https://aim.landscapetoolbox.org/design/

As you go through each step, fill out the corresponding **Monitoring Design Worksheet** which provides a step-by-step template for designing BLM AIM efforts. A Monitoring Design Worksheet template can also be found on the AIM Sharepoint site. We encourage you to work through the design process as an ID team, but completion of the worksheet should be done in coordination with your state lead and the AIM team at the NOC. Completion of the worksheet is an iterative process and can be revised and updated throughout the life cycle of your AIM project. To request assistance contact Aleta Nafus (**anafus@blm.gov**), AIM Terrestrial Implementation Lead at the BLM National Operations Center, or Nicole Cappuccio (**ncappuccio@blm.gov**), AIM Aquatic Implementation Lead at the BLM National Operations Center. Additional information on the concepts described here is also available on the **Landscape Toolbox site**.

Step 1a: Develop management objectives or goals related to resource condition and resource trend

- One of the first and most important steps in the AIM process is identifying management objectives that will be the focus of your monitoring effort. Management objectives should provide the context for why monitoring information is needed and how it will be used. Together, management and monitoring objectives (Step 2b) inform all subsequent decisions, including where and how points are selected and what will be measured and at what frequency.
- During this step, it is helpful to think broadly across programs and jurisdictions to identify the desired conditions in the landscape of interest. Then determine whether efficiencies can be gained in the combination of monitoring and assessment efforts if they share similar management objectives. Generally, each additional management objective will require some additional sampling effort. If multiple management objectives are to be addressed, ensure that adequate resources exist (e.g., sample points, crews, funding) to assess them all.
- After gaining management approval, assemble an interdisciplinary team to review existing documents which describe management history, planned management actions, previous data collection efforts, and relevant policy. Some examples of documents that should be included in your review are listed below:
    - BLM Land Health Handbook (4180)

    - Land Health Standards (click here for an overview of the relationships between land health standards, land health fundamentals, and AIM indicators)
        - Ecological processes
        - Watershed function
        - Water quality and yield
        - T&E and Native Species
    - Sage grouse habitat management objectives
    - Resource Management Plans
    - Commitments in NEPA documents or Biological Opinions
- Based on this review, what ***management goals*** would you synthesize? Provide citations to the relevant supporting background documents. Since many of these documents relate back to the Land Health Standards for the area, Land Health Standards are a good place to start. Then add objectives not covered by Land Health Standards as needed. These may include objectives related to resource trend.

Step 1b: Select additional ecosystem attributes and indicators to monitor
Review the terrestrial and lotic core and contingent indicators (indicator tables below; **BLM Tech Note 440**, **BLM Tech Reference 1735-1**, **BLM Tech Reference 1735-2**) and think about how these indicators relate to your management goals.

- The core and contingent indicators were selected because they are relevant across BLM managed ecosystems and can be used to address many BLM monitoring and assessment requirements, including Land Health Standards. For example, vegetation cover and composition data might be useful to address habitat, grazing, and fire recovery objectives.
- If there are management and monitoring goals which will not be satisfied by the core or contingent Indicators, consider adding supplemental indicators. See additional guidance in Step 4

Step 2a: Set the study area, reporting units, define the target population, document the geospatial layers used to describe these areas, and select the existing sample designs to be used for revisits

- First, identify the ***study area*** (e.g., field office), or geographic extent of the resource (e.g., vegetation, animals, streams) you want to report on (e.g., grazing allotment, watershed, field office, district, state). The study area should include the entire landscape area or extent of the resource that you plan to monitor to meet your management goals.
- Next, determine the desired ***reporting units*** (e.g., grazing allotment, watershed, field office, district, state). Reporting units are the geographic

areas for which indicator averages and error estimates will be computed and thus minimal sample sizes are required. Reporting units are typically nested within the study area, but depending on the management goals, the reporting unit and the study area can be the same. Generally, reporting units are administrative areas where AIM data need to be summarized for a particular analysis. In contrast to strata reporting units can be defined at any point during an AIM project life cycle and do not affect how AIM data is collected. The number of acres (terrestrial) or stream kilometers (lotic) in each of the reporting units are documented in step 3.

- Define your ***target population***. The target population (or sample frame) refers to the overall resource being monitored, and sample points are selected from within the target population. The definition of the target population should contain specific information about the resource of interest: its spatial extent, ownership status, and size (e.g. all streams or just first order streams?). Examples of the target population include: all BLM lands within a reporting unit, **all perennial, wadeable streams on BLM land**, and sage grouse habitat on BLM lands. (Monitoring Resources, 2017).
- Once your study area, reporting units, and target population are established, document the geospatial layers used to delineate these polygons. Whenever possible, use the same layers that were used to generate points in the master sample for both terrestrial and stream and river resources. More information about the master sample tool and the geospatial layers used to generate master sample points can be found on the **Understanding the Master Sample** webpage. Information about the number of acres (terrestrial) or stream kilometers (lotic) in the study area will be added in step 3.
- Lastly, when documenting a revisit design, select the sample designs and document the geospatial layers used to generate the monitoring locations which you plan to revisit, these may include probabilistic and targeted designs. Describe which sampled points you wish to revisit and review any rejected plots that may be suitable for revisits. Should those still be rejected or included in your revisit design?

Step 2b: Develop monitoring objectives related to resource condition and resource trend

- During this step, you will fill out either the **Resource Condition and Trend Objectives Tables** or the Monitoring Objectives Worksheet in the **terrestrial and lotic benchmarks tools**. Instructions on how to fill out the Monitoring Objectives tables in the benchmark tools can be found in the benchmark tools themselves.
- Identifying and documenting clear monitoring objectives is extremely important preparation for the design phase of an AIM monitoring effort. Objectives guide how and where to focus sampling efforts so that there is sufficient data to address your management goals.
- Objectives are also necessary for the data analysis phase of an AIM monitoring effort. Monitoring objectives must be identified before any data analysis can take place.
- Begin by listing your management goals in Column 1 of the **Resource Condition and Trend Objectives Tables** . As you fill out the table each management goal should have one or more corresponding monitoring objectives. Lotic projects with differing objectives among reporting units will need to complete separate **Resource Condition and Trend Objectives Tables** for each reporting unit (see step 2a).
- Monitoring objectives are quantitative statements that provide a means of evaluating whether management goals were achieved. Monitoring objectives should be specific, quantifiable, and attainable based on ecosystem potential, as well as resource availability, and the sensitivity of the methods. Quantitative monitoring objectives may be available in your resource management plans (e.g., for sage grouse, Clean Water Act requirements) or they may be developed in the monitoring planning process.
- At a minimum, monitoring objectives should include: 1. the ***indicator(s)*** that will be monitored; 2. quantitative ***benchmark(s)*** for each indicator (**read more about benchmarks**); and 3. if you seek to make inference beyond the plot or reach-scale, the ***proportion of the resource that is required to meet the benchmark***. The most robust monitoring objectives also clearly identify the reporting units, a time frame for evaluating the indicator(s), and the desired confidence level (e.g., 90% confidence) in the objective.
- Resource trend objectives are used to describe the desired change in indicator values over a specified time period. These may include short-term objectives (e.g. evaluating recovery of a study area following a disturbance) or long-term objectives. At a minimum, select an indicator(s)

and the related measurement units for each management goal, the desired direction of change (upward, downward, or no change), and the time period for assessing change. The time period for assessing change could be the amount of time following or preceding a particular event (e.g. change in management or a disturbance); a comparison between two time periods (e.g. 2015-2019 compared to 2020-2024), or a fixed interval (e.g. trend over the next 10 years). For robust trend analyses it is beneficial to specify the magnitude of desired change – this is equivalent to a benchmark for trend and is the specific amount or range that the indicator should change in order to meet your objective.

- The interdisciplinary team should document benchmarks, benchmarks sources, and the proportion of the resource that is required to meet the benchmarks for each indicator of interest in columns 3-5 of the **Resource Condition and Trend Objectives Tables.** This exercise will quickly reveal indicators for which you will need to seek professional judgement, the development of ecological site descriptions, or other resources to aid in future data interpretation.
- For more information, see the webpage on **benchmarks**.
- Example monitoring objectives for condition:
    - Terrestrial:
        - *Management goal*: Ensure achievement of land health standards for threatened and endangered (T/E) species; maintain sage grouse habitat according to the habitat standards as described in the Resource Management Plan.
        - *Monitoring objective*: Determine whether sagebrush cover of 15% or greater is maintained across 70% of the Resource Management Planning area with 80% confidence.
    - Lotic:
        - *Management goal*: Manage streams and rivers using the sustained yield principle and in compliance with Federal Land Policy and Management Act and the Clean Water Act.
        - *Monitoring objective*: Determine whether salinity levels are at or below 300 µS/cm in 90% of perennial wadeable stream miles in the Resource Management Planning area, over a 2 year period, with 80% confidence.
- Example monitoring objectives for trend:
    - Terrestrial
        - *Management goal*: Ensure achievement of land health standards for threatened and endangered (T/E) species;

maintain sage grouse habitat according to the habitat standards as described in the Resource Management Plan.
        - *Monitoring objective*: Determine whether sagebrush cover has increased by 10% 5 years following seeding treatment.
    - Lotic:
        - *Management goal*: Manage streams and rivers using the sustained yield principle and in compliance with Federal Land Policy and Management Act and the Clean Water Act.
        - *Monitoring objective*: Determine whether average salinity levels have decreased by 50 µS/cm in the Resource Management Planning area from 2011 to 2020.
- More guidance on selecting indicators and setting benchmarks can be found in Technical Note 453: Guide to Using AIM and LMF data in Land Health Evaluations and Authorizations of Permitted Uses

Step 3: Select criteria for stratifying the study area (if necessary)
In this step you will identify whether strata are necessary and, if so, which strata or different types of land or water body types will be used for your design and begin filling out the Sample Design Table. Specifically, you will identify which strata you will use, how many sample points will be collected in each, and the amount of resource that will be represented by each stratum.

- ***Stratification*** can be used to distribute sample points across the landscape or resource and/or to ensure that areas of interest, including reporting units, are sufficiently sampled (i.e., have adequate sample sizes for reporting). Stratification considers properties of the study area like physiography, management boundaries, ownership, or other attributes of the resource that need to be described to meet the monitoring objectives. Stratification decisions should be captured in Sample Design Table.
- The design process will typically start with the creation of a simple, *minimally* stratified, design across a broad area (e.g., LUP/RMP). That "draft" design will then be reviewed by the project lead and ID team to determine if the design is adequate or if different point allocations are necessary in certain areas. If more points are needed in specific areas, you may then add an ***intensification*** to the design in the future to ensure that you will obtain enough necessary information within those areas.
- Additional strata may be included in the design if deemed necessary. However, adding strata should be done with considerable thought, as sample sizes, required resources, and the complexity of data analysis increase with each additional stratum. Justify in 1-2 sentences why you have chosen your

particular stratification scheme – do you strata add to your ability to answer your monitoring objectives?

- Additional stratification or point allocation approaches include but are not limited to:
  - Resource Management Plan boundaries
  - Strahler stream order categories
  - Habitat areas for sage grouse or other species of special concern such as T/E fish species

Terrestrial Designs

- <u>The general recommendation for terrestrial monitoring designs is to not stratify. If stratification is necessary, the recommendation is to stratify by physiographic properties</u>**. Note that physiographic properties are not typically used as reporting units.**
  - Stratifying by physiographic properties also helps allocate sample points to underrepresented or more variable portions of the landscape without sacrificing the ability to describe the whole landscape.
- Terrestrial monitoring has often stratified by ***LANDFIRE biophysical setting (BpS) groups,*** a remote sensing-derived layer that is conceptually very similar to NRCS Ecological Sites but is available as a continuous and consistent layer across the western US and therefore is used in the master sample. BpS groups represent natural vegetation potential on the landscape based on biophysical environment and historic disturbance regimes. For more information, see the page on **stratifying using LANDFIRE BpS.** Other biophysical strata may be preferable in some cases. If you are planning to use alternate biophysical strata, you will need to create a GIS layer that spatially displays the stratification scheme and identifies the stratum names in the attribute table. This layer needs to be shared with the NOC and partners.
  - For example, if you are grouping ***Ecological Sites***, please send a polygon shapefile of the Ecological Sites that you grouped together either already "dissolved" and named by group, or with an attribute field containing the stratum name that each Ecological Site belongs to.
- To identify the design strata, examine the GIS layer that you plan to use to develop your strata (e.g. LANDFIRE Biophysical Setting) in GIS and determine how many different types of terrestrial ecosystems exist within your study area.
  - If you have more than 10 different types in the study area, you may need to combine some of these ecotypes into groups in order to keep the design simple and manageable. For example, you may want to combine all BpS groups which are dominated by Wyoming Big Sagebrush into a

single stratum. Document these groupings in the Stratification Lookup Table found in the appendix of the monitoring design worksheet.

        - Often, several different types of land that individually make up a small portion of the landscape will be grouped into an “Other” category to avoid inflating the number of points required by the design. If any of the strata are less than 3,000 acres or 1% of the study area, the NOC recommends that you group them with other strata so that the resulting stratum is greater than 3,000 acres or 1% of the study area.
    - If you group several polygons to obtain your final strata, be sure to document how you made those decisions, and which polygons were combined to create the groups.
- Note that there are specific formats that need to be followed when you are compiling strata. Please refer to the **Terrestrial AIM Project Design Data Requirements** for formatting instructions.

Lotic Designs

- The general recommendation for stream and river monitoring designs is to limit the use of strata unless we will not meet minimum sample sizes to report on specific areas or species of interest. However, all designs will be stratified by Strahler Stream Order, grouped into three categories:
    - Lower 48: small streams (1st and 2nd order), large streams (3rd and 4th order), and rivers (5th order and above).
    - Alaska: small streams (1st order), large streams (2nd and 3rd order), and rivers (4th order and above).
    - If any of the stream or river strata contain less than 1% of the total stream kilometers or result in less than three sample points, we recommend grouping that stratum with another stratum.

Step 4: Select and document supplemental monitoring methods; estimate sample sizes; set sampling frequency; develop implementation rules

Step 4a: Select and document supplemental monitoring methods (if required)

- Decide whether ***supplemental indicators*** are necessary to meet management and monitoring goals. Keep in mind that adding supplemental indicators will require additional work in the field and beyond (see below).
- If supplemental indicators are necessary to meet management goals and monitoring objectives, first evaluate the core and contingent methods to determine if these supplemental indicators can be calculated using a core or contingent method.

- If a necessary indicator cannot be calculated from the core or contingent methods, select a ***supplemental method***:
  - Select supplemental methods that are used by other monitoring programs, state regulatory agencies, and are documented clearly in a peer-reviewed method manual.
  - Other desirable characteristics of supplemental indicators and methods include: relevance to Land Health Standards; ability to be measured objectively and consistently in many ecosystems by different observers; scalability; and applicability to multiple objectives.
  - Be sure to document the rationale for including the supplemental indicator as well as a citation for the method. We strongly advise against creating new methods or modifying existing methods.
- Additional tasks to complete in order to implement supplemental indicators include:
  - Practicing the supplemental method in the field to establish how it will work with AIM plot or reach layout and requirements (e.g., not walking on left side of a terrestrial transect, for lotic sampling, collecting water quality before instream sampling begins)
  - Identifying data management protocol and tools for the supplemental method, including: data recording, electronic data capture, data storage, quality assurance and control, and analysis and reporting.
  - Establishing calibration standards for the supplemental method.
  - Identifying capacity to provide technical support for the supplemental method (e.g., who will answer questions about it during the field season).
  - Planning sufficient training for successful implementation of the supplemental method. This cannot be during a core methods training, although we recommend that it follow soon after.
  - Considering the additional time required for a crew to complete the supplemental method at each sampling location to ensure that the cumulative impact of supplemental methods does not impair the crew's ability to visit the desired number of plots or reaches..
  - Using the process outlined in tables 1, 2 and 3, determine how data generated from supplemental methods will be used to inform management decisions

Step 4b: Estimate sample sizes (Completed by National AIM Team)

- The number of monitoring locations needed for a monitoring design is a function of several factors: 1) the amount and quality of existing or legacy monitoring information, 2) the amount of resource that needs to be monitored, 3) statistical considerations, and 4) funding and personnel limitations.

- If significant amounts of comparable, high quality monitoring data already exist, the required sample size may be smaller than when such data is not available. Make sure to inventory pre-existing monitoring data when you begin to plan your AIM monitoring efforts.
- If stratification is used, the number of points required in each stratum should balance the proportion of the resource that will be represented by the stratum with the weight of the points (see below for more information).
    - For more information about statistical considerations, see Step 5.
    - A terrestrial field crew with 3 people can monitor approximately 50 plots per season.
    - A lotic field crew with 2-3 people can monitor 25-35 reaches per season.
- The default method for allocating sample sizes is to ***proportionally allocate points*** based on the area/length that the sampling frame or stratum covers. For example, if you plan to sample 50 points in a season, chose to stratify, and have a particular stratum that covers 10% of your study area, then you would sample 5 points in that stratum.
- The recommendation is to start with the proportional allocation approach and then adjust sample sizes up or down as needed. Frequently, the number of sample points will need to be increased in areas that cover a small percentage of the study area in order to achieve a ***sample size*** sufficient enough to provide information for management decisions. For example, black sagebrush areas often occupy a small portion of the landscape but provide important sage grouse habitat, and thus will need to be well represented in a design that is focused on sage grouse.
- If you increase the desired number of points in one stratum, others may have to be reduced, to keep the total number of points sampled the same. Changing sample sizes will affect point weights (see below) in each stratum, and should be done with care.
- Allocating zero points to any strata is not recommended because it will limit your ability to draw inference to the entire landscape, and should not be done unless: 1) the stratum is not part of the target population defined by your monitoring goals and objectives (e.g., open water in a terrestrial monitoring effort) or, 2) the stratum is being monitored as a part of a separate monitoring effort.
- ***Point weights*** are the area (in acres or hectares) or length (in stream kilometers) represented by an individual sample location. Weights are used

to generate statistical estimates of resource status or condition across the landscape (i.e. proportional estimates). Specifically, weights are used to adjust the relative influence that each point has on the final estimates; points with larger weights have more influence, and points with smaller weights have less. The weight of each point depends on the specifics of the design, how it was implemented (see final designations), and the reporting area of interest.

Instructions for filling out the remainder of the Sample Design Table:
When no stratification is used, fill in the first row of the **Sample Design Table** with information regarding your entire sample frame.

- ***Proportional area or length:*** Divide the number of acres or stream km represented by each stratum by the total number of acres or stream kilometers in the entire study area to get proportional areas/lengths.
- ***Proportional points per stratum:*** Calculate the proportional number of points per stratum by multiplying the proportional number of acres or stream km by the total number of points to be sampled.
- ***Final Points per stratum (optional):*** If a proportional allocation of points will not satisfy your monitoring objectives, adjust the number of points that will be monitored for each stratum. Calculate the number of sites you would like to sample in each stratum, taking the four factors mentioned above into account. In the event that points are allocated in a way that is highly disproportionate to the proportion of the landscape that is represented by a given stratum, the proposed point allocations should be reviewed by someone at the NOC. Final point numbers normally refer to the total number of sampling sites visited within one sampling cycle (e.g. over 5 years). If specifying point number for a different time period this should be specified in the sample design table
- ***Point weights:*** Once all of the other columns in the **Sample Design Table** have been finalized, point weights can be calculated as the total number of acres or stream km within the stratum, divided by the number of points to be monitored for that stratum. For assistance in completing this section contact the NOC, particularly for more complex revisit designs.

Step 4c: Define revisit parameters (Use the Revisit Frequency Table to document decisions made in this section)

i) Set the revisit frequency and the number of years sampled per cycle -
Most monitoring efforts need to be spread out across several years to accommodate field crew capacity and to ensure that interannual variability is captured by the monitoring data. Once the total number of sample points and the point weights have been calculated, determine how many years of sampling

might be necessary to achieve the desired sample size. Factors to consider when setting revisit frequency include:

- Reducing bias from year-to-year climate variability (e.g., drought) by using a rotating ***panel*** design (where a certain number of points, all contributing to the same design, are sampled over several years) is typically recommended. Rotating panels help ensure that sample points are randomly distributed across the entire project area every year.
    - For example, a 20-year design with a 5-year revisit frequency would consist of 5 revisit panels, where each point is assigned a specific year in which it should be sampled. All points in the same panel will be revisited every 5 years for a total of 4 data collection efforts (cycles) at each point over the 20-year design. See the Monitoring Design Worksheet example for more details.
    - In contrast, when specific geographic areas are sampled in only 1 or 2 years rather than during every year of the design, bias from climate variability can affect condition estimates. However, it may be appropriate in Lotic sample designs to sample only a proportion of the years in each sampling cycle based on logistical and funding limitations e.g. 2 years sampled out of 5.
- Detecting change in condition through time (i.e., trend) is a common monitoring objective that requires setting an interval for revisiting points over time. Questions to consider when setting revisit frequency include:
    - What revisit frequency makes sense relative to the disturbance or management event? For example, ES&R monitoring dictates annual re-visits for three years, whereas monitoring stream geomorphic changes following livestock removal might occur on a 3 to 5-year basis, and changes in upland condition might occur over 5-10 years.
    - How resistant and/or sensitive to disturbance are the areas that you are monitoring? How resilient are those areas following disturbance events? You may want to consider establishing more frequent revisit intervals in areas that are more sensitive or less resilient to disturbance than in areas that are highly resistant and resilient.
    - How variable and/or sensitive are the indicators you will use to evaluate your management objectives? You may want to

        - consider more frequent revisit intervals for indicators that are particularly sensitive to inter-annual variability in abiotic conditions.
    - What resources will be available (e.g., funding and personnel)?
- The default revisit interval for Resource Management Plan effectiveness monitoring is every 5 years for terrestrial systems and every 5 years for lotic systems, unless natural conditions or management actions occur that would elicit landscape-scale responses on shorter time-scales.

ii) Set number of cycles and the total duration of your design – A cycle is a defined time period over which a group of panels are visited e.g. 5 years. The number of cycles in your design depends on both your revisit frequency and total design duration such that numbers of cycles = design duration ÷ revisit frequency.

- Typically for terrestrial revisit designs the standard number of cycles is 4 with a total design duration of 20 years (using a 5-year revisit frequency).

iii) Set the proportion of your design points which will be revisited - Depending on objectives, only a subset of points may need to be revisited. In general, trend assessments are most effective when by revisiting approximately 80% of the points sampled within a year or cycle. Factors to consider when determining the proportion of design points which will be revisited include:

- Revisitation involves resampling existing points and can help to explain changes over time. The higher the proportion of revisit points, the more statistical power you have to detect trend.
- Non-revisit points add new sampling locations across the landscape and help to explain spatial variability in resources. The higher the proportion of non-revisit points the higher the precision of condition estimates.
- What are your management goals? If trend assessment is a priority and existing trend data is unavailable a higher proportion of revisits will be beneficial. Conversely, if management goals are more focused on precise condition assessment at a single point in time, a higher number of non-revisits points will be preferred.
- In general, a good balance between trend and status estimates is reached using 80% revisits and 20% non-revisits each year.

- Some monitoring efforts will not need to determine sampling frequencies on account of various project constraints or intentional design.

Step 4d: Develop implementation rules

- Review standard AIM implementation rules, including rejection criteria, on aim.landscapetoolbox.org under Data Collection.

- Proper design implementation involves documenting the fate of each point in a given design. Documentation of point fate should be tracked using the Terrestrial Plot Status populated in Collector Map, and the Lotic Office Evaluation Webmap. For more information and to download these tools and their instructions, visit the **Point Evaluation and Rejection page**.
- If the implementation rules need to be customized to meet you monitoring objectives, consult with the NOC when developing the additional criteria to ensure the design will remain statistically valid. For terrestrial design implementation consult the **TerrADat Ingestion Tree** to review the minimum requirements for Terradat data ingestion.

Step 5: Collect and evaluate available data to determine sampling sufficiency and the validity of the strata (if available)

- In this step, you will use existing data to determine if you need to make any adjustments to the samples sizes that you identified in step 4. Consult with the NOC, USU, and Jornada to implement this step. This step addresses the following question: "How much data should be collected across the study area to address the management goals and monitoring objectives?" Analysis of existing data and monitoring objectives will provide information about the number of points required to detect whether an objective for a particular indicator has been met (e.g., the number of sites needed to determine whether 70% of areas with the potential to support sagebrush have greater than 15% sagebrush cover).
- Consider sample size requirements in terms of your management objectives and the information needed for the decision at hand. Look at multiple indicators and take a preponderance of evidence approach. For example, if one indicator requires many more samples than the others, then you may be able to rely on the preponderance of evidence from the other indicators to make your decision. If many indicators are showing insufficient information, then you likely need more monitoring points.
- Most AIM efforts seek to estimate the proportion of a resource (in acres for terrestrial ecosystem and kilometers for perennial streams) within the project area that are meeting or not meeting objectives, within a certain level of confidence. Given the goals of estimating condition, the general recommendation for such monitoring efforts is to take an approach that minimizes the likelihood of not detecting a difference in conditions when a difference actually exists (i.e., Type II errors).
- From a statistical standpoint, the sample size required (e.g., number of plots or stream reaches) to determine the proportion of the resource that is achieving the desired conditions will depend on three factors: 1) the amount

of existing AIM-compatible data (e.g., WRSA points, LMF plots), 2) estimated proportion of data meeting an objective, and 3) the desired confidence level.

- For many new AIM projects, data are already available from other AIM monitoring efforts or from the Landscape Monitoring Framework (LMF) or Western Rivers and Streams Assessment (WRSA). Always evaluate and consider using pre-existing data when determining sample sizes.
- Depending on monitoring objectives and previous sample date and condition, LMF, WRSA, and other AIM data may be used to offset sample size requirements for new monitoring objectives. At a minimum, these data can be used to help assess the proportions of a resource that are meeting an objective and help estimate the required sample size for your monitoring objectives.
- If you seek to have a high degree of confidence (e.g. 95%) in the condition estimates derived from your data you will require large sample sizes. To balance the desire to minimize Type II errors (i.e. failure to detect a difference) with the need for a realistic workload, the specific recommendation is to establish sample sizes using an 80% confidence interval. If monitoring data are to be used to support a contested management decision, higher percent confidence interval with smaller margin of error may be necessary.

- To answer your question "How much data do I need to address my management goals and monitoring objectives," follow the steps below:

    A. Identify the indicators of interest and the proportion of the landscape that is likely be in a given condition (e.g, % of landscape having suitable or unsuitable habitat). It can be helpful to look at pre-existing data to estimate the proportion of sites currently meeting monitoring objectives as a starting point.

    B. Select an appropriate confidence level for the monitoring objective.

    - With the information identified above, you can then estimate your initial sample sizes with **these sample sufficiency tables**.

- After each year of sampling, it is recommended to do a more formal sample sufficiency analysis with the collected monitoring data to determine if your current sampling intensity is appropriate or if you need to plan to increase this intensity to obtain a larger sample size.
- Additional points can be added to a monitoring effort to increase the precision and accuracy of estimates as needed. If adding more points is not feasible, an alternative approach is to accept a lower level of confidence for some reporting units. In these cases, data from other sources (e.g., remote sensing, use data) can be valuable for a preponderance of evidence approach.

Step 6: Apply stratification and select statistically valid monitoring locations

In this step you will document the process of creating, reviewing, and finalizing the sample design. Additionally, document how the design(s) were created, any additional notes and information on the sample frame, and what revisions were made and why. If the design process or sample sufficiency analysis resulted in different sample sizes than those identified in step 4b, document those changes here as well. Consult with the national AIM team to implement this step.

- Standard AIM statistically valid monitoring designs are developed using the GRTS method **(Stephens and Olsen 2004**).
- Several tools are available to complete statistically valid monitoring designs. For brand new designs the standard approach is to use the master sample point draw which makes designs more consistent and facilitates analysis and reporting. For more information, please visit the Understand the Master Sample page. For designs encompassing previously sampled points the standard approach is to spatially balance new points around existing sample locations and revisit a proportion of existing locations. More information on this process can be found in the Revisit Designs Presentation
- For terrestrial projects in small geographic areas, one-year designs or designs that exclude some areas of the landscape, we recommend the web-based Spatially Balanced Sampling tool hosted by the Jornada Landscape Toolbox. Either approach can result in a statistically valid design and data that can be uploaded to the national AIM database.
- Once a draft design has been created, review the draft design to make sure it will meet design criteria described in steps 1-4.
- Evaluate the need for intensification of sample points within reporting units. Questions to ask when reviewing your draft design include:
  - Do I have enough points in all of the areas for which I need data?
  - Are there any areas that were left out of the design that should have been included?
  - Do you notice any inappropriate clumping (i.e., too many points) of points in a certain area(s)?
- If needed, work with the NOC, NAMC, or Jornada to refine the sample design.

- Once the final design is achieved, document the following in step 6: what tool was used to create the design(s), who ran the design(s), what (if any) modifications were made to the draft design(s), and where the design files are stored. If modifications were made, please include an updated and final version of the Sample Design Table in Step 6 as well.

Step 7: Develop quality assurance and quality control (QA and QC) procedures and data management plans

- Review the standard QA and QC procedures for AIM efforts to ensure that you understand your roles and responsibilities when it comes to data management. General information can be found on the AIM Landscape Toolbox under **Quality Assurance and Quality Control**.
    - Terrestrial protocols are described in the **2020 Terrestrial Data Management Protocol** on the AIM Landscape Toolbox (**aim.landscapetoolbox.org**) and in the *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems*.
    - Lotic procedures are found in the **Lotic Data Management and QAQC Protocol**.
- Data management for BLM AIM efforts is supported by the NOC through standardized electronic data capture and management. More information is available on the AIM Landscape Toolbox under **Data Management**.
- Document what data management and QA and QC procedures will be implemented during each field season, including whether you plan to follow or add to the standard procedures.
- For supplemental monitoring methods, additional data management plans and QC procedures will be needed, including training and electronic data capture and storage. Document those procedures here