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DECISION SUPPORT TOOLS: BRIDGING THE GAP BETWEEN SCIENCE AND MANAGEMENT

John D. Alexander,[1,4] Jaime L. Stephens,[1] Geoffrey R. Geupel,[2] and Thomas C. Will[3]

[1]*Klamath Bird Observatory, 1497 East Main Street, Ashland, Oregon 97520, USA;*

[2]*PRBO Conservation Science, 3820 Cypress Drive #11, Petaluma, California 94954, USA; and*

[3]*U. S. Fish and Wildlife Service, 1 Federal Drive, Fort Snelling, Minnesota 55111-4056, USA*

Abstract. Within a Partners in Flight conservation strategy Decision Support Tools (DSTs) provide a mechanism for the transfer of science-based information to communities who implement strategies that benefit birds and their habitats. DSTs link priority land management challenges and bird conservation objectives using audience-specific delivery approaches to convey the best available scientific information through synthesis and interpretation of bird monitoring data. Effective DST development should be driven by a collaborative process between scientists, decision makers, and educators, through which the decision maker is involved in most, if not all, phases of data collection and delivery. This will assure monitoring results better target and inform the specific decisions managers face. We considered characteristics that describe and enhance development of effective DSTs that serve to integrate bird monitoring within management and conservation practices. Careful consideration of these characteristics will enhance the use of bird monitoring within the adaptive management framework, improving decision-making and evaluation of management effects with regards to bird conservation.

Key Words: Decision support tool, monitoring, adaptive management, conservation objectives, matrix.

HERRAMIENTAS DE APOYO EN LA TOMA DE DECISIONES: SALVANDO EL ESPACIO ENTRE LA CIENCIA Y LA GESTIÓN

Resumen. Dentro de la estrategia de conservación de Compañeros en Vuelo (Partners in Flight), las Herramientas de Apoyo en la Toma de Decisiones (DSTs), proveen un mecanismo para la transferencia de información de basamento científico, a las comunidades que implementan estrategias en beneficio de las aves y sus hábitats. Las DSTs conectan los desafíos priorizados en la gestión de terrenos, con los objetivos de la conservación de aves. Utilizan para ello enfoques de orientación a audiencias específicas, transmitiendo la mejor información disponible a través de la síntesis y la interpretación de datos del monitoreo de aves. El desarrollo efectivo de las DST, debe estar impulsado por un proceso colaborativo entre los científicos, los tomadores de decisiones y los educadores; donde quienes deciden el curso de acción están inmersos en la mayoría, sino en todas, las fases de la obtención y la entrega de datos. Esto asegura que los resultados del monitoreo se orienten e informen mejor, sobre las decisiones específicas que los gestores deben enfrentar. Se tomaron en cuenta características que describen y amplían el desarrollo efectivo de las DSTs y que sirven en la integración del monitoreo de aves, dentro de las prácticas de gestión y conservación. La consideración especial de estas características, amplía el uso del monitoreo de aves dentro de la estructura de gestión adaptativa, mejorando la toma de decisiones y la evaluación de los efectos de la gestión con respecto a la conservación de aves.

INTRODUCTION

Integrating bird monitoring within management and conservation practices was recently identified as a primary goal to improve bird monitoring by the North American Bird Conservation Initiative (U.S. North American Bird Conservation Initiative Monitoring Subcommittee 2007). The authors suggest that monitoring should contribute more to decision-making and evaluation of management effects within the adaptive management process. In response, Partners in Flight (PIF) has set as a high priority the effective transfer of science-based information to communities of conservation actors who can implement strategies that benefit birds and their habitats. Decision Support Tools (DSTs) provide a mechanism for achieving this goal.

[4] E-mail: jda@klamathbird.org

In this paper we considered the characteristics that describe the effective development of useful DSTs and discuss the audiences and decisions for which DSTs should be developed.

DECISION SUPPORT TOOLS

A Decision Support Tool (DST) is an instrument used for conveying scientific information that informs decision-making through synthesis and interpretation of quantifiable and repeatable scientific data. DSTs can be broadly defined as the process through which decisions are made (e.g., adaptive management itself) or more narrowly defined as something used in the process. To inform specific land management related decisions from a bird conservation perspective DSTs consider management alternatives through analysis, prediction, and visualization of bird and habitat monitoring data and other knowledge sources. Conservation focused DST's deliver the best available scientific information to target audiences and identify bird conservation opportunities within land management challenges. To support a decision making process DSTs should organize a decision problem, formulate alternatives, and analyze future consequences, assisting decision makers in their ability to explain and reproduce decisions (Rauscher 1999).

DSTs can be broadly applicable to an array of decisions, some of which are currently unknown and will emerge from future conservation needs or opportunities. Alternatively, DSTs developed to address specific decisions facing a targeted audience are advantageous. Within this range, there is a great variety of DSTs that deliver science to decision makers. DSTs are produced in various formats (e.g., conceptual designs, interactive computer programs, brochures and pamphlets, white papers). Korscghen et al. (2005) describe DSTs along a continuum defined by the inverse relationship between ease of use and functionality for target audiences. Simple DSTs that are easy to use likely have limited function; however, they are often well-targeted for wide-ranging yet specific audiences. DSTs that incorporate more complex models have increased functionality; however, they are often difficult to use and are only applicable to a limited audience (e.g., researchers and technical analysts).

Data visualizations often comprise an important component of DSTs. These visualizations can be generated through interactive computer packages (i.e., decision support systems) that provide guidance for decision makers who interactively explore a set of questions related to management alternatives. In contrast to this dynamic approach, static visualizations delivered on a one-page pamphlet briefly relate scientific results to a decision that a given manager faces. Within the range of visualization delivery options the critical questions are, "what is the validity of a data visualization systems and what level of data visualization is sufficient for environmental planning and management?" (Daniel 1992). Analysts need to remember that data visualizations are "sufficient to the extent that adding detail, higher resolution, color fidelity, animation or other features does not improve the match between representation-based and direct responses" (Daniel 1992).

Collaboration—Scientists, Decision Makers, and Educators

The development of effective DSTs requires purposeful attention to the relationships between potential science providers and target audiences. With such attention we will be better able to identify information gaps and transfer points that require the development of new tools. Development of DSTs has often been driven by technology, not by needs and requirements of decision makers (Rauscher 1999). We suggest that to be effective, DST development must instead be driven by a collaborative process between scientists, decision makers, and educators. As communications specialists, management and conservation oriented educators can facilitate effective DST development by helping to identify issue driven links between science and management challenges. Through collaboration scientists, decision makers, and educators should: 1) identify information needs relative to priority land management challenges and conservation opportunities; 2) develop the questions that become the foundation of monitoring efforts designed to fill such information needs; 3) deliver the results of monitoring efforts in formats that meet the information needs of both the science and management communities; and 4) use the information to make educated land management decisions that effectively target bird conservation needs.

Within this collaborative framework decision makers become increasingly involved in most phases of data collection and delivery, assuring the results of hypothesis-based monitoring efforts better target and inform the specific decisions managers face. Such collaboration will also help scientists and conservation planners better understand their audiences, the types of decisions that challenge them, the environment within which they make decisions, and the scale at which these decisions influence conservation actions. Given the different motivations and information needs of alternative audiences, a number of questions must be considered at the outset of a collaborative DST development process:

- Are the decision makers aware of the data and information formats that are or could be made available that would help them effectively integrate a conservation action within their decision?
- What kind of decisions (e.g., policy or management action), and what specific decisions, are to be supported?
- Who is making the decision?
- At what scale is a decision being made?
- Who might most effectively deliver a DST to a given decision maker?
- How does the DST need to be delivered to be most effective?

With the high rate of turnover in land management agency personnel the relationship between the scientist and the decision maker becomes even more relevant. Documentation of monitoring schemes and the delivery of monitoring results as DSTs are necessary to assure that the new agency personnel making decisions are aware of ongoing data collection and DSTs designed to support future decisions (Geupel and Nur 1993).

Matrices

We present three matrices that address three foci: 1) scale, 2) alternative DSTs, and 3) conservation design. In designing matrices that guide in development of DSTs, we first consider matrix structure. The rows define the subjects of the matrix and the columns define the variables that compare each subject.

The first matrix is built around the subject of scale, (i.e., the rows of the matrix) (Table 1). The matrix identifies target audiences, the decisions that they need to make, related research questions, conservation actions, and measures for evaluating conservation and management actions (i.e., the columns of the matrix) for each scale and contrasts them across scales. Table 1 shows that there are some characteristics that persist within each variable across scales (e.g., decisions about monitoring), while other characteristics are scale-dependent (e.g., aspects of planning decisions).

The target audience for a given DST depends on scale, including policy makers at the continental scale, regional program managers who remain involved at all scales, and project managers involved at landscape and local scales (Table 1). At the continental scale decisions about management program directions are made. Management objectives and monitoring strategies are influenced at both broad and narrow scales. At the broader scale, questions will be long-term in nature and will focus on continental and regional response variables, whereas at the local scale questions might be both long- and short-term in scope. DSTs should attempt to integrate conservation objectives with policy direction planning at the continental and regional scales, and project implementation at the landscape and local scales, while considering scale appropriate monitoring and evaluation measures (Table 1).

To further illustrate this matrix, we developed a second matrix to contrast three DSTs (Table 2). We used three of the same variables (i.e., the columns of the matrix) (Audience, Information Need/Decision, and Conservation Issue/Opportunity), with the addition of Scale to identify characteristics of each DST and the decision they support. The DST presented by Geupel et al. (2007, 2008) specifically targets agencies involved in federal-aid programs for private landowners within California's Central Valley Joint Venture administrative boundary. This DST prioritizes watersheds and projects that maximize the effectiveness of limited conservation dollars on species of concern, as well as PIF focal species that represent a range of important ecosystems processes (Chase and Geupel 2005). Tautin et al. (this volume) are targeting a wider audience who decides where Purple Martin conservation efforts should be focused. Stephens and Alexander (2008), targeting local land managers, developed a DST that supports decisions about the type of fuel treatment that best satisfies local bird habitat conservation needs (Table 2).

The second tier of columns in this matrix (Format, Input, Measure, # of Species, and Resulting Decision) (Table 2) further describe each DST. The first two DSTs are interactive computer decision support systems. Geupel et al. (2007, 2008) developed a web-based system that uses count and spatial data to model predicted species occurrence and existing and potential population abundance. The resulting outputs are used to predict and evaluate riparian restoration projects' relative contribution to basin-wide targets of the Central Valley Joint Venture (Central Valley Joint Venture 2007). Tautin et al. (2008) described their use of Breeding Bird Survey data (Sauer et al 2007) to compare Purple Martin trends at smaller scales within the species' range to determine where conservation programs are most needed. In contrast, the Stephens and Alexander (2008) DST is a brochure that describes and translates results from two management-related bird and habitat monitoring projects (Alexander et al. 2007 and Seavy et al. 2008) to inform decision makers

Table 1. A matrix using scale as a framework for describing Decision Support Tool target audiences, decision types, and related monitoring questions, conservation actions and monitoring/evaluation tools.

	Target Audience	Decision	Monitoring Question	Conservation Action	Monitoring/Evaluation Measure
Continental (e.g., North America, United Sates)	Washington/Regional- • Policy makers • Leadership • Program managers (e.g., wildlife, fire, forestry, education)	Program planning- • Direction • Management objectives Monitoring strategy	Long-term continental population response?	Integration: PIF & policy direction- • Conservation objectives • Monitoring tools (continental)	Policy • Direction • Objectives Focal species (continental)- • Trends (BBS) • Population estimates (BBS) • Vital rates (Constant-effort with banding)
Regional (e.g., Western US, Bird Conservation Region, Bioregion)	Regional/Management unit- • Leadership • Program managers	Management planning- • Objectives • Alternatives Monitoring strategy	Long-term regional population response?	Integration: PIF & planning- • Conservation objectives • Monitoring tools (regional)	Policy & management plan- • Direction • Objectives Focal species (regional)- • Trends (BBS, extensive point counts) • Population estimates (BBS, extensive point counts) • Vital rates (Constant-effort with banding)
Landscape (e.g., Bioregion, Watershed)	Regional/Management unit- • Leadership • Program managers • Project managers	Management planning- • Objectives • Alternatives • Program design & implementation Monitoring strategy	Long-term landscape population response?	Integration: PIF, planning & project implementation- • Conservation objectives • Monitoring tools (landscape)	Policy, management plan & project - • Direction • Objectives • Implementation Focal species (landscape, project)- • Trends (extensive/intensive point count) • Population estimates (extensive/intensive point count) • Vital rates (constant-effort with banding, spot mapping/nest search/behavior)
Local (e.g., Watershed, Project Area)	Management unit- • Leadership • Program managers • Project managers	Management planning- • Objectives • Alternatives • Program design & implementation Monitoring strategy	Project-level population response?	Integration: PIF, planning & project implementation- • Conservation objectives • Monitoring (effectiveness monitoring)	Project- • Implementation Focal species (landscape, project)- • Trends (intensive point count) • Population estimates (intensive point count) • Vital rates (constant-effort with banding, spot mapping/nest search/behavior)

(1) Attributes of each variable that change as one moves down the matrix from broad to narrow scales are identified by changing the font style. Those attributes that are newly added at each scale are underlined, while those that are dropped in the following scale are italicized.

TABLE 2. A matrix comparing three Decision Support Tools (DST) presented during the 4th International Partners in Flight Conference. This matrix describes the basic characteristics of each DST as well the target audience and the associated decision being supported.

Bridging the Gap Presentation	DSTs Discussed	Audience	Information Need/ Decision	Conservation Issue/ Opportunity	Scale
The unexpected values of multi-species monitoring programs to guide conservation (Geupel et al.)	Riparian bird conservation potential in the California Central Valley	Central Valley and Riparian Habitat Joint Ventures	Where to spend limited resourses on riparian bird conservation implementation?	Maximize potential of implanting PIF species and habitat conservation objectives	Regional - management unit
Addressing regional declines in Purple Martin populations (Tautin et al.)	Purple Martin conservation	Agencies, NGOs and citizens	Where are conservation actions needed?	Purple Martin declines	Range wide - region
Integrating research into land management - KBO works with the Medford BLM (Stephens and Alexnader)	Oak woodland fuels treatment alternative	BLM biologists and fuels managers	Which fuels reduction alternatives?	Aligning fire reduction with habitat objectives	Watershed- management unit

Author	Format	Input	Measure	# of Species	Resulting decision
Geupel et al. 2008	Interactive computer decision support system	Point count/GIS habitat occurrence and potential	Population potential (# of individuals gained from restoration)	Multi-species	Where to fund on the ground conservation
Tautin et al. this volume	Interactive computer decision support system (BBS)	BBS; Complimentary surveys	Trend	Single	Establish of regional working groups
Stephens and Alexnader 2008	Brochure	Point counts	Relative abundance	Multi-species	Choice of treatment alternative

TABLE 3. A matrix that evaluates the Stephens and Alexander (2008) Decision Support Tool from its audience's perspective, considering the types of decisions being informed, as well as the five elements of conservation design (Will et al. 2005) and the scale associated variables outlined in Table 1. The simple DST presented by Stephens and Alexander (2008) summarized two studies that measured the bird community response to alternative oak woodland fuels reduction treatments (Alexander et al. 2007, Seavy et al. in press).

Decision Support Tool: Stephens and Alexander (2008)

Design Elements					
Landscape Assessment	Population Response Models	Opportunities Assessment	Optimal Landscape Design	Monitoring/ Evaluation	
Informs condition-specific composition of oak woodlands at watershed and sub-regional scale	Responses to management alternatives for roll up	Identifies beneficial management option as well as detrimental one	Informs balance of cost-effective fuels treatments with more expensive ones that also meet PIF objectives	Presents effectiveness monitoring tool that links PIF and priority management objectives	
Scale Matrix					
Scale	Target Audience	Decision	Research Question	Conservation Action	Monitoring/ Evaluation Measure
Local scale results; specifically informs planning at the watershed and sub-regional scale; demonstrate monitoring approach that is useful within the region and beyond	Program and project level land managers	How to treat a site; how to configure treatments at the watershed and sub-regional scale; widely applicable effectiveness monitoring tool that identifies opportunities to meet multiple objectives	What are the ecological effects of alternative treatments as represented by bird community response	Oak woodland treatments that meet priority fuels management and bird conservation objectives	Habitat and bird community (current and desired conditions; oak woodland birds associated with current and desired conditions)
Additional Variables					
Conservation Issue	Targeted Resources				
Oak woodland conservation- fire suppression, wide scale fuels treatments	Oak woodlands; urban interface				

about how alternative habitat treatments affect oak woodland focal species. This tool informs the decision maker who is prescribing fuel management treatments with information that helps them meet both priority species habitat objectives and fuel load and wildfire severity reduction objectives.

In a third, more complex analysis of DSTs, we added a third axis to the previously described two-dimensional matrices (Table 3). Here, we evaluate the Stephens and Alexander (2008) DST by considering the Five Elements of conservation design (Will et al. 2005) and the scale-associated variables outlined in Table 1. This additional dimension helps to tie the management decision back to conservation opportunities through the Five Elements framework. The Five Elements framework involves partners working together to determine where on the landscape sufficient habitats of different types can be delivered to meet bird population objectives (Will et al. 2005). Within this framework of conservation design the Stephens and Alexander (2008) DST offers information about comparative bird community responses to alternative management treatments at local scales. The results from the monitoring efforts described in the DST (Alexander et al. 2007, Seavy et al. 2008) not only address decisions being made at that scale, they also inform population response models at larger scales through a step-up process (Stockenberg et al. 2008) and provide an effectiveness monitoring tool that links bird conservation objectives with priority management objectives.

CONCLUSIONS

To adequately integrate science and monitoring within management and conservation practices, DSTs that use current monitoring results should present bird conservation alternatives and considerations within an adaptive management decision-making process. Information from monitoring programs that are used in DSTs should also be used to evaluate achievement of conservation objectives. Scientists and educators should work together with land management decision makers in all stages of DST development. Accordingly, DST target audiences must be identified at the outset of the development process, including the design of monitoring efforts that are used to build DSTs. Working with the target audiences, scientists and educators can better identify specific attributes of the decisions and recognize opportunities for integrating bird conservation objectives and monitoring programs within land management practices.

Through this collaborative process, more relevant monitoring programs can be designed around questions directly linked to management challenges. With involvement in developing hypothesis-based monitoring efforts managers help to frame questions, assuring the results better inform the decisions with which they are challenged. The manager helps to determine a format for a given DST that is most appropriate for a given decision making environment, increasing the likelihood that the decisions be best informed by science and linked to conservation opportunities, resulting in more conservation on the ground. Scientists must foster strong and ongoing working relationships with decision makers throughout the process of implementing monitoring efforts and should work with educators to assess how information is best delivered.

As on-going monitoring programs produce results that are increasingly relevant to land management issues, scientists should not only publish, they should also continue to work with educators to ensure results are delivered to decision makers through targeted and timely means. This enables a transfer of information to inform current decisions and address new opportunities that are constantly emerging through the land management decision-making process. Stephens et al. (this volume) present a description of the Avian Knowledge Alliance, a group of non-government organizations that are dedicated to delivering bird monitoring data via DSTs and the Avian Knowledge Network (Miller et al. this volume).

Partners in Flight has articulated a conservation planning strategy to advance the integration of bird conservation objectives and land management planning that focuses on the relationships of scientists and conservation planners with their audience, the management decision makers (Alexander et al. 2005, Alexander in review). A collaborative process in which scientists, educators, and decision makers work together to build a common understanding of decision challenges is critical to the development of DSTs that present the link between specific management issues, science-based results, and bird conservation objectives. Together, the group delivers the best available science in a format that supports the transformation of a decision challenge into a conservation opportunity.

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