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A Ten-Step Program that Links Monitoring to Management

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"When you've got a situation where there's not enough money to go around, you have to pick your highest priorities" (Former DOI Secretary Sally Jewell, July 19, 2013). When the U.S. Fish and Wildlife Service (USFWS) established a new policy in 2014 for population monitoring on the national wildlife refuges, it said that the scientific monitoring conducted on refuges should be linked to management issues on the refuge or broader landscapes. The policy described a process (Figure 1) by which surveys should be selected. It included a handbook with guidelines for the protocols used in conducting the surveys, and it promoted conducting surveys in coordination with partners that also had an interest in the results.

Selecting surveys has several straightforward steps that start with making a comprehensive list of all possible surveys—including those that are relevant to measuring the impact of climate change. The next step is to prioritize surveys by objective criteria that consider the purpose of the surveys. Surveys can then be selected by assigning a status that considers final priority scores along with the capacity (in personnel time and operational costs) of the refuge to conduct it. Future surveys

Citation: Weber, Samantha, ed. 2017. *Connections Across People, Place, and Time: Proceedings of the 2017 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites*. Hancock, Michigan: George Wright Society.

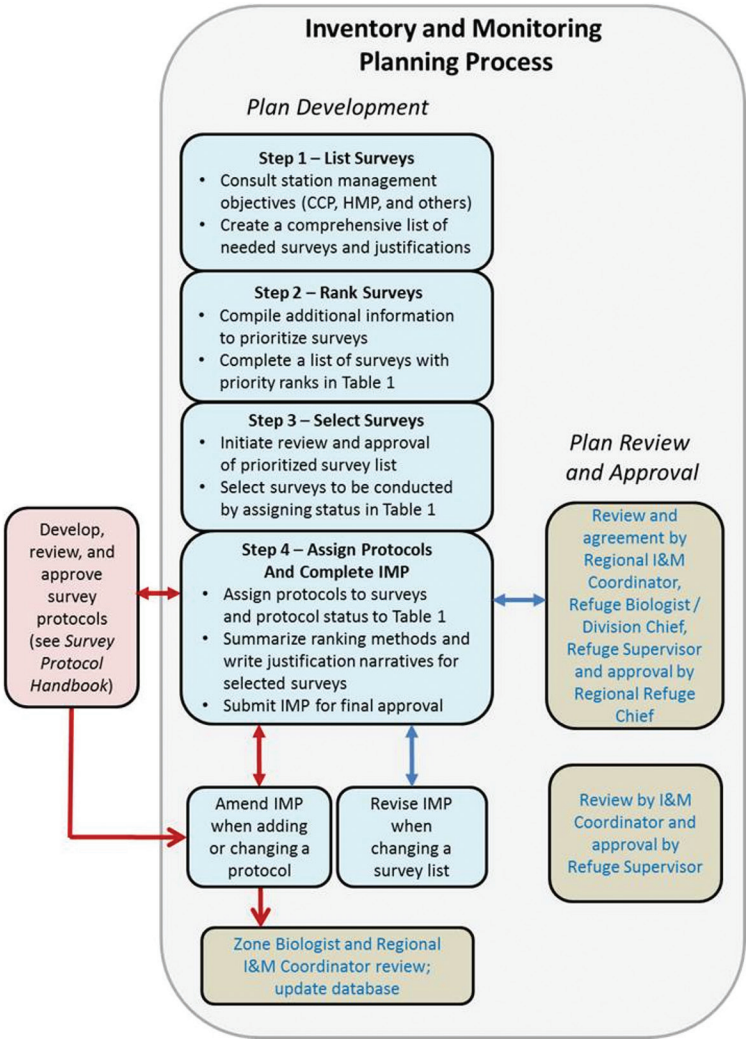


Figure 1. The process for developing inventory and monitoring plans and protocols in the USFWS inventory and monitoring policy.

are those that are low priority or would require lots of additional capacity. A refuge's inventory and monitoring plan defines the surveys that are or will be conducted over the life of the plan, usually 15 years. Once a refuge has a ranked list of surveys, attention can turn to ensuring the quality and relevance of the highest priority surveys.

In order to facilitate high quality biological monitoring, particularly on national wildlife refuges, members from different branches of the USFWS developed a road map for designing a monitoring survey. It starts with the assumption that monitoring is hard to sustain. Good survey design is essential because ecosystems can take a long time to respond to either stressors (e.g., drought, floods, fire) or management actions. Quick results are the exception. That means that time and resources spent on monitoring span multiple years, so detecting change in ecosystems usually is an expensive, long-term enterprise.

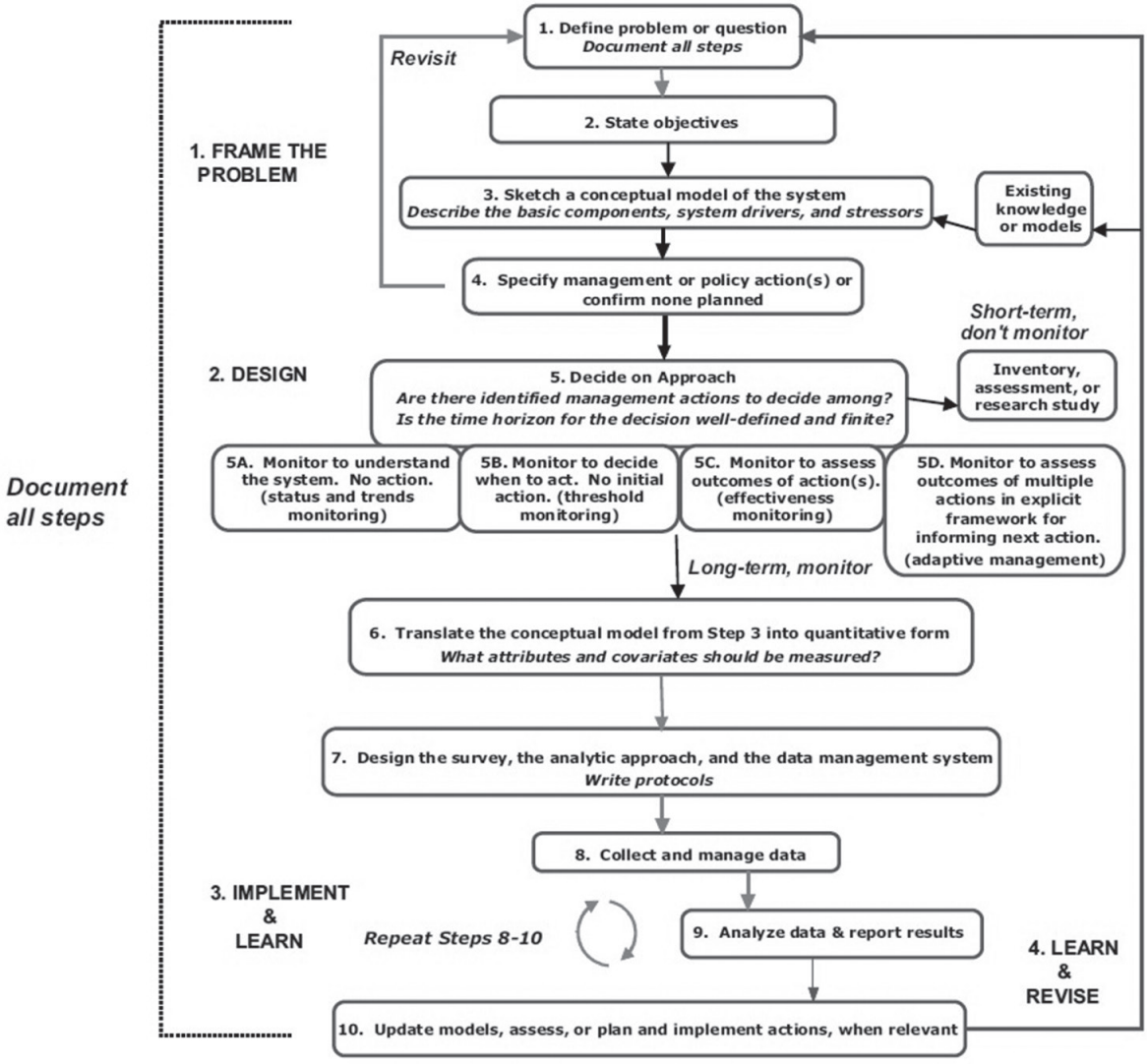
What are some of the attributes of inadequate monitoring design? A useful survey should address key questions facing resource managers. Too often, surveys are focused on the wrong management problem or the problem is too vague to guide the survey design. Secondly, flaws in sampling design or in the data collection methods can result in years of data that cannot be properly analyzed

using statistically rigorous methods. The time to subject your monitoring design to a biostatistician's review is prior to fieldwork. Also, because monitoring is so demanding and expensive, it is important to consider other approaches. Sometimes a research project will get you to the answer faster, and sometimes that research has already been conducted and is in the scientific literature.

If you think monitoring might be your best approach, we recommend a ten-step process, both to make sure that monitoring is necessary and to ensure it yields useful results (Figure 2). Borrowing from structured decision making, we start by defining the problem in a way that is agreed on by all those with a stake in the decision. It is important to document this problem definition, and all future steps in the process.

The purpose of Step 2 is to state your objectives. These are usually expressed as the desired future conditions in wildlife refuge comprehensive conservation plans, habitat management plans, or resource management plans.

Figure 2. The road map for designing a monitoring program.



Step 3 is to sketch a conceptual model. While many people do not think of monitoring as based on a conceptual model, almost all approaches to monitoring come out of some preconceived idea about how the system works. By writing down those ideas, we are in a better position to evaluate where the evidence is not strong and requires monitoring. One of the benefits of creating the conceptual model is to identify the key factors that may influence the attribute of interest and could confound the survey results. Moreover, all monitoring should in some way help update our conceptual model of how the ecosystem functions, and the more explicit this objective is beforehand the more likely it will meet with success.

Our Step 4 recalls why we said some monitoring fails. Now that the objectives are identified and there is a model of how the system functions, this step specifies the actions that are being taken to alter or maintain aspects of the system. It also identifies additional factors expected to influence the outcome of actions. Once those actions are identified, ask what role monitoring would play in informing those actions.

It is at Step 5 that we determine if monitoring is the best approach, and if so, what type of monitoring addresses the resource problem. Because monitoring generally requires a long-term commitment, it is important to consider alternative approaches. If monitoring is necessary, it is important to determine what type of monitoring will best address the problem. If you are primarily concerned with characterizing changes in the ecosystem over time, then status and trends monitoring would likely be most appropriate. If changes in a key component of the system might trigger you to act, then threshold monitoring might be the best approach. If assessing the consequences of an action is critical, then effectiveness monitoring should be considered. Finally, if there is considerable uncertainty about the expected responses to two or more actions, then adaptive management monitoring is probably the best approach.

Regardless of which type of monitoring you have selected, the following basic design steps apply. In Step 6, you further develop the conceptual model started in Step 3, transforming general or qualitative relationships into mathematical relationships. You make a series of decisions about what attributes are important, what variables reflect those attributes, and exactly how you plan to measure those variables. This is part of moving from broad objectives to SMART (specific, measureable, achievable, relevant, and time-specific) objectives.

With all of the preparatory work completed, you are ready to design the survey (Step 7). Sampling design comes in this phase as does a data analysis plan. It is in this step that you should write your monitoring protocols and have them reviewed by a biometrician and a data manager. All of the information gathered in the previous steps should at least be referenced in the protocol.

Step 8 puts you in the field, collecting the data, doing any initial quality control, and managing the data and including the necessary metadata so it can be used by others. At Step 9 you analyze data and report results. Reporting usually takes multiple forms, with the form often depending upon what is most important to the target audience. Managers need the take-home message up front, followed by the methods and analysis that support your conclusions.

The final step is to learn from your results, and to revise your model of the system if necessary. It is in Step 10 that management actions are implemented as warranted, and in the case of adaptive management, comparisons of the effects of alternative actions are made. For example, mowing

or burning are alternative actions for prairie restoration with uncertainty as to which is better; a well-designed monitoring program is yielding information that will reduce that uncertainty. In sustained monitoring, Step 10 is also when you intermittently revisit the survey design and sampling effort decisions in light of what you've learned about the system.

It is no accident that this ten-step program puts so much emphasis on forethought before going into the field to collect data. The initial seven steps aim to ensure that the resulting data will indeed be relevant and useful for guiding management decision making. In a time of rapid environmental change, scientific monitoring clearly presented will be ever more important to managers.

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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