V. Monitoring Management Impacts in Sandplain Grasslands

Introduction

This review by the Sandplain Grassland Network focuses on using information gathered from previous management experience to improve future conservation management in ways that both maintain existing grasslands and create new areas of sandplain grasslands. The ability to adapt management over time relies on effective monitoring to assess management success. This section will address *why* you should monitor, w*hat* you should monitor, and *options* for monitoring.

Adaptive management requires setting management goals and monitoring of success and failure so the management can be altered in the future. Goals will differ by location but can include maintaining diverse plant and animal communities, and eliminating or reducing cover of non-native and invasive plants. Criteria for success will vary from project to project and property to property. The following list details some important considerations for establishing a useful monitoring protocol.

- A clear definition of management goals;
- determine what and how often to monitor to evaluate if management is successful;
- assess what resources are available for monitoring and design a monitoring scheme that is achievable;
- determine the kind of data you want to collect. Quantitative data, such as regular counts or surveys, can be time consuming and expensive to collect, but provide a depth of information over time. Qualitative data are typically faster and less expensive to collect but can provide useful and repeatable information;
- when possible, baseline monitoring prior to management will help to determine the effects of management.

What to monitor depends upon the management goals for a particular location, as well as by the resources available for monitoring. One of the stumbling blocks to successful monitoring is selection a monitoring plan that is either too little to detect changes in the face of natural variability, or too ambitious to be implemented successfully or sustained. Below we describe various types of monitoring with different goals in mind, and when one method might be more appropriate than another. Many of these methods may be used in combination to have the greatest effect.

Options for monitoring include landscape photomonitoring, vegetation monitoring (both of the plant community and of key individual species), wildlife monitoring (particularly birds, small mammals or other species of key interest), insect diversity monitoring, soil monitoring, water quality monitoring, or others. Because grasses and forbs create the structure of sandplain grassland habitats, and because reduction of woody plants is so important for grassland management, most sandplain grassland monitoring involves some assessment of vegetation and vegetation change over time.

Prior to designing a monitoring plan, asking certain questions will help define and design a monitoring approach. For example, what are key management objectives? Are there particular species that are of high interest? Are there particular landscape-level issues that require assessment (such as spread of invasive species, or impacts of human visitation)? Clear identification of monitoring goals can help define the kinds of data needed and whether qualitative or quantitative data are needed. In addition, this will help to define the time frame of monitoring, such as whether it can occur every three years, every 10 years, or whether it is needed every year. All of these questions will help to develop a monitoring plan that will not be over- or under-designed, and one that can effectively inform future management.

Qualitative Vegetation Monitoring

Qualitative monitoring of vegetation is the most common way that sandplain grassland management is monitored and it is typically the most practical and cost-effective monitoring to implement. Qualitative vegetation monitoring techniques can be used as part of a larger quantitative vegetation monitoring plan, but they can also stand alone to provide basic information.

Photomonitoring

Photomonitoring involves identifying permanent locations to take photos of a site in a way that can be easily replicated over time to track change in vegetation composition, structure, and land use. Photomonitoring can be simple, rapid and extremely reproducible. Photomonitoring is useful to show change over time or to compare pre to post management. Photos, while they do not tell a complete quantitative story of vegetation change, are important for presentations and reports to boards, administrators and the public because the visual results of management. Photomonitoring is an important tool that can be included as a part of all monitoring plans.

Individual photopoints (locations of reproducible photos) must be permanently marked to allow resampling over time. Photopoints can be marked with rebar in the ground (detectable with a metal detector), wooden posts, flagging, or existing landmarks such as large rocks or fence posts. A compass is used to document the direction a photo is taken and to allow future reproduction. A camera or phone is held at a standard elevation (dbh, or diameter at breast height, is a good reference). The digital photos must then be well labeled and stored. Because these photopoints are revisited over time, a photographic record of change over time can be created.

Table 1. Examples of sandplain grassland sites where photomonitoring has been used.

Name of project	**Location**	**Citation**
Peter Dunwiddie land history	Nantucket, MA	Dunwiddie 1992
Camp Edwards	Cape Cod, MA	Jake McCumber, personal communication
NCF Property Monitoring	Nantucket, MA	NCF 2017
Middle Moors	Nantucket, MA	Middle Moors Case Study

Species Presence/Absence

The occurrence of individual plants at a site can indicate management effects, particularly when management is intended to affect rare or invasive plants or a particular suite of plants, such as shrubs. Monitoring species presence/absence at a site consists of using a systematic way to document whether a particular species is located on the site during a particular sampling time. By systematically exploring a particular property or management unit, and documenting all plants observed, a species list is created for that time. Repeating this method can generate additional species lists that can be compared over time. Monitoring can also focus only on one particular plant or group of plants. Examples could be documenting the presence/absence of rare plants, non-native, invasive plants, or functional groups of plants such as shrubs. The presence/absence of these plants can be tracked over time and can be used to signal the need to manage. Presence/absence surveys can be conducted in combination with the quantitative surveys discussed below and can be particularly useful at documenting rare species, which often get missed in more randomly structured sampling protocols that cover less total land area.

Species presence/absence examples

Table 2. Examples of sandplain grasslands where presence/absence of plant species have been collected over time.

Name of project	**Location**	**Citation**
Trustees of Reservations	Multiple sites	Russ Hopping, Interview
Hempstead Plains	Nassau, NY	Hempstead Plains Case Study

Vegetation Mapping

Vegetation can be mapped on the ground or aerially. On the ground, a handheld GPS unit can be used to document the extent of an individual species population or of a defined plant community. In addition, locations of individual plants can be documented with points. This method can be particularly useful for documenting the extent of non-native plants targeted for control or rare species targeted for management designed to increase occurrence. Handheld computers with GPS units can also be used to document other information about the location of mapped vegetation such as slope, dominant surrounding vegetation, hydrology, or disturbance.

Remote Sensing

Mapping of plant communities or population can be done using aerial photos from planes or drones, or from satellite images. Remote sensing data can be very useful for looking at change over time in relation to management or climate, and for tracking phenology (Nagendra et al. 2012). The choice of method depends on the resolution available, area of required coverage, image availability, and cost. Aerial photo interpretation can delineate broad vegetation communities by defining grassy areas, evergreen trees, and shrublands, for example. This method should be used in conjunction with ground truthing, visiting sites in the field to verify aerial photo interpretation. Older and historical aerial photos can be interpreted and compared with more current photos to document vegetation community change over time.

The Nature Conservancy used a combination of aerial photos and ground truthing methods to map the vegetation communities of Nantucket and Martha's Vineyard in the late 1990s (Lundgren et al. 2000). Targeted aerial photos of a management area taken before and after management can be used to investigate coarse-scale change in vegetation. For example, it may be easier to quantify changes in grassland versus woody vegetation from such images. Google Earth images can be used in this way to observe changes over time. The growth over time of patches of black huckleberry (*Gaylussacia baccata*) at a site on Nantucket was tracked using both aerial photos and quadrats along the edge of the huckleberry patches (Harper 1995). Changes to the area of black huckleberry and catbrier (*Smilax rotundifolia*) on Naushon Island were quantified using aerial images from 1932 to 2014 (Champlin 2016). Several products from satellite images are also widely available. Nagendra et al. (2012) discuss a wide range of remote sensing data sources that are used for ecological monitoring in a variety of research projects and programs. The need for high-resolution spatial information that allows mapping of plant species or at least functional groups often limits the utility of even the highest resolution data from satellite images.

Unmanned Aerial Vehicles

Unmanned aerial vehicles, or drones, have been used for a number of survey applications including mapping non-native, invasive plants. On Nantucket, drones were used in 2016 to survey several pond edges for occurrence of the invasive common reed (*Phragmites australis*). While not a sandplain grassland, this demonstrated potential to use drones in these habitats. Drones can be programmed to fly straight transects and so may be ideal for ecological surveys. In post-processing, individual photos taken by the drone are stitched together into photomosaics using computer software to create a high definition image of the survey area. This image is georeferenced and ready to use in any GIS software. The high resolution of the resulting images can be used to observe vegetative change over time. Drone flight requires a licensed operator, the appropriate technology, and the necessary permitting, especially when flying close to an airport. However, the high resolution georeferenced images produced will likely allow users to quantify the areas of certain sandplain grassland vegetation features of high interest, such as shrubs.

Quantitative Vegetation Monitoring

Quantitative methods of monitoring vegetation allow managers and researchers to use summary and statistical data from monitoring to describe trends and responses of vegetation to management over time. Quantitative monitoring can also be used to identify vegetation community thresholds that prompt the use of management to maintain more open sandplain grassland habitats. For example, quantitative vegetation monitoring can indicate that, over time shrubs recover to pre-management dominance three years after a fall burn so management should be performed every three to four. Quantitative vegetation monitoring is more time consuming than most qualitative methods. Quantitative monitoring can be performed on a multi-year rotation and potentially combined with annual qualitative monitoring. Two of the most common quantitative measures of the plant community in sandplain grasslands are plant cover and species richness or species diversity.

Percent Cover Estimation

Plant cover monitoring in sandplain grassland is typically conducted using visual estimation of percent cover of individual species and/or functional groups (woody species, graminoids, forbs, scrub oak, etc.). In this method, permanently-marked plots or quadrats are located throughout the management area and visited on a set schedule to record cover (Fig. 1). The plot is visually assessed for the percent cover of each plant species and/or functional group within each plot, where visual assessment is typically a birds-eye view from above the plot. This method can include measures of every plant identified to the species level, groupings of plants such as cover of all oak species, and measures of bare ground or litter. Cover values are typically recorded within ranges of percent cover and percent cover ranges are converted to cover range midpoints for statistical analysis (Lezberg et al. 2007). The method can be used in grasslands, shrublands, and woodlands and has been widely used across the northeast US sandplain grassland region (Motzkin et al. 2002, Eberhardt et al. 2003, Wheeler et al. 2015). Percent cover estimates of plants and functional group can be used to examine species composition and also statistically to compare effects of management both over time and between sites. Advantages of this method include its nondestructive nature, its repeatability in the same location, and the large number of plots that can be measured in comparison to methods that require harvesting. Drawbacks of this method include the difficulty of reliably assessing patterns of change for species with consistently low cover values, difficulties identifying all plants at one time of year, and subjective variability of cover estimates if different people record cover in different years.

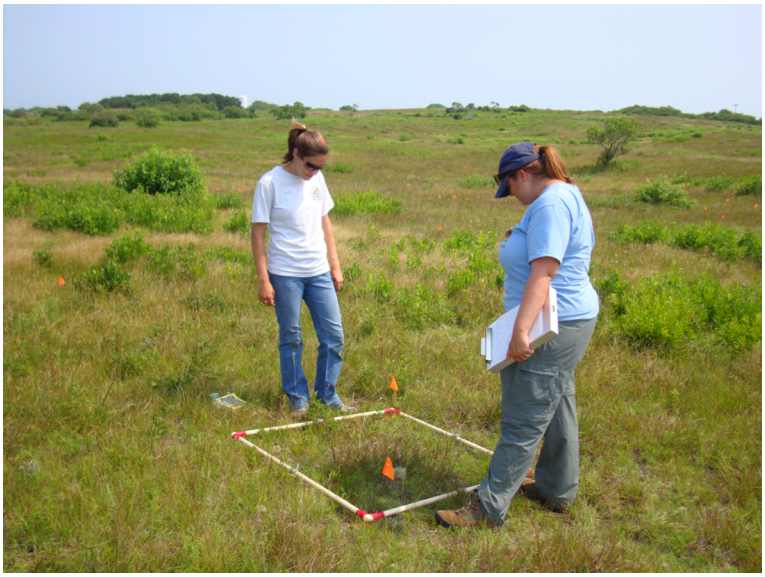

Figure 1. A one square meter plot frame used to assess percent cover within a sandplain grassland on Nantucket. Photo Credit: Nantucket Conservation Foundation.

Permanent plots can also be used to collect other information including evidence for herbivory, individual stem counts, vegetation height, soils and other environmental variables. Plot size depends on the stature of the vegetation and the time required to identify and record all species. Open grassland and low shrubland habitats can be estimated using $1m^2$ plots. Denser woody areas typically will require larger plots up to 9 m^2. Information from the cover quadrats can determine the proportion of each species or functional group relative to the entire plant community. Elzinga et al. (1998) provide useful specifics for determining quadrat size, number of quadrats needed per area, and percent cover categories.

Table 3. Examples of sites that used vegetation cover in quadrats to monitor plant community change.

Name of Project	**Location**	**Citation**
Katama Plains	Martha's Vineyard, MA	Katama Case Study
Squam Farm	Nantucket, MA	Squam Farm Case Study
Herring Creek	Martha's Vineyard, MA	Wheeler et al. 2015
Middle Moors	Nantucket, MA	Middle Moors Case Study

Point-intercept Method

The point-intercept method is another way to estimate plant species cover that is often used in grasslands and shrublands (Fig. 2). Multiple transects are randomly established across the site. A sampling dowel, laser, or pin flag is lowered to the ground at particular regular intervals along the transect (e.g., on a 50 m transect, the pin could be placed at every meter mark to create 50 sample points per transect). At each sample point, every plant species that touches the pin is recorded as present. In addition, plants that touch can be recorded as well as ground cover. At each sampling point, a plant species is recorded only once, even if it touches the pin more than once. Percent cover of plant species and/or functional group can then be estimated as the percentage of sample points at which species occurs along the transect (e.g., on a 50 m transect, little bluestem might be encountered at 30 points, so its cover is 60%).

Figure 2. Transect set up at a site for the point intercept method. Photo Credit: Nantucket Conservation Foundation.

This method is particularly useful for sampling variation and quantifying changes in plant species cover over time. Cover can be estimated at different heights, and canopy cover can also be estimated. The point-intercept sampling is often less time consuming than plot percent cover estimates. This method does under estimate rare species and is recommended to be combined with presence/absence searches.

Point intercept examples

Table 4. Examples of sandplain grasslands where point intercept methods have been used.

Name of Project	Location	Citation
Frances Crane Wildlife Management Area	Falmouth, MA	Calijouw, Interview
Property Management Monitoring	Nantucket, MA	NCF 2017

Frequency

Assessing how frequently a particular species is encountered in a specific plot or unit is another method for documenting species response to management. This method is most often used for targeted surveys of rare species, non-native species, or key target species. Frequency is best estimated at the plot level, and plot establishment is typically targeted, not random. The rare eastern silvery aster (*Symphyotrichum concolor*), located in the Smooth Hummocks Coastal Preserve on Nantucket, was surveyed over time within several targeted quadrats. In addition to plant stem number, this method also recorded plant height, flowering, and seed output before and after burning and mowing treatments (Freeman et al. 2005). Individual species frequency surveys can often be used in combination with point-intercept, or percent cover assessments to look for additional species not detected in either sampling scheme. This method can be used to document changes in individual species occurrence over time, and in response to management.

Frequency examples

Name of Project	**Location**	**Citation**
Symphyotrichum concolor targeted monitoring	Nantucket, MA	Freeman et al. 2005
Agalinis acuta monitoring by TNC	Martha's Vineyard, MA	Tom Chase, personal communication

Monitoring Considerations

Number and size of quadrats or transects

The appropriate size and number of quadrats, number and location of photopoints, and number and length of transects per area are other things to consider when establishing a monitoring program. These depend on: (1) the size of the area to be sampled, (2) the uniformity of the area to be sampled, (3) the money and person-power that can be devoted to monitoring, and (4) the sample size needed for sufficient statistical power. Simple pilot studies can be used to determine a sampling design that can be applied to other similar management areas. Good explanations of sampling design can be found in Elzinga et al. (1998) and Gotelli and Ellison (2013). Often, successful monitoring programs in similar or nearby areas can be used as guides to determine a monitoring design and the sampling effort needed. This saves time and can provide the additional advantage of creating an opportunity to compare results.

Frequency of monitoring

The frequency of monitoring depends on the goals of monitoring and management, as well as available resources. Short-term monitoring is often used to assess success of a particular management treatment or regime and may not need to be repeated long term. This can be valuable information, but long-term monitoring provides additional valuable information. Long-term monitoring plots allows the collection of quantitative data on the effects of different management techniques. With changing climate, permanent long-term monitoring plots may detect longer-term changes: climate-caused impacts of management on vegetation

communities. For example, some managers argue they are starting to see longer-term impacts of management on mycorrhiza and plant associations (R. Lombardi, Interview).

One option to sustain long-term monitoring would be to sample more intensively just prior to and after management, and then less frequently at other times. For example, the direct impacts of prescribed fire on vegetation communities are thought to be less important three to five years post-management. Sampling every year up to five years after management, and then transitioning to sampling every two to three years may be an effective long-term monitoring protocol. In this instance, it would be appropriate for high frequency monitoring during the treatment phase of management, with a transition from project monitoring to long-term, follow up monitoring (C. Neill, Interview).

Monumenting

Whatever type of monitoring is chosen for the property or project, it is important to properly mark, or monument, each plot, transect end, or photo point locations. This will allow for repeated sampling at the same location. Methods of monumenting vary, but will depend on whether they need to withstand mowing or fire, visual aesthetics, or potential disturbance by animals or people. The answer to these questions can be very site-specific. Some examples include survey flags for temporary markers, rebar with labeled caps for more permanent markers (height above ground based on height of mower deck), or nails and washers flush to the ground. All points should be georeferenced with a GPS unit or related to some other permanent marker. Flagging tape can additionally mark survey points for ease of visibility, but it rarely lasts longer than one season, can attract herbivorous activities of deer, and may be removed by people.

Monitoring Results

Whether the data are quantitative or qualitative, it is important to summarize, visualize, and analyze results where possible (Elzinga et al. 1998, Gotelli and Ellison 2013). These results will likely inform the kind and frequency of future management. It is also extremely important to share results. The effort of monitoring results by the Sandplain Grassland Network aims to help share information and knowledge derived from a variety of locations and monitoring efforts.

Use of Citizen Science

Depending on project goals and locations, monitoring projects may be an excellent way to incorporate citizen scientists into data collection. With a simplified protocol and some training, much qualitative and quantitative data might be collected on a larger scale with volunteers. This monitoring method would be more successful if tapping into an already-established citizen science program. Another option would be to coordinate before and after data collection with a regional university or college course, high school science class, or local master naturalist program. While the availability of such programs is location-specific, they can be very useful resources and add an education or outreach component to a management project.

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Vitz, Drew. Interviewed by Lena Champlin on November 20, 2016

Lombardi, Roberta. Interviewed by Lena Champlin on February 1, 2017

Monitoring for other species and environmental conditions

Vegetation tends to be the most commonly monitored component of ecosystem response to restoration and/or management but, depending on your goals and resources, there are many other categories that can be monitored.

Other species of Interest

Birds

Sandplain grasslands edged with coastal shrublands provide habitat for several bird species, many of which are special concern, threatened, or endangered due to loss of habitat. Concern may exist to track recovery of bird populations, or guarantee that management does not negatively impact bird populations. Birds can often be a good charismatic symbol for changes in grassland habitat but can potentially hide changes if the bird populations are slow to change in response to changing habitat (J. McCumber, Interview).

Sampling Methods

Various methods exist for monitoring bird populations and range from extremely time intensive to the use of occasional citizen scientists. Point counts involving observations and call identifications as well as using electronics to monitor calls over set periods of time can collect quantitative data for analysis on bird diversity at a site. Mark recapture and telemetry studies can document target bird movement patterns over an area in a season and over time. Nest location surveys and opportunistic observation can help document bird presence at a site. Using citizen scientists to document bird sightings using programs such as eBird can collect long-term qualitative data on bird use of a location.

Examples in Sandplain Grasslands

- At Francis Crane, bird populations are monitored yearly, with general surveys every year and standardized surveys every three years to track potential changes in bird populations (D. Vitz, Interview).
- Camp Edwards has 26+ years of bird monitoring data conducted by the same individual and focused on occurrence of state-listed birds (J. McCumber, Interview).
    - On Martha's Vineyard, annual counts of grasshopper sparrows are conducted at Katama Plains to track population (Revised management plan for the Katama Plains Conservation Area 2000).
- On Nantucket Island, long term surveys for Northern Harrier populations includes locations of nest sites to inform burn timing and locations in an effort to avoid impacting populations (Massey et al. 2008).
- On Nantucket, grassland bird surveys have been conducted in different projects to document bird populations. Surveys were conducted in 50m circular plots in early morning (typically between 6am-9am) but all species visually or auditorily identified during the sampling period were recorded. (Zuckerberg and Vickery 2006; NCF 2018).

Protocols and Resources

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Invertebrates

Sandplain grasslands serve as strongly associated habitat for a variety of invertebrates including many species of conservation concern. The American Burying Beetle, the purple tiger Beetle, and multiple moth and butterfly species of special concern are all dependent on these grasslands in some way. Monitoring at a particular site may be geared to directly detect populations of these species due to localized concerns.

Sampling Methods

All sampling methods for invertebrates need to consider that invertebrates can experience large population fluctuations between years, often making sampling necessary over multiple years to document species occurrences (P. Goldstein, Interview, M. Mello Interview). Standardized invertebrate monitoring methods within sandplain grasslands are not common.

Typical monitoring methods include conducting presence/absence inventories of individual species or a suite of species. Pitfall traps and sweep netting for insects are common as well as light traps to document moth species. Becoming more common in grasslands is the use of modified garden leaf-blowers to 'vacuum' sample invertebrates (Cherril et al 2017).

Examples in Sandplain Grasslands

- Dunwiddie (1991) collected arthropods using sweep nets along 50m transects during 3 sampling days in summer 1985, representing monitoring pre- and post-burn management.

- Bee populations were catalogued on Nantucket and Martha's Vineyard by using bee bowls placed along transects and filled with soapy water. Insects attracted to the color of the bowls would be captured, collected and processed for identification (P. Goldstein, Interview).
- On Nantucket, pitfall traps consisting of pyrex test tubes fitted into a PVC sleeve and placed flush with the soil surface allowed sampling of ground-dwelling/leaf litter insects and other invertebrates in a management site (NCF 2017).
- Many of these sampling methods are broad range and lead to bycatch, depending on your sampling goals. Additionally, the biggest limit to sampling invertebrates is the ability to accurately and quickly identify the species you have sampled.

Protocols and Resources

Cherrill, A., Burkmar, R., Quenu, H., & Zentane, E. 2017. Suction samplers for grassland invertebrates: The species diversity and composition of spider and Auchenorrhyncha assemblages collected with VortisTM and G-vac devices. Bulletin of Insectology 70: 283–290.

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Small Mammals

Small mammal populations can often be used as indicators of an ecosystem's response to management and can provide a measurement of biodiversity. Small mammals serve as the prey sources for larger mammals and birds of prey while remaining fairly sensitive to microclimate changes in habitat. Additionally, small mammals tend to be relatively abundant, making sampling easy to conduct, particularly in grasslands and low shrublands.

Sampling Methods

Live trapping of small mammals using Sherman live traps is the most common sampling method due to its efficiency and ease. Sherman traps are available in various sizes and trapping success does depend on appropriate trap size for the targeted mammals. Some protocols vary trap size optimize sampling. Trapping often occurs during the breeding season, but can be conducted year-round depending on your monitoring questions. Trapping during extreme weather can cause stress for animals and lead to mortality, so take care to follow standard protocols for establishing, checking, and insulating traps. Traps are typically placed along

established transects and baited as appropriate. Traps are typically opened in the evening and checked and rechecked the next morning and at regular intervals to prevent animals being in the traps for too long.

Pitfall traps can be used to detect smaller small mammals such as shrews and gophers. Pitfall traps often can be lethal unlike correctly deployed Sherman live traps. Wildlife cameras placed at bait stations can also be used to sample mammals, particularly larger wildlife species not able to be sampled using the Sherman live traps.

*Staff should be sufficiently trained in handling small mammals. Rabies vaccinations may be required to handle small mammals, and permits for sampling may be necessary.

Examples in Sandplain Grasslands

- On Nantucket Island, small mammals are being sampled as part of a sandplain grassland restoration project involving harrowing and brushcutting relative to reference grasslands. Sherman live traps are deployed relative to random vegetation sampling plots. Each sampling session involves five trap nights and with traps opened and baited in the evening and checked prior to 8am the following morning. (NCF 2017)

Protocols and Resources

Nantucket Conservation Foundation (NCF). 2017b. Head of the Plains reset project: Small mammal trapping protocol. Science and Stewardship Department, Nantucket MA.

Manley, P.N., Van Horne, B., Roth, J.K., Zielinski, W.J., McKenzie, M.M., Weller, T.J., Weckerly, F.W., & Hargis, C.D. 2006. Multiple species inventory and monitoring technical guide. Citeseer, Gen. Tech. Rep. WO-73. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 204p.

If you are interested in monitoring the response of a particular species to management, check the literature or reach out to other managers in the area. Chances are someone has already done the work of creating a monitoring protocol or plan you can adopt at your site. This box indicates a number of locations at which studies have occurred and are good resources for finding protocols.