Waterbirds around the world

A global overview of the conservation, management and research of the world's waterbird flyways

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Biological planning for bird conservation at the landscape scale: developing shared conservation strategies in the United States

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INTRODUCTION

The mandate to conserve bird populations in perpetuity is vast. Compared to this mandate, legal authorities and funding appropriated for habitat conservation are severely limited. In the United States, natural resource management agencies preside over a slow but inexorable deterioration of environmental function, including the capacity to sustain populations of most species. The challenges we face demand new approaches to the conservation enterprise – approaches based on applied science, coordinated conservation, and the cooperative communication of compelling conservation strategies.

The purpose of this paper is to illustrate (1) the importance of partnerships in affecting conservation at landscape-scales, and (2), more specifically, the role of biological planning in forging these partnerships and insuring that our collective conservation actions are effective and efficient. This paper is not intended to be a comprehensive description of the process of biological planning and evaluation, or of the diverse literature on various aspects of this iterative process.

CONSERVATION PARTNERSHIPS

In the U.S., political boundaries – among states and various government programs – have contributed to a traditionally fragmented and piecemeal approach to conservation with needs expressed implicitly rather than explicitly. Our challenge in the conservation of migratory birds is to coalesce the pieces of the conservation puzzle vested in diverse agencies into a comprehensive international, multi-agency strategy for conservation. When a conservation strategy is developed and implemented through partnerships, it reflects a community vision, with each partner committing their programs and influence with external entities to delivering components of the whole.

One challenge in developing a community conservation strategy is that partners’ jurisdictional boundaries often do not conform to a common theme. Most are based on states or aggregates of states. This facilitates program management but is not particularly conducive to the strategic management of populations and habitats. In the U.S., the geographic currency of partnerships is joint ventures initially formed under the banner of the North American Waterfowl Management Plan. Aligned along ecological boundaries, thereby transcending political barriers, joint ventures are partnerships of government agencies, non-governmental organizations, and others whose purpose is the efficient conservation of migratory birds.

Joint ventures are only valuable to the extent that they enable conservation that exceeds the sum of the potential actions of the individual agencies and organizations that comprise them. Joint ventures are uniquely structured to capture this added value. An ideal joint venture is comprised of two parts – a management board and a biological planning and evaluation team. The biological planning and evaluation team is charged with developing a science-based community conservation strategy. The role of management board members is to exert influence on the political process, and to shape how government agencies deliver their programs, to support implementation of the community strategy.

Through this dual structure, joint ventures position themselves as a nexus for information between the scientific community and the agencies and programs seeking natural resource enhancement benefits through habitat conservation. Neither half of the joint venture can function effectively without the other. To use a different paradigm, a business is comprised of manufacturing and sales. A joint venture’s product is a science-based conservation strategy. This product is marketed by the management board.

BIOLICAL PLANNING AND EVALUATION

Most wildlife management agencies are charged with the conservation of populations. Habitat management on public and private lands is an important tool in attaining this goal. As land-use pressures escalate, the question “How much habitat is enough?” is being asked more and more often. To make a compelling case for additional conservation resources and
Translating a population goal into an estimate of how much habitat is enough to attain this goal requires that we consider similarities and differences in the ways different species relate to habitats and respond to management, i.e., our planning must be spatially explicit, and we must design a landscape that maximizes collateral benefits and accounts for management conflicts. The development of spatial analysis techniques that integrate the biological foundation for management with digital spatial data using Geographic Information System (GIS) technology has been instrumental to science-based strategic conservation.

Collectively, a landscape design and habitat objectives predicted to sustain populations at desired levels constitute a conservation strategy (Fig. 1). The reliability of our assumptions about population-habitat relationships, and the degree to which managers are able to conform to the landscape design in delivering conservation, determine the relevance of our habitat objectives.

This type of strategy is not a stack of papers that is bound and sits on a shelf gathering dust. It is a living suite of tools that are continually augmented, updated and refined through the iterative process of evaluation and planning anew. Different components of our strategy speak to different audiences. For example, regional or national habitat objectives mean little to a field-level manager; however, landscape designs that help managers decide where to apply management treatments, e.g., protect grass or wetlands, reforest, etc., are invaluable. The opposite is true for agency administrators that need clear statements of regional and national habitat objectives to gain support for conservation programs from elected officials.

The scientific foundation for a conservation strategy is inevitably imperfect. In practice, this foundation is a set of assumptions about how species are predicted to respond to landscape structure, patch-scale dynamics, and management actions. Often, these assumptions are founded on very limited information. Yet the process of guiding management actions by articulating clear goals, applying the information that does exist, stating our underlying management assumptions (hypotheses) explicitly, evaluating the validity of our assumptions, and feeding refined assumptions into future management decisions is incredibly powerful. Most will recognize this process as adaptive resource management. Adaptive management of bird populations is founded on biological planning and evaluation for habitat conservation.

**Model-based approaches**

Biological models are the vehicles for translating science into conservation strategies. The sole purpose of models is to improve the outcomes of management decisions. A model is simply a set of assumptions expressed in measurable terms. Models are commonly developed for focal species, i.e., priority species that are sensitive to landscape structure, patch-scale characteristics, and management that affects the structure of the plant community. Focal species are presumed to represent the habitat needs of a wider array of other species that are often less sensitive to these factors, although evaluation of this assumption is critical.

A model's value is measured by the extent to which it adds useful information to the management of focal species. Generally speaking, as model complexity goes up, so does the added value for decision making because model predictions move beyond our capacity for intuition. For example, models such as range maps or basic habitat associations offer managers little that they do not already know. In fact, if a species' habitat relationships are adequately described by a basic habitat type (e.g., emergent wetland or deciduous forest), it is probably a poor candidate for a focal species for biological planning, because it captures little of the more refined habitat needs of other species which respond to factors such as landscape configuration or patch size.

Models are applied to digital spatial data to predict the potential population impacts of delivering a particular management treatment at a specific place in the landscape. Typically, the potential of every unit of the landscape is assessed in developing these decision support tools (DSTs) for the management of focal species.

Biological planners commonly use models that fall into two broad categories. Conceptual models, which may or may not include empirically-based parameter estimates, are compiled from a variety of sources including the personal experiences of individuals knowledgeable about the interactions of a species and its habitat. Conceptual models are sometimes called heuristic models, in that they carry a heavy burden to evaluate their inherent assumptions and future improvement in model performance is expected accordingly. Conversely, empirical models are more initially data driven and are typically developed from discrete data sets. Empirical model coefficients also require regular assessment, but if their foundation is long-term, spatially extensive data sets – clearly the preferred source – evaluation and model updating are inherent components of the periodic data collection protocol. Both types of models are data driven in the iterative biological planning and evaluation paradigm.

Lastly, while assessing apparent habitat suitability is often useful, developing a comprehensive conservation strategy that...
includes priority areas for specific conservation actions and habitat objectives requires that we use models that reliably predict carrying capacity or some other measure of population potential, developed in an awareness of the ecological factors or processes that limit populations.

**QUALITY CONTROL IN PARTNERSHIP-BASED CONSERVATION**

Why do partnerships such as joint ventures invest in biological planning and evaluation? (1) It can increase their efficiency – vital, given the magnitude of their mandate relative to the resources available to them; (2) it is a transparent and defensible application of sound science which enhances the partnership’s credibility – collectively and individually; (3) it is a framework for identifying critical information gaps for actual management decisions rather than things we would simply like to know more about, which has characterized much of our past statement of research needs; (4) it enables the development of coordinated conservation strategies for multiple groups of wildlife; and (5) it sets the stage for greater influence in the implementation of other State and Federal programs. To return to our business paradigm, biological planning and evaluation represent joint venture quality control.

**Efficiency**

The benefits of biological planning are predicated on the idea that every unit of a landscape, and every alternative management action at that location, has a unique potential to affect populations and unique costs to management agencies and society of doing so. Balancing these factors in pursuit of high impact per dollar expended is the essence of efficient conservation. While calculation of management costs may be relatively simple, assessing the probable impacts of applying a particular treatment at a particular location to populations of multiple species requires applications of science in a spatially-explicit environment.

**Transparency and defensibility**

Application of science to clearly defined management goals and information needs yields inherently defensible management strategies and decisions. The only question is whether the science is adequate to support a particular action that otherwise would not occur. In the U.S., biological planning serves two fundamental roles:

- targeting existing program resources and activities; and
- assessing the need for additional resources and programs.

When strategies and decisions are based on explicitly described assumptions, founded on the best available science, the decision-making environment is inherently transparent and defensible. Moreover, by acknowledging that our assumptions are based on imperfect knowledge, we isolate the decision process from its outcomes, and we set the stage for a productive dialogue on strengthening the biological foundation.

Finally, the maps and other products of biological planning are powerful tools that enable managers to communicate effectively with elected officials and the public, both to support their proposed actions and to resist actions that may be inefficient or undesirable.

**Building the biological foundation**

A model is really just a set of assumptions described in measurable terms. All assumptions are imperfect. As we go through the biological planning process, it is often obvious which assumptions are the most tenuous. Furthermore, refinement of some assumptions will have little impact on the decision we make. Others will have a large impact. Assumptions that are the most tenuous and that have the greatest potential impact on our management decisions are the highest priorities for research.

Thus, model-based biological planning is a systematic way of identifying and prioritizing information needs, i.e. identifying missing critical research and monitoring, and distinguishing these needs from things about which we are simply curious. This is a more strategic approach to building the biological foundation for conservation than traditional, more haphazard means of identifying research needs.

**Coordination of conservation for multiple species**

When biological planning is conducted in a spatially-explicit context, collateral benefits for multiple species can be assessed and management conflicts can be resolved. Maximizing site-level collateral benefits, within the constraints of program purposes and priorities, and minimizing collateral adverse impacts at landscape or eco-regional scales are essential to efficient conservation. Furthermore, the process of spatially-explicit planning is open-ended, i.e. other environmental and socio-economic functions of habitats can be assessed in the same fashion and integrated with spatial decision support tools developed for wildlife.

**Greater influence**

In intensively altered ecosystems, relatively little land is typically in public ownership. A private land conservation solution is required. A variety of Federal land management programs and environmental protection policies exert a profound impact on these landscapes. In the U.S., none is more important than the U.S. Department of Agriculture’s “Farm Bill”. The Farm Bill supports the apparently conflicting goals of sustaining high agricultural production by subsidizing farming operations, while simultaneously paying land owners to convert farmland into habitat for prevention of soil erosion, enhancing water quality, and providing wildlife habitat. In recent years, Farm Bill expenditures have exceeded by nearly 200 times the combined total of all Federal agencies for bird conservation. Clearly, influencing these farming subsidies and agricultural programs is of paramount importance in conserving birds. As the ultimate responsible entity for migratory bird conservation, the U.S. Fish and Wildlife Service (USFWS) has a special interest in Farm Bill policies and programs; however, in the political process of establishing these policies, the USFWS requires the support of state and non-governmental partners.

As noted, the products of landscape-scale biological planning can be compelling, because of their visual impact and because they are transparently derived and built on sound science. Being compelling, they provide a vehicle for reaching out beyond traditional conservation programs to other programs that affect public and private land-use management. Despite long-standing challenges in working with agriculture, bird conservationists in the U.S. have recently had success in targeting Farm Bill conservation programs, amounting to...
millions of dollars each year, in regions of the country where the capability for biological planning and evaluation exists.

**A CASE STUDY**

We illustrate these concepts in the following case study from an area of five counties in the Prairie Pothole Region of Minnesota. Although the models and maps of species-specific landscape priority areas are real, the population goals and some assumptions, and thus the integrated landscape design and habitat objectives, are hypothetical.

Our case study begins with the identification of an ecological perturbation (grassland habitat loss and fragmentation) and focal species that are sensitive to it. We consider the full suite of priority grassland-dependant birds in light of their response to stand height and density, patch size, and landscape structure. For our example, we chose three focal species. The Marbled Godwit *Limosa fede*o*, an apparently area-sensitive priority breeding shorebird, uses native or disturbed tame grasslands, studded with shallow wetlands, in landscapes with low terrain relief. The Greater Prairie Chicken *Tympanuchus cupido* is similarly sensitive to patch size and landscape structure. It requires short grass for nesting, but uses taller stands for brood rearing and other functions. Lastly, we chose to use the Mallard *Anas platyrhynchos* as a focal species. Mallards are grassland generalists and are relatively insensitive to grassland landscape structure; however, they require the juxtaposition of grasslands and wetlands, and there is great public demand for this species, with correspondingly high population goals.

A diverse conservation partnership is active in this five-county area. For each of our focal species, the partnership established population goals (Table 1). Above minimum viable population sizes, a partnership’s population goals are value-based predictions of public demand for wildlife and public willingness to pay the costs of attaining those goals. Ideally, population goals should be established iteratively by setting goals, assessing costs, and revisiting goals and costs until an acceptable level of consensus is achieved.

We assembled models and other assumptions that relate focal species populations to grasslands. An empirical model for Greater Prairie Chickens that included only remotely-sensed variables was published by Niemuth (2003). This logistic regression predicted the probability of a site supporting a Greater Prairie Chicken lek. This model predicted relative habitat suitability, and it was necessary to make additional assumptions about average population size of leks, ratio of males to females in the vicinity of leks, and size of the females’ home range (Fig. 2).

A poisson regression was developed for Mallards from pre-existing field survey data. This regression predicted the capacity (in number of breeding pairs) of individual wetland basins, based on basin size and water regime. These estimates were combined with other data on the maximum travel distance of female Mallard from wetlands to upland nesting sites to estimate the number of ducks that could nest in a tract of grassland based on the number and characteristics of surrounding wetlands (Fig. 2).

Pre-existing survey data were inadequate to construct empirical models for Marbled Godwits. We developed a conceptual model in consultation with biologists with some expertise in habitat use by godwits (Diane Granfors, U.S. Fish and Wildlife Service, unpubl. model) (Fig. 2). As with the model for Greater Prairie Chickens, it was necessary to make additional assumptions to relate godwit populations to potential habitat.

Each of these models required assessment. We used pre-existing data, such as state Heritage Society data, to check model predictions, and, coincident with conservation delivery, collected additional field data to evaluate model assumptions and performance.

Models were applied to spatial data on grasslands and wetlands to:

- assess current eco-regional capacity to sustain populations of focal species;
- establish restoration objectives;
- assess contributions of lands currently in the conservation estate (Table 1); and
- identify priority sites and landscapes to protect and restore habitats in order to conserve populations as effectively as possible at goal levels (Fig. 2).

Establishing restoration objectives implies an awareness of current carrying capacity and assumptions about probable future loss of existing capacity. In most cases, it is unrealistic to try to protect all existing capacity. These losses must be offset by restoration. Furthermore, it is desirable to consider the amount of existing capacity that should be formally protected versus the amount that should remain in private, unprotected status. This proportion will depend on the importance of the landscape to a species’ range-wide population and the risk of habitat loss over a finite time-scale. In our case study, we chose a strategy of perpetual protection of the full habitat potential needed to secure our population goals.

<table>
<thead>
<tr>
<th></th>
<th>Mallard (pairs/recruits)</th>
<th>Marbled Godwit (pairs)</th>
<th>Greater Prairie Chicken (hens)</th>
<th>Total habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partnership’s population goal</td>
<td>26 000/32 000</td>
<td>60</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>Contribution of the existing conservation estate</td>
<td>9 163/9 536</td>
<td>32</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Conserved population deficit</td>
<td>16 837/22 464</td>
<td>28</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Species-specific habitat objectives (ha)</td>
<td>106 098</td>
<td>10 781</td>
<td>37 195</td>
<td>154 074</td>
</tr>
<tr>
<td>Collateral impacts</td>
<td></td>
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<tr>
<td>Mallard</td>
<td>12</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marbled Godwit</td>
<td>1 487/1 863</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater Prairie Chicken</td>
<td>4 365/5 675</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated habitat objectives (ha)</td>
<td></td>
<td></td>
<td>115 027</td>
<td></td>
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</tbody>
</table>
By developing priority sites and landscapes for individual species, it is possible to develop species-specific habitat objectives (Table 1). Summing these species-specific habitat objectives indicates that approximately 154,000 ha of additional grassland must be conserved to attain our population goals.

Driven by program priorities, which are often defined in legislation, different agencies and organizations will play different roles in attaining goals for a particular focal species; however, implementation of one program often has collateral impacts, positive or negative, on other focal species (Table 1). An awareness of these collateral impacts is essential to efficient attainment of population goals. Therefore, we develop an integrated landscape design by combining priority areas for multiple focal species. This integrated landscape design is the foundation for our actual habitat objectives (Fig. 3).

This integration of species-specific priority conservation areas may result in conflicts based on impacts of grassland management on our focal species. For example, Marbled Godwits and Greater Prairie Chickens require native prairie or disturbed tame grasslands, while Mallards select tall, rank idled grasslands for nesting when available. This conflict was resolved in each area that is a priority for Mallards and for Greater Prairie Chickens or Marbled Godwits. We used an *ad hoc* process based on prediction of adverse impact on Mallards of managing grassland patches for prairie chickens/godwits and vice versa, and the relative importance of each conflicted geographic unit to each species in our integrated landscape design. This altered the predicted carrying capacity for each species of our landscape design, and required that the design, and our habitat objectives, be adjusted accordingly. Thus, like all other aspects of biological planning, the development of an integrated landscape design is iterative.

Based on our integrated landscape design, we estimate that approximately 115,000 ha of additional grassland habitat must be conserved, in the context of our integrated landscape design.
to attain the partnership’s population goals (Table 1). Compared to our previous estimate of 154 000 ha, this represents a 25% increase in conservation efficiency. How close this habitat objective is to the amount of habitat we ultimately have to conserve to attain our population goals depends on how closely we are able to conform to our integrated landscape design. In practice, this habitat objective is a minimum estimate because some deviation from an optimal strategy is inevitable.

Despite our increased efficiency, restoring and providing some degree of protection to 115 000 ha of grassland habitat is still a massive challenge which underscores the need to capture the full wildlife conservation potential of the U.S. Farm Bill and other Federal programs.

**PREDICTED SPECIES RICHNESS MAPS**

In some cases, the increased availability of remotely-sensed digital land-cover data and GIS technology has led to the use of simple habitat associations (e.g. emergent wetland or deciduous forest) in lieu of more informative models, and to the creation of maps of predicted species richness by overlaying deterministic predictions of apparent habitat suitability for large numbers of species. At best, these maps provide little information for management, and at worst result in a misallocation of program resources, for the following reasons:

**Process deficiencies**

- Overlaying deterministic species-specific predictions about habitat suitability results in high, but seldom estimated, uncertainties in predicted species richness.
- The product fails to provide information on what form conservation should take at a particular location. The implied action is protection of existing habitat, which is only one tool available to managers.
- The process does not acknowledge conflicting species responses to management, and does not accommodate resolution of potential management conflicts.
- The process does not consider populations, and does not result in defensible, population-based habitat objectives.
- Because of the simplicity of models and the failure of models to make explicit predictions of abundance or vital rates, the process does not connect management with research/monitoring.

**Model deficiencies**

- The need to use overly simplistic species-population relationships (models) because of the large number of species being considered.
- A failure to consider limiting factors or larger-scale habitat or landscape factors influencing actual habitat suitability, carrying capacity, or vital rates.
- A failure to consider population viability driven by “patch” and landscape-scale factors.

**Scale deficiencies**

- The scale of assessment is disconnected from the scale of management when species richness is “summed” for larger units such as 7.5 quadrangles of 7.5 x 7.5 geographical minutes, or watersheds, which are almost always larger than the scale at which management is applied on the ground, thus violating the assumption that all of the species accounted for in the species richness estimate will be benefited by a single management action.

In short, single maps of species richness (biodiversity) are typically poor predictors of actual or potential species distributions, are often driven by local or landscape-scale habitat heterogeneity more than importance to populations, often are not useful for management unless they are dissimilated into the elements used to construct them, and as such, have little value for directing conservation actions. Nevertheless, maps of species richness are often compelling, as is the idea of using them to conserve biodiversity. As such, they can inadvertently impede more sophisticated approaches to landscape design, based on higher level critical thinking about trust responsibilities, limiting factors, management compatibility and spatial scales.

**CONCLUSIONS**

Biological planning is critical to efficient, transparent, and credible management decisions. Planners and managers are forced to be explicit about their assumptions about population-habitat relationships. Thus, it provides a foundation for strengthening the biological foundation through evaluation which in turn contributes to reliable future conservation strategies. When conducted in a spatially-explicit environment, biological planning provides a means of integrating the conservation needs of migratory birds with other species of wildlife, and other environmental and socio-economic functions of habitat.

The magnitude of our mandate dwarfs traditional conservation resources. Wildlife conservation agencies must use their programs strategically to conserve the habitats that are most critical to their mission, and must develop the capacity to engage other government agencies and the public and more effectively harness their conservation potential. Partnerships for the development of community conservation strategies and for outreach are invaluable to conservation.

This implies that wildlife conservation agencies will rethink their roles and responsibilities. Rather than think of their roles as solely one of active habitat and population management, agencies have to view their role as equally one of nurturing, stewarding, and promoting the biological foundation and strategies for migratory bird conservation, i.e. we must provide leadership and an explicit strategy for the conservation of migratory birds, and coordination of conservation partnerships. The foundation for this leadership will be biological planning at landscape scales.

**REFERENCES**