2 Standardizing Invasive Plant Assessment Methods for Field Inventory

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Abstract

The standard limitations of collecting field information are time and money. Both reduce the much needed collection of invasive plant species lists and location information on Florida's public lands. An added limitation is the diverse pattern of distribution exhibited by invasive plant species, and the frequency with which remotely sensed data fail to adequately and accurately portray understory and even overstory species. With a goal of developing a standardized assessment method that maximizes utilization of existing knowledge about invasive plant distribution and the affected habitats, while minimizing staff requirements, cooperating agencies are testing the practicality and limitations of time sensitive site survey methods.

Introduction

One of the daunting tasks facing resource managers is documenting the spatial distribution of any biological entity, including the distribution of alien invasive plants, and estimating the operational dollars that will be needed to manage those plants. There is an incredible range of sampling methods available, all attempting to provide useful information about the uneven distribution of biological entities of one kind or another. Along with differences in actual application are fundamental differences among the methods in the objectives being satisfied and the time and equipment requirements. This paper will review examples of several types of survey sampling methods and the procedure that leads to the current method being employed.

Among the simpler methods is "time-constraint sampling" (Campbell and Christman 1982). This method uses aerial photography, maps, interviews, personal information, and other available sources to define the most likely locations within the property to host the target plant or animal species. After sites are selected, trained personnel visit each site, collecting the required data (counts, habitat conditions, age, etc.) for a specific length of time (determined prior to site visit). The legitimacy of this non-random, non-objective approach has been discussed numerous times, and the necessity of concentrating available personnel and time on the most likely areas of infestation is recognized by agencies, researchers, and courts. For example, "To maximize the chances of locating breeding activity if it was present, we concentrated on aquatic sites that, in our subjective view, were 'good' amphibian breeding habitat" (Fisher and Shaffer 1996). Data collected, then, represent "a reasonable indication of the patterns . . . in prime habitat in a given region" (Fisher and Shaffer 1996).

Several groups of researchers are taking advantage of survey methods that have been established for use across the entire continent. These methods are far more complex, requiring considerable time and training, but have the advantage of widespread comparability with other research and operational programs using the same methods. An example of this is the variety of projects done as part of the national, multi-faceted Forest Health Monitoring Program (FHM), a nation-wide interagency survey of forest resources in the United States. FHM objectives include the monitoring and statistical estimation of status, changes, and trends in indicators of the ecological condition or health of the nation's forests, on a regional and national scale. One focus of the FHM is to investigate status and trends of biodiversity indicators, including exotic plant species. The FHM sampling design is patterned after the Environmental Monitoring and Assessment Program (EMAP) design (Stehman and Overton 1994; Stevens 1994). The nation is tessellated (Fig. 1) with hexagons, with grid points approximately 27 km apart, each covering approxi-

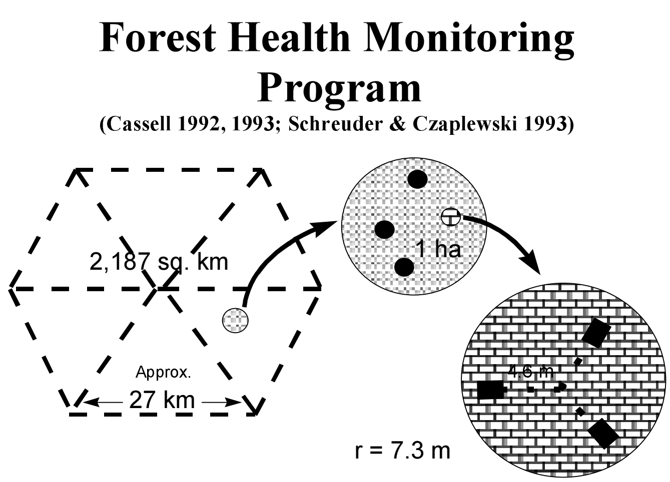

Figure 1. Sampling protocol for the Forest Health Monitoring Program.

mately 634.5 km^2. "Official" use of this method requires 12 hours of specific training and the passing of a rigorous certification test.

Data were recorded for four height classes (strata) of living vegetation. Disturbance was recorded if indicated by "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (White and Pickett 1985). Field protocols for determining disturbance types are detailed by Scott and Bechtold (1995) and Tallent-Halsell (1994). Types of "anthropogenic" disturbances include artificial regeneration, harvesting, cutting, thinning, prescribed burning, application of fertilizer or herbicide, grazing by domestic livestock, and construction. Types of "natural" disturbances include alterations by weather, disease, insects, and wildfire, as well as natural reversion to forest from unforested plots. Disturbance is an extremely important consideration for objectively located sampling procedures, since comparability of sites is only ensured if sites with understood disturbance patterns are analyzed.

After reviewing the sampling options available, prioritized goals were identified by state water management district representatives, to better enable selection of a testable sampling protocol to be used in the standardized assessment method (SAM). These goals were (1) to estimate invasive plant control costs quickly and without adding to the budget, (2) to identify species and distribution, (3) to assess the degree of control provided, and (4) to monitor trends over time. From this discussion, it was determined that no objectively located (random or random within plant community types), replicated sampling method would provide the information needed without significantly increasing budget requirements. Another factor was the acknowledged desire to avoid simply making species lists at various locations, recognizing that extremely limited use can be made of simple lists.

As a compromise between information needs, information wants, and financial realities, a non-bound (no time or space limitations or requirements) recording of invasive plant species within subjectively prioritized locations was selected as the starting point for field sampling. A data form was developed (Appendix) and the first of many assumptions was made. The form was revised after the Lake Jessup and Frog Pond workshops.

Materials and Methods

Initial assumptions included an average walking speed of 2 mph and an average scanning width of 20 ft. This allowed converting the number of any particular species recorded per minute into a number per acre. Group consensus resulted in a decision to conduct the SAM in British units of measurement (inches, feet, etc.). Definitions used in the SAM were as follows: seedlings and young plants (anything small enough that it would not be herbicided individually); scattered (present occasionally during the survey); uniformly present (visible during much of the survey).

The original data form (Appendix) included space to record location information to calculate the estimated density of invasive plant species and estimated cost for operational control programs, and additional information to provide a description of the plant community in which the invasive species were found, the reproductive status of those species, and the potential for spread into additional areas. The location and calculation data are obviously necessary; the additional information should not require more than a few minutes to collect at each site, and may assist in longer term assessment of invasive plant biology, ecology, and distribution.

This form provided sections to record general information about the date, site (location, county, map coordinates, access, working conditions, suitable habitat for expansion), observers (names), vegetation (native overstory dominants and understory dominants), community type (hardwood hammock, pine flatwoods, etc.), and invasive plant species (number of each species, height of tallest individual, reproductive status, and density). The final information was start and stop time for the SAM (total time taken is entered in the designated space).

Lake Jessup (Sanford) Field Workshop, 22-23 October 1997

The first workshop was conducted in a cooperative manner with vegetation management supervisors from four water management districts to better understand district needs, and to observe firsthand the practical problems with field implementation of the SAM. The data form was used by pairs of observers at St. Johns River Water Management District (SJRWMD) property at Lake Jessup. This property included two distinct types of invasive plant community. In the southern part of the property, *Schinus terebinthifolius* Raddi (Brazilian pepper) was scattered throughout a palm stand, with smaller amounts of *Sapium sebiferum* (L.) Roxb. (Chinese tallow). The tallow also occurred as isolated individuals in the adjacent grassland. The second type was a mesic hammock with Chinese tallow, Brazilian pepper, and *Cinnamomum camphora* (L.) J. Presl (camphor tree). Paired observers were directed to conduct their SAM within a defined area; results were compared to determine if independent assessments could provide anything approaching similar results. All-terrain vehicles were provided by SJRWMD to facilitate access to the observation areas and simulate actual field operations. Invasive plants species in the area were reviewed with the participants to ensure familiarity.

Several questions arose during this workshop:

- How are numbers of individuals per unit time translated into stems per acre and cost estimates?
- What counts as an individual in a multiple stemmed plant that branches at or below the ground surface?
- How are numbers of individuals for species that have stems too numer-

ous to count but no identifiable main trunk or sprouting region, such as many vines, recorded?

- Should information about soil/substrate type be included?
- Should information about disturbance at the site be included?

The first question was addressed in the Introduction. The goal of the second year of this study is to incorporate operational control data (time, personnel, and herbicide used) to refine the spreadsheet and provide better cost estimates.

The second question came up frequently during the year. The first attempt to address it was a decision to record any plant as a separate individual if operation control would require that. In other words, if that plant species would be cut near the ground and have herbicide applied to the stem, each stem would be counted as an individual. Next, it was determined that multi-stemmed species simply cost more to control, and the operational data on which spreadsheet calculations are based would already reflect that. Based on this assumption, a best-guess would be made of the actual numbers of individuals - the spreadsheet would account for the multiple stemmed nature of that species. For the last workshop (May 1998), the data form was revised to allow entry of individuals by stem diameter. As long as treatment remains the same, e.g., herbicide applied to cut stems and the cutting of small individual stems takes approximately the same time as cutting one large stem, it makes little difference whether a multi-stemmed plant is recorded as ten 1 inch stems or as one 3 inch trunk. The important difference is if the size of the single trunk gets large enough to require a different technique, e.g., a chainsaw is used for cutting, and that different technique requires measurable differences in time or herbicide. This is the type of refinement that will be sought during the second year of this study.

The third question has not been thoroughly tested in the field. Some discussion has been held about the merits of using area (size of clumps) instead of counting individuals for vines, such as *Paederia foetida* L. (skunkvine), and grasses, such as *Imperata cylindrica* (L.) P. Beauv. (cogon grass). The diameter counts used in the last workshop could be used to estimate area covered in specific area categories that would be defined just before the start of the assessment. For example, in areas where very small patches of cogon grass occur, the spaces (in the data form) could represent 0-1 sq ft, 1-3 sq ft, 3-6 sq ft, etc. If patches were larger, the base could be 100 sq ft (0-100 sq ft, 100-300 sq ft, 300-600 sq ft, etc.), or 0.1 ac (0-0.1 ac, 0.1-0.3 ac, 0.3-0.6 ac, etc), or even 1 ac (0-1 ac, 1-3 ac, 3-6 ac, etc). Any suitable base could be used, as long as the observers were certain of the meaning of each category, and were comfortable making estimates at that scale. Regardless of the scale, the number of clumps would be recorded by the appropriate category and the data entry question in the spreadsheet would convert to acres covered. This will be investigated during the second year of the study.

The last two questions resulted in revisions to the orginal data form prior to the second field workshop (January 1998). GPS longitude and latitude was changed to Universal Transverse Mercators (UTMs). UTMs are marked with blue ticks along all sides of U.S. Geological Survey topographic maps; each tick represents 1000 meters and connecting the ticks provides a square kilometer grid system for the map. This system is much easier to use than longitude and latitude, which must be converted from degrees and minutes into a commonly used measurement system. Several plant community types were added to the General Habitat option. More information was allowed by providing categories (scattered, common, too numerous to count) to the seedling and young plant sections. Space was provided to allow recording of invasive plants in the area that had been previously treated, listing of dead species present, and noting degree of disturbance, source of infestation, and substrate/soil type.

Frog Pond (Homestead) Field Workshop, 21 January 1998

The Frog Pond, situated just east of Everglades National Park, is owned by the South Florida Water Management District (SFWMD). The area combines floral diversity (both native and alien plant species) and difficult working conditions, including extremely dense vegetation, snakes, and uneven, unforgiving terrain. It is about 3 sq mi in area, with about 70% in abandoned agricultural fields; roads are found throughout. There are three rockland hammocks in the north end, with easy access to the edges, but pinnacle rock is found throughout. SFWMD has been spot treating invasive alien species; however, there are young Brazilian pepper plants appearing in the abandoned fields.

Three teams of paired observers were brought to the same entry point in each hammock. Teams were rotated from one hammock to the other and could not observe where other teams had assessed. Alien invasive species were reviewed with the participants to ensure familiarity with the target species.

Suggestions received during and after this workshop included the use of Global Positional System (GPS) technology to provide an accurate recording of specific sites, a general line map of the area covered, and a better means of estimating the distance traveled during the assessment. This would provide better data to calculate number of stems per acre.

Three additional questions arose during this workshop:

- What constitutes an individual grass plant?
- Will the walking speed of the observer and the total length of the observation vary considerably based on difficulty of vegetation and terrain?
- Should the observer estimate the width actually observed?

The first question is still being addressed, as reviewed above. The second question will be an issue unless the GPS units can provide better information about distance covered during the observation. The third question resulted in the addition of a "Visual Width" section to the data sheet.

Several changes to the data form were made prior to the last field workshop. Total length was added (to be generated by hand-held GPS units), visual width was estimated to allow the observer to indicate what they felt was the average for that assessment, and space was provided to allow counting invasive plant individuals by diameter classes (in inches).

Pumpkin Hill (Jacksonville) Field Workshop, 20-21 May 1998

Continuing questions about stem size and operational control costs led to data form revisions that allow recording stem or trunk diameter for each species (see Appendix).

On the first day of the workshop, two-person teams toured approximately 2000 ac within the Pumpkin Hill land holding, identifying (using GPS) specific sites where SAM observations should be made. Access was relatively easy through the property, although vehicles were restricted to roadways because of dense understory. On the second day, two-person teams conducted assessments at four of the sites identified.

Results and Discussion

Lake Jessup Field Workshop

Data sheets from four two-person teams were compared to assess the variation in information recorded (Table 1). Descriptive statistics for those data sheets show that one value for each invasive plant species (Team 1- *Cinnamomum camphora*, 7.5; Team 4- *Schinus terebinthifolius*, 2.5; Team 1- *Sapium sebiferum*, 6.0) is outside the 95% confidence interval for the sample data. The confidence interval statistic shows the range within which the population mean (the "true" mean) lies with a confidence of 95%. The large ratio of highest to lowest value (25, 5.2, and 20 for *Cinnamomum*, *Schinus*, and *Sapium*, respectively) indicates that estimates for control cost on this particular property could have varied as much as 25 times depending on which pair was sent to survey the property.

After considerable discussion, a goal was established of a maximum of a four times ratio (highest to lowest value) for multiple independent assessments in the same general area. The remaining field workshops, and subsequent training for operational implementation, will be designed to obtain this goal, if possible.

Frog Pond Field Workshop

Table 1. Number of plants per acre for three invasive species at Lake Jessup, by SAM survey team. "Ratio" is the highest team values divided by the lowest team value for each species.

	Species		
	Cinnamomum camphora	*Schinus terebinthifolius*	*Sapium sebiferum*
Team 1	7.5	11.0	6.0
Team 2	1.3	9.0	1.3
Team 3	0.3	13.0	0.3
Team 4	2.5	2.5	0.5
Upper	6.0	13.3	4.7
Mean	2.9	8.8	2.0
Lower	-0.2	4.4	-0.6
Ratio (h/l)	25.0	5.2	20.0
Mean ratio	16.7		

Surprisingly, overall mean ratio for this property was 8.4, about half of the ratio for Lake Jessup (Table 2). With the high species diversity, awkward walking conditions (pinnacle rock is extremely uneven), and dense plant growth, it was expected that the differences among teams would actually be greater that in the previous workshop, even with the added training provided. One hammock (Dense Hammock) was so thick with vegetation that some team members were forced to crawl on their hands and knees to negotiate the site. The lower ratio is, in part, an artifact of the working conditions. Because walking space was so limited, teams were almost forced to follow the same general walking path. This site had the only variability (ratio=17.6) that was much greater than the desired maximum ratio of 4.

Pumpkin Hill Field Workshop

This was the first workshop in which participants were asked to identify specific locations where SAM surveys should be completed and then conduct the survey. Location identification was conducted by four two-person teams during a three hour period. All four teams identified the same locations for SAM surveys to be

Table 2. Number of *Schinus terebinthifolius* plants per acre at three hammock sites in the Frog Pond, by SAM survey team. "Ratio" is the highest team value divided by the lowest team value for each site.

	Hammock site		
	Jungle	Dense	Bear
Team 1	8.8	0.9	7.1
Team 2	9.4	18.5	13.1
Team 3	19.5	10.4	2.8
Upper	19.5	17.1	13.8
Mean	11.5	8.8	7.7
Lower	4.2	0.6	1.8
Ratio (h/l)	3.0	17.6	4.8
Mean ratio	8.4		

conducted, but this result was undoubtedly influenced by the very obvious distribution of invasive plant species within this property. The observers were told that the site had been used for dumping in years past; the dumping was apparently confined to specific dump sites and few invasive plants were found away from the dump sites. Since direct human influence introduced the invasive plant species present, it follows that the sites would be adjacent to roadways and thus easy to locate.

One of the objectives of this field workshop was to incorporate hand-held GPS units into the survey process by using the information from the GPS screen to mark the location of "areas to be surveyed," and to measure the overall distance traveled by each pair of observers. The "old" method assumed a traveling speed of 2 mph and a visual width of 20 ft. The "new" method used the GPS total distance value and teams estimated the "visual width" covered during the survey. The data were analyzed using both methods. The very low ratio for the old method (mean=8.1, standard deviation=16.2) compared with the new method (mean=20.9, standard deviation=34.8) demonstrates some obvious problems.

It was determined during the workshop that the GPS units were not accurately totaling the distance covered during the survey. Because of this, most teams simply added a few tenths of a kilometer to the 0.1 km recorded by the GPS unit as the total distance traveled for most surveys. One team had no access to a GPS unit and made total distance estimates that were considerably longer than the other teams' estimates. In addition, the "visual width" estimates varied a great deal, from 40 to 200 ft. This survey method is sensitive to "area covered" estimates, and specific attention will be paid to improving these numbers. We will attempt to solve the GPS total distance problem, or test the use of "distance traveled" meters. To simplify the "visual width," we will consider restricting all surveys to a set width, dependent on the terrain, vegetation density, and information sought.

Other problems that arose during this workshop included the reporting measurements, such as "<0.1 km", which does not provide a specific number for data entry. This will be addressed during future training sessions.

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Appendix. Sample data sheet for the 1998 SAM Field Workshop, Pumpkin Hill, Florida, 20-21 May 1998.

Record __0001 Date:	Location:		Number by diameter class (inches)					Reproduction (F=flowers; S=seeds; E=Seedlings; Y=young plants) E1/Y1 = scattered E2/Y2 = common E3/Y3 = too numerous to count	Density (W=widely scattered, S=scattered; U=uniformly present; D=dense	Working Conditions for Control (E=easy; M=moderate D=difficult; I=nearly impossible)	Suitable habitat for expansion (S=some; M=moderate; E=extensive)
	General Habitat	Non-native Species	0-1	1-3	3-6	6-12	>12				
Observers:	Scrub Forest	1.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Hammock Forest	2.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Bay Tree Forest	3.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Inland Swamp	4.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Cypress Forest	5.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Cypress Heads	6.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Pine Flatwoods Forest	7.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	High Pine Forest	8.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
County:	Mangrove Swamp	9.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Salt-water Marsh	10.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
UTM North/South:	Fresh-water Marsh	11.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Wet Prairie	12.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
UTM East/West:	Saw-grass March	13.						F S E1 E2 E3 Y1 Y2 Y3	W S U D	E M D I	S M E
	Slough, Pond, Lake	Dominant Native Tree Species:	Area previously treated? Y N Dead plants present of ______________ (species). Degree of disturbance: ______________.								
Access:	Tree-island	1.	Source of infestation: ______________.								
	Ag. Land/Pasture	2.	Substrate/soil type: ______________.								
		3.	Notes:								
		Dominant Native Understory Species:									
		1.									
Start Time:		2.									
		3.									
Stop Time:		4.									
		5.									
Total Time:	Total Length:	Visual Width (complete width edge to edge, not from center line to one edge):									