Chapter 10: Monitoring and Adaptive Management

10.0 Introduction

Monitoring and reporting are mandatory elements of all Habitat Conservation Plans (HCPs) (50 CFR 17.22, 17.32, and 222.307; 65 FR 35242 [June 1, 2000] (see the HCP Handbook Toolbox). When properly designed and implemented, they should provide us with the information we need to determine whether or not:

- a permittee is in compliance with their incidental take permit and HCP,
- progress is being made toward meeting an HCPs biological goals and objectives,
- the HCP's conservation program is effective at minimizing and/or mitigating impacts, and
- there is a need for adjusting measures to improve the HCP's conservation strategy.

The scope of an HCP's monitoring, reporting and adaptive management program should be commensurate with the scope, duration, and certainty of the HCP's conservation program and project impacts. Monitoring programs for large-scale or regional planning efforts may be elaborate and track more than one component of the HCP (e.g., habitat quality or collection of mitigation fees). Conversely, monitoring programs for HCPs with lesser impacts of short duration might only involve filing simple reports that document whether the HCP has been

implemented as described. The Services must help with the development and approval of monitoring plans for HCPs. Many of the recommendations provided in this chapter are to provide an example of what a monitoring program could aspire to be, as appropriate.

To learn as much as possible from monitoring programs and to improve management actions, the two must be integrated. The integration of these two parts of an HCP's conservation program is essential to the success of them both. As discussed in depth in Chapter 9, the conservation program must be oriented toward achieving biological goals and objectives. The monitoring program must help inform us if those biological goals are being met to improve our understanding so we can improve future management actions.

Many of the concepts in this chapter are being promoted not as requirements that every plan must do, but as ideas, that if followed will allow for more efficient learning, which will lead to better management decisions, which will lead to more efficient accomplishment of goals and objectives. Ideally, the Services and the permittee will work in partnership to figure out what to monitor and how to evaluate the HCP. This team-based approach can take advantage of the resources and knowledge of all parties to efficiently and effectively meet goals and objectives.

10.0.1 Roles and Requirements for HCP Monitoring Programs

The Endangered Species Act (ESA) emphasizes the necessity for "reporting requirements… for determining whether [incidental take permit] terms and conditions are being complied with" (section 10(a)(2)(B)(v)). An applicant's HCP must include steps to monitor the effects of take (50 CFR Part 17.22(b)(1)(iii)(B), 17.32(b)(1)(iii)(B), and 222.307). We interpret this to mean HCP monitoring programs must: provide the information necessary to assess compliance and project impacts, and verify progress toward the biological goals and objectives. However, with thoughtful planning, HCP monitoring programs can speed up the learning process and increase the efficiency of management actions in meeting goals and objectives.

Ideally, the Services and the permittee will work in partnership to develop the monitoring program and to implement, evaluate, and adjust the monitoring program and management actions. The Services should provide technical assistance to the applicant on the development, implementation and evaluation of monitoring results. The Services should also provide data and help share information to ensure the conservation community can benefit from it. This team-based approach can take advantage of the resources and knowledge of all parties to efficiently and effectively meet goals and objectives. Ultimately it is the applicant's responsibility for developing the monitoring program, implementing the monitoring program, and evaluating the results to track progress in achieving goals and objectives.

When HCPs are integrated with other permits, the Services and the applicant should coordinate the HCPs monitoring efforts with other permitting programs. Projects that require another permit will likely have compensatory mitigation and monitoring requirements that if coordinated with an HCP, could provide additional funding and other resources for conservation and could provide efficiencies with the two permit programs. To improve efficiency of monitoring efforts and to minimize conflicts with other permit programs or other agencies, it may be prudent to coordinate early in the HCP development process.

10.1 Monitoring

Monitoring should be viewed as an integral component of the HCP's conservation strategy, not as a separate piece. Monitoring goals should be explicitly tied to the hierarchy of goals and purposes of the HCP. Clearly defined monitoring goals and objectives will drive the usefulness of the monitoring program.

We use monitoring results to assess the status of systems or populations and efficacy of management and restoration efforts. They can provide early warning of impending threats and a basis for understanding and identifying meaningful change in natural systems.

The HCP monitoring program can include some of the following aspects:

- identify specific monitoring objectives;
- evaluate competing hypotheses about the effectiveness of management actions where effectiveness would be highly uncertain;
- assess the state of the system or species in the plan area;
- provide a way to track progress toward meeting biological goals and objectives, and general compliance with the HCP's conservation strategy (including any avoidance or minimization measures to be implemented);
- focus on crucial information needed to resolve uncertainty and improve management effectiveness;
- explicitly show monitoring data's purpose and use in the adaptive management processes established in the HCP;
- make data and reports transparently available to the public using existing information systems;
- track implementation of covered activities to ensure the effects of those activities analyzed in the HCP, the National Environmental Policy Act (NEPA) document, and the Services' decision documents remain accurate; and
- increase understanding of the system being monitored.

Collecting detailed information is not helpful in and of itself—data needs to be collected with a purpose in mind. Consultation with a statistician is recommended to maximize sampling efficiency. Nichols et. al. 2006 make a strong case for designing a monitoring and implementation program based on hypotheses and associated models of system responses before management actions are implemented instead of designing monitoring programs without laying out possible system results before implementing the management actions. They argue monitoring that collects data without a *specific* purpose is an extremely inefficient way to gather information for improving management practices. Understanding the effectiveness of management actions means we have to get updates on the status of the system or species in mind, which will allow us to update our models or understanding of how the system works (by proving or disproving our hypothesis about effects of management actions and system function).

The development of a monitoring program should be tailored to answer specific questions needed for the decisions that need to be made. What are the decisions? What are the consequences of uncertainty? These are key questions to think about when developing the objectives of an HCP monitoring program.

Monitoring and reporting can be divided into three categories for HCPs:

- monitoring for baseline information,
- effectiveness monitoring to support ongoing conservation decisions, and
- monitoring to evaluate compliance with permit terms and conditions.

10.1.1 Monitoring for Baseline Information

Resist the temptation to ask for more data than is necessary for the purposes of the HCP monitoring program, even though it might provide interesting information about the biology of the covered species. Baseline information about abundance or distribution in a plan area may or may not be critically important for the HCP, depending on the specific decisions to be made. There are many cases where baseline information collection is critical to developing a meaningful conservation strategy or deciding which management action should be implemented. You may need more baseline information during plan development because of circumstances such as: to assess which species occur in the plan area, to identify areas to avoid for impacts, to identify areas that are important to conserve, to identify areas where more research is needed, etc.

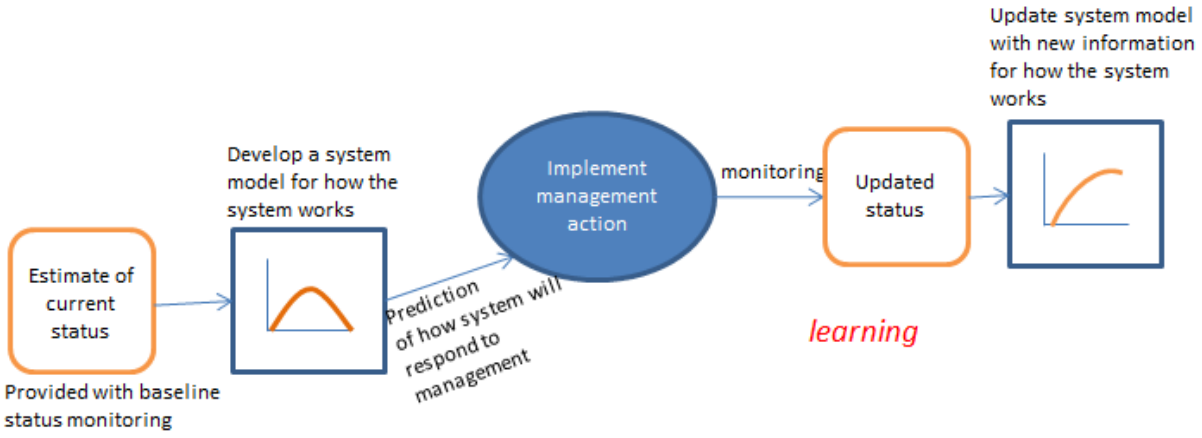
You may also need more baseline information during plan implementation because you need key information about species occurrence or some form of habitat conditions to make a management decision.

In some instances, there's enough existing information to support planning or implementation decisions. For example, recent surveys revealed an ESA-listed species occurs in the plan area, so if the decision is whether to cover the species or not, the information on hand may be adequate. However, if the decision is about where development could occur and that species was critically imperiled (where the loss of even one individual was unsustainable), then focused surveys to document more precise occurrences may be warranted for the decision.

10.1.2 Effectiveness Monitoring to Support Ongoing Conservation Decisions

HCP monitoring programs should help the permittee and the Services decide which management actions are most effective in meeting HCP goals. At its best, this is done by developing competing hypotheses about how the system will respond to management actions taken through implementation of the conservation strategy.

Figure 10.1a: The Importance of Monitoring to Support the Learning Process of Management Decisions



10.1.2.1 Development of Competing Hypotheses and Conceptual models

In most cases, management decisions are made with uncertainty: to help us *learn from our management actions* and to reduce uncertainty, we should develop detailed hypotheses and associated models of system response to those management actions. This information can be collected from expert opinion, research, gray literature, published works, or other useful sources. While decision can be made without developing hypotheses, it will help speed our learning process and increase efficiency of management actions from what we learn.

Development of multiple hypothesis can keep us open to new ideas and keep us from ignoring information that may be important. Focusing on a single hypothesis may cause us to miss the fact that multiple interactions may act together, to account for the results. For more on how to develop competing hypotheses, go to the HCP Handbook Toolbox.

It's critical to decision making to organize our information in a manner that follows a consistent and clear process that:

- captures our understanding,
- makes our assumptions clear,
- highlights areas of uncertainty, and
- identifies critical gaps in our understanding.

Conceptual models can be a template or a process that documents our understanding of how the species or system works. Framing our thinking and understanding in a conceptual model, allows us to show different hypotheses about specific system or species functions that can be tested through monitoring. Conceptual models are a key foundation upon which the integrated approach to development of goals and objectives, monitoring and evaluation, and adaptive management systems are built. All of these tie into our understanding of the system and what we are going to do about it to conserve species.

Hypotheses about responses of populations or systems to management actions can involve many interactions and may be difficult to develop, but they are important. These models and their

assumptions about system function guide our management efforts and focus our monitoring. The focus that comes from laying out our assumptions is essential to development of an efficient management and monitoring program. Even if we begin taking management actions with system models that have a high degree of uncertainty, laying out our hypothesis of system function explicitly will give us something to test and learn from to improve future system models.

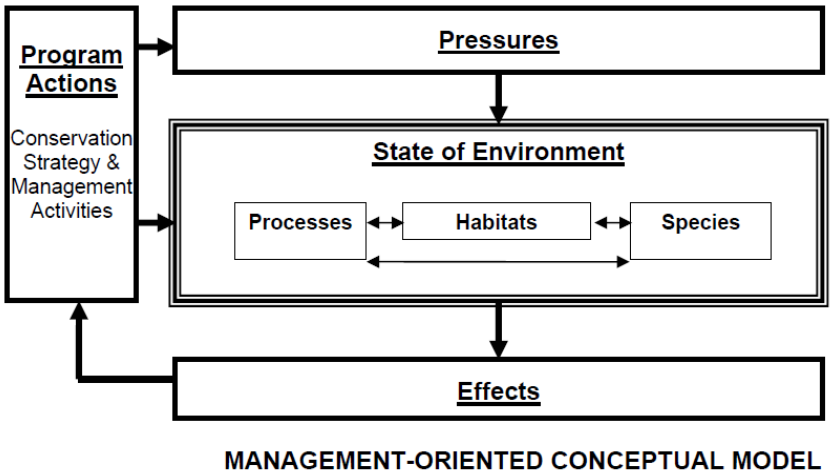
You can think of a system model as a hypothesis of how the system works. Where there is uncertainty about how the system works, you may need multiple models to test. A conceptual model may be an entirely adequate form to develop the hypothesis. The focus of the system or population models should be on those influences that are thought to be primarily responsible for the present state of the system or population.

Keep the following in mind when developing conceptual models about system function and hypotheses about management effects:

- They should not capture every detail.
- Focus on the major influences of the system or population.
- Multiple models may be strung together rather than using one complicated model—models are difficult to make comprehensive and remain useful.
- Models can be conceptual and qualitative (see discussion on conceptual models) but need to be illustrative of your assumptions.
- Develop the simplest model possible that represents the key population or system function processes/influences.

There are many good sources on developing conceptual models. Below are examples that may be useful for your HCP. Because different types of models are used for different reasons, you should understand the purpose of the conceptual model before you begin to develop one for your purposes.

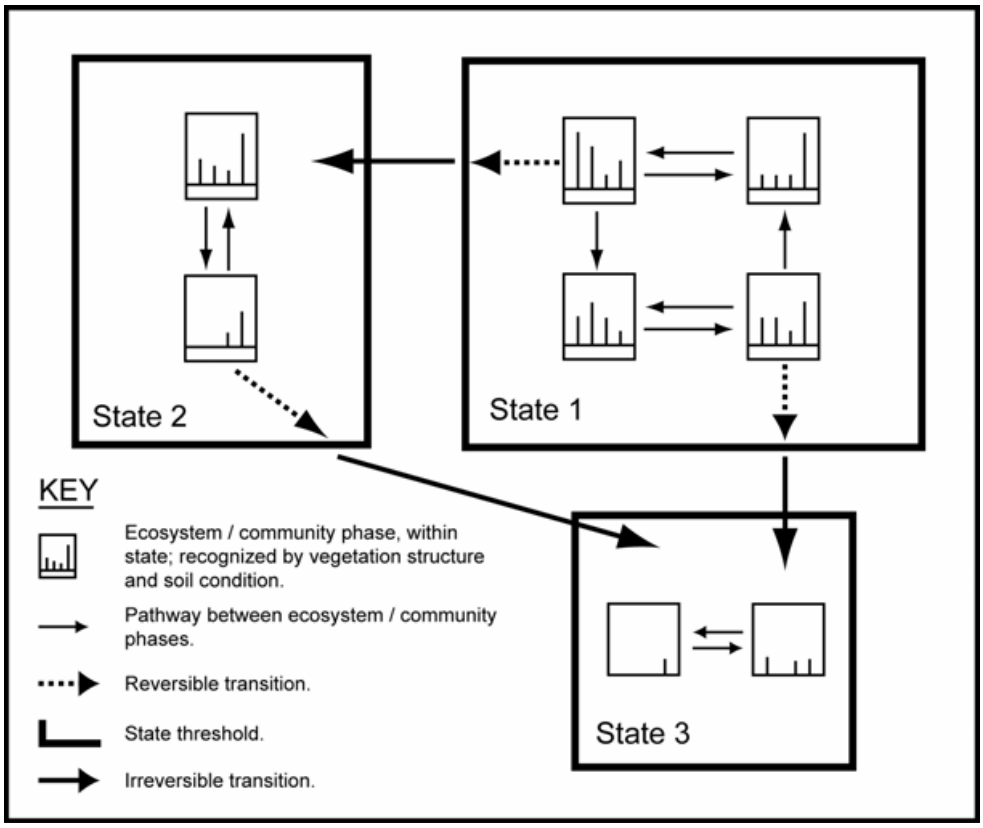
Figure 10.1b: A Management-Oriented Conceptual Model



MANAGEMENT-ORIENTED CONCEPTUAL MODEL

You can use a management-oriented conceptual model to illustrate how the conservation strategy affects species or habitat of concern, and the stressors that affect them.
From: Atkinson et. al., 2004

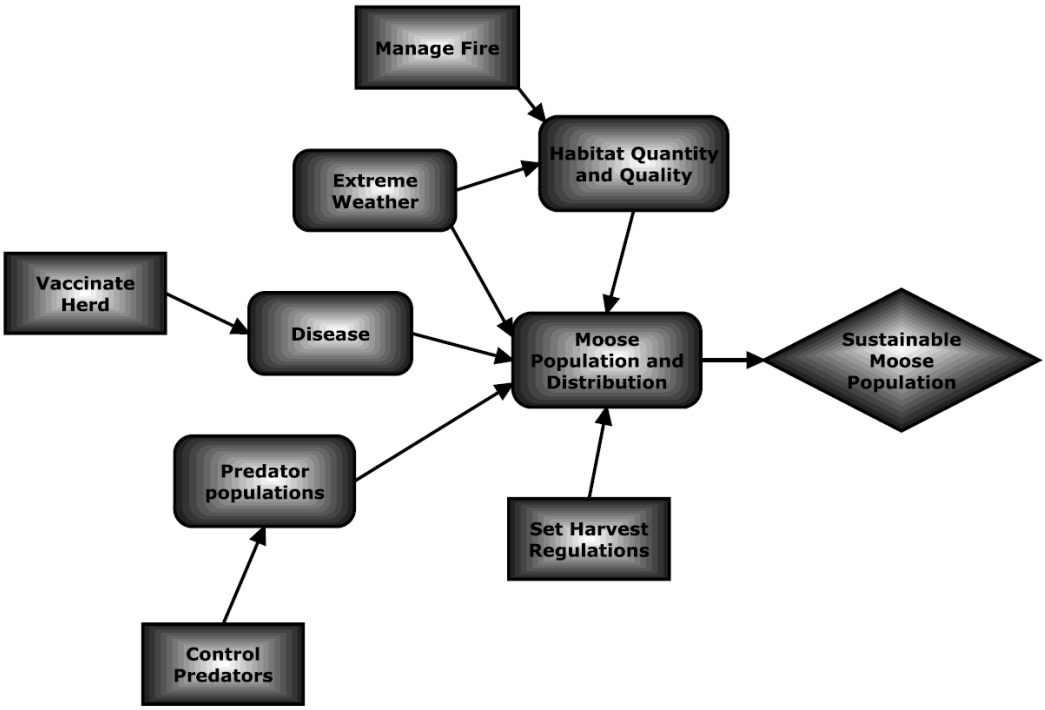
Figure 10.1c: State-and-Transition Models



You can use a management-oriented conceptual model to illustrate how the conservation strategy affects species or habitat of concern, and the stressors that affect them.

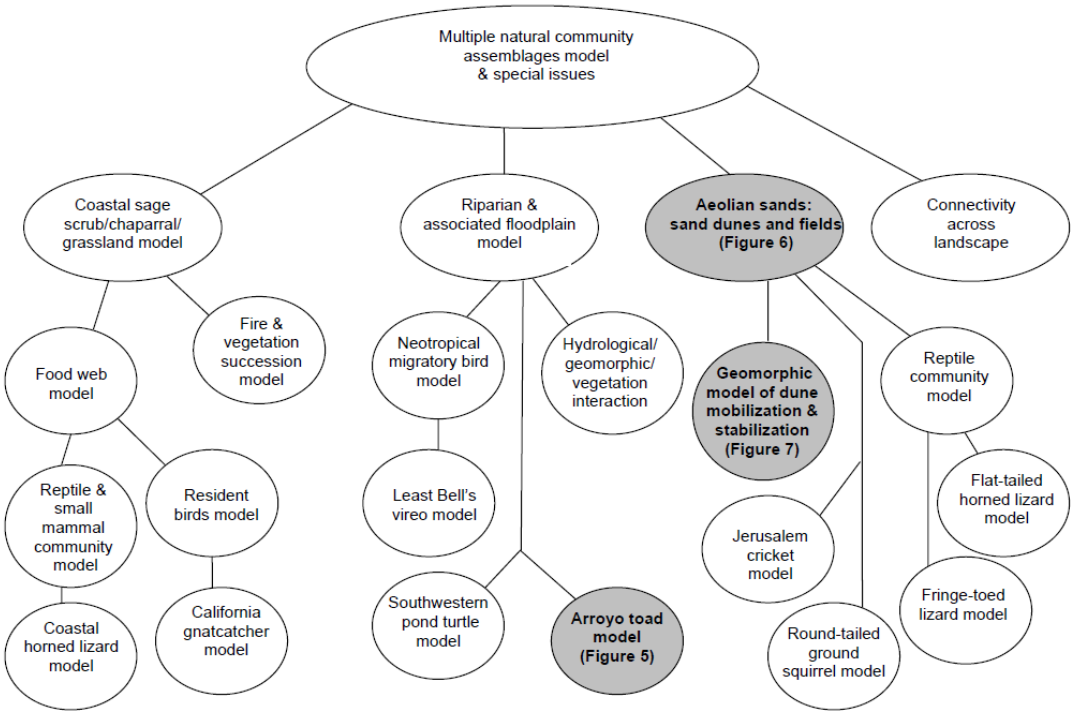
From: Gross, 2003.

Figure 10.1d: An Influence Diagram



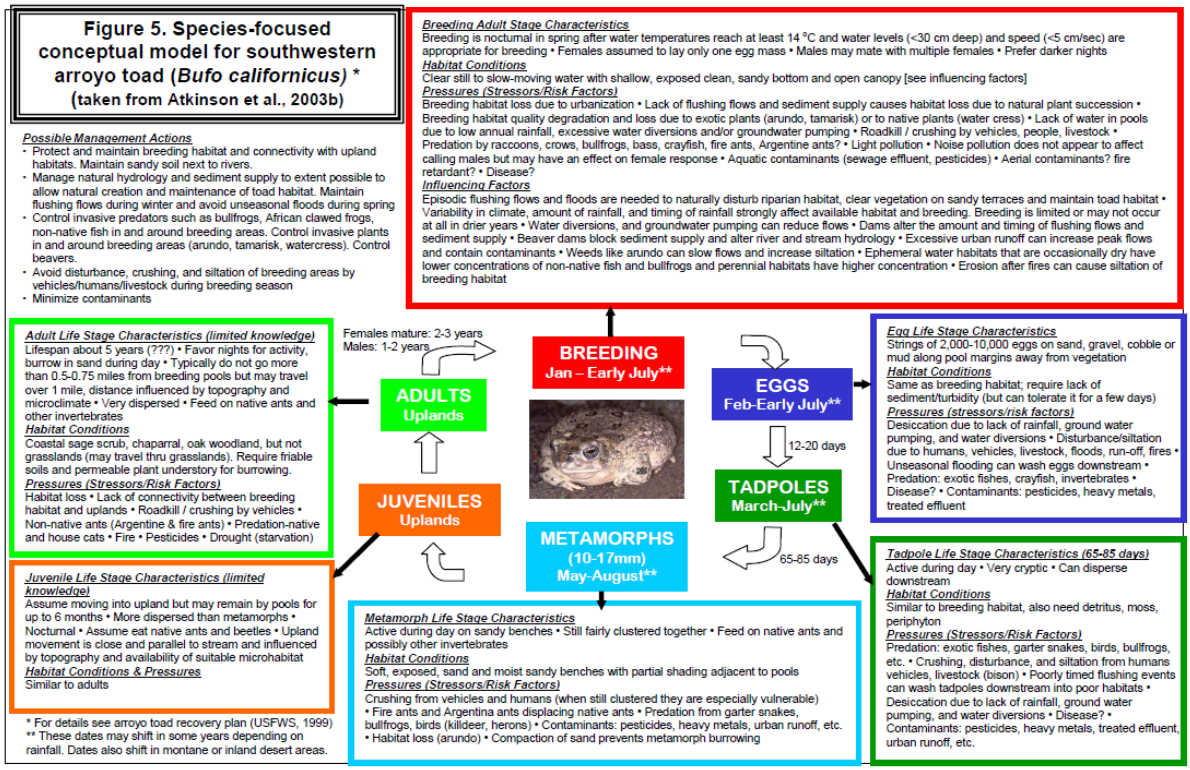
An influence diagram is a simple conceptual model that illustrates the 'big picture' associated with a problem and also indicates where decisions or actions could be applied. The objective of the action in the example above is to sustain the moose population (diamond). Factors are in rounded rectangles; they are the things that contribute to the objective, including chance or stochastic variables (weather) as well as factors that may respond to actions or decisions (habitat quantity and quality, disease, predator populations). Potential management actions are shown as rectangles.
From: Designing a Monitoring Program A Road Map for Planning a Biological Monitoring Program. Reynolds et.al., 2015.

Figure 10.1e: Nested Conceptual Model



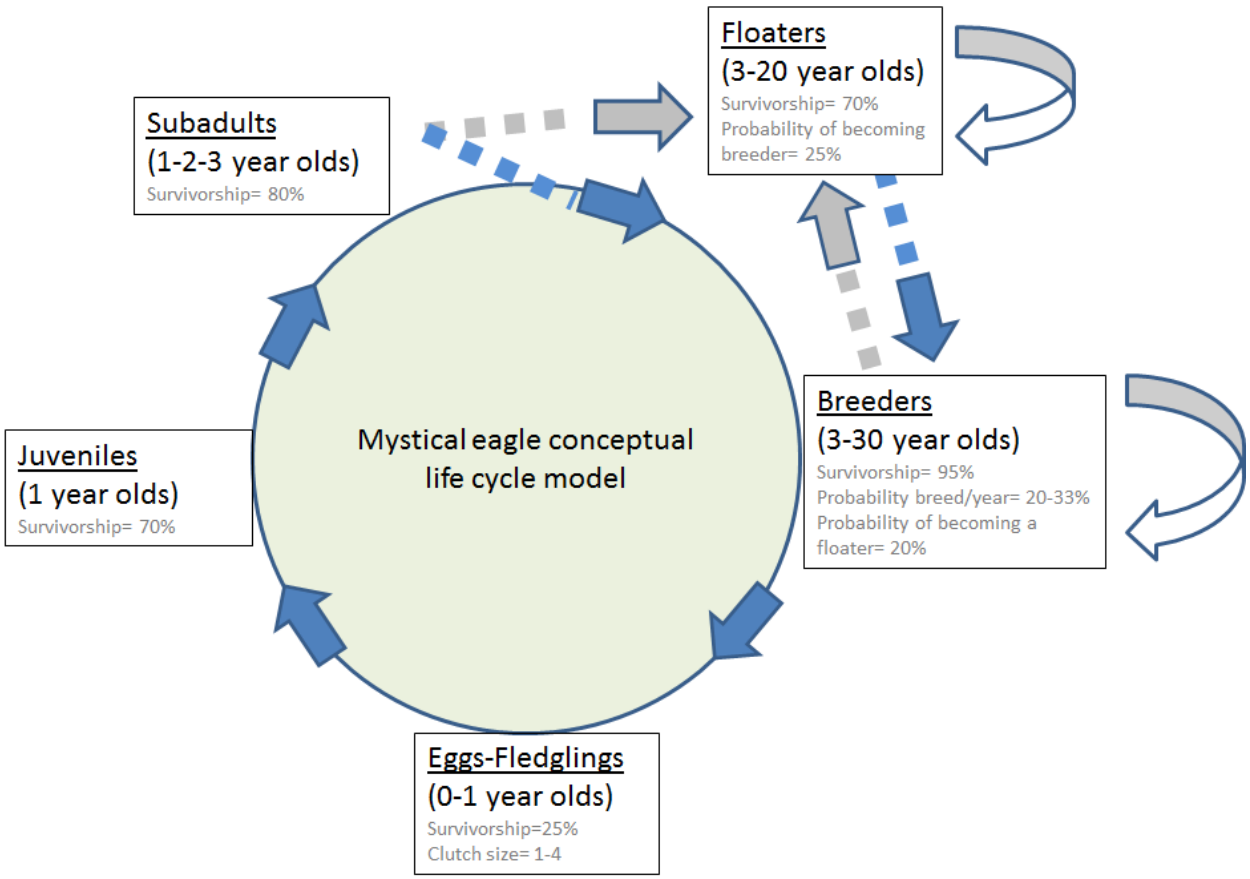
Models can be nested to accommodate different levels of detail while still allowing you to see the big picture. This hierarchy includes an overarching multiple habitat model, a natural community assemblages model, various sub-models such as on processes (vegetation and food-web), and specific covered species.
From: Atkinson et. al., 2004,

Figure 10.1f: Example 1-Species-Focused Conceptual Model



Species-focused conceptual models vary in complexity, but are a way to simply show a species life-cycle and the factors that may affect each stage.
From: Atkinson et. al., 2004.

Figure 10.1g: Example 2- Species-Focused Conceptual Model



A species-focused conceptual model, such as this one can easily transition into a simple spreadsheet model to outline the life-cycle of a species or population.

10.1.3 Reporting Compliance with Permit Terms and Conditions

In general, permittees report compliance, and the Services must evaluate if the reporting demonstrates compliance with permit terms and conditions.

Our staff must answer a key question: did the permittee implement actions consistent with the permit terms and conditions? We may need to follow up with field visits to verify the reports the permittee submits. The use of remote sensing or aerial imagery may be an efficient approach to verifying compliance.

We should keep permittee annual reports and write a memo to the file every year that describes our assessment of the permittee's compliance with the terms and conditions. Where lessons can be learned from management experience and results of monitoring or research, we should consider writing a "lessons learned" white paper to share with anyone who can benefit from it. Sharing these experiences will speed up learning and information exchange to improve conservation in other places and situations.

What must the permittee be in compliance with?

The report and memo should explain how the permittee is in compliance and include information on:

- implementing the HCP (e.g., avoidance, minimization, and mitigation measures that occur within the time period),
- specific reporting measures in the permit, and
- progress towards achieving the biological goals and objectives, as described in the HCP. Ultimately the permittee must meet the biological goals and objectives. Developing a schedule of progress with interim goals in the HCP is a useful way to ensure there are clear expectations for progress and compliance with the permit.

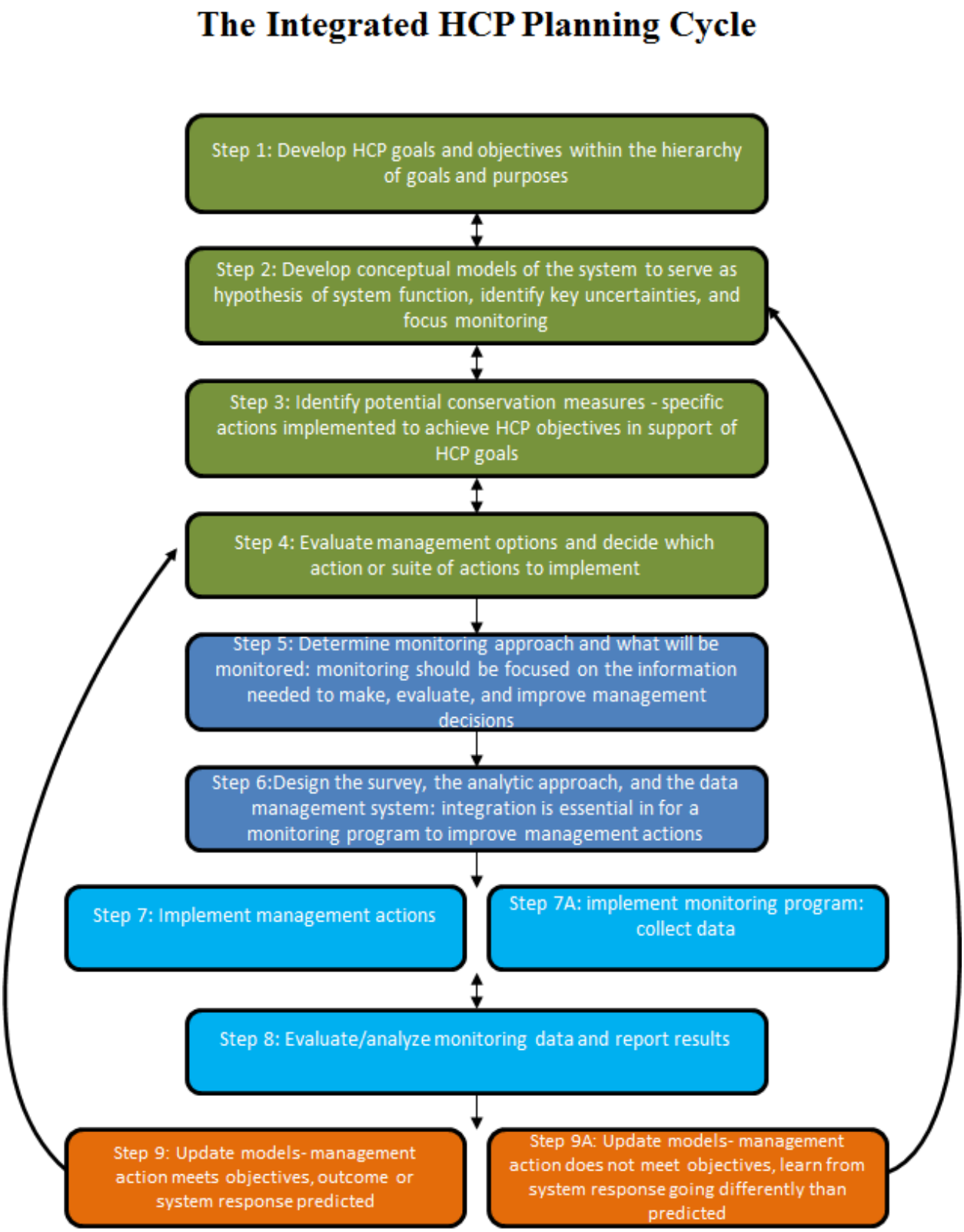
More information about reporting is in section 10.4.

10.2 Steps to Develop a Conservation and Monitoring Program

This discussion relies on the draft report "A Road Map for Planning a Biological Monitoring Program" prepared by the FWS for the National Wildlife Refuge program. What is presented here is an aspirational example of components a monitoring program might include.

Figure 10.2a, is a quick summary of the sequence and steps that should be considered when developing a conservation program, including designing a monitoring program (steps 5-8), implementing the monitoring program (steps 8-9), and implementing the adaptive management program (step 10).

Figure 10-2a: Sequence and Steps for Designing a Conservation Program



10.2.1 Frame the Problem

Step 1: Develop the HCP biological goals and objectives within the hierarchy of goals and purposes (see chapter 9). As a part of our problem definition, we should have defined:

- the temporal and geographic scope of the problem (HCP plan area);
- management actions (conservation measures) that have been identified to address the problem;
- who decides what actions to take (and when);
- decision constraints; and
- key uncertainties where the value of information is high enough that monitoring is worth dedicating funds to reduce uncertainty. Reducing these uncertainties (management effectiveness, key information) is a large part of what the monitoring effort aims to address.

Describe the biological goals and objectives of the HCP (see chapter 9). Goals describe the desired future conditions of an HCP. Objectives are incremental and measurable steps we take to achieve the HCP goals.

Step 2: Develop conceptual models of the system components. To design monitoring, the conceptual model should make explicit the linkage between the system conditions/variables and the drivers of those conditions. We can use the conceptual system models as a hypothesis for how the system works and as a foundation upon which a monitoring program is built to prove/disprove or reduce key uncertainties needed to improve management actions. Information gained through monitoring should improve our understanding of how the system works and evaluate management effectiveness in moving the system toward the desired condition (accomplishing goals and objectives). The size and complexity of the conceptual models should scale with the size and complexity of the threats and of the plan, and with the available information about the species or system.

Step 3: Identify potential conservation measures. Conservation measures describe specific actions that the permittee will implement to achieve objectives in support of the goals. Conservation measures can be any of the avoidance, minimization, or mitigation actions identified to meet the HCP goals and objectives (e.g., restoring habitat, removing non-native species, etc.).

Step 4: Evaluate management options and make decisions. Evaluate the range of decision alternatives, project the outcome of each alternative action, use conceptual models to identify and understand the importance of key uncertainties, assess risk tolerance for potential consequences of decisions, account for future impacts of present decisions, and account for constraints. Decide which option best meets the desired outcome.

10.2.2 Design the Monitoring

Step 5: Determine the monitoring approach needed and what will be monitored. Monitoring should be focused on precisely the information needed to support conservation management decisions. The broad kinds of answers we need from a monitoring program include: How well

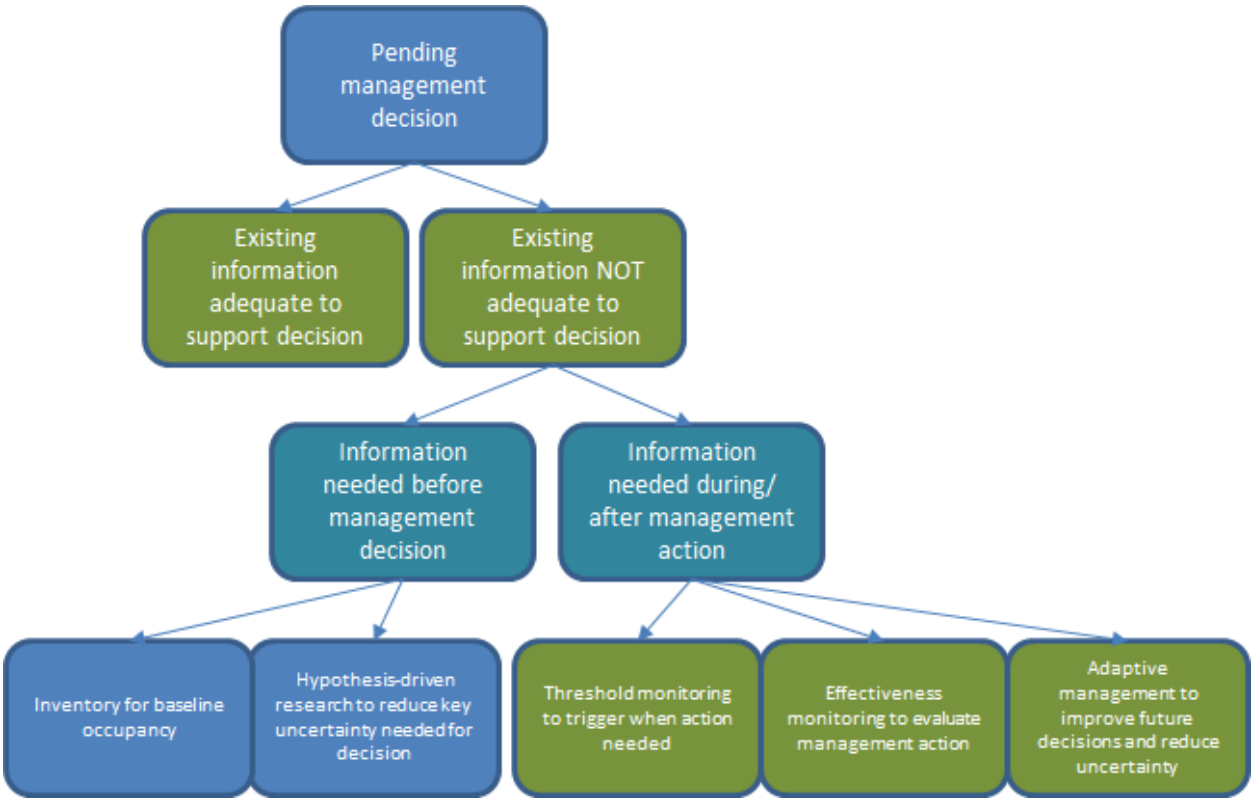
are we doing in meeting biological goals and objectives? How can we improve effectiveness of management actions? What information do we need to support or improve future management decisions to meet goals and objectives?

The management decisions in question and the key uncertainties must be clearly articulated, as these will guide what is monitored. When thinking about the management decisions in question, we should evaluate information gaps or uncertainties to decide if the value of obtaining that information is important enough to invest resources to reduce the uncertainty. It may not be. For more information about how to analyze the value of information, the 2015 book *Decision Making in Natural Resource Management: A Structured, Adaptive Approach* by Conroy and Peterson is a good reference. In addition, the short chapter on "Tracking Action Effectiveness and Ecological Response" in *Climate-Smart Conservation*: *Putting Adaptation Principles into Practice* is a valuable resource (Stein et. al., 2014, chapter 11).

Compile and examine existing information and seek the help of experts to reduce or remove the need to conduct certain monitoring activities. In some instances the information may already be available or studies may have been conducted in the area/topic of concern. Making use of existing information can reduce monitoring needs, time, and costs.

Monitoring purposes can generally be put in two categories—monitoring for baseline information and monitoring of effectiveness to support active management. The uncertainty that needs to be addressed will drive which of these two is pursued for any monitoring question. Monitoring for baseline information gathers information needed before a management action is taken (e.g., establishing baseline occupancy information, providing key information upon which a management action is based, etc.). Monitoring for active management generally occurs during and after a management action is taken (e.g., evaluate the effectiveness of the action, adaptive management, etc.). How long the monitoring occurs depends on the information that is needed. For example: if monitoring to evaluate effectiveness of a restoration action, monitor for a duration sufficient to demonstrate the project has met ecological performance standards.

Figure 10.2.2a: Decision Tree to Assist with Selecting the Appropriate Monitoring Type



The FWS's 2013 "*National Wildlife Refuge System's Survey Protocol Handbook*" is a great resource for designing standardized survey protocols (see the HCP Handbook Toolbox).

The conceptual models developed in step 2 can be helpful in determining what will be monitored to measure success. How well are we doing broadly or from a specific action in meeting biological goals? The conceptual models serve as hypotheses for how the system functions and how the system is expected to respond to management actions. This is the focus of what will be monitored and will help determine success of our actions and to improve future decisions.

When selecting what to monitor, consider these questions:

- *What objects or individuals will be measured?*

  The decision of what to measure will affect cost, drive the sampling design, and may constrain the statistical analysis. Is it possible to consistently detect the object to be measured? If not, it may not be a good measure for the sampling design.

  It may not be possible to measure everything, in particular for large-scale plans. Focusing monitoring on the key uncertainties and providing the information to support decision making is helpful to develop a program of practical scale and cost.

- *What specific attribute of the object or individual will be measured and how?*

Table 10.2a: Examples of Attributes and Ways in Which They Can Be Measured	
Attribute	How attribute could be measured
abundance	complete counts, plot sampling, mark -recapture, distance sampling, occupancy models
occurrence	plot sampling, occupancy models, indirect counts (hair traps, photo traps, etc.)
reproduction rate	complete counts or plot sampling to estimate: number of births/unit of time/average population
sex ratio	complete counts or plot sampling
survival rate	complete counts, plot sampling, mark -recapture

In addition to the ideas in Table 10.2a, depending on what the question is, habitat or indices of species/population health may be an appropriate way to assess the status of a population or attribute. It's important to understand the relationship between the habitat or indices to the population or attribute you're analyzing. We can't rely on this relationship without understanding it. In addition, we need to consider whether and how habitat-species relationships may be altered in relation to climate change and its effects, e.g. habitat conditions may change substantially. The types and abundance of predators and competing species may be likely to change over time and those changes can influence the status and trend of measures of attributes of species covered by an HCP.

Although oversimplified for this chapter, the examples below focus on the importance of validating our assumptions about relationships when using habitat or indices to assess the status of a species.

Example 1:
Assumptions: Pool filling depth is a good indicator of health of species x, so measuring pool depth is a good way to assess the status of species x in the area.
Validation needed: Study to understand the relationship between pool filling depth and status of species x.

- Are they related? Is the relationship linear between pool depth and health of species x? Are there thresholds of pool filling that affect the status of species x?
- Does a full pool guarantee good status for species x?
- What does a half full pool mean to the status of species x?
- Are there other factors that need to be considered? For example, due to climate change, pool depth alone might no longer be a suitable indicator for species x if it has water temperature limitations for part of its life cycle. If that's the case, pool depth in combination with a certain range of water temperature may be important for species x.

Example 2:

Assumptions: The status of two species are closely taxonomically related; therefore, monitoring the status of species 1 is adequate to understand the status of species 2.
Validation needed: Study to understand the relationship between the status of both species.

- How closely related is the status of both species?
- Are there conditions where their status is closely related (e.g., average weather)?
- Are there conditions where their status is not closely related (e.g., drought conditions and species 1 is more drought tolerant), or is species 1 in a location experiencing or likely to be impacted by spread of non-native invasive species, increases in competitors, or other responses to climate change or other stressors?

- *What is the appropriate level of effort for monitoring?*

  In general, there are two ways to determine the appropriate level of effort for monitoring:

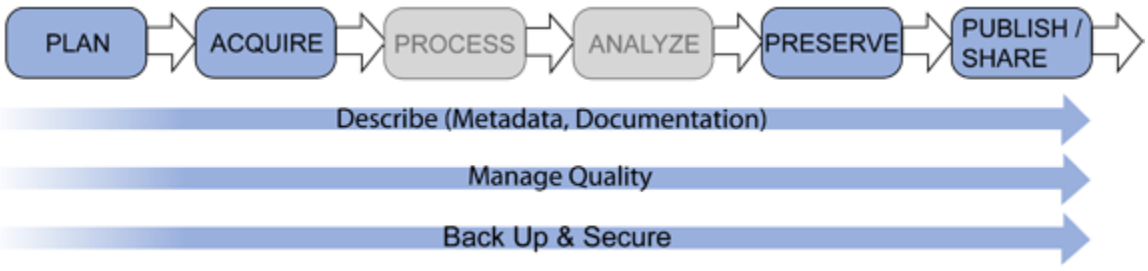
  - Focus on the statistical analysis and use the needs of the analysis (e.g., sample size) to determine the level of effort needed for monitoring
  - Focus on what is feasible for monitoring and adjust the expectations regarding anticipated results of statistical analysis to fit the expected level of data collection.

Focusing on the data needs for the statistical analysis is the more robust way to approach this decision. If more accurate data is needed, focusing on statistically robust methods is the preferred approach.

Step 6: Design the survey, the analytic approach, and the data management system: Integration of all of the above is essential in executing a useful monitoring program that yields information to improve management actions. If a statistician has not been consulted by now, this is probably a good time to bring one in as the world of analysis can be overwhelming.

As part of step 6, a data management and delivery plan should be developed. This plan is critical to ensuring data is collected and managed in a way that it can be efficiently accessed and used. See Figure 10.2c and the HCP Handbook Toolbox.

Figure 10.2c: U.S. Geological Survey (USGS) Data Lifecycle Diagram



As shown in the above diagram there are many aspects to data management, each is important, and how they will be handled should be described in each HCP's data management plan.

10.2.3 Implement the Conservation Program and Learn

Step 7: Collect and manage data and implement management actions. Knowing what data will be collected, why data is being collected, and how data is being collected is crucial in making the data useful. Documenting the implementation of management actions (who, what, when, why, where, how) will be useful for repeating successful actions and understanding why those actions weren't effective in accomplishing the desired outcome. It could be the action was correct, but implemented in a manner that was ineffective, so documentation of how that action was implemented may be key to understanding the results later. Thus, the monitoring design and collection of data will need to include relevant information about changed circumstances that we expect will occur, and information about unforeseen circumstances, since these could account for or contribute to understanding the relationship between the HCP management actions and their effects, especially if the effects are not as expected.

Step 8: Analyze data and report results. Now that data has been collected in a certain way for a certain purpose, we must analyze it to answer the question(s) for which it was collected. Monitoring implemented for baseline information is used to understand fundamental questions about how the system works or to establish a specific system state (e.g., how many of species x are there in this area). Monitoring data collected to support active management decisions should be collected and analyzed to evaluate the assumptions and hypotheses about the predicted system response. Just as we monitor for a specific purpose to make better informed management decision, reporting data in a way that is useful for managers to access them is very important! The utility of the monitoring and evaluation effort will suffer if reports aren't timely (within the decision timeframe) or in a format that isn't easy to use.

Step 9: Update models and plan action. Information gathered and analyzed must now be plugged back into our conceptual and quantitative models to improve our understanding of the system and how it responds to management actions. Updating the system models with the latest information on what we have learned is important to improve future management decisions.

To check if the HCP is on track or why something may have succeeded or failed, you should:

- consider your results in the context of your conceptual models,
- review your assumptions of how the system works,
- evaluate progress towards meeting goals and objectives,
- review the conceptual models to determine if there are important factors that were not included or monitored and that may have affected the outcome,
- identify and document what was learned about the system, and
- identify new information needs.

10.2.4 Changes to the Monitoring Program

One of the issuance criteria for an incidental take permit is that the applicant will assure adequate funding to implement the HCP and respond to changed circumstances. This generally results in a monitoring program developed at the same time as the HCP with an estimate of how much it will cost to implement it. In some cases, years into HCP implementation, the permittee and the Services may agree that the monitoring program is not on track to provide useful information to

evaluate and provide the information needed to improve management decisions. What do you do next?

For small scale plans, or plans that are short in duration, developing the monitoring strategy during plan development may be feasible, but for regional plans or plans with long-term permits, it may not be feasible. Adjustments to the monitoring program are inevitable and should be planned for during HCP development.

For regional plans, consider writing a summary of the monitoring program, or a "monitoring framework," that outlines the general components of the monitoring program (not detailed or specific monitoring protocols), including the biological goals and objectives and the estimated costs of the monitoring program in the HCP. The detailed information about how to implement the monitoring program could be developed as a companion document either when developing the HCP or subsequent to permit issuance, depending on the plan and species. A process for how the monitoring program will be developed and amended should be included in the HCP. Ideally, changes to the monitoring program should be arranged so that they do not require permit amendment (Chapter 17.4). The Services must be involved in the development of the monitoring plan, and we have final approval before it is completed. How to make adjustments to the monitoring program should be part of the original cost estimates (including inflation), so that a plan amendment isn't necessary. Keep No Surprises assurances in mind when developing the HCP and monitoring program; we can't come in later and require more. We should work with the applicant to develop an appropriate monitoring program that can be adjusted within the bounds set up by the HCP to meet the needs of the HCP.

10.3 Evaluation

The evaluation of monitoring data should be done as a partnership between the Services and the applicant. As focused monitoring data becomes available, it must be analyzed. As with the selection of monitoring methods, you should make sure the level of analysis matches the information needs to support better decision making. You should determine the level and type of analyses deliberately before monitoring begins and evaluate them as the monitoring program is being developed. Don't leave it until the end when you have a pile of data sheets that you now must figure out what to do with. Understanding the analytical framework will make it easier to observe and understand changes, solve problems, and make project improvements.

Any statisticians, analysts, data managers, and data collectors you involve in the process must understand the data being collected, stored, and how it will be analyzed. Adjustments are often needed to monitoring and analysis, and ensuring everyone understands the entire data cycle is valuable as each party has a unique perspective and insight for keeping the effort on track.

When you are preparing for and executing the data analyses, it is important to ensure continued involvement of the entire project team. Input from outside experts could also give useful perspective and insight into your analyses of monitoring results.

Depending on the type of data that you have and your information needs, these analyses can range from formal statistical studies to simple qualitative assessments. Just as with developing a

monitoring program, finding the appropriate analysis to answer the question at hand is essential. The range of analytical techniques is staggeringly big and ever growing.

Key to the success of the evaluation process is thoughtful design of the analysis that occurs before the monitoring. Issues like sampling design and sample size can determine what can be evaluated.

Keep the following suggestions in mind when considering the evaluation phase of an HCP:

- Consult a statistician early in the development of a monitoring program.
- Efficient learning can be promoted by focused, hypothesis-driven studies vs. unfocused exploratory evaluations where data is collected without clear purpose.
- Correlation is not the same as causation. Understanding causation often requires focused studies.
- Randomization of sampling points can help remove sampling bias.
- Stratification of sampling design by habitat type or priority level will improve efficiency in uncovering trends and inferences.
- Opportunistic sampling can *complement* systematic sampling efforts.
- Species surveys have imperfect detection probability; factoring in those that are missed can be important for evaluation of population trends.
- Traditional evaluations may not always work. For example, using a "proportion area occupied" approach may get enough information about population status with less effort.
- Consider conducting a power analysis to determine the minimum sample size needed to detect trends with an acceptable level of confidence.
- Thresholds suffer from:
    - uncertainty in establishing appropriate thresholds,
    - needing management before the trigger is tripped,
    - over-reaction if a threshold is exceeded, and
    - temptation to manage to the threshold rather than more biologically valid goals.
- Statistics and models should assist with decision making, but are not a replacement for common sense.
- Take advantage of extreme circumstances to learn more about the system. How often does a major flood event happen?
- Take advantage of monitoring data available from efforts that are at a larger scale than the HCP and relevant to understanding conditions in the HCP area. For instance, monitoring at landscape scales is increasingly common as a means of tracking and understanding changes in habitat and plant-animal species composition, distribution, and abundance in relation to climate change. If such large-scale monitoring encompasses the HCP area (or is relevant for other reasons), it may be very useful for design, evaluation, and interpretation of the HCP monitoring.

10.3.1 Dealing with Uncertainty in the Evaluation Process

Uncertainty is a given in any ecological condition and is important to address in the evaluation process. However, there is not a prescription that will completely solve the challenges of uncertainty.

As an example of how to deal with uncertainty, if there is a high degree of uncertainty associated with evaluation of impacts, there may be two choices the Services and the applicant should consider:

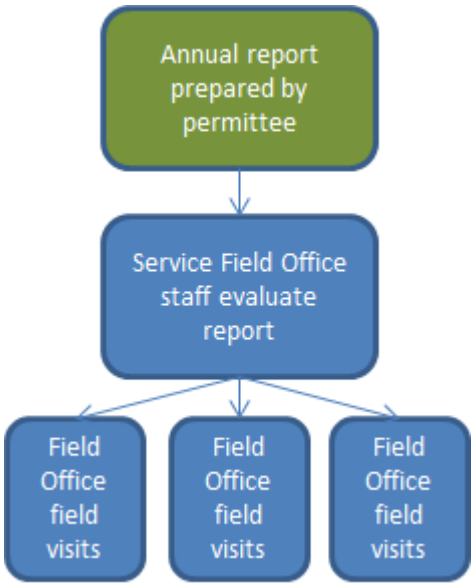
1. increasing levels of monitoring, or
2. making assumptions of impacts that err towards the highest potential impact.

Improved confidence in survey and evaluation data can reduce the need for assumptions, but may come at the cost of increased surveys. Balancing these factors is tricky but important. It is important to be transparent about sources of uncertainty and any relevant assumptions made in the evaluation process.

10.4 Reporting and Compliance Evaluations

An important element of annual reporting is for the permittee to demonstrate compliance with the HCP. Regulations at 50 CFR 13.45 and 222.301, provide the authority for us to require periodic reports unless we specify otherwise in the incidental take permit. As shown in Figure 10.4a, our field office staff must review reports to ensure they contain the information required to ensure the permittee is complying with the HCP and terms and conditions of the permit, and to evaluate whether or not the HCP is meeting biological objectives. The data and report requirements should provide the information needed to unambiguously monitor and enforce permit compliance.

Figure 10.4a: Services Role in Evaluating Annual Reports



Typically, all reporting requirements should be described in the HCP and the permit. In most cases the reporting requirements in the permit are the same as those found in the HCP. The Services and the applicant should determine and specify during HCP development the level of detail required in the reports. Coordinate timing of HCP reports with other external reporting requirements to help streamline multiple requirements that permittees may have, such as those

for State wildlife agencies. We should ensure that the reporting requirements are tailored for documenting compliance with the incidental take permit.

Information and data that the permittee shares typically occurs annually, however it can be more or less frequent depending on the plan. Some plans have reporting requirements that are more frequent early in implementation (when many of the impacts and conservation actions are taken) and less frequent (as impacts and conservation actions decrease). Consider sharing the following information:

1. Summaries of or a list of the covered activities implemented.
2. Quantify the impacts from covered activities.
3. Quantify and describe the extent of take for each covered species as a result of the covered activity.
4. Description how the conservation commitments of the HCP were implemented and their results.
5. Description of the monitoring results and survey information.
6. Description of any circumstances that made adaptive management actions necessary and how it was implemented.
7. Description of any changed or unforeseen circumstances that occurred and explain how they were addressed.
8. Summarize funding expenditures, balance, and accrual.
9. Summarize any minor or major amendments.
10. Description of any non-compliance issues and how they were resolved.
11. Include any other information as required by the permit or HCP.

10.4.1 Data Sharing

The Services and applicant should transmit data per the data management and sharing plan that was developed early in the process. Data shared should include any relevant information for helping us understand compliance, habitat conditions, and the status of covered species. This data is not only important to document compliance, but it is also useful in linking conservation efforts across bigger scales.

Table 10.4a: HCP data sharing requirements				
Data to be shared*	**When to share data**			
	draft HCP	final HCP	annual update	required element
Plan area boundary	**X**	**X**		**X**
Conservation areas	**X**	**X**	**X**	**X**
Impact areas	**X**	**X**	**X**	**X**
Permittee HCP tracking and reporting			**X**	**X**
Species impacts (what was impacted-habitat/individuals)			**X**	**X**
Species survey information (locality, presence/absence, abundance, etc.)	**X**	**X**	**X**	**X**
Habitat restoration data			**X**	
Models inputs and outputs	**X**	**X**		
*not all elements will be developed for each plan.				

Traditionally, HCP annual reports come in paper copy or as a PDF at roughly the same time each year. These reports demonstrate compliance and lay out basic plan implementation information. However, we can do more with the information if it is collected and transmitted with the full data lifecycle in mind, not just that for one particular HCP, but also for regional conservation efforts for the species.

- All data delivered to FWS should have fully compliant metadata that meets Federal Geographic Data Committee (FGDC) or ISO 19115 metadata standards
- What are the survey protocols? Are there other ongoing efforts to monitor the same species? Are the methods compatible with this HCP?
- How is the data going to be housed? Can data collected for this HCP be combined with data gathered from other ongoing conservation efforts?
- Was there geospatial information gathered for this HCP? How/where is it housed?
- Is the data going to be analyzed? What techniques will be utilized? Where will the analysis be kept? Can it be combined with other ongoing analyses? How robust is the analysis? Could it be improved by combining with other ongoing efforts?
- Be especially careful if the Services are going to replicate analyses independently of the applicant (or their consultant). In this case, more data will likely be transferred and more specific information about how the analyses were conducted should accompany the data.

The Services and applicant should think carefully about the full data lifecycle for how and what the permittee will collect, and the plan should identify, at a minimum, the required data deliverables. Consider the following:

- If there are multiple efforts ongoing in an area that cover the same species or habitat types, is there a way to link the efforts through standardized protocols and a centralized database?
- Has a data management plan been developed (see the HCP Handbook Toolbox)? How can data be shared with others?
- Are there adjoining HCPs in an area, or other relevant efforts? Is there a benefit for them to work together on conservation and data collection/housing/ analysis?

In some instances linking the monitoring to ongoing monitoring efforts outside the plan area will allow for better quality information at reduced effort and cost. USGS has prepared a useful summary of the full data life cycle (see the HCP Handbook Toolbox).

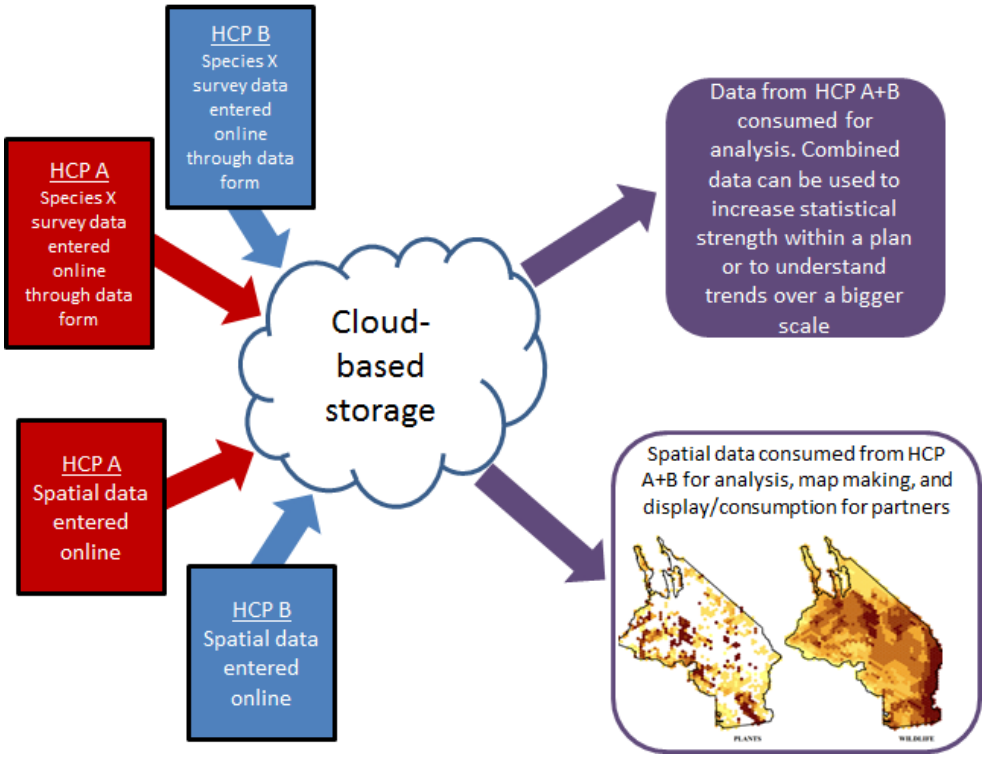
Helpful Hints:

- **Data are valued assets: We need to manage data over their entire lifecycle beyond the immediate need.**
- **All delivered datasets should have fully compliant metadata.**
- **The goal of managing over the data lifecycle is to eliminate waste, operate efficiently, and practice good data stewardship**
- **By linking to other efforts, we can be more efficient and improve conservation efforts.**
- **A good data management plan can help organize and plan for all phases of the full data lifecycle (see the HCP Handbook Toolbox) for additional materials pertinent to management plans).**

10.4.2 Technology and Reporting

The emergence of cloud-based data housing opens up a world of options for sharing data and for improving how information collected or developed in the HCP can be consumed by the Services and partners. Systems like USGS ScienceBase (see the HCP Handbook Toolbox) present opportunities to house and manage data online in a Federal data repository where it can be made discoverable and usable by other applications such as data.gov. Web map services like Databasin and ArcGIS (see the HCP Handbook Toolbox) offer online map making and collaboration services. These tools should be an integral part of sharing data between the permittee and the Services and increasing transparency.

Figure 10.4b: Data Sharing and Collaboration Using Cloud-Based Services



Ideally, the Services office (Regional or Field) will have developed a system for the applicant/permittee to directly enter data through an online portal or an online database. Setting up an online data system with proper data quality controls, allows for easy information exchange, facilitates coordination with other HCPs and protected areas during plan development and implementation, and allows us to roll up of many spatial analyses into landscape level planning for species and ecosystems.

10.4.3 Outputs from Monitoring and Evaluation in Annual Reports

Annual reports must document the status of *plan compliance* including:

- land acquisition/protection activities implemented,
- management activities implemented,
- monitoring activities implemented, and
- funds expended for implementation.

Annual reports should document the effectiveness of plan implementation in meeting stated biological goals and objectives, including:

- status and trends of resources (e.g., quantitative data on covered species, biodiversity, vegetative composition and structure),
- status and trends of known threats, and
- effects of management actions in achieving the desired condition.

Annual reports should document *targeted research or studies* implemented to provide information we need to support management decisions including:

- resolving critical uncertainties to improve understanding of species or system function, and
- results of experimental management treatments.

10.4.4 Evaluating HCP Compliance

It is incumbent on the Services to read and evaluate the annual reports that the permittee submits. Field office staff resources should be dedicated to compliance monitoring, especially for the larger HCPs, including the development of guidance for site visits by staff on a regular schedule and the use of periodic independent audits for compliance reporting. Field offices should develop HCP monitoring plans to determine staff requirements and to ensure the actions are assigned to appropriate individuals. They may include line item budget items to ensure resources are allocated for this important task (Chapter 17.2).

See Chapter 17.6 for more information about what to do if the permittee is out of compliance during plan implementation.

Permittee-conducted monitoring should also include checks on when and if changed circumstances have been triggered. For plans that have a long permit duration, the status of fire, drought, floods, etc. provide context for implementation of the entire conservation program.

It is important to keep in mind that each HCP is different, and the approach to evaluating compliance of HCP implementation varies between HCPs. Complex programmatic plans may involve ongoing coordination with oversight committees, while a simple single-family lot development may only require a one-time confirmation of an in-lieu fee payment.

10.5 Adaptive Management

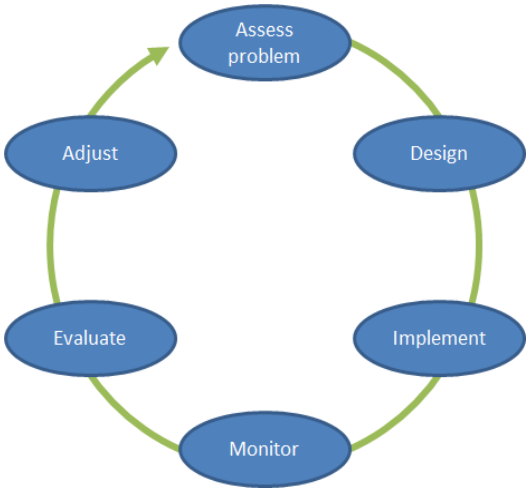
We will consider adaptive management as a tool to address uncertainty in the conservation of a species covered by an HCP. Whenever an adaptive management strategy is used, the approved HCP must outline the agreed-upon future changes to the operating conservation program. Not all HCPs or all species covered in an incidental take permit need an adaptive management strategy. However, an adaptive management strategy is essential for HCPs that would otherwise pose a significant risk to the species at the time the permit is issued due to significant data or information gaps.

Adaptive management has traditionally been viewed and designed for large-scale systems. However, in some situations we may want to retain the flexibility of addressing uncertainty through an adaptive management strategy at a smaller scale. In such situations, an adaptive management strategy could take many forms including creating a simple feedback loop so that management changes could be implemented based on results of the HCP's monitoring program.

Possible significant data gaps that may require an adaptive management strategy include, but are not limited to, a significant lack of specific information about the ecology of the species or its habitat (e.g., food preferences, relative importance of predators, territory size), uncertainty in the effectiveness of habitat or species management techniques, or lack of knowledge on the degree of potential effects of the activity on the species covered in the incidental take permit. Often, a direct relationship exists between the level of biological uncertainty for a covered species and the degree of risk that an incidental take permit could pose for that species. Therefore, the operating conservation program may need to be relatively cautious initially and adjusted later based on new information, even though a cautious approach may limit the number of alternative strategies that may be tested.

A practical adaptive management strategy within the operating conservation program of a long-term incidental take permit will include milestones that are reviewed at scheduled intervals during the lifetime of the incidental take permit and permitted action. If a relatively high degree of risk exists, milestones and adjustments may need to occur early and often. Adaptive management should not be a catchall for every uncertainty or a means to address issues that could not be resolved during negotiations of the HCP. There may be some circumstances with such a high degree of uncertainty and potential significant effects that a species should not receive coverage in an incidental take permit at all until additional research is conducted.

Figure 10.5a: Conceptual Adaptive Management Process



What exactly is adaptive management? In its simplest form adaptive management is learning by doing, but that definition sells short the process and thought that goes into it. Adaptive management is more than monitoring and changing management actions; as the 2009, Department of the Interior *Adaptive Management Technical Guide* (see the HCP Handbook Toolbox) describes it:

> *An adaptive approach involves exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management focuses on learning and adapting,*

through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems.

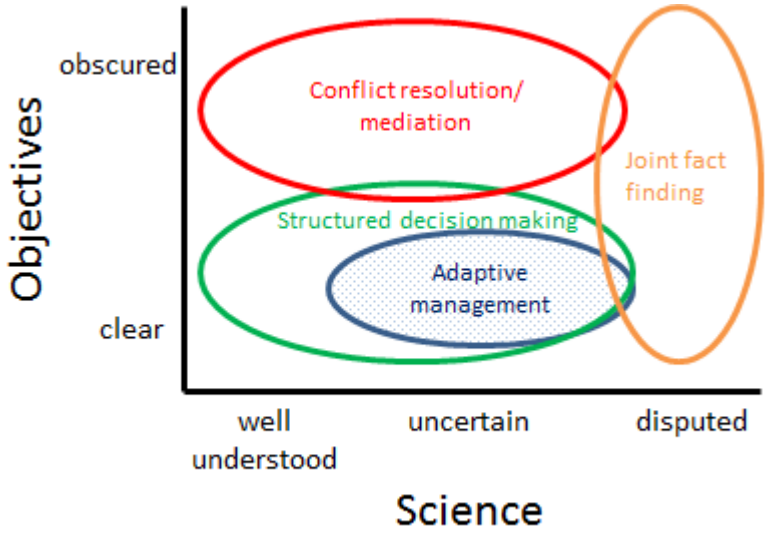
The outcome is better management decisions, but the process of learning and making more informed future decisions is what adaptive management is all about.

Increasing attention is being given to understanding, adjusting, and applying the concepts of adaptive management in the context of climate change and its effects (see *Climate-Smart Conservation,* Stein et. al., 2014, and *Informing Decisions in Changing Climate,* National Research Council, 2009). This may be particularly important in light of climatic conditions changing at rates different than current and historical trends. We must evaluate if the expected changes are significantly different enough to require more detailed modeling and responses than if we assumed the past or current rate of changing continuing. In some cases, greater emphasis on proactive adaptation management to alleviate the effects of a change climate may be more efficient and effective than reactive management that takes place after impacts have occurred.

Before we issue a permit, there must be a clear understanding and agreement between the Services and the permittee as to the range of adjustments to the management actions that might be required as a result of any adaptive management provisions. We should work with the applicant to develop, in advance, a mechanism for determining the magnitude of strategy change that may need to be employed based on the results of the monitoring and the level of deviation significance from the desired condition. This will help to ensure all parties are clear about what might need to happen and can communicate and react at the appropriate time. Avoiding misunderstanding and miscommunication is the best way to minimize compliance problems (Chapter 17.6). Changes to the conservation program should be planned to minimize the need for amending the permit (Chapter 17.4).

Not everything can be fixed through adaptive management. Deciding when to employ adaptive management is an important step in the process. See Figure 10.5.

Figure 10.5: Employing Adaptive Management



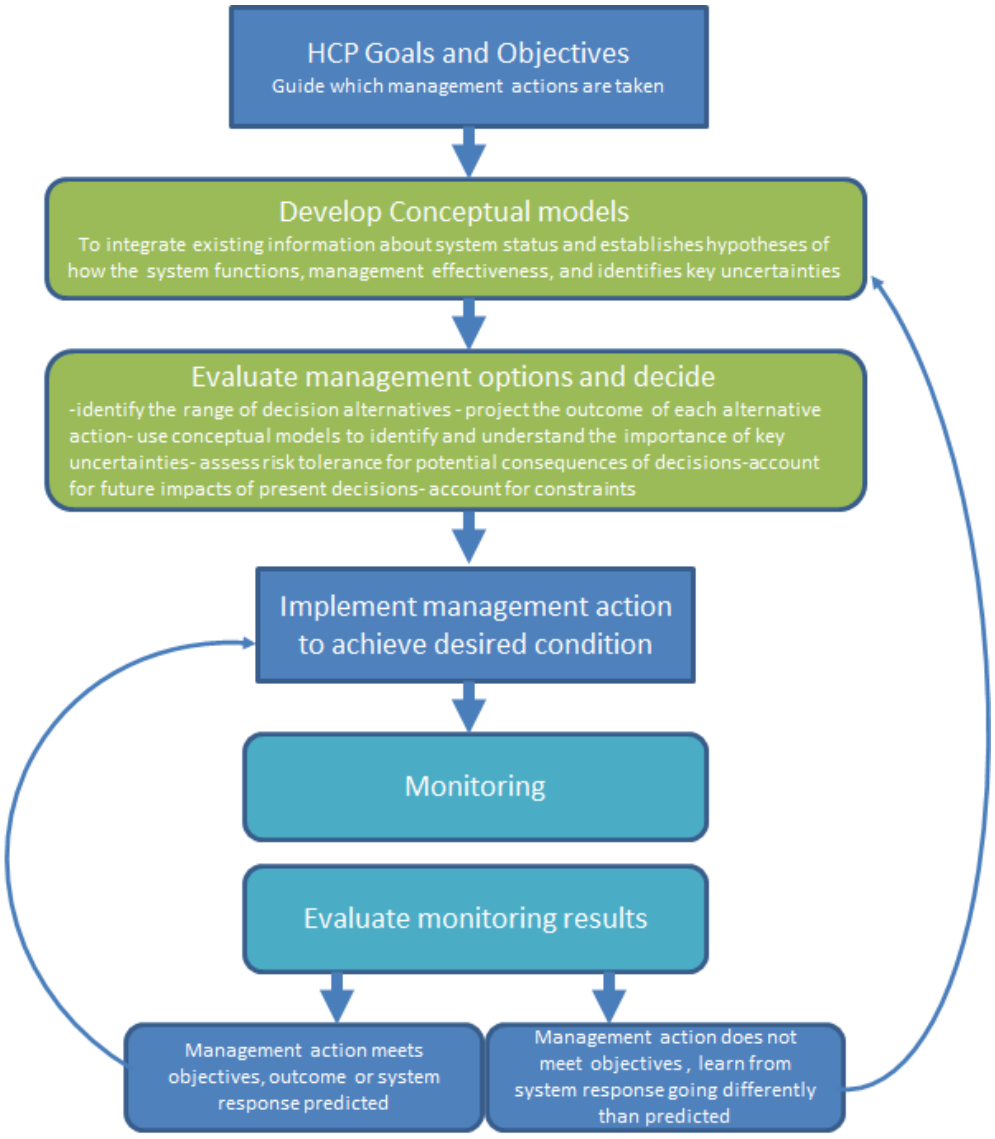
Adaptive management is best employed when the objectives are clear, but there are some uncertainties in the science about how to reach those objectives. Structured decision making requires a commitment to a rigorous process to analyze and make decisions. More information about structured decision making is in Chapter 3, section 3.10. There is considerable overlap between structured decision making and adaptive management. At their best, combining these two processes can lead to a robust decision making process and set the stage for efficient learning and improved decisions about how to proceed with management actions.

10.5.1 How to Incorporate Adaptive Management into an HCP

Much of what we need to develop an adaptive management approach relies on the integrated approach to developing the HCP. This integrated approach is described in depth throughout this Handbook and can be summarized in the following way:

1. Define goals.
2. Develop conceptual models to serve as hypotheses for how the system works and to identify key uncertainties.
3. Evaluate management options.
4. Develop a monitoring and evaluation program that can answer questions to reduce uncertainty.
5. Implement management action and monitoring.
6. Evaluate information and incorporate it into decisions to improve system models.
7. Use updated system models for future decisions.

Figure 10.5c: Integrated Approach to Adaptive Management and HCP Implementation



This integrated approach to goal development, monitoring plan development, data evaluation, and adaptive management is the key to each piece working efficiently to support the entire conservation strategy and improve future decisions. See Figure 10.5c above.

Adaptive Management Triggers

The Services must work with applicants to specify thresholds that trigger implementation of a particular adaptive management strategy or open reassessment of an adopted strategy. For example, Montana's Native Fish HCP requires mitigation actions if stream temperature increases by 1.0° C. When possible, the HCP should trigger specific actions that must be taken, not merely provide a general review of strategies.

10.5.2 Uncertainty in Management Decisions

Very few, if any, management decisions have 100% certainty. The adaptive management framework allows managers to explicitly acknowledge uncertainty through our conceptual models, and lays the foundation to evaluate the importance of those uncertainties and reduce them when appropriate. In any decision, each variable is not equally significant, so focusing on those variables that are significant, but have associated uncertainty, can focus models or monitoring to reduce the uncertainties and make better management decisions.

10.5.2.1 Accounting for Uncertainty

There are many types of uncertainty that can influence the management of natural resources. Some general sources of uncertainty commonly encountered in HCPs include:

- *system process*: limited understanding of how the ecosystem works
- *effectiveness of management action*: limited understanding of how effective the management action will be in having the desired outcome
- *basic biology*: limited understanding of basic biological needs or functions of a species
- *occupancy*: limited information/understanding about species presence in an area
- *survey strength to detect individuals/trends*: uncertainty of accuracy our survey methods have to capture information about species
- *model uncertainty*: uncertainty inherent in models, which are simplifications and involve assumptions about processes and relationships

Each one of these sources of uncertainty can affect or obscure the quality of information that goes into any decision-making process in an HCP. We need to identify these uncertainties so they can be evaluated and reduced where appropriate.

Adaptive management can help us deal with uncertainty by explicitly recognizing it and bringing it into the decision-making process. For example, for environmental variation, we can include environmental conditions in the resource models and assign probabilities or ranges to those that are relevant. This gives decision makers either a probability of the information being accurate or a range of possibilities the variable is thought to cover. If the probability is low or the range is wide, and this particular variable is extremely important, it can be factored into the decision making when determining how to proceed.

A few steps worth considering when dealing with uncertainty are:

1. Identify sources of uncertainty through models or relevant logic structure.
2. Characterize each source of uncertainty by type.
3. Identify which sources of uncertainty are important enough where the value of obtaining more information is worth the investment of staff time and funds.
4. Identify appropriate solutions for dealing with the specific type of uncertainty.

Also see Table 10.5a below.

Table 10.5a: Dealing with Uncertainty		
Type of uncertainty	**Potential solutions for dealing with uncertainty**	**Repeat decision?**
basic biology or system function: limited understanding of biological or system function effectiveness of management action: limited understanding of how effective the management action will be in having the desired outcome	-evaluate if those uncertainties are important to the decision-making process -focus research before decisions are made to resolve key uncertainty OR -implement management actions as an experiment with hypotheses about response, monitor and evaluate, update models	yes
occupancy status: limited information/understanding about species presence in an area	-evaluate if those uncertainties are important to the decision-making process -make assumptions about occupancy -if important enough, conduct baseline surveys to establish occupancy status before making management decisions	no
detectability of individuals/trends: uncertainty of accuracy of survey methods to capture information about species or system	-evaluate if those uncertainties are important to the decision-making process -make assumptions about detectability -make assumptions about trend -if important enough, conduct research to reduce uncertainty of survey method	no

Where can I learn more about adaptive management and an integrated approach to development of a conservation strategy? The following documents are in the HCP Handbook Toolbox.

- Climate-Smart Conservation: Putting Adaptation Principles into Practice
- Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans, U.S. Geological Survey
- Guidance for Designing an Integrated Monitoring Program. National Park Service
- Miradi: a user-friendly program that allows nature conservation practitioners to design, manage, monitor, and learn from their projects to more effectively meet their conservation goals
- The Department of the Interior Adaptive Management Technical Guide
- The Open Standards for the Practice of Conservation
- The San Diego Management and Monitoring Plan

10.5.3 Oversight Committees

For large-scale or regional, programmatic HCPs, oversight/technical/or steering committees, made up of representatives from the permittees and the agencies that issue local permits (i.e., building or grading permits, etc.) are often used to ensure proper and periodic review of the monitoring program. These types of teams also ensure that each program properly implements the terms and conditions of the incidental take permit. They evaluate the permittee's success in reaching its identified goals and objectives. Technical experts or affected stakeholder groups may also work on these teams when significant adaptive management might be expected. These teams can be particularly helpful in advising the permittee on changes needed to the monitoring program and how to adaptively manage the HCP to efficiently meet goals and objectives.

Committees that the applicant or a non-Federal stakeholder forms and operates are not be subject to the Federal Advisory Committee Act. We should participate, but we should not oversee or "manage" such committees. They should be organized by the applicant or other non-Federal stakeholder. Oversight committees should meet regularly and review implementation of the monitoring program and filing of reports as defined in the HCP and incidental take permit. The committees should meet annually, although they may meet less often depending on management results, frequency of changed circumstances, or increased confidence in the plan's management methods.