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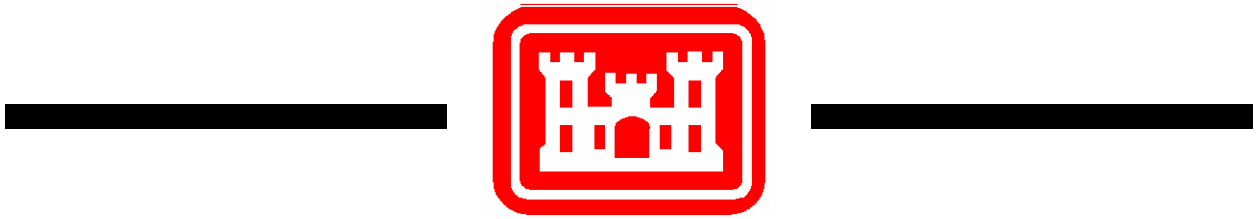
GENERAL MAPPING GUIDELINES FOR TERRESTRIAL INVASIVE PLANT SPECIES



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Facilities Engineering
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GENERAL MAPPING GUIDELINES FOR TERRESTRIAL INVASIVE PLANT SPECIES

1. Purpose.

a. This Public Works Technical Bulletin (PWTB) provides an overview of mapping strategies for the mapping and monitoring of invasive plant species on Army installations.

b. All PWTBs are available electronically (in Adobe® Acrobat® portable document format [PDF]) through the World Wide Web (WWW) at the National Institute of Building Sciences' Whole Building Design Guide web page, which is accessible through URL:

http://www.wbdg.org/ccb/

2. Applicability. This PWTB applies to all U.S. Army facilities engineering activities within the United States.

3. References.

a. Army Regulation (AR) 200-1: Environmental Protection and Enhancement. 21 February 1997.

b. AR 350-4: Integrated Training Area Management. 8 May 1998.

c. Clean Water Act of 1977 (Public Law 95-217, 33 U.S. Code 1251).

d. Executive Order (EO) 13112: Invasive Species. 3 February 1999.

4. Discussion.

a. The Clean Water Act established standards for water quality in the United States and limits contaminant discharges, including those on and around military lands. To comply with this and other regulations, Army Regulation 200-1 states that the Army will plan and conduct peacetime mission activities to minimize adverse impacts on the environment. Further, Army Regulation 350-4 provides for the repair and rehabilitation of training lands, including protection of natural resources, compliance with statutory regulations, and prevention of future pollution and a reduction of hazardous waste and toxic releases. To prevent introductions and spread of invasive species, EO 13112 requires federal agencies to provide for restoration of native species. Given all these regulatory requirements regarding environmental stewardship on military lands, balancing competing regulatory requirements can prove difficult.

b. This PWTB provides an overview of mapping invasive plants for the purpose of developing control strategies on Army training lands. Military training and testing create unique problems for sustainable land management. These activities often create disturbances that affect the functioning and sustainability of the training landscape. Vehicle traffic, munitions impacts, and similar occurrences that disturb soils and plant life can facilitate the establishment and spread of invasive plant species. Invasive plant species are of concern to the military land manager because of negative impacts on soil stability, water quality, and threatened and endangered species habitat. In order to effectively manage the occurrence and spread of invasives, land managers need a practical system to survey and map the distribution and occurrence of populations of invasive species.

c. Appendix A contains background on the purpose for mapping invasive plant species on Army installations.

d. Appendix B addresses methods and approaches to ground based mapping/survey.

e. Appendix C contains an overview of remote sensing and its applicability to mapping/monitoring.

f. Appendix D provides population measurements.

g. Appendix E contains suggestions for invasive plant species sources.

h. Appendix F is a sample windshield survey sighting report.

i. Appendixes G and H contain a bibliography and a list of Internet resources, respectively.

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Appendix A. Background

Introduction

Military training and testing create unique problems for sustainable land management. These activities often create disturbances that affect the ecosystem processes and sustainability of the training landscape. Vehicle traffic, munitions impacts, wildfire, and similar occurrences that disturb soils and plant life can facilitate the spread of invasive plant species. Invasive species are of concern to the military land manager because of negative impacts on soil stability, water quality, and threatened and endangered species habitat. In order to effectively manage the occurrence and spread of invasives, land managers need a practical system to survey and map the distribution and occurrence of populations of invasive species.

Invasive plant mapping protocol can vary greatly based on the intent and scale of the effort. Methods and resources for the inventory and survey of species spread across large geographic regions or across political boundaries will differ from those needed to map weed infestations in localized areas for the purposes of applied land management. This bulletin provides an overview to serve as a guide for the latter; mapping of terrestrial invasive plant species for control and management. Methods discussed are suitable for the wide array of vegetation types and ecological factors that are present on Army installations. Additionally, the methods described are “biased” because of a focus on landscapes receiving anthropogenic disturbances or other factors that will increase the probability of the occurrence of an invader. For general landscape survey of plants that may occur in limited or benign circumstances, unbiased methodologies are needed.

Purpose of Invasive Weed Mapping

Military lands natural resource managers require comprehensive and objective data on plant distribution and spread to establish priorities and measure outcomes of a weed management program. The existence of large well-established populations may not be a suitable management priority compared to new, localized populations. In addition species that could negatively affect

either Soldier health or training land suitability may be more important to focus on compared with species that have little impact on training. Through the process of mapping, installation land managers are able to develop a systematic record of their invasive weed populations. These data can then be used to develop and prioritize management actions.

Systematic records of plant infestations can help support understanding of:

1. What invasive plant occurs, where and when,

2. Changes in area and density over time; and

3. The effect of land management practices and plant management programs.

Appendix B. Methodology

Mapping Methods

Methods for mapping plant populations can generally be divided into two categories: ground based and remote sensing. Ground-based approaches require a high degree of in-person observations of invasive species populations to collect accurate data on population parameters (i.e., species composition, population density, patchiness, and accurate boundaries). These types of data are critical for successful control and management strategies. Remote sensing methods are often well-suited for regional awareness and higher level policy making, but often lack the ability to provide the information needed for practical land management. For these reasons, this document concentrates on describing ground-based approaches, as they are of the most use in providing accurate management-related data for the land manager. Remote sensing technology is discussed to aid in the decision-making process for planning purposes.

Ground-based Approaches

Ground-based mapping/survey approaches can be broken into two types. The first type is the sighting or ocular survey approach, which is often referred to as a “windshield survey.” Plant populations are documented as they are found on the installation. In order to accomplish this survey, the surveyor must be familiar with possible species that may exist in the geographic area. A standard record keeping and reporting system is also necessary. The second approach is a systematic survey, which is an effort to thoroughly survey the entire landscape for a plant population. This approach requires extensive planning and resources.

Windshield surveys

This type of survey may be a primary activity (i.e., a dedicated tasking) or a secondary activity conducted during the course of routine field work, driving through a training area, or any other occasion when a previously undocumented plant colony is observed. The objectives for a windshield survey should be limited in scope. Primarily the method serves as a reconnaissance for documenting previously undetected or new populations because most new infestations occur in areas of anthropogenic disturbance. Data through a windshield survey can

be used to develop the more detailed sampling approaches required for a systematic survey.

The method for this approach is straightforward. When natural resources staff members are in training areas, they document new populations of plants encountered. Data gathered during the "windshield" survey are usually limited to easily obtainable parameters including species name, ocular estimates of area and density, and location. These data are recorded on a sighting report (Appendix F) and the locations identified using a global positioning system. Sighting reports should be entered in a central database as soon as surveyors return to the office.

Systematic surveys

The systematic survey is a dedicated effort to characterize invasive plant populations within the area of interest. The area of interest is defined as all or part of an installation (i.e., training areas, cantonment, or recreation areas). The survey technique is designed to sample evenly across the particular area of interest.

The approach for designing the survey depends on the size of the survey area and the level of detail to be collected (i.e., types of field measurements). The first step is to conduct a preliminary search to identify locations of invasive plants. Small areas can be sampled randomly or by using systematic transects. Larger areas can be broken down into strata (e.g., sub-areas) to facilitate manageability. These strata can be defined along land management boundaries such as training areas and major roads or defined by natural features such as streams or ridgetops. Strata can also be defined along vegetation/cover types; land areas with similar vegetative composition such as forest versus grassland. Additionally, if known plant species with specific soil, moisture, or similar types of requirements are expected to be encountered, strata based on these requirements can be used. For instance if an invasive species requires relatively deep high moisture soils, the search should focus on streambanks, riparian areas, and sheltered low lying areas.

Once the area that is to be surveyed is selected and strata defined, a sampling strategy is chosen. Both random and systematic sampling strategies rely on statistical probabilities for determining optimal sample sizes based on population variances. For practical purposes, however, these procedures can be worked around and an accurate survey produced.

Army training land special consideration for invasive plants

Searching for and planning invasive plant mapping exercises can be time and resource intensive. A major factor in this process can be attributed to the large geographic area that many Army installations encompass. The simplest way to optimize efforts is to target areas that have a high probability of plant establishment and spread based upon disturbance. Invasive plants, by their nature, establish in disturbed areas on Army lands and very often a majority of disturbance is anthropogenic. Areas of installations that receive frequent/high disturbance or similar conditions that facilitate invasive plants include:

1. Bivouac sites

2. Staging areas

3. Wash rack facilities

4. Tank trails

5. Road sides

6. Access points used by tactical vehicles to enter and exit training areas/installation maneuver training areas (especially those areas that are highly degraded or have soils/vegetation that are easily displaced by tactical vehicles).

Periodic update of weed maps

As with any aspect of a training landscape, invasive plant populations are spatially and temporally dynamic. To account for these changes and remain an effective strategy, mapping efforts should be repetitive in nature. Windshield surveys are ongoing activities that will provide new information on infestations over time. Systematic surveys are often extensive efforts that require planning and dedicated resources. Known populations should be monitored, with new mapping data collected after management practices are executed, new or heavy land disturbing military exercises are conducted, or after a suitable length of time (number of growing seasons). The intent is to be able to have data to judge the effects of management, human disturbance and/or natural spread of the species. Circumstances, funding, and resource availability will vary across installations, and species life history will influence the interval of time between mapping exercises from 2 to 20 years.

Appendix C. Remote Sensing

Remote sensing offers a potential tool to characterize and monitor some invasive plant species. Remote sensing can provide frequent and timely surveys with complete spatial sampling when calibrated and validated with ground observations. The success of remote sensing methods to identify individuals or patches of invasive species assumes they can be identified in the context of the plant community and soil in which they are embedded. In general, remote sensing is more suitable to landscape level surveys and detection rather than monitoring and control of localized infestations. However, the following discussion is included to give the reader a general overview of the potential capabilities of remote sensing applicability.

Remote observations of leaf spectra are dominated by four variables: chlorophyll, water, dry matter, and a structure parameter related to leaf thickness. Remote image classification or segmentation relies on spectral attributes of subjects that are observed, as determined by their biophysical properties, in order to identify and categorize similar and dissimilar subjects. All plants, including invasive plants, share a common biochemistry (photosynthetic pigments, water, cellulose, etc.). Invasive plant species must exhibit a spectral response that is sufficiently different from surrounding plants and background soil in order to be discernible from its surroundings.

Traditional multispectral imagery often cannot distinguish between the spectral ambiguity of a plant species of interest and its surroundings. Insufficient variation in spectral response will not allow for automated segmentation of digital imagery. Hyperspectral image analysis provides a potential solution to spectral ambiguity, as higher spectral resolution imagery allows for differentiation of species based on specific physical and chemical characteristics that otherwise would not be detectable.

The scale and distribution at which many invasive plant species are found in the landscape may not be comparable to the scale of observation of remote imagery. If the invasive plant or patch occurs at a smaller scale than the scale of observation (i.e., a single pixel), the spectral signature of that pixel is a mixture of spectral characteristics from all components or objects that

exist within that pixel, including surrounding vegetation and bare ground. Such occurrences are referred to as mixed pixels, which are also problematic when utilizing standard, automated image processing routines for identification of individual species. This inability to detect small patches or populations of an invasive plant species is important when deciding whether to use remote sensing to map invasive species.

An additional challenge associated with remotely sensed characterization of invasive plant species (particularly for military installations in the Southeastern United States) is that they may occur under forest canopy and are not observable with optical remote sensing systems that cannot penetrate the canopy. Observations are possible through gaps in the canopy, but spectral ambiguity between canopy vegetation and invasive shrubs and forbs is still problematic. Due to spectral ambiguity, observation-scale issues resulting in mixed spectra, and masking from canopy material, routine identification using remote sensing of many invasive plant species on military installations has been elusive. The number of example case studies where remote-sensed imagery has been used to characterize the spatial location and distribution of invasive plant species has increased in recent years and remote sensing and image analysis does provide some opportunity to supplement field survey methods for invasive plants species characterization, particularly in western ecoregions where forest canopy cover is minimal.

Appendix D. Population Measurements

Collection methods

Once invasive plant populations are located; collecting population parameters on colonies/populations is a useful way to determine the potential impact of management practices and population trends. Methods for doing this can be divided into two levels: general descriptive and quantitative.

General descriptive parameters include species name, location, and population area. Locations and boundaries can be either directly identified on paper maps or collected with the aid of a global positioning system (GPS). Use of a GPS is optimal as it allows the easiest, reduced-error method for transferring data to a Geographic Information System (GIS) for further analysis.

Quantitative measurements quantify relevant population parameters. The most well known method for collecting these data is through the use of a "quadrat" or square sampling frame. The dimensions of this frame are generally between 0.1 and 1 meter-square. The quadrat is used to establish plots within the invasive plant population from which measurements are taken. The number of plots depends on the size (area) of the population and the size of the quadrat. Sample size (number of plots per population area) can be computed based on population variance; however, as a rule of thumb, a 2 to 10 percent sample is adequate.

Useful quantitative measurements

Frequency: The relative number of quadrats that contain the invasive plant. Presence is recorded as presence/absence. The number of quadrats containing the plant is divided by the total number of quadrats, then divided by 100. The result is expressed as a percentage.

Density: Density is the number of plants per unit area or the average number of plants per total quadrats. This measurement is time consuming in areas with large numbers of invasive plants, but smaller quadrat size can mitigate this problem.

Cover: Cover is the area of the quadrat occupied by above ground plant parts across a projected two dimensional plain.

Cover is usually expressed as a “cover class” or range of values bounding the cover (e.g., 0%, 10%, and 25%). Several methods have been developed to measure cover, including point sampling and line intercept sampling. Especially when used with a cover class system, an ocular estimate of cover is generally sufficient (and most time efficient) for mapping purposes.

Appendix E. Invasive Plant Lists/Information

Whether using windshield surveys or quantitative mapping, accurate listings of invasive plant species for the installations locality are needed for optimal results. Sources for this information will vary depending on the installation, state, and region. Floral inventories and herbarium data from installation Range and Training Land Assessment (RTLA) / Land Condition Trend Analysis (LCTA) programs and the Integrated Training Area Management (ITAM) program are good initial sources as they will contain species already encountered on the installation. Additionally, LCTA/RTLA plot data will contain species information collected over multiple years.

Local, county, and state natural resource agencies, university extension programs, and (in western states) county weed control boards can often provide information on plant species found within the county(s) the installation resides in. Local conservation clubs are especially useful for finding out information on species that may be associated with training lands.

Federal agencies (i.e., U.S. Department of Agriculture [USDA]) and national conservation groups are also useful points of contact for invasive plant-related data. The USDA’s Plants database and similar Nature Conservancy databases are useful sources for data. Additionally, the U.S. Army Engineer Research and Development Center’s Environmental Laboratory has produced the Plant Management Information System, an interactive database containing plant information and control strategies for many species. Internet links for these sources are available in Appendix H.

Appendix F. Sample Sighting Form

Invasive Weed Sighting Report Form

Weed Species_____
Date_____

Specific Location: UTM: Northing_____ Easting_____

Description (Give detailed description of location, including a sketched map):

Growth Form (circle one): Basal rosette Upright growth

Growth Stage (circle one): Preflowering Flowering Seeding

Number of Plants_____ Size in acres_____

Frequency (circle one): Spot Scattered Patch

Action Taken (circle one): Pulled Chopped None

Reporting Official_____

Appendix G. Bibliography

The following list includes useful sources of information pertaining to invasive weed mapping on military disturbed sites.

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Ustin, S. L., D. DiPietro, K. Olmstead, E. Underwood, and G. J. Scheer. 2002. Hyperspectral remote sensing for invasive species detection and mapping. IEEE Geoscience and Remote Sensing Symposium (IGARSS) 2002. *IEEE International* 3: 1658-1660.

Whitson T. D., ed., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 2006. *Weeds of the West*, Western Society of Weed Science in cooperation with the Western United States Land Grant Universities Cooperative Extension Service.

Appendix H. Internet Resources

Internet Site	URL
USDA Plants Database	http://plants.usda.gov/
USDA Plants Database/Noxious Weeds	http://plants.usda.gov/java/noxiousDriver
The Nature Conservancy Global Invasive Species Initiative	http://tncweeds.ucdavis.edu/
Center for Invasive Plant Management	http://www.weedcenter.org/
Center for Invasive Plant Management - Online Textbook	http://www.weedcenter.org/textbook/toc.html
US Geological Service - Invasive Weed Site	http://biology.usgs.gov/invasive/
NBII Invasive Species Information Node	http://invasivespecies.nbii.gov/models.html http://159.189.176.5/portal/community/Communities/NBII_Home/
A Weed Managers Guide to Remote Sensing and GIS (USDA Forest Service)	http://www.fs.fed.us/eng/rsac/invasivespecies/index.htm
North American Weed Management Association	http://www.nawma.org/
Mapping Noxious Weeds In Montana	http://agri.state.nv.us/nwac/montanaweeds.pdf
Armed Forces Pest Management Board	http://www.afpmb.org/

Internet Site	URL
Plant Management Information System (PMIS) US Army Corps of Engineers (ERDC)	http://www.erdc.usace.army.mil/pls/erdcpub/!www_fact_sheet.product_page?ps_product_numb=51501&tmp_Main_Topic=&page=SOURCE (Users will need to copy the above link and paste it in their browsers.)
USACE Jacksonville District	http://www.saj.usace.army.mil/invasive_species/index.htm