Inventorying and Mapping Invasive Plants

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Index terms: invasive species, non-native species, weeds, weed management, weed mapping

Invasive plants can have many adverse impacts on natural areas (e.g., Randall 1995, 1996). Therefore, it is imperative that invasive plants be controlled if they pose significant threats to the conservation values of a particular area. However, it is also important to adopt a strategic approach to plant management so that scarce resources are spent effectively (Macdonald 1990). A key element of a strategic plant management approach is inventorying and mapping occurrences of invasive plants.

The purpose of an inventory is to locate, document, and map the occurrences of invasive plants. For many natural areas, there are often more invasive species present than can be inventoried with available resources. In such cases, inventories should be focused on those invasive plant species that pose the most significant threats to the conservation values or other high-value resources of the natural area and that are known or are likely to occur there (Hiebert and Klick 1988, Hiebert 1997; A. T. Carpenter and T. A. Murray, unpubl. data). The Virginia Department of Natural Resources has also devised a useful set of guidelines (see *www.dcr.state.va.us/dnh/rankinv.pdf*). We suggest focusing the inventory on three to six target species and mapping all of their occurrences during the inventory. Occurrences of a larger group (3–10) of less disruptive, yet still worrisome, invasive species can also be mapped if they are encountered while searching for target species. Certain ubiquitous but less threatening weed species may not be inventoried at all; however, we recommend noting their presence during the field inventory for future reference. Local weed managers will probably be able to recommend particular invasive plant species as the target of the inventory. An invasive plant inventory is a key part of establishing priorities for managing invasive species and detecting incipient invasions, and should be repeated periodically (ca. every five years) on affected natural areas. Organized inventory and mapping procedures have recently been developed for weeds and are being continually refined (Cooksey and Sheley 1998, Carpenter et al. 2000, Anonymous 2001).

The products of an inventory are a set of maps and a companion database that show the locations, sizes of invasive plant occurrences, the invasive plant species present and their abundance(s). Other relevant data about the occurrences may also be included.

We offer suggestions for inventorying and mapping invasive plant species occurrences in natural areas. Prepare for fieldwork by learning to sight-identify the target invasive plant species, as well as other species that will be mapped if encountered. Field guides, drawings, photographs, and dried specimens, especially those laminated in plastic that can be carried in the field, are very useful. A plant press can be used to preserve unknown invasive plants for later identification. A very serviceable, low-cost press can be made from two sheets of extra thick cardboard, a tabloid newspaper, and two meters of rope. Review the biology and ecology of the target species to learn when they will be most readily identifiable so the date of the inventory can be set accordingly. It may be necessary to compromise on the inventory date when only some of the target invasive plant species may be conspicuous. Multiple inventories may be needed for species that are difficult to locate when not in flower and when the flowering periods of the target invasive plant species do not overlap.

Small natural areas (tens of hectares) can be searched thoroughly for invasive plants, but this is not possible for most larger areas. We recommend searching for the target invasive species in (a) disturbed areas, (b) other habitats where the target invasive plant species typically grow (e.g., wetlands), and (c) high-value resource areas. Disturbed areas include roadsides, trails, building sites, parking areas, livestock handling facilities, and riparian areas. Some invasive species have relatively high fidelity to certain habitats such as riparian areas or wetlands. Ideally, high-value resource areas would already be defined and mapped prior to the inventory. Small, disturbed areas such as parking lots, trail heads, and picnic areas can be inventoried very thoroughly. Smaller linear areas such as stream corridors and irrigation ditches can also be searched thoroughly by walking along them. Within larger areas of suitable habitat, we recommend using a structured search approach to the inventory, such as line transects where observers walk along parallel transect lines. The distance between transect lines depends on one's ability to detect the most obscure target species. ATVs can be extremely useful in searching large expanses of relatively gentle, open terrain and can greatly reduce searching time without significantly damaging the land.

Prior to beginning an invasive plant inventory, decide what patch size of invasive plants will be used as the minimum mapping unit. Patch size may vary for different invasive plant species, and mapping units may have to be revised as the inventory proceeds. We strongly advise recording the locations of very small occurrences (e.g., 1 m^2) of the most troublesome invasive plants if they are isolated from other occurrences of the same species. Small, isolated occurrences of the worst invasive plants will be high priorities for control. In addition, the minimum distance between adjacent invasive plant occurrences (within which invasive plants would be considered to be in the same occurrence) should be determined. We suggest combining occurrences closer than ca. 30 m to avoid mapping a very large number of small but

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nearly contiguous occurrences.

We strongly advise recording the locations of invasive plant occurrences with a global positioning system (GPS) unit. Thanks to the de-scrambling of GPS satellite signals by the US Department of Defense in May 2000, inexpensive GPS units (ca. $130) are now accurate to about ± 5 m, sufficient for most inventory purposes. A cutoff size below which invasive plant occurrences are recorded as points and above which they are recorded as polygons must be determined. You may also decide to record invasive plant occurrences along linear features as lines. Record the center of each small occurrence (< 0.5–2 ha [1–5 acres]) that is recorded as a point, and record several points around the perimeter of larger occurrences that will be mapped as polygons. Avoid recording excess points on the perimeters of polygons. For control and monitoring purposes, occurrences of mapped invasive plants can be easily relocated in the field using a GPS unit and an invasive plant occurrence map.

Polygons can also be recorded directly on orthophotos. These are aerial photographs that have been rectified to remove distortions that arise from the fact that the surface of the earth is curved and not flat. Certain features such as floodplains, vehicle ways, trails, fence lines, pastures, and parking areas that often harbor occurrences of invasive plants are often readily visible on orthophotos. Hand-drawn polygons can be digitized and imported directly into a geographical information system (GIS) for mapping along with point data from a GPS unit.

Invasive plant occurrence and GPS data can be recorded on a hand-held computer equipped with data management software. We have had excellent results using FieldWorker/Pro (FieldWorker Products, Ltd, Toronto, Ontario, Canada), a very flexible proprietary software program that can be connected with a GPS unit. The software allows one to create custom datasheets and enter invasive plant attribute data directly in the handheld computer. The invasive plant attribute files can be easily converted into spreadsheets or even uploaded directly into a GIS. This system eliminates tedious data entry and office work, but the initial expense of purchasing equipment is significantly higher than using paper data sheets. FieldWorker software costs about $500; handheld computers cost between $500–$1000 each (Fieldworker products can be ordered from *www.fieldworker.com*). We caution that a period of learning / debugging may be needed on first use of this software. This may be particularly true for persons who are inexperienced with computers.

We recommend estimating the abundance of the target invasive plant species at each occurrence. Invasive plant abundance can be used later to help establish priorities for management. For herbaceous plants, we have found that a single ocular estimate of the average canopy cover for the entire occurrence is sufficient to characterize abundance. This value can be multiplied by the size of the occurrence to obtain an estimate of the land area within the occurrence that is actually covered by the target invasive plant species. We acknowledge that cover estimates are notoriously subject to observer bias and often have low precision (Elzinga et al. 1998). However, a rough estimate of invasive plant abundance is generally all that is needed to help prioritize invasive plant occurrences for management. If precise estimates are needed for subsequent monitoring, it may be more appropriate to record multiple cover estimates and calculate an average value or use another measure of abundance (e.g., invasive plant density or frequency or standing crop).

We recommend computer mapping of invasive plant occurrences. The locations of invasive plant occurrences can be recorded on inexpensive, commercially available digital topographic maps if GIS access is lacking. DeLorme (Yarmouth, Maine: *www.delorme.com*) makes seamless digital topographic maps of entire states for between $100-$200. The software for these maps allows one to download waypoint data stored on a GPS receiver and display it over the digital topographic map. Unfortunately, the software doesn't allow one to symbolize and color the waypoints to facilitate distinguishing different invasive plant species. Instead, one must export the map as a JPEG or Bitmap image and reopen it in a drawing program (e.g., Microsoft Paint or Paint Shop Pro) in order to draw the appropriate symbols for each waypoint. As can be seen, this method is inexpensive on the equipment side but labor intensive and is not recommended for those with access to GIS resources.

If you have access to a GIS, either upload the invasive plant occurrence data from a hand-held computer into a personal computer or enter invasive plant occurrence data from paper field forms in a spreadsheet. Data from the spreadsheet can be imported to a GIS and high-quality maps can be easily produced. Maps can be revised or updated as new data become available and are excellent marketing tools for conveying the extent and severity of invasive plant occurrences to key decision-makers. We strongly urge creation of a metadata file to document important information about the invasive plant mapping process.

Acknowledgments

We thank the *Natural Areas Journal* editorial board for constructive suggestions that improved the manuscript.

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