Title

Waterfowl Migration Case Study from the Structured Decision Making Workshop
25-29 March 2007
Upper Mississippi River Environmental Science Center - LaCrosse, WI, USA

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Decision Problem

The public demands accountability for resource management actions and this will require sound records of decisions. We attempted to address the following over-arching questions: Where, when and in what numbers are migratory birds using stopover habitats? Are there important sites that are not protected? Where in a region should we focus acquisition and restoration activities? How should individual patches be managed to optimize stopover quality? Our goal was to develop a structured process for decision-making useful for multiple stakeholders in resource management agencies, at multiple levels, responsible for conserving migratory waterfowl.

Background

Spring-migrating waterfowl depend upon stopover habitats that provide protection and nutrient acquisition to allow them to complete migrations and to meet their energetic demands for breeding and subsequent nesting efforts. Landscapes of the Upper Mississippi River and Great Lakes watershed are highly altered and may be limiting to migrant waterfowl. A continuous onslaught of habitat loss and degradation requires repeated decisions regarding protection, restoration and efficient management of spring stopover habitat patches.

A primary purpose of USFWS - National Wildlife Refuges (NWR) is to provide stopover habitat for migrating waterfowl. State wildlife agencies also established wildlife management areas (WMA) for a similar purpose.

There are several problems that NWRs and state WMA's face regarding management of migration habitat. No one has determined the minimum area or acreage of specific habitat types (considered a limiting factor) required by different waterfowl populations during migration. No one has determined the optimal spatial and temporal distribution of migration habitat.

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No one has estimated how much migration habitat is available for the different waterfowl populations, and how it is distributed among the different state, federal, NGO, and private lands. No one has estimated how the amount and quality of habitat might vary with climatic conditions (e.g., droughts, wet periods). The general consensus in the waterfowl community is that migration habitat is important and might be limiting to waterfowl populations.

It is technically possible to estimate the amount of migration habitat available by waterfowl guilds (divers, dabblers) using GIS data sets and wetland maps from relevant states. Estimating optimal spatial and temporal distributions over a range of climatic conditions will be more difficult, but not impossible. It also is possible to derive a standardized approach to monitoring migrating waterfowl that could be fairly efficient given the number of land management units that currently monitor migrating waterfowl.

It is important to note that without more precise measures of food energy availability and patterns of temporal and spatial variation in food supplies and food availability across all wetland types we are limited in our predictive capability. These type of data represent the most pressing need for the Upper Mississippi/Great Lakes partners to improve delivery of habitat programs (e.g., NAWCA funded projects).

Decision Structure

Alternative actions

Management responses could be manifest as an attempt to increase patch quality (increase forage quality, lower disturbance) or increase patch quantity & density (habitat acquisition). The challenge is to optimize recruitment or non-breeding survival via these two options.

Objectives

The over-arching goal of this effort was to maximize long-term (e.g., 10 year running) average of breeding duck population to meet NAWMP goals. Our objective was: To manage the distribution and availability of quality migration stopover habitat to optimize body condition and daily survival rate while providing for public use.

Predictive model

A conceptual model was developed (**Fig. 1**) to frame the concept of interconnectedness of local management efforts, and their influence on critical vital rates, to regional and continental population size. Initial parameters included initial body condition, the energy cost of flight (a function of distance between patches) and patch quality (survivorship). We developed decision rules related to daily survival rate, patch survival rate and body condition and related these to life status (dead or alive) and residency times in habitat patches of variable quality (**Fig. 2**).

Decision Analysis

We used simulation techniques that incorporated foraging quality scores and loafing decision trees. For each patch, we summed forage values and loafing values; final patch quality was determined by converting area to a quality index (**Table 1**).

Uncertainty

Major assumptions include: 1.) Migration habitat quality and availability affects body condition and daily survival; 2.) Residency time in a given habitat patch is dependent on arriving body condition and patch quality; 3.) Patch quality is function of food availability and disturbance (previous step); 4.) As distance traveled increases cost increase (i.e., energetics); and 5.) Body condition and survival at the end of migration determine recruitment potential and non-breeding survival.

Discussion

Value of decision structuring

Conservation of optimum spring stopover sites is a priority goal for several entities, including: the Upper Mississippi River/Great Lakes Joint Venture; Ducks Unlimited; The Nature Conservancy; US Fish and Wildlife Service; State-level Departments of Natural Resources in Minnesota, Illinois, Wisconsin, Michigan, Indiana, and Ohio; and other agencies and NGOs involved in coastal and inland habitat protection and restoration.

This effort will provide a decision making tool that will allow more transparent, accurate and cost-effective determination of habitat priorities for the Upper Mississippi and Great Lakes regions. It will provide an assessment of how well an area meets foraging habitat objectives. It will consider the arrangement and juxtaposition of habitat patches relative to energy needs of waterfowl and help elucidate strategies to improve the amount and arrangement of protected habitats.

Further development required

Only one unknown variable (body condition upon arrival) exists within our prototype model. Knowing maximum distance a duck can travel helps us put bounds on body condition upon arrival. We need to identify clusters of patches with “quality deficits” at regional or continental scale. At the local scale, we need to evaluate how to reduce deficits of patch quality in order to achieve our objectives.

We need to consider if a simpler examination based on habitat suitability and location/distribution in the environment, without heavy computations, might provide utility.

Instead of simulating bird movements from breeding to wintering areas, or vice versa, we could calculate a moving window of survivorship from patch to patch and pool several of these by latitudinal bands to determine where survivorship declines. This might elucidate whether we need habitat improvements or more habitat patches.

We may wish to assess waterfowl body condition at patch *A* with prior knowledge that a duck came from patch *X* and lost some energy during flight, such that you arrived in condition *Y*. Temporal period (spring or fall) might then be inconsequential.

We may assume that a duck starts at maximum or minimum body condition (but not Ø) - this will allow us to put bounds on starting condition and use a moving window to look at patches in the landscape. This would provide a long term average or breeding condition but it would allow us to identify dead end locations.

We need more work for least-cost path analysis:

- Simulated point-to-point duck movement model
- Altered probability distribution to ensure northward movement
- Need energy rules about movement included
- Add probability that a duck survived or died
- Add patch quality measure
- Can be reversed to simulate N or S migration

The NAWMP 2004 update identified an important goal as the need to fulfill population-scale, multi-regional conservation planning. Conduct a coordinated, large-scale satellite and conventional telemetry study of mid-continent mallards (and possibly other species of interest) in conjunction with traditional banding, population, and harvest surveys to track within-season and annual movement patterns, monitor body condition, and estimate survival rates.

Local and regional scale research will provided insights into local conservation efforts. But, there has been limited progress made toward large scale assessment.

Prototyping process

The rapid prototyping process provided a vehicle to steer modeling efforts to sensible answers to our questions while producing little tolerance for “weedy” endeavors.

Recommendations

Some potential values of the model include the following utilities: 1.) assess whether and/or under what conditions migration habitat might be limiting; 2.) assess effects of significant changes in the amount CRP enrollment or climate; 3.) Assess what would happen in worst case years, etc.

We must continue to evaluate whether our objective is achievable. Assess the potential outcome of refining the model to inform management from both a regional and patch perspective.

If our preliminary model shows promise, develop action plan to move forward to address known deficiencies and uncertainties. Evaluate whether a manuscript describing the process is desirable.

Next Step
Is the stated objective achievable? Yes, within model constraints. Potential outcome of refining the model to inform management (regional and patch perspective). Can we measure such change in the real world?

Future Needs:

- Quantitative measures to replace qualitative indices (KCAL/area)
- Quantify body condition in real world terms (relate to recruitment and daily survival.
- Go from federal boundaries to full landscape of available habitat
- We're using harvest disturbance for fall but we've not identified a measure for disturbance in spring.
- More work on bird movement need (rules).
- Additional species (add more birds)
- Continue to partition additional sources of disturbance (predation, bird watchers, boaters, etc.)
- Wetness plus NLCD might be useful for spring migration
- NLCD is too coarse for us to link forage availability
- Integration of foraging and loafing habitat
- Need to identify what is suitable migration habitat
- Time needed to complete migration needs to be incorporated as a constraint
- Varying patch size
- Varying patch quality
- Hunting as compensatory/additive
- Philopatry incorporated into movement
- Maximum residency time needs to be refined
- Change in patch quality resulting from bird exploitation of food resource
- Incorporation of body condition into patch skipping – flight range
- Accounting for affect of adjacent habitat on patch quality (landscape context)
- Defining patch
- Define relative value of forage vs. loafing habitat
- Recalculating distance matrix for each stop while incorporating body condition and philopatry

Literature Cited

Hammond JS, Keeney RL, Raiffa H. 1999. Smart Choices: A Practical Guide to Making Better Life Decisions. Broadway Books, New York.

Tables

Table 1. Patch Quality (index to body condition [values]).

		Forage		
		H	**M**	**L**
Disturbance	**L**	**100**	**75**	**50**
	M	**75**	**50**	**25**
	H	**50**	**25**	**0**

Figures

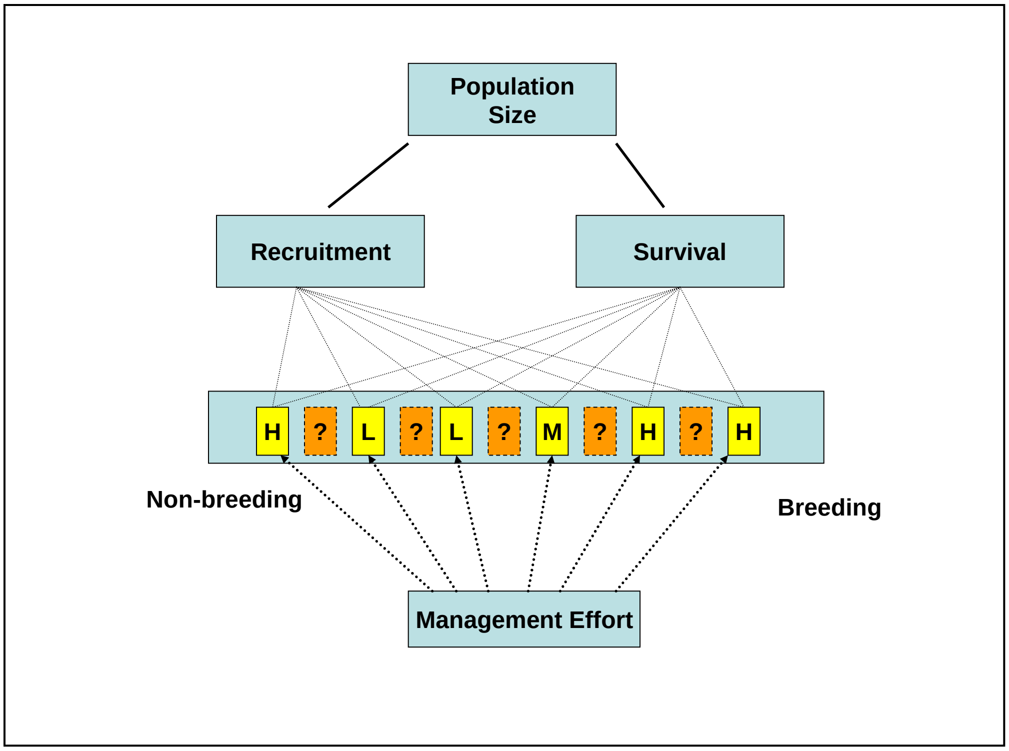

Fig. 1. The initial conceptual model shows the connection between local management efforts and their influence on critical vital rates which ultimately influence regional and continental population size.

				actual	reference							
			Total Residence Time	21	15							
			Total Body Gain	37.5	15							
			Final condition	62.5	0							
			starting body condition	75								
			Life Status	1	0							
Patch ID	Flight Cost	Body Condition Arrival	Distance	Forage Quality	Disturbance	Final Quality	Residence Time	Body Cond Gained	Daily Survival Rate	Patch Survival Rate	Body Condition Depart	Life Status Depart
1											75	
2	25	50	50	1	3	0	1	0	0.995	0.995	50	1
3	25	25	50	1	2	25	20	37.5	0.993	0.86893	62.5	1

Fig. 2. Prototype I of the model included initial body condition, the energy cost of flight and patch quality. We developed decision rules related to daily survival rate, patch survival rate and body condition and related these to life status (dead or alive) and residency times in habitat patches of variable quality.

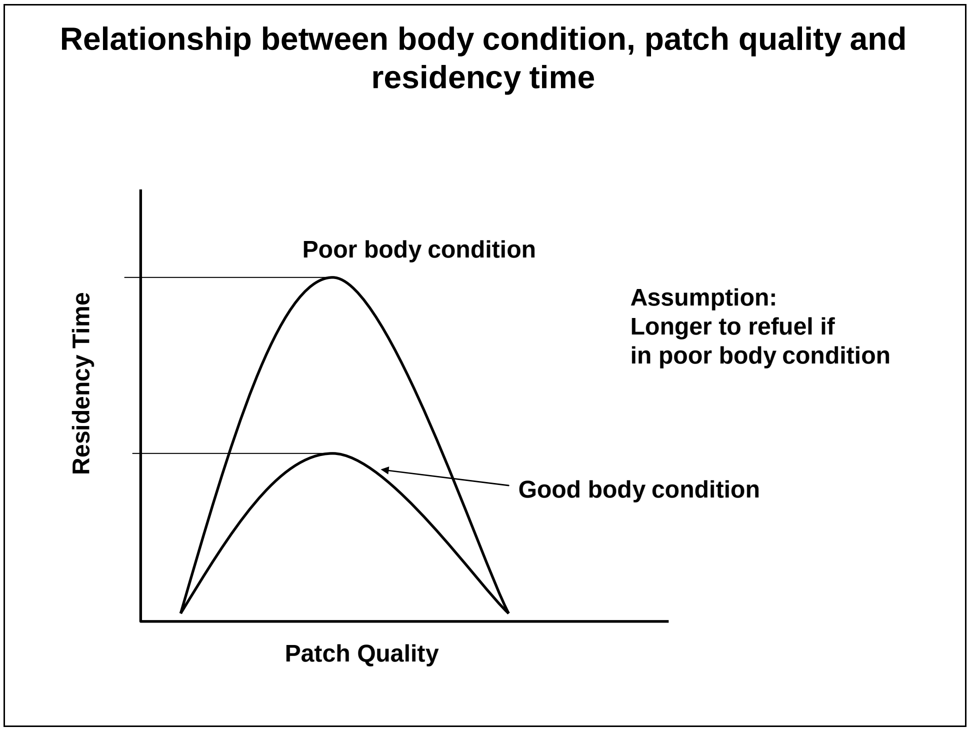

Fig 3. The relationships among waterfowl body condition, patch quality and residency time in patches.