Development of Monitoring Strategies and Methods for the DNR Landowner Incentive Program

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Cover photo: Chris Hoving, DNR Wildlife Division Lanowner Incentive Program Biologist monitoring Karner blue butterflies. Photo by Ryan P. O'Connor.

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1. Executive Summary

Numerous publications on monitoring have been developed and are available from a wide variety of sources. This overview summarizes two of the most widely used and accepted documents on developing monitoring strategies and monitoring methods: the USDA Forest Service's Development of Protocols to Inventory or Monitor Wildlife, Fish, or Rare Plants (Vesely et al. 2006) and the BLM publication Measuring and Monitoring Plant Populations (Elzinga et al. 1998).

Monitoring is an essential component of any management program. Monitoring changes in habitat and species populations is essential to implementing ecosystem management and provides the critical feedback that enables managers to make effective adaptive management decisions. The first and more important step in monitoring is to clearly articulate the overall purpose and specific objectives of the monitoring, followed by selecting the most appropriate monitoring methods to answer the question at hand. Lastly, thought must be given to the details of data collection and analysis. It is important for both academic researchers and field biologists to recognize that it is not necessary for all monitoring to be conducted at the same level of detail and statistical rigor. Rather, the methods of data collection, sampling design, and analysis flow from the overall purpose and objective.

A tremendous variety of monitoring methods have been developed for both species and habitats. A range of methods for monitoring species population that vary by intensity, level of statistical rigor, time, and cost are discussed including visual encounter surveys, point counts, Pollard-Yates, line-transect distance, and mark-release-recapture. Vegetative habitat measures include photographic, density, frequency, and percent cover. For each measure, a variety of sampling methods are outlined, ranging from low time and resource intensity to high time and resource intensity.

Finally, a monitoring strategy for the Michigan DNR Landowner Incentive Program is presented as an example, including project compliance monitoring, species monitoring, and habitat monitoring. Specific monitoring objectives and methods are briefly described for target species and habitats, following the strategic outline described earlier in the document. Species monitoring strategies are described for the Karner blue butterfly, Mitchell's satyr, eastern prairie fringed orchid, dusted skipper, eastern massasauga, and grassland birds (Henslow's sparrow, grasshopper sparrow, etc.). Habitat monitoring strategies are described for prairie fens, oak barrens, and pine barrens, as well as for tracking the success of management activities including a study on the effectiveness of different methods of shrub control and monitoring the survival of planted mesic conifers.

2. Developing a monitoring strategy

Development of a monitoring strategy is absolutely essential to conducting a successful monitoring program. Your strategy must be clearly articulated, and include specific, measurable parameters that will provide essential feedback for your purpose. Well-defined monitoring strategies will help determine what type of data to collect and which methods are most appropriate. Though it is often an afterthought or even skipped entirely, developing a strategy is the single most important step in the entire monitoring process. Developing a monitoring strategy should include three components:

Identifying Objectives

- What is the overall purpose of monitoring? (e.g., to inform adaptive management, track general habitat trends, publish peer-reviewed research, etc.)
- What level of detail is required? (e.g., qualitative, visual estimates, statistically rigorous)
- What will be monitored? (e.g., species or habitat)
- What is the geographical area of interest (e.g., specific site, region, watershed, state-wide)

Selecting attributes, methods, and study design

- What attribute(s) will be measured? (e.g., population size, density of plants, percent cover of shrubs)
- Which method(s) will be used to collect the data?
- What sampling design will be used?

Data collection and analysis

- How will the data be collected? (e.g., paper field forms, data loggers, etc.)
- How will the data be analyzed? (e.g., visual comparison of photos, rigorous statistical tests, etc.)

2.1 Identifying objectives

<u>What is the overall purpose of your monitoring?</u>
Clearly defining the overall purpose of the monitoring is the first and most critical step in the process, and will help answer questions about what attribute to

measure, how much detail is required, and which methods to use to collect the data (Elzinga et al. 1998, Vesely et al. 2006). Each project will have its own goals and purpose, and should be evaluated independently of other unrelated projects. For example, if the purpose is to conduct a research study and publish in a peer-reviewed journal, statistically rigorous sampling designs and analysis will be required. However, if your purpose is to simply inform adaptive management, such as assessing whether a prescribed burn reduced shrub density and cover, simple photo points or coarse-level visual estimates may be more suitable, saving a great deal of time and money.

<u>What level of precision and detail is required?</u>
The level of monitoring should flow directly from the larger purpose of the project. If the purpose is to track general trends of shrub cover in a prairie fen, visual estimates or photo points should be sufficient; establishing an elaborate system of transects or permanent plots wastes valuable resources. On the other hand, if the purpose is to help answer a larger research question, such as the effects of burning on a particular plant species, neglecting to set up a proper study design with pre and post sampling of permanent plots or transects as well as controls will result in a failure of the entire study objectives. An assessment of precision level should also include what confidence level is desired if conducting statistical analysis and what level of sensitivity to change you desire to detect.

<u>What will be monitored?</u>
Is the primary subject of interest the habitat or a species within the habitat? This can often be a difficult question, since the ultimate aim of habitat management or research is often to benefit a species, but directly monitoring species or their use of the habitat can be difficult from a practical standpoint. Furthermore, changes in some attribute of a species (population, habitat use) is also very difficult to directly correlate with management. For example, if trying to improve habitat for the eastern massasauga, finding and tracking this cryptic species will be difficult, and observations of snakes following habitat management such as shrub thinning may mean that they are successfully responding to management activities, or it may mean that they are simply more easily observed after obstructing vegetation is removed. Overall, habitat attributes are often much more easily measured and changes are more likely to be directly correlated with management or the lack of it. The downside is that assumptions must be made in linking changes in habitat to some benefit to the species.

If time and financial constraints allow, a reasonable compromise on a large project with numerous sites may be to monitor just the habitat at most sites, and set up a more rigorous species-level monitoring at a select number of sites to attempt to correlate some attribute of the species (population size, reproductive success, use of habitat) with various habitat attributes. This will help establish a stronger connection between the species and the habitat and improve the interpretation and meaning of habitat monitoring at other sites.

<u>What is the geographical area of interest?</u>
Establishing where monitoring will be conducted helps focus efforts prior to going into the field. Will monitoring be conducted at all sites where management might being conducted, or just a subset? At a given site, will monitoring focus on the entire area, or just a portion of particular interest? These details are important in deciding which attributes to measure and which method to use (Elzinga et al. 1998). For example, if the area of interest is a large landscape, several long transects that bisect the site may be necessary to gather adequate data, but if working primarily in a small patch an acre or less in size, photo points, visual estimates or a permanent macroplot may be more appropriate.

2.2 Selecting attributes, methods, and study design

<u>What attribute(s) will be measured?</u>
Though it is often tempting to jump to this issue first, clearly defining the objectives beforehand will help ensure that the attributes selected are the best fit for the larger goals of the monitoring. Attributes for species will be vastly different that those for habitats, and will depend largely on the type of species of interest and the ability to adequately collect meaningful data. The range of possibilities is large, and may include presence/absence, population size, reproductive success, and habitat usage among other things.

Habitat monitoring can be broken into biotic and abiotic (hydrology, temperature, soil). This report focuses on biotic (vegetative) habitat monitoring, which primarily includes measures of density, frequency, and percent cover. Other measurements not specifically addressed here but of potential interest may include vigor, such as biomass production, number of shoots, and number of flowers or fruits produced, as well as demographic measures that use reproduction and mortality rates to produce models of population dynamics (Elzinga et al. 1998). Habitat monitoring is especially useful in making management decisions. In addition to tracking functional changes in the ecosystem, habitat monitoring can also provide a surrogate measure of the size and health of species populations if more costly and time-intensive population monitoring is prohibitive.

<u>Which method(s) will be used to collect the data?</u>
This is also one of the first questions usually considered. Start first by working top down starting with firmly establishing the overall objectives for monitoring. Once the other monitoring criteria are outlined, select the best method that meets your needs. Monitoring methods vary on a continuum of the level of detail collected, the level of analysis that can be conducted, and the amount of money and time needed to collect the data (Table 1).

<u>What sampling design will be used?</u>
Good sampling designs ensure that the data collected accurately reflect reality, that resources and time are used efficiently, and that statistical variance is minimized, especially if conducting statistical analysis (Vesely et al. 2006). Sampling should cover a large enough spatial area to capture all potential habitat at a given site. If tying to make larger inferences about a management practice, replicating the management as well as having controls is necessary. If statistical analysis is planned, minimizing variation between samples is particularly important. For example, many sites contain environmental gradients such as slopes, changing soil conditions, and water tables. It is critical to set up a sampling design that runs perpendicular to other gradients, so that the only difference between samples is the effect of the management.

Variance can also come from natural patterns of growth in plants. Many plants exhibit a non-random spatial distribution, and instead grow in clumps. If sampling the density of such a species with small, randomly scattered circular plots, it will likely result in many plots with measures of zero, and a few plots with very high density (Elzinga et al. 1998). The average may or may not reflect reality, and the variance among plots will be very high, possibly obscuring changes due to management. A popular, more suitable design for clumped species is to use long linear transects that each bisect numerous clumps, providing a more accurate, less variable estimate of density (Elzinga et al. 1998). For a practical example of this, please refer to the section 5.2.3 in Examples from the Landowner Incentive Program: Eastern prairie-fringed orchid on page 11.

In many cases involving studies where high levels of sensitivity and precision are desired, conducting pilot studies and power analysis are extremely beneficial in determining how many samples need to be collected to detect the desired degree of change (Vesely et al. 2006). Collecting too many samples for your intended purpose wastes time and resources, but not collecting enough samples may result in a failure of the entire study. Collecting preliminary data to provide estimates of critical parameters will help ensure that monitoring is done most efficiently over the long term. Statisticians can help in setting up pilot studies and in conducting power analysis.

2.3 Data collection and analysis

<u>How will data be collected</u>
One of the last steps prior to conducting field work is to plan out the detailed methods of how data will be collected, including how sampling units will be established on site, how points, plots, or transects will be marked, and how data will be recorded (e.g., develop the proper paper field form or pull down menus on a hand held PC). It is important to be consistent in sampling during the same time of year if monitoring habitat changes over time. When monitoring animals, it is especially critical to match the sample time to the season, time of day, and weather conditions when species of interest are likely to be most active.

<u>How will data be analyzed?</u>
Finally, consider how the data will be analyzed. This may range from simple visual comparison of photo-points over time to complex statistical analysis. Either way, planning out the analysis prior to sampling will save you time and resources later on and ensure you have collected the right data to conduct your preferred analysis. This report does not cover statistical theory and analysis techniques, but numerous resources are available to guide this process (Sokal and Rohlf 1995, Elzinga et al. 1998, Krebs 1999, Vesely et al. 2006).

Table 1. Generalized description of species population and vegetative habitat monitoring along a continuum of detail of data collected, time needed to conduct the monitoring, and cost.

Species Monitoring	Habitat Monitoring	Level of detail	Time	Cost
Presence/absence	Photo-point	Low	Fast	Low
Timed meander survey	Course-level visual estimates	↓	↓	↓
Distance sampling	Line-intercept transects			
Mark-recapture	Permanent plots	High	Slow	High

3. Levels of Monitoring

3.1 Overview of Monitoring levels

Monitoring can occur at different levels depending on the goals and level of detail required to adequately answer the monitoring question. Course scales may be appropriate when little detail is necessary, such as tracking the general trend of shrub density in a large open prairie to inform adaptive management. Where more detail is required, such as providing statistical evidence of the effects of specific management activity, fine scales will be most useful. In general, it is important to remember to select the best level and method that suits the monitoring needs and goals. What is best at one site may not be best at another. Simply duplicating the same level and method may result in costly over-collection of unnecessary data, or may lead to a critical lack of data necessary to answer a rigorous scientific question. There is often a tradeoff between level of rigor and resources used (time, equipment, etc.). Often, selecting a finer level of monitoring may mean conducting the monitoring at fewer sites, whereas a courser level of monitoring may allow data collection at a greater number of sites, but will result in less detail and analysis capabilities. To chose the proper level and method, each time a new monitoring issue occurs, always start by asking: 1) What do you really want to know? And 2) Why do you want to know it? Answering these questions and going through the three steps of defining your monitoring goals will ensure the most appropriate monitoring level and method is selected.

3.2 Course scales

Coarse scales of monitoring include species presence/ absence through visual encounter surveys, habitat monitoring through point-points, qualitative assessments of species abundance or habitat, and course-level visual estimates of key habitat variables, such as shrub cover in a fen. The benefit of monitoring at coarse scales is that they are generally fast and require little set up, training, or analysis. The downside is that they may be more dependent on observer skill and experience, have a higher degree of observer bias, and have little if any statistical rigor. Issues related to observer bias can be minimized by having the same individual conduct the monitoring each time, or by establishing teams of at least two observers who jointly assign values to attributes of interest.

3.3 Fine scales

Fine scales of monitoring involve collecting quantitative information such as estimates of species populations through various Pollard-Yates methods, Distance sampling, and mark-recapture techniques. Vegetation monitoring methods that fall into this category include using transects, quadrats, and plots to measure variables such as species composition and structure through estimates of density, frequency, and percent cover. Most fine-scale methods can incorporate statistical analysis, a benefit when conducting scientific research, though different methods vary in their statistical rigor. The main downside to fine scale monitoring is that it is generally more time consuming to set up, conduct, and analyze. It may also require more equipment, training, and expertise than less rigorous methods.

4. Monitoring Methods

4.1 Species Population Monitoring

For each method below, a short description is included with references to more detailed methodology. The descriptions are not intended to be used to set up and conduct a monitoring program, but rather to provide an overview of the range of possibilities to consider. Methods vary along a continuum of cost, time, and the level of inference that can be drawn from them, and each method has pros and cons. (Table 2).

4.1.1 Visual encounter surveys

Overview: Visual encounter surveys principally involve walking through suitable habitat to determine whether or not a given species is present or absent. The surveyor may walk along an established route or transect, or may be free to meander through the site, seeking out the best potential habitat. All species of interest are recorded, and the results are expressed either in presence/absence, or number of individuals observed per unit of time. Visual encounter surveys work well with amphibian and reptiles (Manley et al. 2006), and with easily observed invertebrates such as butterflies. For a more detailed description of this method please refer to the chapter on Visual Encounter Surveys (Crump and Scott 1994) within Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians (Heyer et al. 1994).

Pros: The benefits of visual encounter surveys include little to no set up time and allowing observers to spend time efficiently by searching the best habitat.

Table 2. Comparison of methods of monitoring species population across level of rigor, time, and cost.

Method	Level	Statistical Rigor	Time	Cost	Pros	Cons
Visual encounter	Qualitative or course quantitative	Very low	Fast	Very low	Fast and efficient, little to no setup	Observer bias, year to year comparisons difficult, non-statistical
Point count	Quantitative	Mod	Mod-fast	Low	Relatively fast, preferred for birds	Variations in detection probability, requires keen ear and ID expertise
Pollard-Yates	Quantitative	Mod-high	Mod-slow	Mod - low	Faster than other population estimates, can select best habitat	Less accurate than other methods, estimates difficult to compare across sites
Line-transect distance	Quantitative	High	Slow	Mod	High level of accuracy compared to MRR, preferred for butterflies	Time consuming to setup and conduct, estimates not reliable with very high or low sample sizes
Mark-release-recapture	Quantitative	Very high	Very slow	High	Best accuracy, well-proven and accepted techniques	Extremely time and personnel-intensive, often cost-prohibitive

Cons: The main downsides are that a true population estimate is difficult to obtain, and that estimates are not comparable from year to year, especially if using a free meander approach. In general, visual encounter surveys work best if trying to determine whether or not a given species is present at a site before investing more time and energy into more rigorous population estimates.

4.1.2 Point-count surveys

Overview: Used primarily to detect songbirds, point count surveys involve listening and watching for a wide variety of species at each point in a predefined survey route. Observers spend a specified amount of time at each point, recording the presence and number of each species heard or seen. Multiple points at a given site should be located a minimum of 200 meters apart. Length of time varies according to the specific protocol used, but generally ranges from 3 minutes (Breeding Bird Survey) to 10 minutes (U.S. Forest Service Protocol, Manley et al. 2006). In general, longer time frames are better for picking up species that call infrequently, but it is suggested that information be collected in such a way to make it compatible with other methods, such as recording data in three time intervals: 3, 5, and 10 minutes.

Point counts are primarily used for song birds, but may also be used for owls, raptors, and wetland birds using playback of recorded vocalization and listening for a response. Point counts can also be used to sample for vocal mammals and amphibians (e.g., frogs and toads). As with all animal surveys, point count surveys must be timed to coincide with the active, most vocal season and time of day. For most songbirds this is early morning in spring and early summer, but may vary with any particular species of interest. For more information on point count surveys for birds, refer to the Handbook of Field Methods of monitoring landbirds (Ralph et al. 1993).

Pros: The benefits of point-count surveys are that estimates of population size can be obtained for species otherwise difficult to sample by other means. It is generally the best and most well-accepted method for conducting songbird surveys.

Cons: Drawbacks of this method include varying detection rates for each species. This makes comparisons across taxa difficult, with species that vocalize softly or infrequently being particularly underrepresented. Multiple visits ar e needed at each location to have adequate probability of detection. In addition, key habitat areas may missed depending on how transects are established. Finally, this method requires a keen ear and expertise in identifying the full range of possible species by call.

4.1.3 Pollard-Yates surveys

Overview: This survey method derives estimates of population size from a combination of meander surveys and more structured line-transect surveys. Transect lines are established in a stratified manner such that they bisect the best potential habitat. As transect lines are walked, the number of individuals observed for each species encountered and its distance from the transect line is recorded (Pollard and Yates

1993). Other variations allow an observer to meander along the transect within a certain distance of the line.

Pros: This method is popular for monitoring butterfly populations and has several advantages over simple meander surveys. It provides the ability to obtain more accurate and repeatable population estimates, while still allowing an observer to search the best habitat possible. In addition, meandering along transects is generally faster than distance surveys and yields better results at low butterfly population numbers (less than 10 individuals per transect when using distance surveys) (Heather Keogh, USFS, pers. com. 2007).

Cons: This approach has some drawbacks, including difficulty in comparing measurements across sites and may result in artificially low or high population estimates (Brown and Boyce 1998). For example, in situations with small clusters of exceptional habitat, the ability of an observer to preferentially seek out the best habitat may lead to artificially high population estimates when trying to extrapolate to the rest of the habitat patch. Overall, it is a good method to develop an index of population size but not necessarily to estimate a true population.

4.1.4 Line-transect distance surveys

Overview: In this survey method, systematic parallel transects are established perpendicular to a baseline, and as each transect line is walked, the observer notes each individual of interest and records the distance of the individual to the transect line (Buckland et al. 1993). This results in a measure of density, and allows the calculation of an estimate of the total population size for the entire habitat patch. It is widely used for numerous animal species, most recently and notably for the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*), for which transect lines are placed 30 meters apart with observers recording each butterfly and its distance within 4 meters of either side of the transect line (Heather Keogh, USFS, pers. com.; Brown and Boyce 1998).

Pros: The primary benefit of distance surveys is that they yield a relatively accurate measure of population size that is comparable across widely different habitat types with little observer bias. Because transects are placed systematically across the entire site, extrapolation to the entire habitat patch yields an population estimate unbiased by variation in habitat. It is the one of the best accepted and most-used methods of population monitoring for the federally endangered Karner blue.

Cons: The main drawbacks to line-transect distance sampling is that it is more time consuming to set up and conduct than other, less accurate population survey methods. Futhermore, it is based on statistical models that may not work well with very large (over several thousand) or very low butterfly observations (less than 50) as tallied across all transects (Heather Keogh, USFS, pers. com. 2007). Additionaly, since the observer must walk a fixed route, key habitat may be missed if it lies in between two transect lines, though it is assumed that variations in habitat will fall equally within and outside of the survey area based on a random start.

4.1.5 Mark-release-recapture

Overview: The mark-release-recapture (MRR) method of estimating population size is one of the oldest and most-accepted methods of estimating population size. Individuals are captured, permanently marked in such a way they are unhindered, and released. The number of individuals captured and recaptured during the course of continued surveys is tallied, and estimates of the total population is derived from a simple equation (Otis et al. 1978, White et al. 1982).

Pros: MRR is the most scientifically and statistically sound method of estimating the size of animal populations. Frequently, it is the standard against which other methods are compared for accuracy.

Cons: To achieve the best results, it requires large numbers of observers covering all suitable habitat over a long period of time (e.g., for a butterfly species, positioning numerous staff across all potential habitat types at a given site for the entire flight window). Often, it is cost-prohibitive to implement at a wide scale and is used only at critical sites or in comparison studies to identify other, more efficient, but still accurate, monitoring techniques.

4.2 Habitat monitoring

Both biotic (vegetative) and abiotic components of habitat (hydrology, temperature, soil) can be monitored for changes over time. This report focuses on vegetative monitoring, which in addition to sometimes being a good surrogate for more difficult species monitoring, also has the advantage that changes are often directly related to management activities. The question of what attribute to monitor is much more difficult to answer for habitat than for species. Typical targets are aspects of vegetation structure such as density of plants, frequency of occurrence, and percent cover. Separate measurements can be taken for different types of vegetation, such as strata (trees, shrubs, groundcover), taxa group (grasses, forbs), or some aspect of management (flammable fine fuels, flammable course fuels, non-flammable fuels).

As above, the following descriptions of vegetative attributes and methods are meant as an overview only, and more thorough references should be consulted before setting up a monitoring program, such as Measuring and Monitoring Plant Populations (Elzinga et al. 1998). In addition to a brief description, a table showing varying levels of intensity and specific methods for each type of monitoring is provided.

4.2.1 Photographic

Overview: Photographic monitoring entails taking pictures to document changes over time. To be most useful, photos are taken from a permanently marked point, and pictures include a reference object, such as a tree or metal stake, which aids in comparing photos over time (Elzinga et al. 1998). Photographic monitoring is recommended to aid in the visual depiction and interpretation of other quantitative attributes like frequency, density, and cover.

Pros: Photo monitoring is fast, inexpensive, and provides a visual depiction of habitat changes (Table 3).

Cons: Most photo monitoring is qualitative, making statistical analysis difficult or impossible (Table 3).

4.2.2 Density

Overview: Density measures the number of individuals per unit area, most ofen from plots or quadrants, but it can also be calculated through distance measures such as nearest neighbor (Elzinga et al. 1998) (Table 4). For clonal species, defining an "individual" can be difficult since an observer may either count whole clones, such as a shrub with numerous stems, or count each stem separately. Measurements can also be taken in different size classes (seedling, non-reproducing, reproducing) to determine changes in recruitment patterns.

Pros: Density measures are effective in determining a change in the number of individuals, especially due to mortality or recruitment (Elzinga et al. 1998). Because results are expressed in per unit of area, they can be compared across different sized plots or quadrats.

Cons: Density measures will not pick up changes in vigor or biomass, such as the gradual increase of tree or shrub canopy over time or the dramatic increase in biomass of grasses following a prescribed burn (Elzinga et al. 1998).

Table 3. Comparison of photographic methods of monitoring habitat across level of rigor, time, and cost.

Method	Level	Statistical Rigor	Time	Cost	Pros	Cons
Photos	Qualitative	None	Very fast	Very low	Very fast, requires no setup.	Not repeatable without permanently marking photo point.
Photo-points	Qualitative	Very low	Fast	Low	Fast, provides visual depiction.	Qualitative, need to establish photo-points.
Photo-plots	Semi-quantitative	Low-moderate	Moderately Slow	Mod	Provides aerial depiction of small plots, useful for visual comparison with other data.	Complicated frame assembly, time-consuming camera set up, need other field data for high statistical rigor.

Table 4. Comparison of methods of measuring plant density across level of rigor, time, and cost.

Method	Level	Statistical Rigor	Time	Cost	Pros	Cons
Quadrats	Quan-titative	High	Moderate	Low	Statistically rigorous, minimal analysis.	Must develop firm rules for determining whether individuals on a boundary are in or out.
Distance measures (nearest neighbor, wandering quarters)	Quan-titative	High	Relatively Fast	Low	Works well if species of interest is sparse and not likely to fall in a quadrat.	Most techniques require a random distribution, and do not work well for clumped or well-dispersed species.

4.2.3 Frequency

Overview: Frequency is measured at the percentage of time a species occurs across a number of plots or transects (Table 5). Whether a species occurs in a plot is the only factor of interest, abundance within a plot is irrelevant. Because the likelihood of a species to occur in a plot increases with larger plot sizes, frequency measures are highly dependent on plot size and shape, and cannot be compared across multiple studies unless the plots are identical (Elzinga et al. 1998).

Pros: Frequency is an appropriate measure for almost any growth form, from annuals to rhizomatous grasses and requires no definition of what is an "individual" as with measures of density. It is also relatively stable throughout the growing season, once the plants of interest have germinated, unlike measures like cover that change dramatically as plants grow (Elzinga et al. 1998). Frequency measures are also relatively easy to obtain, with little training in methodology and have very little observer bias.

Cons: Changes in frequency are difficult to interpret, because they indirectly measure the spatial distribution and density of species. Variations from year to year may be due to either or both of these factors. It is therefore difficult to determine how biologically meaningful changes in frequency measures are when compared to other, more easily visualized values, such as percent cover (Elzinga et al. 1998).

4.2.4 Percent Cover

Overview: Percent cover involves measuring the amount of ground a plant occupies from a birds-eye view perspective. It can be applied both to individual species as well as groups of species based on guilds (i.e. prairie plants or invasive species) or growth forms (i.e. trees, shrubs, forbs, and grasses). Percent cover can be measured by visual estimates in plots, quadrats, or small management units, or calculated from data collected along a transect (Elzinga et al. 1998) (Table 6).

Pros: Cover is both intuitive and ecologically significant, and can be applied equally well to species with different growth habits (trees versus herbaceous plants) and leaf sizes (fine-leaved grasses versus leafy shrubs). In addition, it measures equally well species that are small but common (such as seedlings) and large but rare (single trees or shrubs) (Elzinga et al. 1998).

Cons: Cover may change over the course of the growing season, making it critical to monitor at the same time each year. Differences from year to year may be due to both changes in the number of individuals as well as changes in reproductive vigor, making results difficult to interpret (Elzinga et al. 1998). Some approaches are time consuming, require specific equipment, and those that rely on visual estimates have an unknown degree of observer bias.

Table 5. Comparison of methods of measuring plant frequency across level of rigor, time, and cost.

Method	Level	Statistical Rigor	Time	Cost	Pros	Cons
Macroplots with subplots	Quan-titative	Moderate	Relatively slow	Low	Study area is thoroughly sampled, good for controlled experiments.	Very time-consuming to mark and relocate each random subplot within the macroplot.
Transect with quadrats	Quan-titative	High	Fast	Low	Faster and more powerful at detecting change if transects are permanently marks and same quadrats are resampled.	Need to carefully select appropriate plot size. The transect functions as the sampling unit (not the quadrat), so many transects are needed for statistical rigor.
Transect with nested plots (of different sizes)	Quan-titative	High	Mod. fast	Mod.	Different sized plots are much more powerful at detecting meaningful change in stage classes (seedlings, mature) for multiple species or guilds.	Slower and less efficient than using only one plot size, which is recommended if measuring only one species.

Table 6. Comparison of methods of measuring plant percent cover across level of rigor, time, and cost.

Method	Level	Statistical Rigor	Time	Cost	Pros	Cons
Coarse-level visual estimates	Non-statistical quantitative	Low	Rel. fast	Low	Fast, efficient, minimal analysis required	May not detect small changes, need to first define mgt units, potential for observer bias, not statistical
Point-intercept transect	Statistical quantitative	Mod	Mod. fast	Med	Relatively fast and easy to set up, unbiased, minimal analysis	Sampling pin & frame required, species with low cover underestimated
Line-intercept transect	Statistical quantitative	Mod	Mod	Low	Moderately fast and easy to set up, minimal analysis	Difficult for fine-leaved species or lacy canopies, pole with level required
Visual estimates in quadrats along transect	Statistical quantitative	High	Mod. slow	Med	High statistical rigor	Somewhat time consuming prep and data analysis, potential for observer bias
Visual estimates in permanent plots	Statistical quantitative	High	Slow	Med	Highest statistical rigor, tracks specific location	Time consuming setup, data collection, and analysis, potential for observer bias

5. Examples from the DNR Landowner Incentive Program

The Landowner Incentive Program (LIP) conducts monitoring at three levels: project compliance, species, and habitat. Not all three types of monitoring are done at every site, but rather are selected based on the judgment of the LIP biologist and the objectives of the project.

5.1 Compliance Monitoring

Each project conducted at a given site must be evaluated to ensure it is completed. Simply put, compliance monitoring is checking to make sure the work was completed in an effective and timely fashion. This may involve projects conducted by private contractors such as a grassland planting, or a prescribed burn, or in-kind work pledged by landowners such as removal of invasive shrubs or putting in a burn break to offset the cost of a contracted prescribed burn. In general, compliance monitoring is the fastest and easiest to complete, and is done at every site for every project.

Certain situations may arise, however, that involve evaluating the quality of work. This may include reviewing a grassland planting that achieved a less than satisfactory germination rate, an effort to control shrubs that resulted in numerous resprouts, or a prescribed burn that was attempted but resulted in a large percentage of unburned habitat due to poor weather conditions. In such cases, a decision must be made as to whether or not the pledged work was completed in a satisfactory fashion. These cases can be difficult and are best dealt with by spelling out in the initial contract exactly what it is expected and the timeframe in which it must be completed. For example, a contract might state that to achieve compliance, a grassland planting must be done between April 15 and May 15 and result in a minimum of a 50% germination rate. For a prescribed burn, a contract might dictate that it must be conducted between April 1 and May 30, and burn at least 70% of the acreage of dead herbaceous material. It must be recognized, however, that as a contract becomes more stringent, the contractor or landowner has less flexibility to do the work, and the biologist's evaluation of project compliance becomes more difficult and time consuming.

5.2 Species monitoring

One of the foremost objectives of the LIP nationwide is to benefit rare species populations. Ultimately, the goal is to prevent listing of additional endangered species, downgrade the status of currently listed species (from endangered to threatened or to being delisted entirely), and to prevent critically imperiled species from being extirpated in the state or becoming extinct. These are lofty goals that are difficult to monitor, but gathering information that points to the ultimate recovery of species is critical to the success and continued funding the LIP at the national level.

In Michigan, one to two flagship or indicator species were selected for monitoring in each of the three LIP regions in the Lower Peninsula. The species were selected due to their exceptional rarity with most being federally threatened or endangered and because they are the focus of intensive management efforts to improve habitat and boost populations. In southwest Lower Michigan, management and monitoring is focused on the Karner Blue butterfly and the Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*), both federally endangered species with their last strongholds in Michigan. Mitchell's satyr is also the focus in southeast Michigan, along with the eastern prairie fringed orchid (*Platanthera leucophaea*), a federally threatened plant found only in the upper Midwest. In northern Lower Michigan, monitoring is focused on the dusted skipper (*Atrytonopsis hianna*), a state threatened butterfly that also functions as an indicator species of the quality of pine and oak barrens. Example protocols of monitoring for eastern massasauga (*Sistrurus catenatus catenatus*) and grassland birds are also provided for reference. The monitoring objective and methods for each species are outlined below, following the outline described in the section on Developing a Monitoring Strategy on page 1.

5.2.1 Karner blue butterfly

Objectives

Overall purpose: Document and monitor population size to track progress toward meeting federal recovery plan goals for Michigan federally designated metapopulations on private land (U.S. Fish and Wildlife Service 2003). Less rigorous monitoring will be used to document continued presence at sites not designated as official recovery units in the recovery plan for at least two years after management.

Level of rigor and detail: Rigorous enough for statistical modeling of population size.

Monitoring target: Karner blue butterfly populations.

Area of interest: Each major subpopulation of the metapopulations outlined in the Federal Recovery Plan (U.S. Fish and Wildlife Service 2003) that LIP is working in.

Methods and Design

Attributes being measured: Population density with each occupied site in a given metapopulation.

Sampling method: Methods vary by site, based on estimated population size. At sites with large populations (50 individuals or more), line-transect distance surveys are used (see page 6 for description). For sites with unknown populations, fewer than 50 butterflies per site, or less than 10 butterflies per transect as recorded with distance surveys, a modified Pollard-Yates survey is used, with the observer zig-zagging through a given area along each transect (see page 5 for a description).

Sampling design: Transects are laid out 30 meters apart, perpendicular to a base line that runs through the long axis of the site (Figure 1).

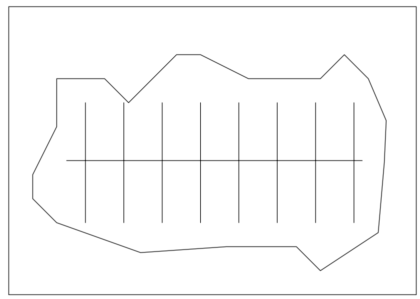

Figure 1. Schematic sampling design for Karner blue butterfly and oak savanna monitoring.

Data Collection and Analysis

Methods: Two observers (one to survey and one to record data) walk each permanent transect, noting each Karner blue butterfly within 4 meters of either side of the transect line, and record the butterfly and its distance (within 1 meter) from the line. Materials required include a sighting compass, 50 or 100 meter tape (optional) and two colors of flagging for laying out or relocating transects, two meter pole for measuring distances, data sheets, clipboard and pencil. Each site takes approximately ½ day to survey, and sites are surveyed once a week for a minimum of three weeks.

Analysis: Data is analyzed using the program DISTANCE to obtain an estimate of butterfly density and a population estimate is obtained by multiplying the average density by the size of the occupied habitat.

For more information, contact Heather Keough, Biologist, USDA Forest Service (hkeough@fs.fed.us), John Lerg, Wildlife Biologist, Michigan DNR (lergj@michigan.gov), or Christopher Hoving, Michigan DNR LIP Biologist (hovingc@michigan.gov).

5.2.2 Mitchell's satyr

Objectives

Overall purpose: Determine total population size and spatial location of each individual butterfly at occupied sites and monitor population trends over time. This is part of a much larger, ongoing study being conducted by the Michigan Natural Features Inventory and its partners.

Level of rigor and detail: Two levels of rigor will be implemented: a highly rigorous statistical calculation of population size at 1-2 sites per year, and a less rigorous estimate of population to track general trends at the remaining sites.

Monitoring target: Mitchell's satyr population and locations of individuals at each occupied site.

Area of interest: Each occupied satyr site being managed through the LIP program.

Methods and Design

Attributes being measured: Population size and spatial location of individuals.

Sampling method: At 1-2 sites, a mark-release-recapture study will be conducted throughout the entire flight window. The remaining sites will be sampled using visual encounter surveys. In both methods, the spatial location and sex of each individual will be recorded with a GPS.

Sampling design: All potential habitat will be thoroughly surveyed by a team of observers.

Data Collection and Analysis

Methods: For the MRR study, a team of observers captures each butterfly observed and marks it with a unique number using a fine-point Sharpee marker. A GPS point is taken at the point of initial observation and a wire flag marked with the individual's number is placed in the ground. Each time an individual is recaptured, it is recorded and a new GPS point and wire flag are established. Each site is monitored daily for the entire flight window, typically late June through mid July. Equipment needed includes an aerial photo of the site, butterfly net, butterfly binoculars, fine-point Sharpee markers, GPS unit, wire flagging, Ivy block, rubbing alcohol or Tech-nu (to limit risk of rash from poison sumac), data sheet, clipboard, and pencil.

For the visual encounter survey, a team of observers walks through all potential habitat, recording the location with a GPS point and the number and sex of each individual on a data sheet. Observers attempt to visit each site once a week during the flight window. Depending on the size of the site, the time observers at a site ranges from an hour to a full day. Equipment needed is similar to MMR, minus the wire flagging and Sharpee markers.

Analysis: Data from the MMR study is analyzed using traditional statistical methods to derive an estimate of total population. Home ranges can be calculated from GPS data if desired. GPS data can also be compared from either method with previous years observations to correlate use of habitat with management activities.

For more information, contact Daria Hyde (hyded@michigan.gov) or Barb Barton (bartonb1@michigan.gov), Conservation Scientists, Michigan Natural Features Inventory.

5.2.3 Eastern prairie fringed orchid

Objectives

Overall purpose: Census orchid flowering population and determine population response to management activities through statistical analyses.

Level of rigor and detail: A highly detailed census will be conducted throughout the entire site.

Monitoring target: Eastern prairie fringed orchid flowering population at a LIP project site designated as a critical population that must be maintained at a status of "high viability" to meet delisting criteria (U. S. Fish and Wildlife Service 1999).

Area of interest: Private and public land at Wildfowl Bay in Huron County, located in the Saginaw Bay region.

Methods and Design

Attributes being measured: Spatial location of each orchid, and where management is planned, the density of orchids within plots in the management unit.

Sampling method: The spatial location of each orchid colony will be recorded with a GPS. In areas proposed for habitat management, long, linear plots will be used to determine density.

Sampling design: Each management unit will have a treatment unit and a control unit of approximately equal size. Within each unit, a baseline that runs perpendicular to the environmental gradient (such as a gentle slope from the upland to the lake shore) will be established with a random start. Along the baseline, a systematic set of parallel plots 20 meters wide by 200 meters long will be established, oriented with the long axis encompassing the full range of the environmental gradient (Figure 2). This will reduce the level of statistical variation between plots due to slope position and soil moisture and increase the likelihood that variations in orchid density are due to management activities (Elzinga et al. 1998).

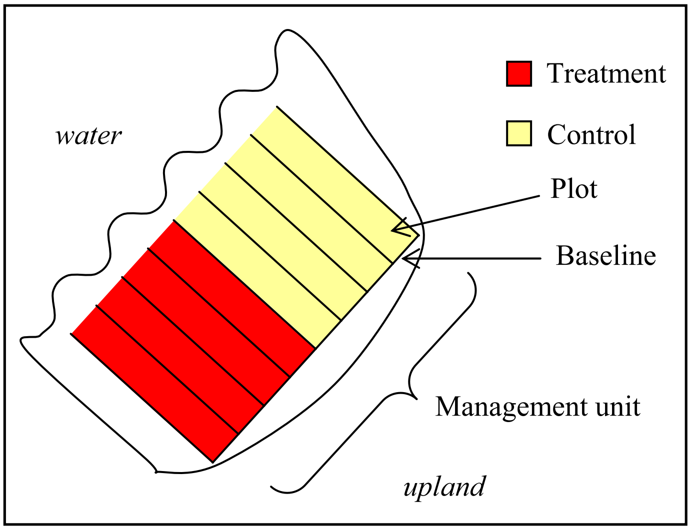

Figure 2. Schematic sampling design for eastern prairie fringed orchid monitoring.

Data Collection and Analysis

Methods: Teams with two observers each will walk the site, recording the location of each orchid group with a GPS point, noting how many flowering plants are present, and marking it with a wire flag to prevent double counting. An orchid group is designated as a cluster of plants falling within 10-15 feet of one another, the typical error rate for a handheld GPS unit under open sky. If more than one team is conducting the census, care must be taken to ensure they do not double count plants. This can be accomplished by first establishing the baseline and systematic set of parallel plots, and assigning a specific set of plots to each team. Where plot lines bisect orchid groups, the team will count and GPS only those orchids within the designated plot. Plants that fall directly on the plot line will be placed in the right-hand plot. Both ends of baselines and plots will be permanently marked with a short piece of rebar buried within a half inch of the soil surface. Wire flags will be collected at the end of the sampling day. Equipment needed will include GPS units (one for each team), rebar cut into 1-2 foot segments and rubber mallet for establishing baseline and plot corners, several 100 meter tapes, pins and a compass for laying out and relocating plots, wire flagging for marking orchids that have already been counted, and field forms, a clipboard, and pencil. At a large site, it is estimated that 2-4 teams of observers could census the orchid population in a day.

Analysis: The total population of orchids at a site will be compared from year to year to track progress toward meeting recovery plan goals. In areas receiving ongoing management, treatments will be compared to controls using standard statistical methods (ANOVA, etc.).

For more information contact Ryan O'Connor, Conservation Scientist, Michigan Natural Features Inventory (oconnorr@michigan.gov).

5.2.4 Dusted skipper

Objectives

Overall purpose: Document continued presence of dusted skippers at managed pine barrens, determine their use of planted nectar plant species, and obtain general estimates of population.

Level of rigor and detail: Population estimates will not involve statistical calculations or comparisons.

Monitoring target: Dusted skipper presence and rough estimates of population, and use of nectar plants where the species occurs at LIP project sites.

Area of interest: LIP pine barrens sites in northern Lower Michigan where dusted skippers have been documented or are likely to occur.

Methods and Design

Attributes being measured: Presence or absence of dusted skippers in each management unit, number observed, and notes on nectar plant use will be recorded.

Sampling method: Observers will use visual encounter surveys, focusing effort on clusters of nectar plants where skippers are most likely to be observed.

Sampling design: Sampling will be based on management units, burning history, and areas planted with nectar forbs. When comparing use of nectar plants in 2008 and beyond, it will also be desirable to establish a parallel survey of unplanted areas, such as a transect that meanders across the site with plots of the same size as used to establish planted forbs centered around naturally occurring clusters of nectar sources.

Data Collection and Analysis
Methods: Observers will meander through potential skipper habitat, focusing on clusters of nectar plants where skippers are likely to be observed. If desired, the number of skippers per transect length can also be recorded to obtain a crude estimate of population size. Management units will include both those that have been burned recently and those that have not, keeping a separate tally of habitat use and number observed in each area. Where forbs have been planted as nectar sources, specific attention will be given to the use of these plants by skippers. A GPS point will be taken at each skipper observation and compiled into a GIS shapefile for the purposes of adaptive management.

Analysis: Data will be assessed qualitatively to determine if skippers are still present in managed areas, and semi-quantitatively to compare number observed across different management units and areas planted to nectar forbs.

5.2.5 Eastern massasauga

Objectives
Overall purpose: Document continued presence of eastern massasauga at managed prairie fens and pine barrens, and determine their approximate level of abundance over time.

Level of rigor and detail: Population estimates may involve limited statistical calculations if sufficient data can be gathered.

Monitoring target: Eastern massasauga presence and rough estimates of population where the species occurs at LIP project sites.

Area of interest: Prairie fens and pine barrens where LIP is conducting management, targeting those sites where massasauga are known or suspected to occur.

Methods and Design
Attributes being measured: Presence or absence of eastern massasauga, number observed, and PIT tag number, if applicable.

Sampling method: Observers will use visual encounter surveys, focusing effort on habitat where snakes are most likely to be observed. This especially includes likely hibernacula sites on warm, sunny days in early spring (April and May) when snakes are likely to be basking in the open. If observers have appropriate training and expertise, snakes will be captured and implanted with a passive integrated transponder (PIT) tag. The tag, about the size of a grain of rice, consists of a coded microchip encased in glass. The tag is injected into a snake's body cavity through a syringe poked between its lower belly scales. PIT tags containing a unique identification number, and when scanned by a decoder, allow observers to distinguish new and repeated observations of individuals, leading to an estimate of population over time (Camper and Dixon 1988, Heyer et al. 1994, Jemison et al. 1995).

Sampling design: All potential habitat will be thoroughly surveyed by a team of observers.

Data Collection and Analysis
Methods: Observers will meander through potential massasauga habitat, focusing on potential hibernacula sites during optimal weather conditions (sunny to partly cloudy, warm days in early spring). Once snakes are found, they will be captured with a snake hook or snake tongs and placed in a fabric bag. If the snake has already been PIT-tagged, it will be scanned with a PIT tag decoder and the identification number will be recorded. If the snake has not been PIT-tagged, data on the sex, weight, and length will be collected. A PIT tag will then be inserted and the unique identifying code will be recorded. Location of all observations and captures will be taken with a GPS, and the PIT tag identification number will be recorded. Sampling equipment required for survey includes snake tongs or snake hook, fabric bag (such as a pillow case), scale, measuring tape, clear tubes or various sizes for safely handling snakes, PIT tags, PIT tag syringe, PIT tag decoder, GPS unit, field form, clipboard, and pencil.

Analysis: Data will be assessed both qualitatively and quantitatively to determine presence and estimated population size.

5.2.6 Grassland birds (Henslow's sparrow, grasshopper sparrow, etc.)

Objectives
Overall purpose: Document presence or absence of grassland birds at remnant and planted prairies.

Level of rigor and detail: Population estimates will be limited to presence/absence and general abundance.

Monitoring target: Grassland bird species, including, but not limited to Henslow's sparrow (*Ammodramus henslowii*) and grasshopper sparrow (*A. savannarum*) at LIP project sites.

Area of interest: Remnant and planted prairies in Lower Michigan.

Methods and Design
Attributes being measured: The presence or absence of rare grassland birds in grasslands in LIP project areas will be recorded.

Sampling method: Observers will use point count surveys, the standard and preferred method for documenting bird presence and population (Michigan Breeding Bird Atlas II Handbook 2002). Alternatively, transect surveys can be used to cover more habitat.

Sampling design: Observers will conduct point count surveys at predetermined points within or adjacent to suitable habitat.

Data Collection and Analysis
Methods: Point count surveys will be conducted using standard methodology outlined in the Michigan Breeding Bird Atlas II Handbook. At each predetermined point, observers will listen silently for 10 minutes, recording the species of each bird heard calling. If possible, the number of individuals of each species and approximate distance from the observation point will also be recorded. Counts should be conducted early in the morning (5:30 to 9:30 A.M.) to correspond with peak bird activity during the nesting season from May through June. Equipment needed includes binoculars, CD or tape of bird calls if observer needs a reference or review, GPS unit, clipboard, field form, map of site, and pencil.

Analysis: Data will be assessed qualitatively to determine if grassland birds are present and using available habitat.

5.3 Habitat monitoring

Although benefiting critically imperiled species is the overall long-term objective of LIP, the focus of projects in Michigan is to improve habitat for a wide variety of rare and declining species. Monitoring only a few key species does not fully encompass the program, and does not capture habitat management in areas where the species noted above do not occur. Therefore, more general habitat monitoring will be conducted as a means of measuring the progress of ecological restoration that will benefit the entire array of wildlife species dependent on the habitat.

In each region in Michigan, one to two priority habitats were identified at the outset of the program. Habitats were selected in tandem with the rare species that occurred in them and their rarity on the landscape relative to historical abundance. In southern Lower Michigan, grasslands and wetlands are the priority habitats. In grasslands, there is an emphasis on remnant prairies and oak savannas, which harbor Karner blue butterflies. Lakeplain prairies are also a focus, which are the primary habitat occupied by the eastern prairie fringed orchid. In wetlands, an emphasis has been placed on restoring prairie fens, which provide the exclusive habitat for Mitchell's satyr. In northern Lower Michigan, pine barrens and early successional jack pine forest are priorities, and provide the only nesting habitat for the federally endangered Kirtland's warbler in addition to a host of other rare species including the dusted skipper. Finally, in Michigan's Upper Peninsula the priority is restoring mesic conifers (primarily white pine and hemlock) to cutover hardwood forests, increasing diversity and improving habitat for a wide variety of raptors, migratory songbirds, and large mammals.

The monitoring objective and methods for each habitat or habitat project (shrub clearing, planting mesic conifers) are outlined below, following the outline described in the section on Developing a Monitoring Strategy on page 1.

5.3.1 <u>Prairie Fens</u>

Objectives
Overall purpose: Monitor restoration progress within management units at a given site at a coarse scale.

Level of rigor and detail: Coarse level of quantitative detail for non-statistical comparisons over time.

Monitoring target: Prairie fen habitat.

Area of interest: Individual sites, broken into management units two to five acres in size.

Methods and Design
Attributes being measured: Percent woody cover, percent cover herbaceous vegetation, percent cover of invasive species, percent cover of flammable materials (to facilitate management with prescribed fire).

Sampling method: Visual estimates to nearest 10% in each management unit, averaged between a team of two observers.

Sampling design: Divide site into two to five acre logical management units based on logical boundaries such as streams, ditches, boundaries of tree or shrub thickets, major trails, etc.

Data Collection and Analysis
Methods: Observers meander through each management unit, visually estimating each attribute to the nearest 10%. Teams of two observers compare their estimates, and record the average on a data sheet. Data is later entered into a GIS database with a record for each management unit in the site. Materials needed include an aerial photo of the site with management units clearly outlined and a clipboard and pencil to record data. In practice, field sampling takes approximately one day per year for a large site.

Analysis: Data is summarized by lumping observations into categories of "excellent," "good," "fair," and "poor" based on percentage classes. Results can then be compared visually on a map or in table form to track restoration progress.

For more info: contact Dan Kennedy, LIP Biologist, Michigan DNR-Wildlife Division (kennedyd@michigan.gov) or refer to recent a publication (Pearsall and Woods 2006).

5.3.2 Oak savannas
Note: This methodology follows U.S. Forest Service protocols for habitat monitoring in occupied Karner blue areas. Other less rigorous and time-consuming methods, such as the course-level metrics outlined for prairie fens, may be more appropriate in pine barrens and unoccupied oak savanna habitat. Deciding which method will be used a given site will be determined by the monitoring goals and objectives of the local LIP biologist.

Objectives
Overall purpose: Monitor Karner blue butterfly occupied habitat and track progress toward meeting management goals for habitat attributes.

Level of rigor and detail: Moderately high precision with ability to calculate statistical comparisons and significant levels of change.

Monitoring target: Sites one to ten acres in size within occupied and potential Karner blue butterfly habitat.

Area of interest: Southwest and west Michigan Karner blue metapopulations. This methodology could also be applied state-wide or region-wide in unoccupied habitat.

Methods and Design
Attributes being measured: Percent cover of: lupine, blooming nectar plants, ferns, invasive plants, canopy closure, and woody vegetation, as well as the frequency of savanna plants.
Sampling method: Observers make ocular estimates of percent cover, based on eight even coverage classes (0-12%, 13-25%, etc.). Estimates of canopy cover are measured using a densiometer. Frequency of savanna plants is measured by identifying plant species present on a predetermined check-off list.

Sampling design: Circular plots, each with a two meter radius, are randomly placed along permanent transects that bisect the habitat. Transects are laid out 30 meters apart, perpendicular to a base line that runs through the long axis of the site (Figure 1). About 10-20 plots are desired for each one to ten acre site. Extremely large sites can be divided in two for the purposes of collecting enough data to adequately described the habitat.

Data Collection and Analysis
Methods: Observers carry a two meter pole and at each sampling point, stand in the center holding the pole horizontal to the ground, and move it in a circle to demarcate the plot. Each habitat variable is estimated to one of eight even cover classes (selected for their ease of use and interpretation). Savanna species within the plot are recorded by marking a check-off sheet. Data is recorded on a paper data sheet.

Materials required include a compass, 50 or 100 meter tape and flagging for laying out or relocating transects, GPS unit for recording plot centers, 2 meter PVC pole, savanna species list, data sheets, clipboard and pencil. Once proficient, observers can complete one plot in 5 minutes or less, sampling 1 to 2 sites per day. Sites are sampled annually or biannually.

Analysis: Data is analyzed using traditional statistical methods, using software to calculate average and standard deviatation for each measure of percent cover as well as for frequency of savanna plants. Results are compared statistically each year to assess whether or not management activities are meeting their goals, which include 5-15% cover of both lupine and nectar plants, less than 5% invasive plants, 5-25% canopy, and 60% frequency of savanna plants.

For more information, contact Heather Keough, Biologist with the USDA Forest Service (hkeough@fs.fed.us).

5.3.3 Shrub control in a lakeplain prairie

Objectives

Overall purpose: Research which time of year and method of using cut-stump herbicide application are most effective in controlling dogwoods in a lakeplain prairie at Saginaw Bay and publish results in a minor journal (such as Natural Areas Journal or Restoration Ecology).

Level of rigor and detail: High level detail suitable for conducting rigorous statistical analysis. Sample size should be sufficient to determine significance at the alpha = 0.05 level.

Monitoring target: Clones of dogwood shrubs in an overgrown section of lakeplain prairie.

Area of interest: Michigan Nature Association's Saginaw Bay Wetlands preserve, located south of Geiger Road in Huron County.

Methods and Design

Attributes being measured: Survivorship following treatment with herbicides and prescribed fire, as well as percent cover of resprouts (relative to initial clone size) for all surviving clones.

Sampling method: Ocular estimations using Daubenmire cover classes (0-1%, 1-5%, 5-20%, 20-50%, etc.).

Sampling design: A ten acre field will be divided in two, one slated for burn treatment, the other a control. Each five acre field will be divided into four quadrants, with each quadrant contain four groups of shrubs, with each group containing five clones randomly assigned to one of five treatments (25% glyphosate, 35% glyphosate, 25% triclopyr, 35% triclopyr, control) (Figure 3).

Data Collection and Analysis

Methods: Each clone will be identified and marked during spring. The prescribed burn will conducted in spring of 2007 and will be measured according to standard parameters both at ignition and completion, including air temperature, relative humidity, average and maximum wind speed, and wind direction. Shrub treatment will occur in fall and winter of 2007-2008. Effectiveness of shrub treatment will be measured the growing season after treatment (summer 2008). Clones will be recorded as either completely killed or resprouting. Resprouts will be measured as a percent cover relative to clone size (i.e. 30% of clone area).

Materials needed include a compass and several 100 meter tapes to mark out quadrants in each field, flagging tape and numbered metal tags to mark shrubs and assigned treatment, and a field form with clipboard and pencil to record data. Weather during prescribed burn is measured with a handheld weather device. All management activity will be carried out by the Michigan Nature Association. It is estimated to take two days to set up the study design and locate and

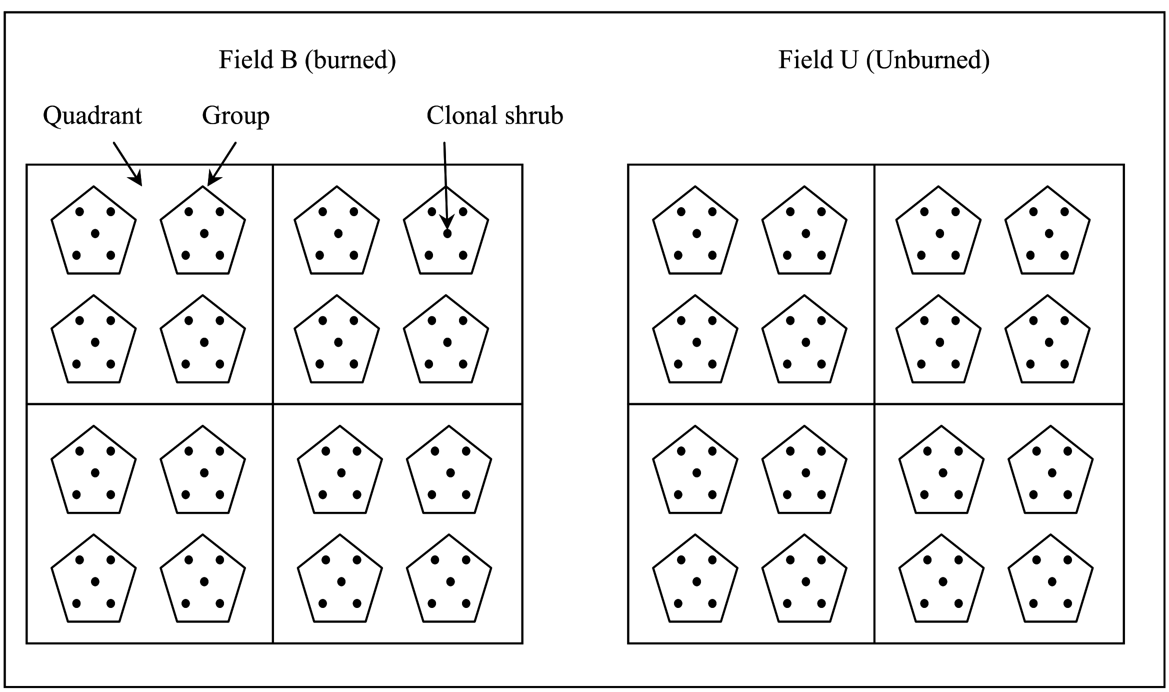

Figure 3. Schematic sampling design for shrub control study.

mark shrubs, and one day to collect the post-treatment data at the end of the study.

Analysis: All statistical analysis will follow a recent parallel study and publication by Donovan et al. (2007). Statistical comparisons will be conducted using a Pearson Chi-Square test to test for differences in outcome (live or dead) among treatments. To test for specific differences in outcome between each herbicide concentration and control, the Brunden method will be used (Everitt 1977, Donovan et al. 2007).

For more information, contact Ryan O'Connor, Conservation Scientist, Michigan Natural Features Inventory (oconnorr@michigan.gov), or Mike Donovan, Biologist, Michigan DNR (donovanm@michigan.gov).

5.3.4 Mesic conifer plantings

Objectives

Overall purpose: To monitor short and long-term survivorship of planted mesic conifers in the Upper Peninsula.

Level of rigor and detail: Moderately rigorous allowing calculation of basic statistics.

Monitoring target: Planted and naturally occurring mesic conifers seedlings.

Area of interest: LIP project sites in the Upper Peninsula.

Methods and Design

Attributes being measured: Stocking levels of mesic conifer seedlings at planting and after one, five, and ten years. Kotar Habitat Classification, browse pressure, and basal area of commercial species will also be recorded.

Sampling method: Observers record the number of seedlings present in a 1/50th acre circular plot (16.6 foot radius).

Sampling design: Circular plots will be arranged in a permanently marked three chain by three chain (3 x 3) grid system (one plot/acre) (Figure 4).

Data Collection and Analysis

Methods: A 16.6 foot rope will be staked in the center of the plot and the examiner will walk the perimeter of the plot and count all specified conifer seedlings within the plot. When possible, planted seedlings and native volunteers will be differentiated. Materials needed include a compass, several 50 or 100 meter tapes, rebar, and flagging tape to set up the sampling grid, and a 16.6 foot rope and stake, dbh tape, data sheet, clipboard, and pencil to collect the data. It is estimated that surveys will go relatively quickly, with five minutes or less needed for each plot. Ideally, the number of 3x3 grids needed at each site will be determined through consultation with statisticians based on the number of seedlings planted, the stocking rate, and the desired level of statistical rigor. Surveys should be conducted one, five, and ten years after planting.

Analysis: Data will be analyzed using traditional statistical methods, using software to calculate average stocking densities at initial planting, after five years, and after ten year. Results will be compared after each sampling period to assess survivorship over time and overall success of the plantings.

For more information, contact Kevin Swanson, LIP Biologist, Michigan DNR-Wildlife Division (swansonk@michigan.gov).

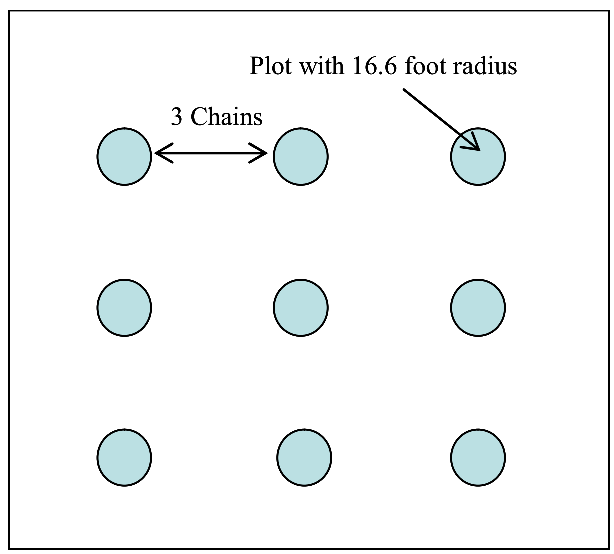

Figure 4. Schematic sampling design for monitoring survival of mesic conifer plantings.

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