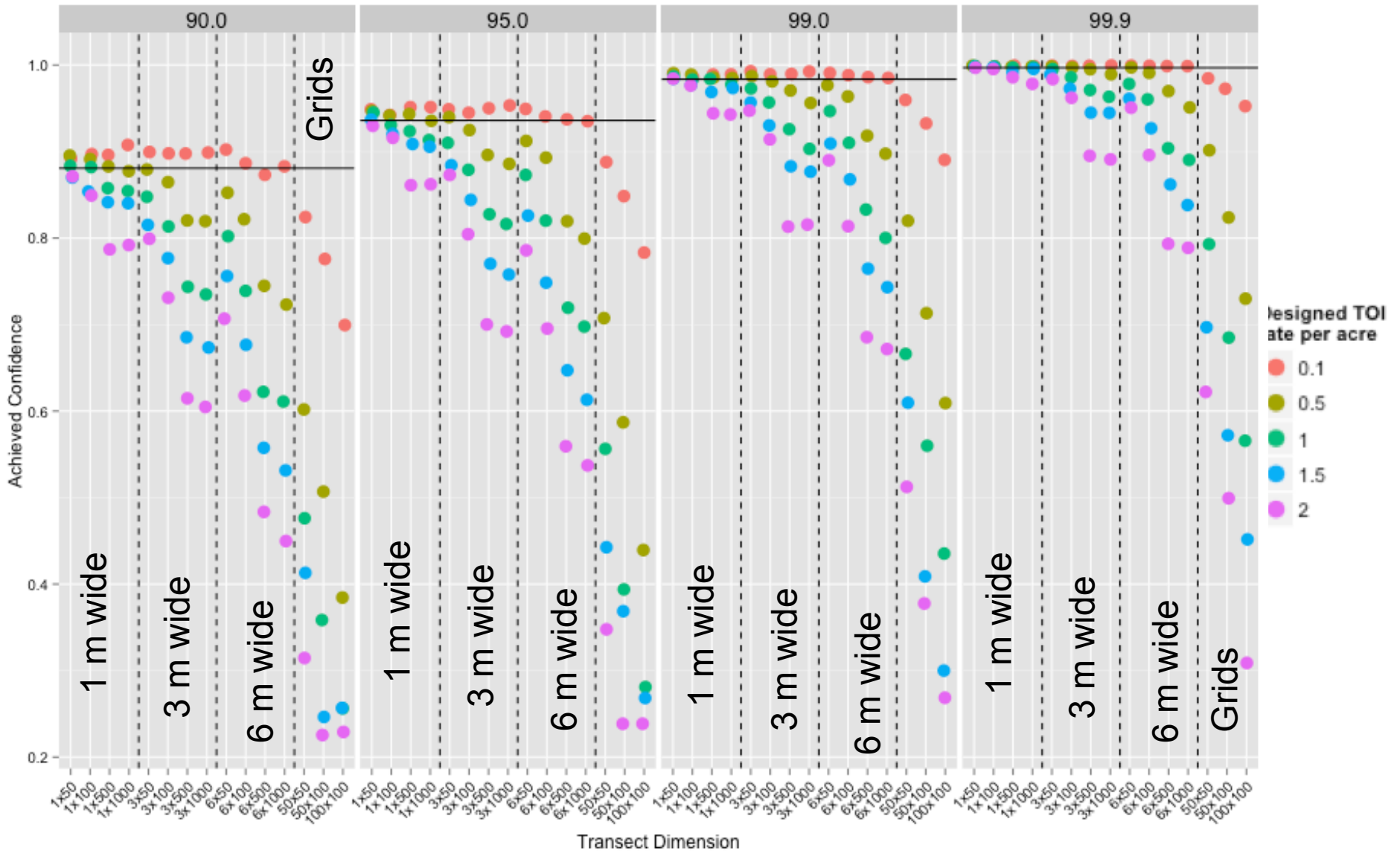
- ◆ 0.1,
- ◆ 0.5,
- ◆ **1.0 (picture shown)**,
- ◆ 1.5,
- ◆ 2.0



Grids vs. Transects: <12%



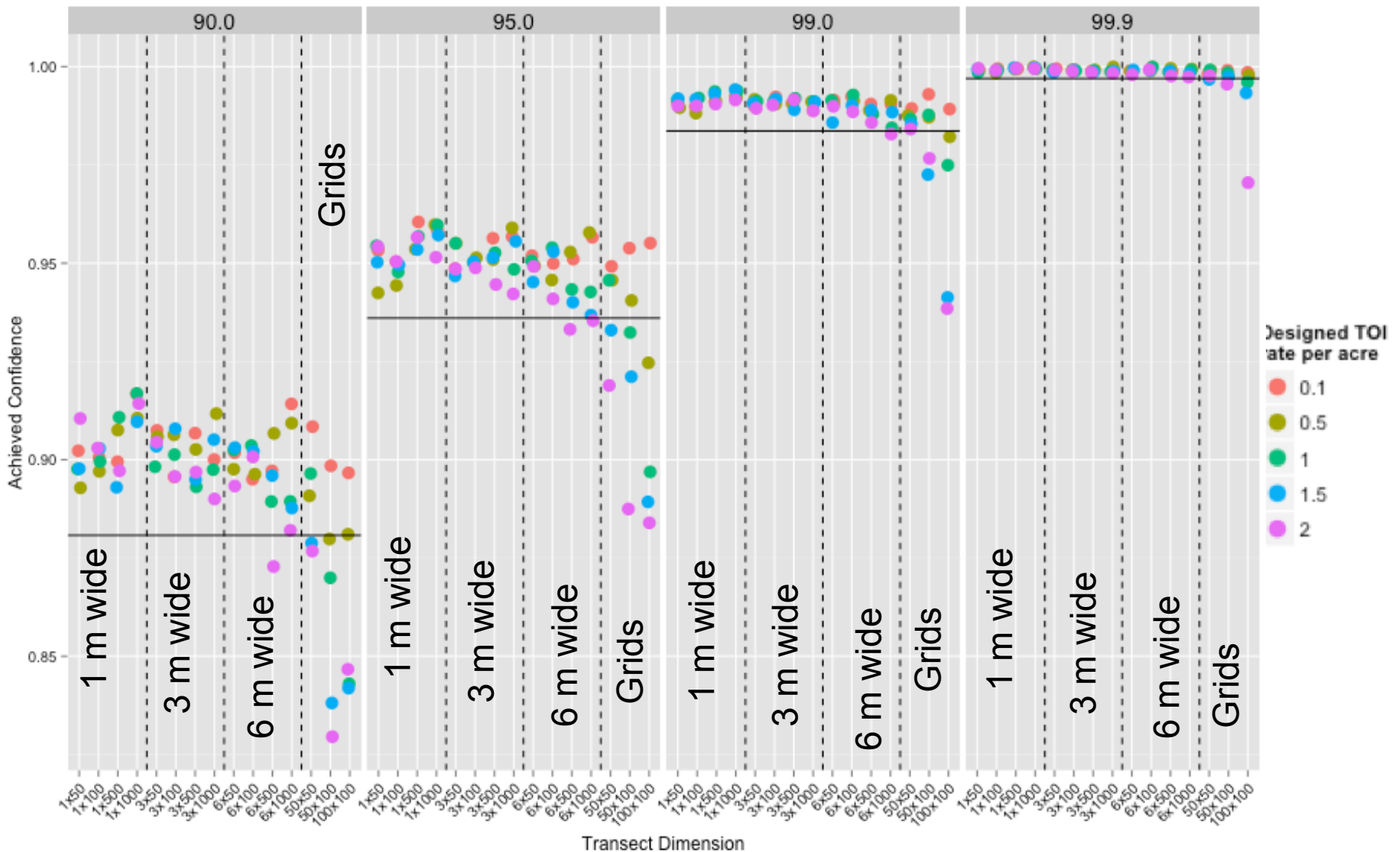
Confidence performance: TOI points can lie in no more than 12% of the sample area



Grids vs. Transects: >90%



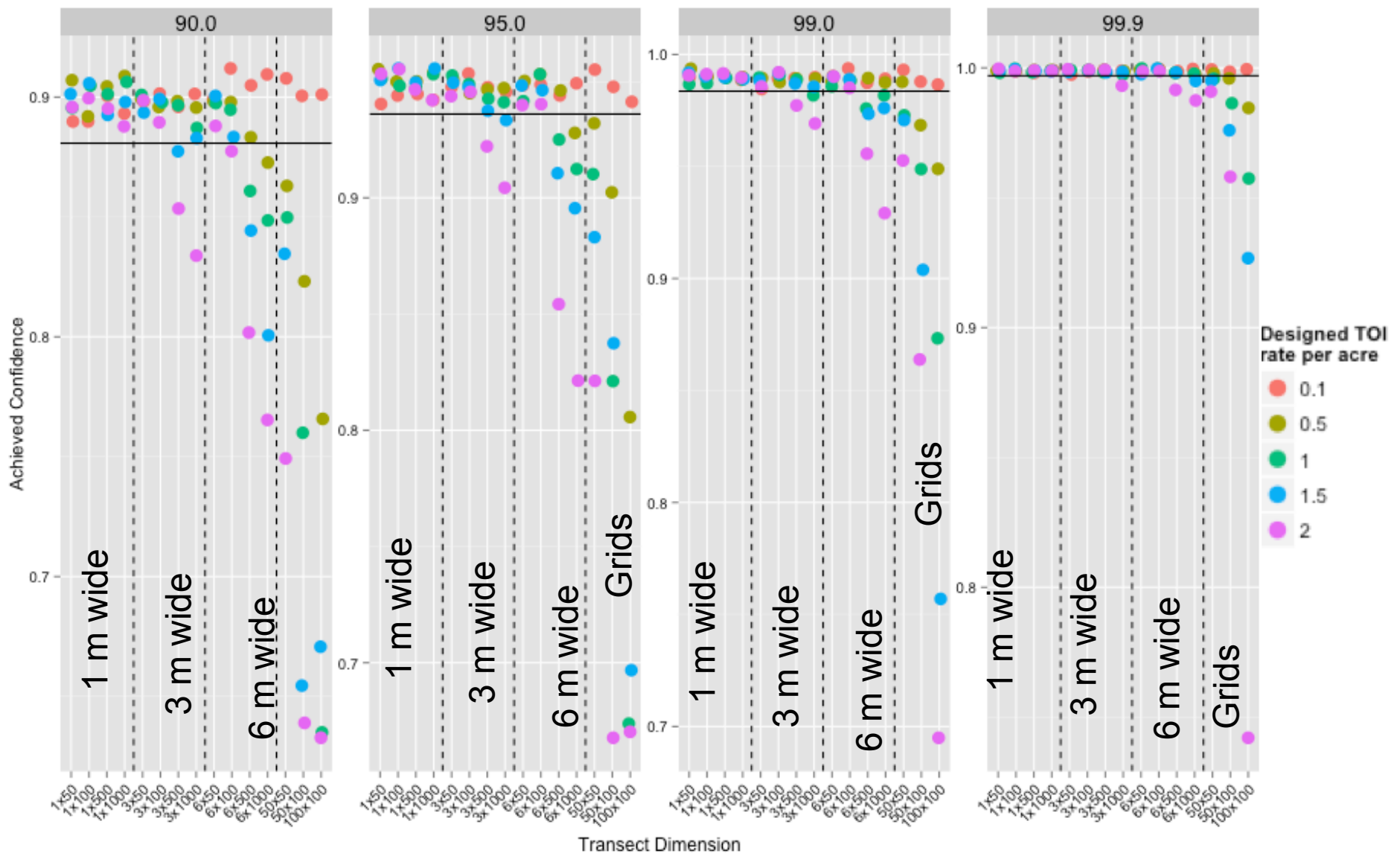
Confidence performance: TOI points can lie in greater than 90% of the sample area



Grids vs. Transects: 23% to 50%



Confidence performance: TOI points can lie in between 23% and 50% of the sample area



Grids vs. Transects Findings

- Any dimension of surface area sampling is going to have difficulties with tightly clustered TOI (<12%)
 - ◆ This is really the area where users should be using impact area discovery designs
- Standard long narrow transects are the most robust to TOI clustering (1 m to 3 m wide)
- Grid sampling is not robust to departures from uniformly distributed TOI (homogeneity)

VSP-UXO Training Courses

Last Course

- Apr 15-16, 2014 Huntsville

Upcoming

- Exploring multiple locations for FY14-15
 - ◆ Planning three for fall/winter
- Late Summer and two in the Winter months
- Contact J. Hathaway with interest to host course



Top 5 Things not to say when you are supposed to be the VSP-UXO expert



1. When asked why you are surveying X% of the site, you say, “I used the VSP”.
 - ◆ With over 15 UXO based designs and over 50 other designs saying you used “the VSP” is like saying you used “Windows” to do your analysis
2. I didn’t know that they offered training courses
3. It is impossible to know which design to use in VSP
 - ◆ With the UXO Guide and improved RI dialogue we hope that even the non-VSP expert can arrive at the correct design
4. VSP only has designs for target area discovery
5. You tell your boss, “We can’t get it the software is too expensive”
 - ◆ It is free at vsp.pnnl.gov