Habitat Management for Multiple Wetland Bird Objectives on National Wildlife Refuges

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Decision Problem

Most U.S. Fish and Wildlife Service (USFWS) managed lands (National Wildlife Refuges, Wetland Management Districts, and Private Lands Programs) contain wetland habitats that are actively managed for migratory bird species. Although most management has focused on producing waterfowl, there are many opportunities to manage wetland habitats for other species such as shorebirds, wading birds, and secretive marsh birds. Moreover, there is great need and potential to coordinate among USFWS managed lands to increase management efficacy by providing the appropriate habitats in the most appropriate places at the most appropriate times for the maximum benefit of wetland birds. In other words, there is need to coordinate among local management entities to provide wintering, migrating, and breeding habitats for wetland birds.

The decision problem this report addresses is how to optimize management of wetland habitats on USFWS managed lands for wetland birds given multiple and often competing objectives. In this report, “wetland birds” refer to wetland obligate birds, including waterfowl, inconspicuous marsh birds (rails, bitterns, grebes), shorebirds, and wading birds. We develop a framework that addresses wetland habitat management decisions at the local (i.e. individual National Wildlife Refuges or Wetland Management District) scale within USFWS Regions 3, 4, and 5. We recognize there are multiple constraints, uncertainties, and tradeoffs within the framework. Decisions for wetland bird habitat management are made at many different temporal scales; many decisions are made annually or biannually, some are irregular, while others are “once-in-a-lifetime” decisions, such as land acquisition or restoring a freshwater marsh to its original saltwater marsh habitat. The principal decision makers are USFWS land managers. However, many decisions at the local level are linked to decisions made at the Regional and

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Flyway level, where guidance on population status, along with spatial and temporal needs are incorporated. . Thus, the decision structure presented here will need to be closely reconciled with efforts at the Regional and Flyway levels.

Background

Land managed by the USFWS includes National Wildlife Refuges, Wetland Management Areas, and Private Land Programs. The decision structure (Hammond, Keeney, and Raiffa 1999) we develop is primarily for lands in the National Wildlife Refuge System, thus we refer only to National Wildlife Refuges (NWRs) throughout the remainder of this report. Although the decision framework is applicable to USFWS administered lands other than NWRs, key elements (e.g., objectives, alternatives) may be different.

NWRs are a critical component of national wetland bird population and habitat management (Fischman 2003). Historically, most decisions about when and where to provide various types of habitat on NWRs were largely made by managers at each NWR independent of other NWRs. In addition, monitoring data used to support management decisions have typically been collected based on refuge specific designs, thus there has been no common database and little sharing of data among NWRs.

Prior to the structured decision making workshop that produced this report two other rapid prototyping efforts were made to structure decisions for wetland birds, one at the Flyway level (Coppen et al. 2007) and one at the Regional level (Laskowski et al. 2008). The overall vision has been to combine these three scales, flyway, regional and local, to produce a coordinated, comprehensive framework for managing wetland birds and their habitats. Although the group responsible for this report considered these earlier efforts, this report represents a draft for structuring decisions only at individual NWRs and does not explicitly link decisions to larger scales. The linking of habitat management for wetland birds at the local scale to the Flyway and Regional scales will be part of a follow-up effort that will be developed in the near future.

Legal, regulatory, and political context

The National Wildlife Refuge System Administration Act of 1966, Executive Order 12996 (in 1996), and the National Wildlife Refuge Improvement Act of 1997 state that first and foremost the mission of the National Wildlife Refuge System be focused on wildlife conservation. This set of orders and laws also recognize that NWRs should manage for wildlife-dependent recreational uses such as hunting, fishing, wildlife observation, photography, and environmental education and interpretation. Other laws, such as the Migratory Bird Treaty Act and the Endangered Species Act, also influence management on NWRs.

All NWRs have establishing legislation, some clearly dictate management priorities, other are more general. Each NWR was created to provide specific resources, such as habitats for migratory waterfowl and other migratory birds or habitat for an endangered species. Together, a refuge's establishing legislation and the laws governing the administration of all NWRs result in the need to consider multiple objectives when planning for resource management.

Ecological context

Wetland birds are the most common group of birds managed for and monitored on NWRs. As a group, wetland birds require a wide range of wetland habitat types, from open-deepwater to wet meadows. In addition, timing of wetland management is critical to habitat delivery because nearly all wetland birds in North America are migratory. NWRs make annual decisions that alter the quantity, quality, and availability of wetland habitat, such as direct habitat manipulations, reduction of disturbance, and the protection of additional lands through acquisition. Thus, the framework proposed herein focuses on decisions regarding habitat management to provide migration and stopover habitat, wintering habitat, and breeding habitat.

Managing habitat for wildlife requires providing food, resting cover, and nesting habitat in the appropriate quantity and quality to meet life-history requirements such as during the migrating or breeding periods (life stage). Matching the amount and quality of habitat to the timing of key life-history periods for individual species is vitally important. Providing appropriate resting cover requires managing for specific habitat types, based on vegetation structure, and species composition. Providing food requires managing the quantity and quality of vegetation along with water levels that are conducive to seed production and ensure prey and food habitats are available (or accessible) to wetland birds. Providing nesting habitat consists of providing appropriate vegetation structure and species composition; protection from predators and other disturbance (i.e. human uses); and ensuring spatial juxtaposition to feeding and resting habitats.

Managing for habitat availability is done at two scales. First, suitable habitat must be available at appropriate times along migration routes, and in wintering or breeding areas. Second, habitat patches in and around individual NWRs must be juxtaposed properly to provide easy movement among nesting, feeding, and resting areas during all life stages.

Decision Structure

Objectives

National Wildlife Refuges are managed to meet multiple objectives in addition to natural resources (Figure 1; see *Legal, regulatory and political context* above). In the NWR objectives hierarchy presented in Fig. 1, habitat management for wetland birds falls under the objectives for conservation of resources of concern and wildlife species. Objectives for habitat management for wetland birds may be complimentary to some NWR objectives, yet compete with others. For example, managing for wetland birds and their habitats may compliment conservation of rare plants and/or wildlife viewing opportunities (i.e. public use). Conversely, meeting cost objectives or meeting objectives relating to easements or water quality standards may preclude some habitat management options. These competing and complimentary objectives will vary among NWRs, and will be dependent on individual NWR establishing legislation.

The fundamental objective for wetland bird habitat management is to maximize a refuge's contribution to flyway populations of wetland birds. This fundamental objective can be further refined, resulting in a similarly stated objective for each wetland bird species (Figure 2, top of hierarchy). Alternatively, guilds of species can replace individual species. Although contributing to the population of each wetland bird species is the fundamental objective, we currently can not asses the efficacy of management at individual NWRs in terms of meeting this objective. For example, although wetlands were created for and used by dabbling ducks at an individual NWR, how can the NWR assess its overall contribution to the flyway population? Therefore, we created lower level fundamental objectives that would allow assessment. These lower level fundamental objectives included providing migration, wintering, and breeding habitat for appropriate species or a composite of species (i.e., a group of rails, dabbling ducks, shorebirds that require similar habitat), which can be measured at the level of individual NWRs.

Alternative actions

Alternative actions for wetland bird habitat management encompass all potential actions individual NWRs undertake to manage habitat. Potential actions range from passive "allow nature to take its course" management, to acquisition of new lands, to actions taken within wetlands such as a drawdown, prescribed burn, disking, herbicide treatment, predator control, etc. Management alternatives may also include a combination of these actions. Alternative actions are aimed at managing the quantity, quality, and availability of wetland habitats.

Predictive models

Predictive models are needed at two stages within the decision framework. First, a 'current conditions assessment' model is needed to predict the habitat an individual NWR can contribute to resting, feeding and nesting habitats for wetland birds based on current conditions. This is essentially a species-habitat relationships model, which predicts the habitat types that an NWR can provide and the timing (migration, wintering, and breeding) at which it can provide to the birds. This information would be relayed to the Region for development of regional objectives regarding the spatial-temporal distribution of needed habitats (see "further development required" in discussion below).

The second stage of the model is a prediction of the efficacy of different management alternatives (actions) to the current habitats and the resulting conditions for wetland bird life stages. This model needs to be spatially explicit and encompass all potential actions that can be undertaken within an individual NWR. Model output is the suite of wetland units, their quantity of life stage habitats, and the juxtaposition of units to each other on the NWR. The model implicitly includes wetland bird species habitat associations, which would allow for predicting the amount, quality, and availability of habitats that can be provided for each wetland bird species or a composite of species.

Development of these models at the individual NWR will be a collaborative work among the NWR, the Flyway, and the Region. The separate entities will develop their own set of models with feedback (or guidance) from each other. For instance, the Flyway and Regions will provide guidance from predictive models on which birds individual NWRs should manage for at what times of year. National Wildlife Refuge information will feedback to the Flyway and Region on what is possible at the NWR given various constraints and uncertainties (based on their own models). Here we present a spatial prototype of a biological model for NWRs based on the breeding season depicted in the conceptual model in Figure 2 that links attributes to means objectives.

Nesting suitability: The first step in calculating the waterbird score at each parcel in a refuge is identifying compatible nesting habitat in the landscape given by the proportion of suitable nesting habitat in a parcel *x* for waterbirds as a function land cover *j*. We also account for species differences in habitat suitability so that the proportion of suitable nesting habitat in a parcel *x* for waterbird species *s* as a function land cover *j*, HN_{sx} is:

$$HN_{sx} = \sum_{j=1}^{J} N_{js} p_{jx} \,, \qquad \text{(equation 1)}$$

where $N_{js} \in [0,1]$ represents compatibility of land cover *j* for nesting by species *s*.

Resting suitability: The second step, identifying suitable resting habitat, is similar to the first in calculating the waterbird score at each parcel in a refuge is given by the proportion of suitable nesting habitat in a parcel *x* for waterbirds as a function land cover *j*. Again, we account for species differences in habitat suitability so that the proportion of suitable resting habitat in a parcel *x* for waterbird species *s* as a function land cover *j*, HR_{sx} is:

$$HN_{sx} = \sum_{j=1}^{J} R_{js} p_{jx} \,, \qquad \text{(equation 2)}$$

where $R_{js} \in [0,1]$ represents compatibility of land cover *j* for resting by species *s*.

Feeding suitability: Waterbirds leave nesting or resting sites to forage so this step requires a spatial analysis of the landscape around potential nesting and resting sites. In our first prototype we use a simple proportion of area suitable for foraging within a foraging radius *r* for each species *s* (Winfree et al 2005) such that its foraging suitability score for parcel x, HF_{sx} is:

$$HF_{sx} = \frac{A\left(r_s, F_{js} p_{jx}\right)}{\pi r_s^2} \,, \qquad \text{(equation 3)}$$

where $F_{js} \in [0,1]$ represents compatibility of land cover *j* for feeding by species *s* and $A(r_s, F_{js}p_{jx})$ is the total feeding area for species *s*. This total is calculated as the weighted sum of habitat within radius *r* of nesting/resting site *x*, which is scaled by the total possible area within foraging radius.

Availability and disturbance: Waterbirds may not use suitable resting or nesting habitat if there is disturbance nearby, rendering the area unavailable. We assume that the magnitude of disturbance to parcel x declines exponentially with distance to a disturbance in source parcel *j*, and that the effect of the disturbance is felt in all directions with equal probability. Therefore, parcels farther away from nest parcel *x* contribute less to total disturbance than parcels nearby, and the total disturbance is the distance weighted sum. This leads to the following prediction for nesting availability as a function of the potential disturbances affecting species *s* parcel *x* , NA_{sx}:

$$NA_{sx} = 1 - \frac{\sum_{m=1}^{M} \psi_d e^{\frac{-E_{mx}}{\alpha_d}}}{\sum_{m=1}^{M} \psi_d e^{\frac{-E_{mx}}{\alpha_d}} + \kappa_s} \,, \qquad \text{(equation 4)}$$

where the fraction on the right-hand side of the equation is disturbance in which $\psi_d \in [0,1]$ represents the magnitude of disturbance *d*, E_{mx} is the Euclidean distance between nesting parcel *x* and parcel *m* (site of potential disturbance), α_d is a distance-decay parameter for disturbance *d* and κ_s is a disturbance tolerance parameter for species *s* representing the amount of disturbance that causes nesting availability to be reduced by half. The overall function in the second term is a saturating function that approaches 1 as the disturbance score in the numerator and first term of the denominator approach infinity or get much larger than κ_s.

Overall parcel index for breeding: Waterbirds are limited feeding and nesting or resting which is itself scaled by the availability of habitat. Thus we combine them simply by calculating their product such that the overall suitability of parcel *x* for breeding by species *s*, B_{sx}, is:

$$B_{sx} = NA_{sx} HF_{sx} \min\left[HN_{sx}, HR_{sx}\right]. \qquad \text{(equation 5)}$$

The last term of the product is a minimum of either nesting or resting because we consider them to be very similar waterbird behaviors and their suitability should also be similar.

To calculate the overall breeding score for a refuge, we simply sum up all the parcels on the refuge such that the total amount of habitat available for breeding by species *s*, B_s, is:

$$B_s = \sum_{x=1}^{X} A_x B_{sx}\,, \qquad \text{(equation 6)}$$

where A_x is the area of parcel x. Thus B_s represents the total area of breeding habitat suitable for species *s* on the refuge.

Decision Analysis

We developed a simple example of how the decision analysis may be constructed during the workshop. For the example we considered habitat management decisions for a single NWR, and used a simulation approach to account for uncertainty. The model described above provides information that is part of the natural resource objective for a national wildlife refuge, but there are other objectives. Subject to a budget constraint, we considered three (fundamental) objectives for NWR: maximize contribution to two wetland bird populations; maximize benefit to public use; and meet legal and regulatory requirement. While we originally consider legal and regulatory requirements to be a fundamental objective, we can incorporate it as a constraint, leaving us with two objectives. Thus the first step of the decision analysis would be to filter out portfolios (a suite of management actions) that were either over budget or failed to meet legal and regulatory requirements.

To select among objectives that remain after the first filtering process, we would choose to use the simple multi-attribute rating (SMART) technique (Goodwin and Wright 2004) because there is more than one objective. Interpreting the consequences table is only a matter of weighting the respective objectives and deciding which portfolio of management alternatives yields the most desirable results. The SMART utility function is simply a weighted sum of scores, in which the scores of each objective have been rescaled on a common metric of 0-100. We do not provide the specific results here but anticipate it as a next step to convert the breeding scores and the benefits to public use into the 0-100 score and then provide the appropriate weights. These weights may vary among refuges.

Uncertainty

Many habitat management decisions on NWRs are iterated over time and decisions made in the current year may affect available alternatives in the next season and/or in subsequent years. Although NWRs may be able to make predictions about the response of habitat to an action in the current year, the effect of habitat manipulations over multiple years will need to be modeled to develop refuge objectives for wetland bird populations and assess management alternatives. In some instances, once certain habitat management actions have been taken (e.g., reconfiguring levees), they may not be reversible and thus may limit management alternatives for wetland birds on an NWR in the future. There may be uncertainty in any of the parameters that are in the above model and incorporating what effect this uncertainty has on choosing management action is an important next step.

Uncertainty owing to variation in environmental conditions is also a concern, and will become more of an issue with changing climate. Depending on location within the continent, prolonged periods of drought and catastrophic events are predicted to increase in frequency. In addition to climate change, the influence of natural variation in weather on the timing of migration needs to be accounted when developing population objectives for habitat management at the Flyway and Regional scales to insure habitat is provided at the appropriate times.

Discussion

Value of decision structuring

The decision structure proposed here does not call for new management alternatives on NWRs, and will likely not result in large changes in species targeted by management. Rather, we believe the proposed structure explicitly states what is already in place (i.e., in the station's Comprehensive Conservation Plan, Habitat Management Plan, and other station documents) but is difficult to articulate and defend to stakeholders. This decision structure is beneficial in providing a transparent and repeatable approach to implementing management alternatives in an adaptive management framework that fit into larger-scale objectives (the Region and the Flyway) and refuge purposes. Explicitly stating such a structure will allow for better coordination of management among refuges to benefit wetland bird populations.

Further development required

The decision framework proposed is complex because it has linked decisions across time and among various spatial scales and administrative levels, and addresses multiple objectives. We outline next steps and a potential timeline for their completion in Table 2. We provide greater detail for a few key steps here. NWRs need to document what wetland habitats they have, what wetland types they could potentially manage for, what management alternative actions they have, and the estimated cost of these actions. If possible, uncertainty resolution priorities should be linked to funding requests. In collaboration with NWRs, the Regions need this information to develop predictive bird-habitat associations-delivery timing models to refuges. Existing databases at the level of NWRs (RAPP, RMADs, RLGIS, and bird survey databases) need to be examined for their contribution to the above and for developing management actions and monitoring programs.

Obtaining support from all stakeholders for the proposed decision framework will be key to its success. Presentation of the framework to the Regional Offices (chiefs, supervisors and planners) and to the Migratory Bird Office should be done early and during further developmental phases of the decision framework (i.e., a fully completed local framework, and the larger scale framework with Flyway and Regional models). In addition, it was felt that incorporating the decision framework into the **NWRS Biological Program Fundamentals** course was necessary. The course is new, geared towards new biologists, and will be piloted in Sept. 2008 at the National Conservation Training Center. The purpose of the course is "to guide and strengthen the continuing development of refuge biological programs, leading to greater success in managing natural resources and promoting long-term, constructive partnerships." Obviously, it is not possible to incorporate this framework into the course this year, but team coordinators should work with the course leaders for future classes.

An adaptive management approach at the refuge level needs to be linked with regional models for objectives, ecological uncertainty, and uncertainty due to partial controllability. When multiple refuges are involved with a similar aspect of wetland bird management, coordination at the regional level is needed. Ultimately, the primary goal is to develop a comprehensive waterbird monitoring program that incorporates all three landscape scales. In cooperation with NWRs, the Regions and Flyways will need to develop a coordinated monitoring program and accompanying databases. We see these as key actions that are needed in order to evaluate management actions and refine alternatives.

Prototyping process

The context of the decision problem was developed prior to, and during the first day of the workshop. It was acknowledged early on there would be multiple, often competing objectives, relating to management of individual wetland bird species. It was clear and agreed upon by participants at that workshop that bird population objectives could not be strictly evaluated at the level of the individual NWR, thus habitat specific objectives (migratory, wintering, and breeding) were adopted and these further refined and presented in an objectives hierarchy. Objectives for wetland habitats were also placed within a hierarchy that encompassed all NWR objectives. The suite of existing management actions used by refuges represented the alternative actions. Influence diagrams were then created at the workshop to represent a snapshot of the decision framework. This led to the creation of a simulation model to analyze a simplified, hypothetical decision on a single NWR.

With the exception of the consultant, all group members were USFWS employees working in the NWR system. We felt this was important to developing a prototype but acknowledge that other affected federal, state, and private groups should be consulted once the decision framework is more fully developed.

Recommendations

Decisions regarding wetland habitat management made on individual NWRs have not been explicitly integrated with Regional and Flyway objectives in the past. We believe that structuring wetland habitat decisions at individual NWRs based on Flyway and Regional goals is essential for delivering the most conservation for the money.

Key to implementing the decision is getting cooperation and support from the Region and all NWRs, and their partners (see *Further Development Required* above). The Flyways and Regions involved have already gone through a rapid prototyping process for related decisions.

These related efforts to structure decisions for wetland birds will need to be connected and their differences reconciled. For example we considered wetland habitat management on NWRs for all times of the year, whereas the Regional effort only considered wetland habitat during migration. In addition, a formalized structure for feedback needs to be developed for Flyways, Regions, and NWRs to exchange information regarding habitat requirements, timing of management actions, status of bird populations, and expected costs.

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Figure 1. A hierarchy of all potential objectives for management of National Wildlife Refuges

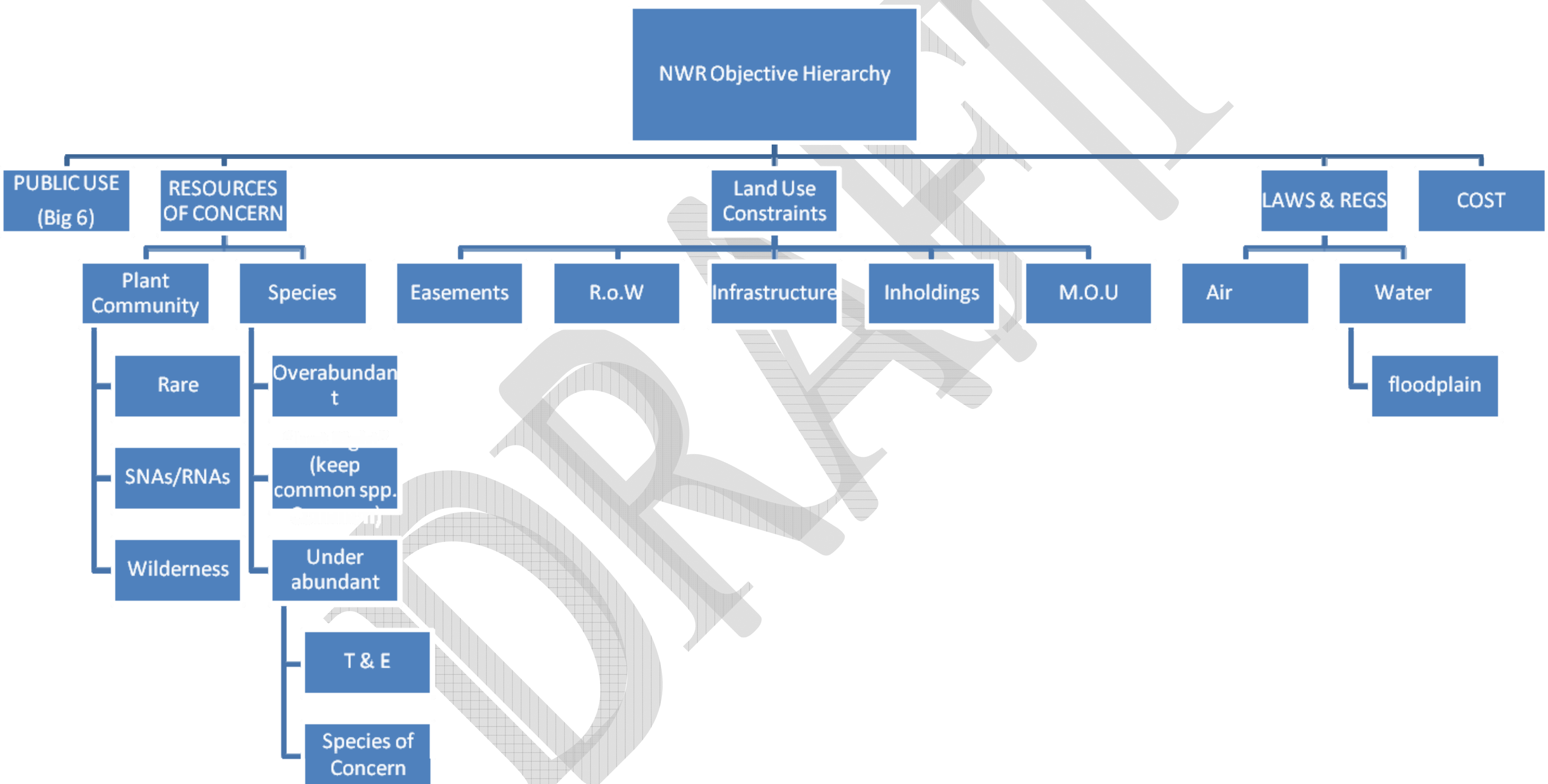

Figure 2. Objectives hierarchy for wetland bird management on National Wildlife Refuges. (This figure includes only wetland bird portion of the hierarchy and is shown in more detail).

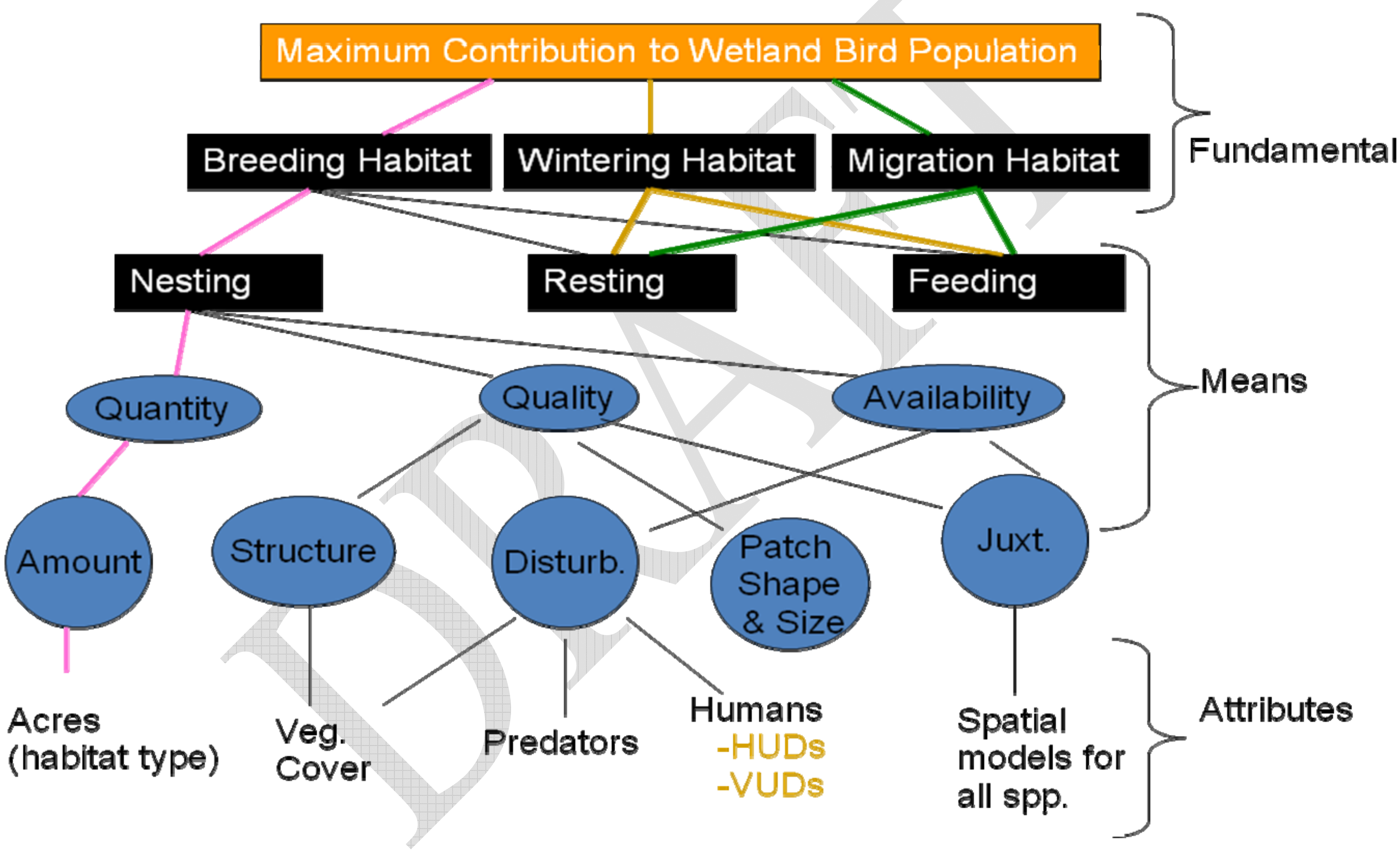

Table 1. Consequences of Action Portfolios for the Fundamental Objectives for wetland habitat management. The next step in analyzing the consequence table is to filter out actions that are either over budget or do not pass laws and regulations. Then, we integrate Public Use and R.o.C. into the SMART technique to determine which of the remaining actions maximizes our objective score.

Quantity Quality Availability	drawdown burn open	maintain burn open	drawdown herbicide open	maintain herbicide open	drawdown burn close	maintain burn close	drawdown herbicide close	maintain herbicide close
Cost	600	500	300	200	600	500	300	200
Public Use	18	22	13	17	8	12	3	7
R.o.C.	5.01	6.03	5.00	5.00	4.97	6.02	5.03	5.00
Laws & Regs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2. Follow-up (next step) goals for habitat management for wetland bird objectives SDM case study.

Goal #	Description of Goals:
1	Determine costs associated with developing the full model
2	Fully develop working decision model
3	Test and revise the model
4	Peer review of the model
5	Presentation to the regional office (Chiefs, Supervisors and Planners) and mig birds.
6	Presentation to the Refuge Managers and Biologists.
7	Develop a waterbird monitoring program and database to inform the decision framework – in progress, will participate in team
8	Model available for Refuges to use.
9	Incorporate model into CCPs, HMPs, etc
10	Explore tweaking the decision structure to be applied to other refuge management decision needs
11	The Region must provide species goals and priorities to field stations.
12	Utilize existing databases where appropriate

Table 3. Proposed timeframe to accomplish next step goals for habitat management for wetland birds.

Goal #	**Timeline**	**Who**	**How**
1	Within a month	Eric (modeler) and BMT members	Through contracts
2	6 months	A modeler (Eric) and SDM group	
3	Within 3 months after development before March 15th	Refuges in regions 3,4 and 5	
4	April – May	Selected Refuge managers, regional office, flyway – mig bird, JV, USGS	
5	Fall 2008	Team Members	Refuge Leadership Team RO Brown Bag Lunch
6	Fall 2009 R5 first week in March	Kevin H./Alex W.	Project Leader Meeting R5 Biologists Workshop Refuge Academy New Biologist Training
7	2009	Team members from the 3 different landscape scales	Collaboration among members through conf. calls, meetings, and emails.
8, 9	2010	Whomever wants to use;	
10	2010	Biologists, managers, BMT staff, modelers	
12		Database and GIS developers	