Modeling Waterfowl Migration

Problem Statement

- **Federal land established to provide habitat for migrant birds**
- **Management staff and funding are limited**
- **Public response to management actions requires transparent decisions**

1. **Where, when and in what numbers are migratory birds using stopover habitats and are there important sites that are not protected?**
2. **Where in a region should we focus acquisition and restoration activities?**
3. **How should individual patches be managed to optimize stopover quality?**

Ultimate Goal:

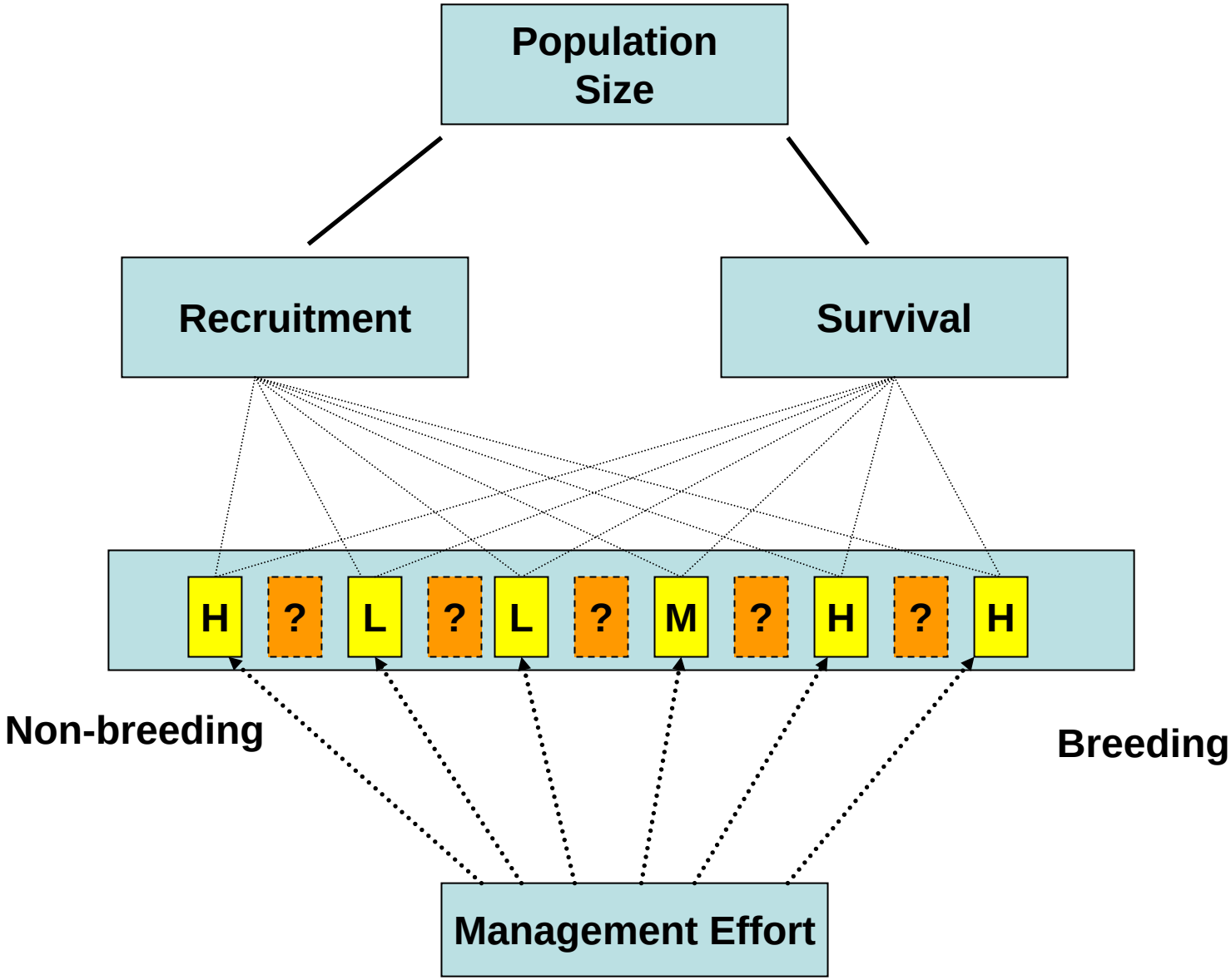
- **Maximize long-term (e.g., 10 year running) average of breeding duck population to meet NAWMP goals.**

Assumptions:

- **Migration habitat quality and availability affects body condition and daily survival.**
- **Body condition and survival at the end of migration determine recruitment potential and non-breeding survival.**

Objective:

- **To manage the distribution and availability of quality migration stopover habitat to optimize body condition and daily survival rate while providing for public use.**


Population Size
Recruitment
Survival
H
?
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?
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M
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H
?
H
Non-breeding
Breeding
Management Effort

Prototype I

I. Determined initial parameters:

- **Starting body condition**
- **Energy cost of flight (a function of distance between patches)**
- **Patch quality (survivorship)**

II. Output variables

- **Residence time**
- **Daily survival estimate**
- **New body condition**
- **Life status (dead/alive)**

III. Started with just a few patches and moved a duck through those sequentially.

IV. Looked at initial output values from model (PopTools) to see if they made sense.

1 **Starting Condition of Bird**
Breeding or wintering grounds

Assumption:
Better breeding (or wintering) grounds > body condition
? Does previous migration affect starting body condition

2 **Energy Cost of distance flown** → *** Isolated patches of poor quality are sinks (effectively a long distance between good patches)**

Assumption:
As distance traveled increases cost increase (energetics)
If cost > energy reserves they die at patch
? Other sources of mortality during flight

3 Patch Quality

Assumption:
Patch quality is related to forage quality and amount of disturbance (high, medium, low)

As forage quality increase patch quality increases
As disturbance decrease patch quality increases

? Varying patch quality over time (with bird use)
? Varying patch density relate to energy cost

4 Residence Time

Assumption:
Quadratic curve relating patch quality to residence time
Time spent in patch dependent on arriving body condition and patch quality
Patch quality is function of food availability and disturbance (previous step)
? Fretwel-Lucas
? Overall migration time constraint
? Maximum residency time (currently 33 days)

5 Body condition gained

Assumption
If arriving patch quality < 50 then can only gain proportion of deficit (based patch quality)
? Examine energy acquisition rate per day as function of patch quality

6 Final Body condition

Assumption:
Arriving body condition plus body condition gained
? No death in patches yet (dead birds fly)

The Model:

				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

Prototype II modifications

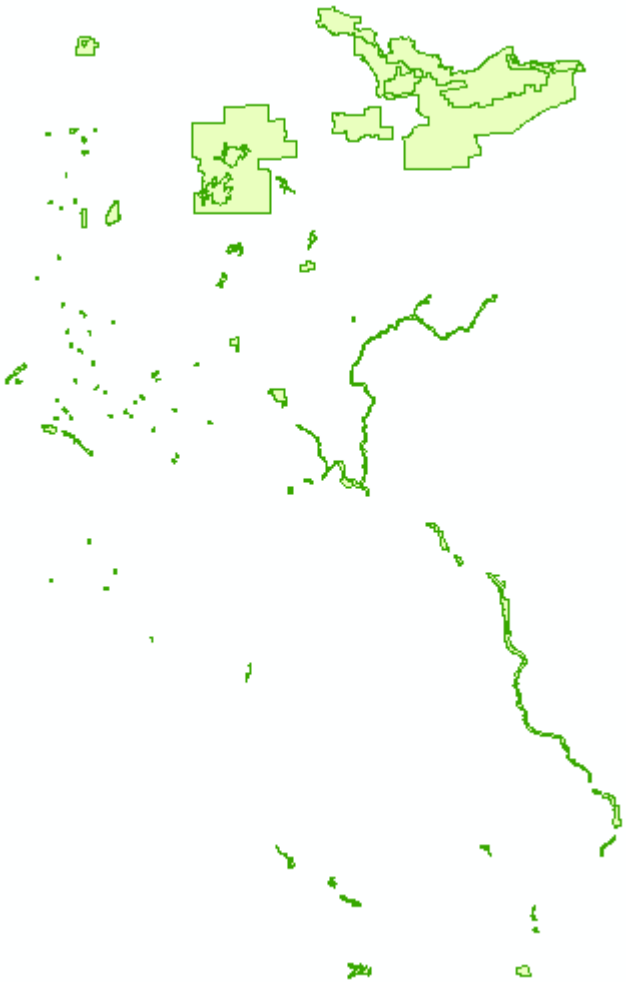
3 **Patch Quality**

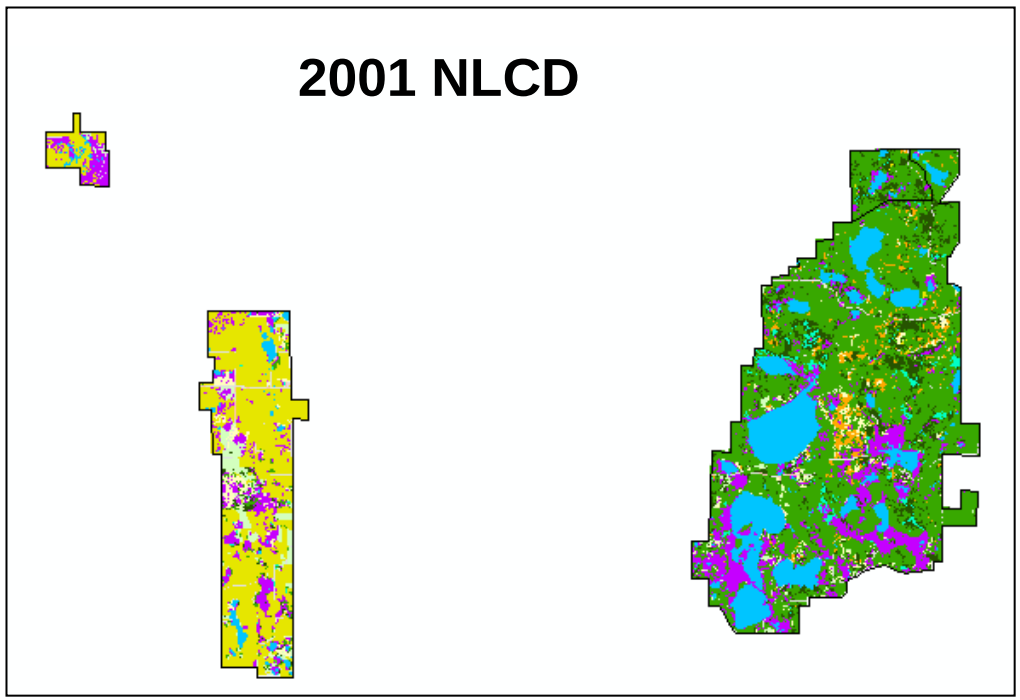
Our first prototype we assumed a patch as just a box.

Selected 2 representative species: Mallard and Canvasback (dabbler/diver)

Redefined patch based on individual habitat (n > 22,000)

Patches – federal lands





Patch Definition – contiguous 30m pixels from 2001 NLCD scored as suitable "duck" forage or loafing habitat

Individual pixels scored for forage/loafing quality, high (10), medium (5), low (0) for 15 land cover types

Patch forage quality score (headache time)

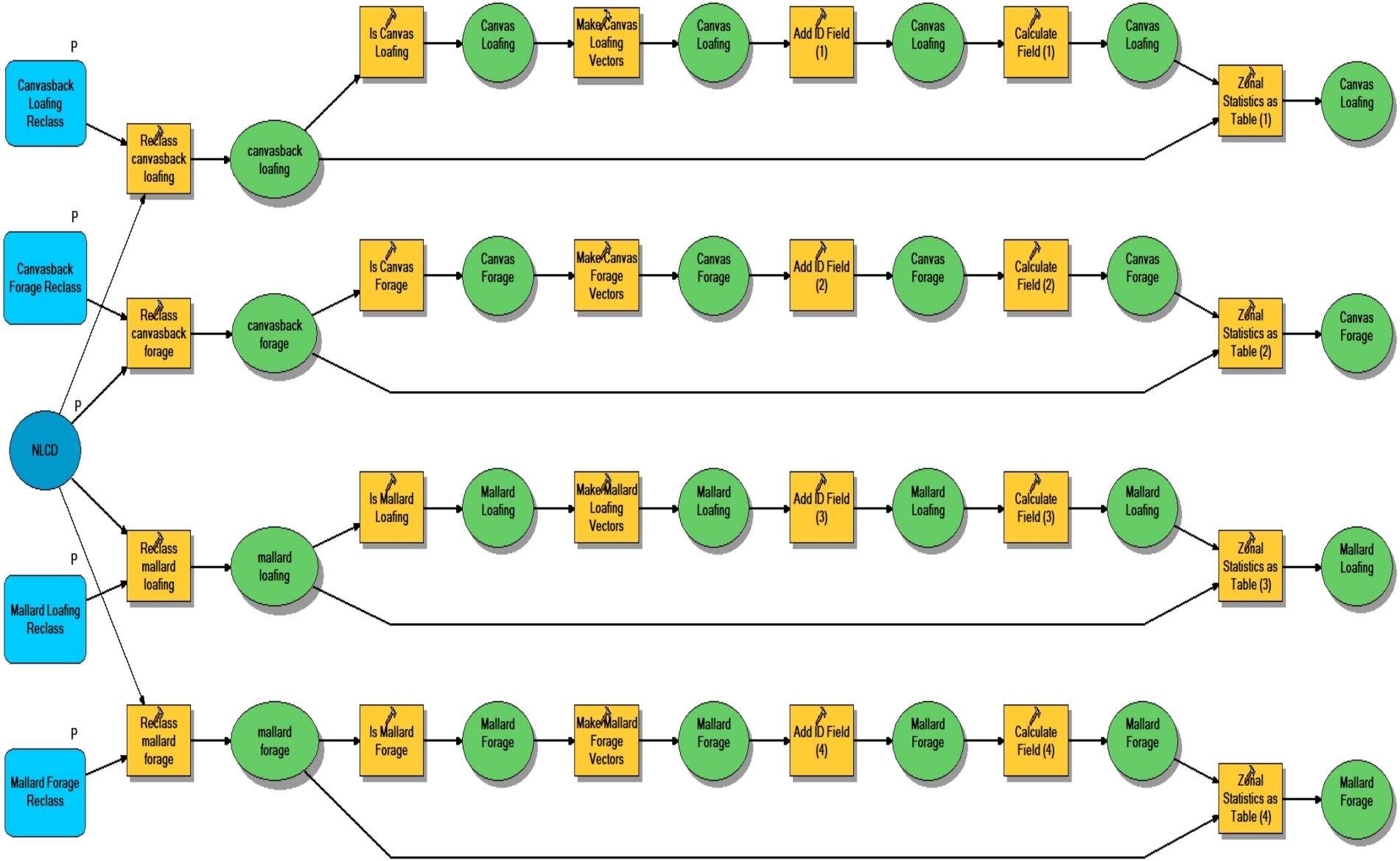
assumptions:

1) higher sum of pixel score results in increased patch score (forage/loafing)

2) higher average score per pixel results in higher patch score

Scoring Forage Quality:

	Habitat	mallard		canvasback	
		forage	loafing	forage	loafing
11	open water	0	10	5	10
21	developed, open	0	0	0	0
22	developed, low	0	0	0	0
23	developed, medium	0	0	0	0
24	developed, high	0	0	0	0
31	barren land	0	0	0	0
41	decid forest	0	0	0	0
42	conifer forest	0	0	0	0
43	mixed forest	0	0	0	0
52	scrub/shrub	0	0	0	0
71	grassland/herb	0	0	0	0
81	pasture/hay	0	0	0	0
82	cultivated crops	10	0	0	0
90	woody wetlands	5	10	5	5
95	emergent wetlands	10	10	10	10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Canvasback Loafing Reclass
Reclass canvasback loafing
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Is Canvas Loafing
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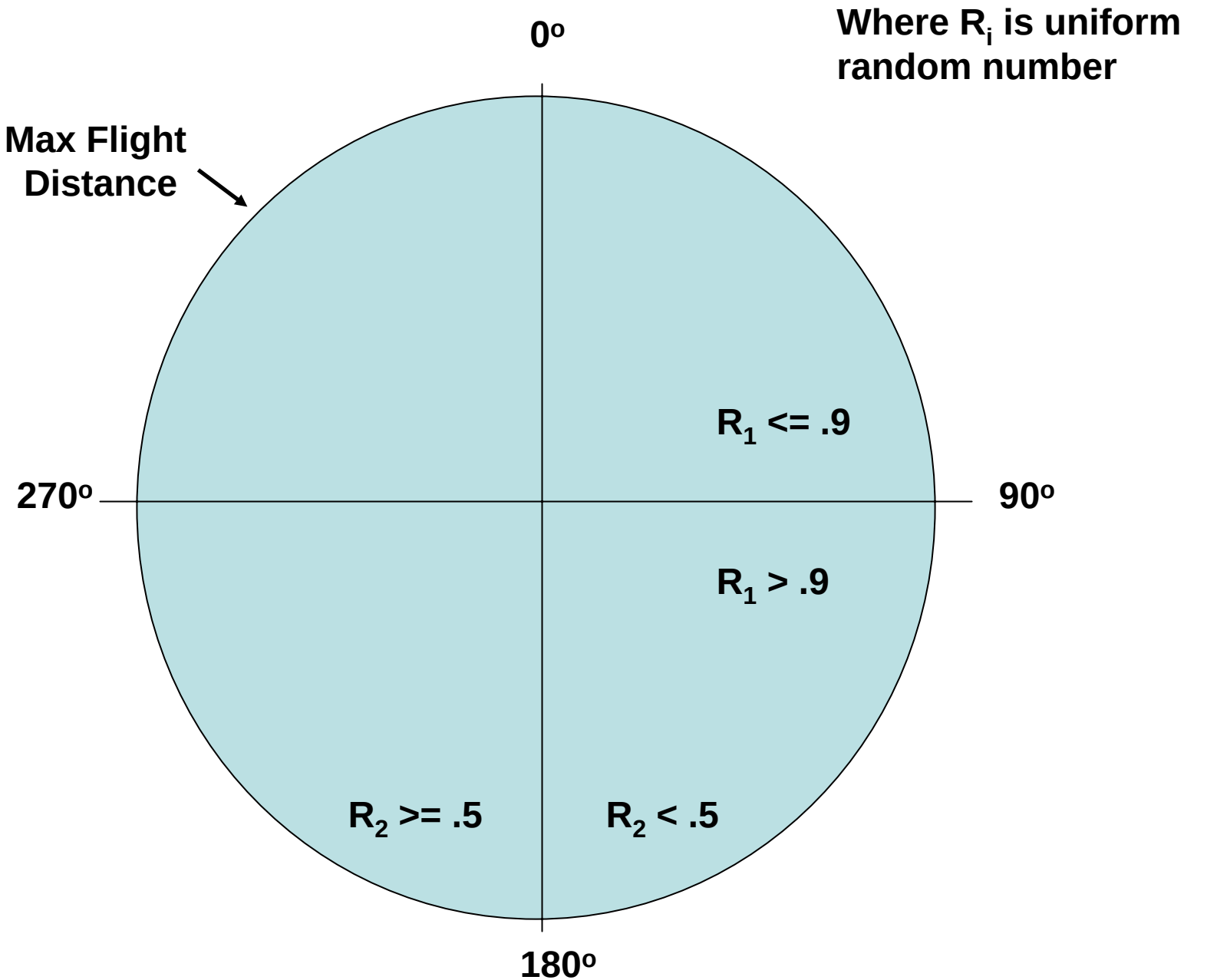
Mallard Forage
Add ID Field (4)
Mallard Forage
Calculate Field (4)
Mallard Forage
Zonal Statistics as Table (4)
Mallard Forage

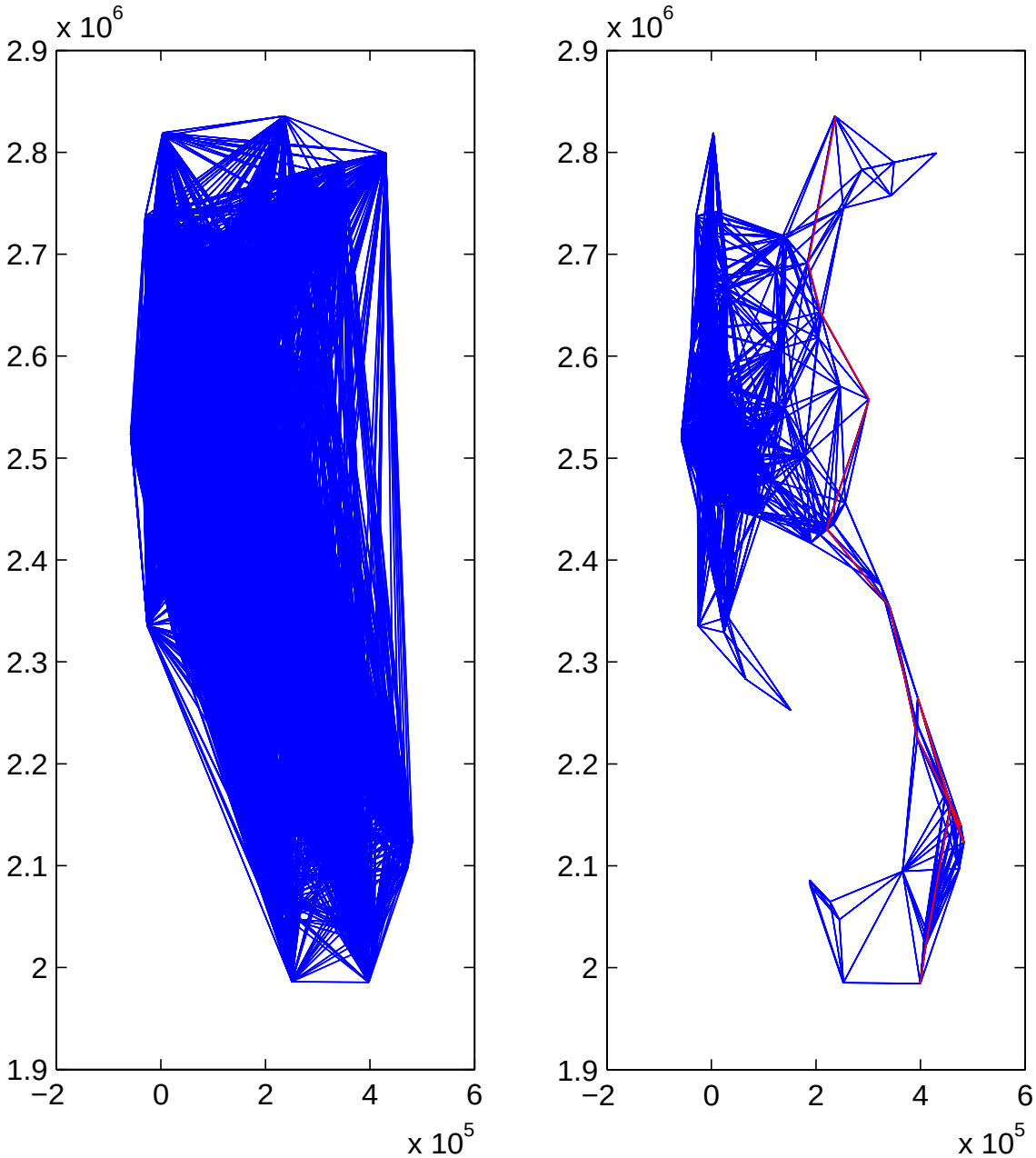
Prototype III

- **Patch definition**
  - **Changed to federal boundaries (n = 112)**
- **For each patch**
  - **Summed forage values**
  - **Summed loafing values**
- **Duck movement thru landscape**
  - **More likely to move in N/S**
  - **Maximum flight distance limits patch selection**

Northward Duck Movement



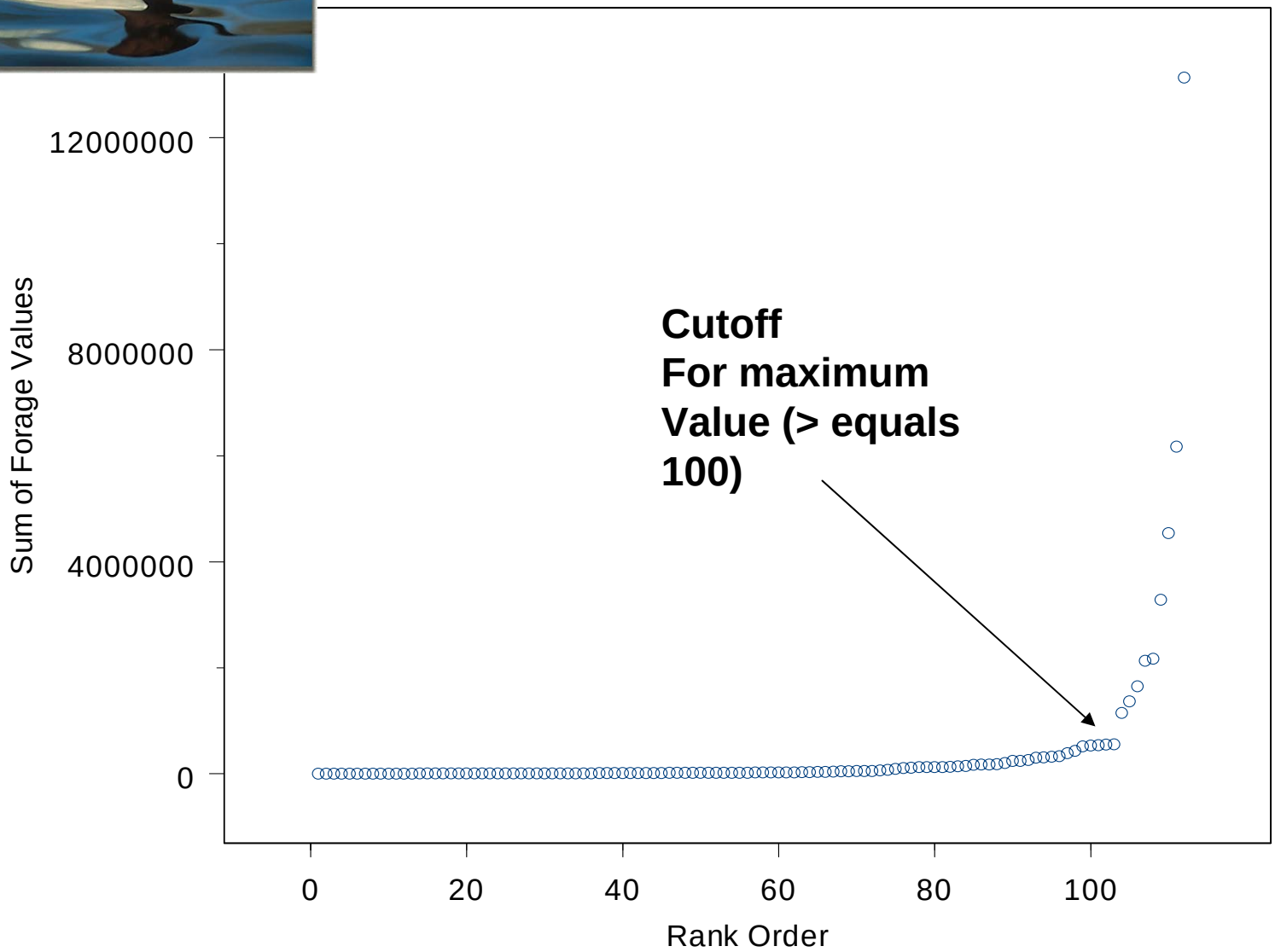
Connectedness of patches depends on flight distance



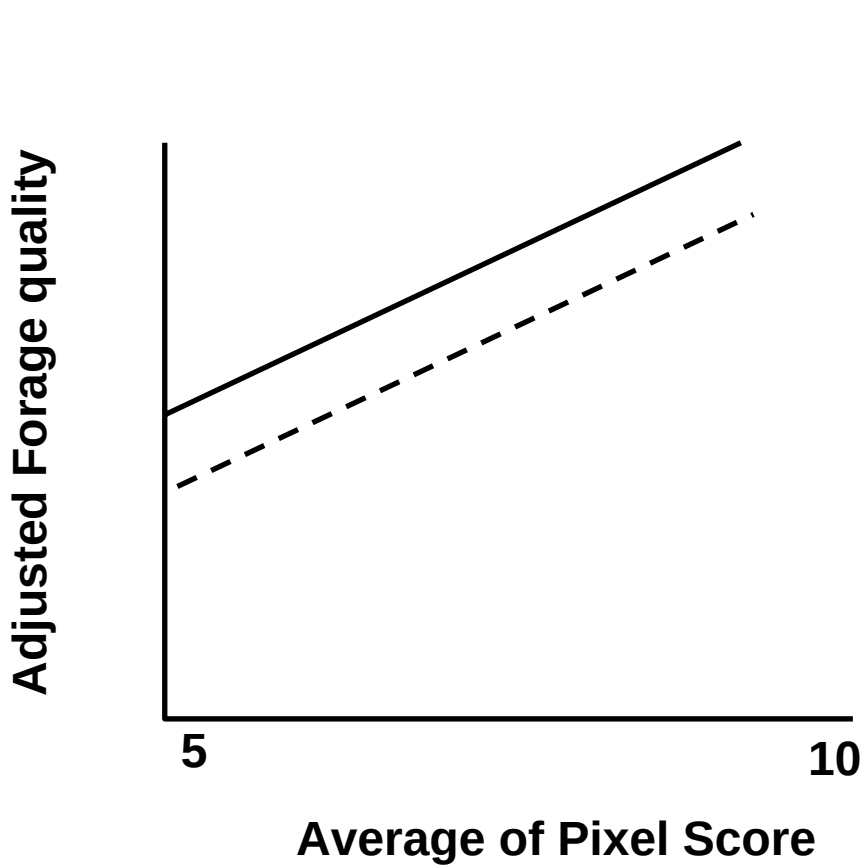
Left panel shows all possible connections between patches

Right panel imposes flight restriction of 160km between patches

Determining Patch Quality
Converting Area to Quality Index



Forage Quality of Patch



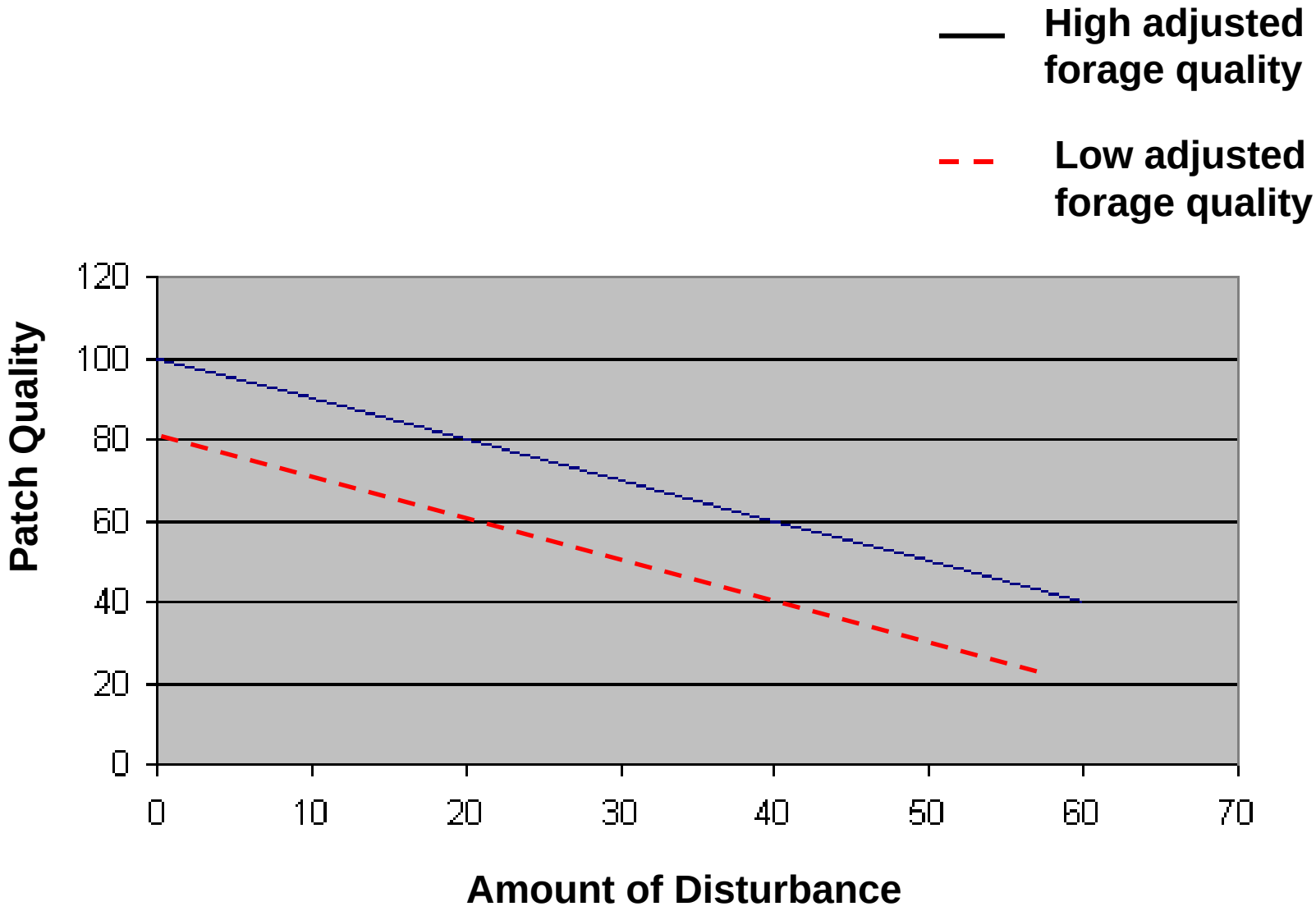
High total Forage

High total Forage

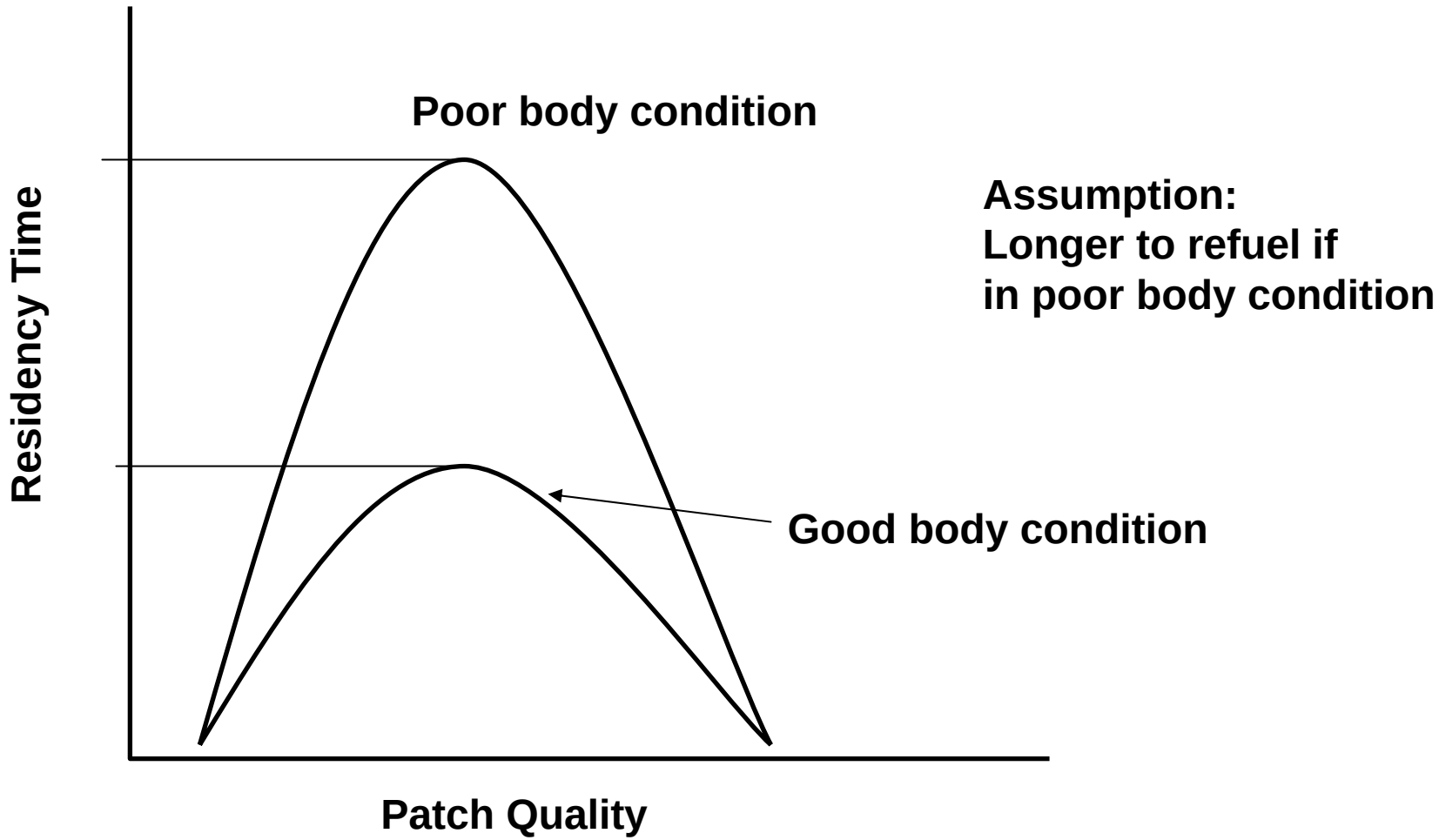
Average pixel score devalues forage quality for patch

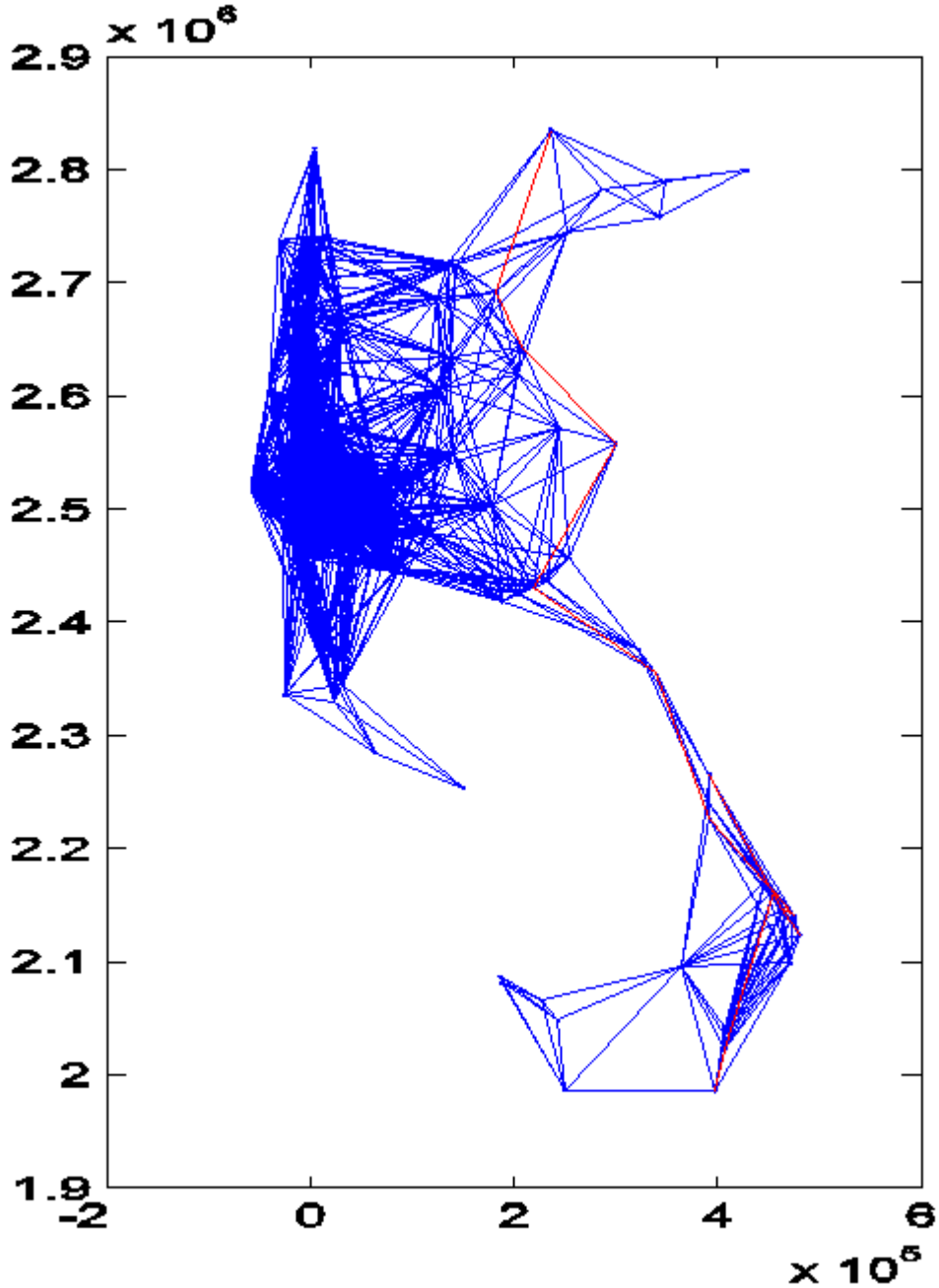
- **Patch disturbance is a function of human use**
  - **using surrogate of county-level estimate of average annual harvest**
- **Assumptions**
  - **annual harvest not adequate surrogate, need to find better correlate for future iterations**

Mean annual harvest of Mallard

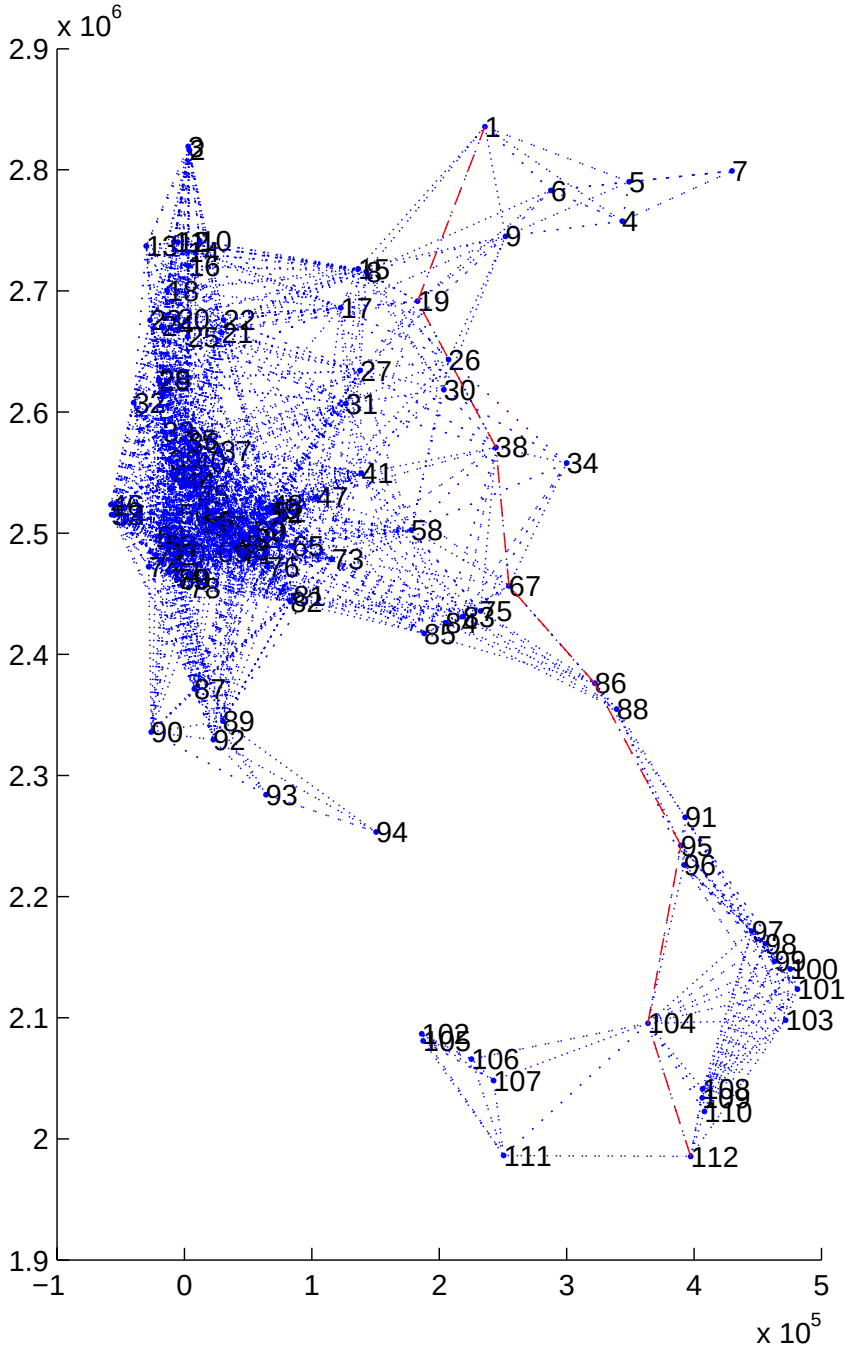

High adjusted forage quality
Low adjusted forage quality
Patch Quality
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Amount of Disturbance

Relationship between body condition, patch quality and residency time



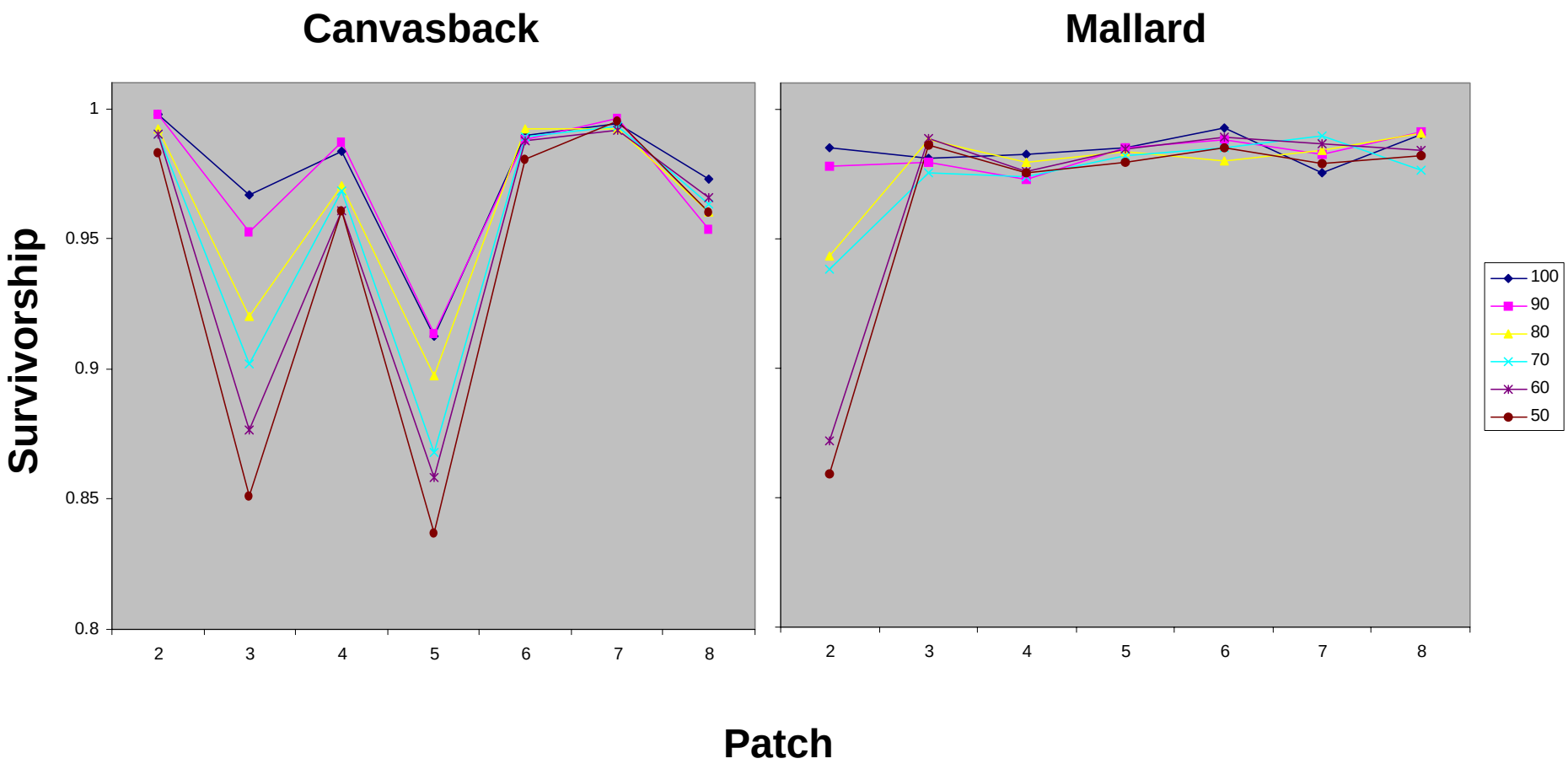


Simulated Movement Through the Mapped Patches

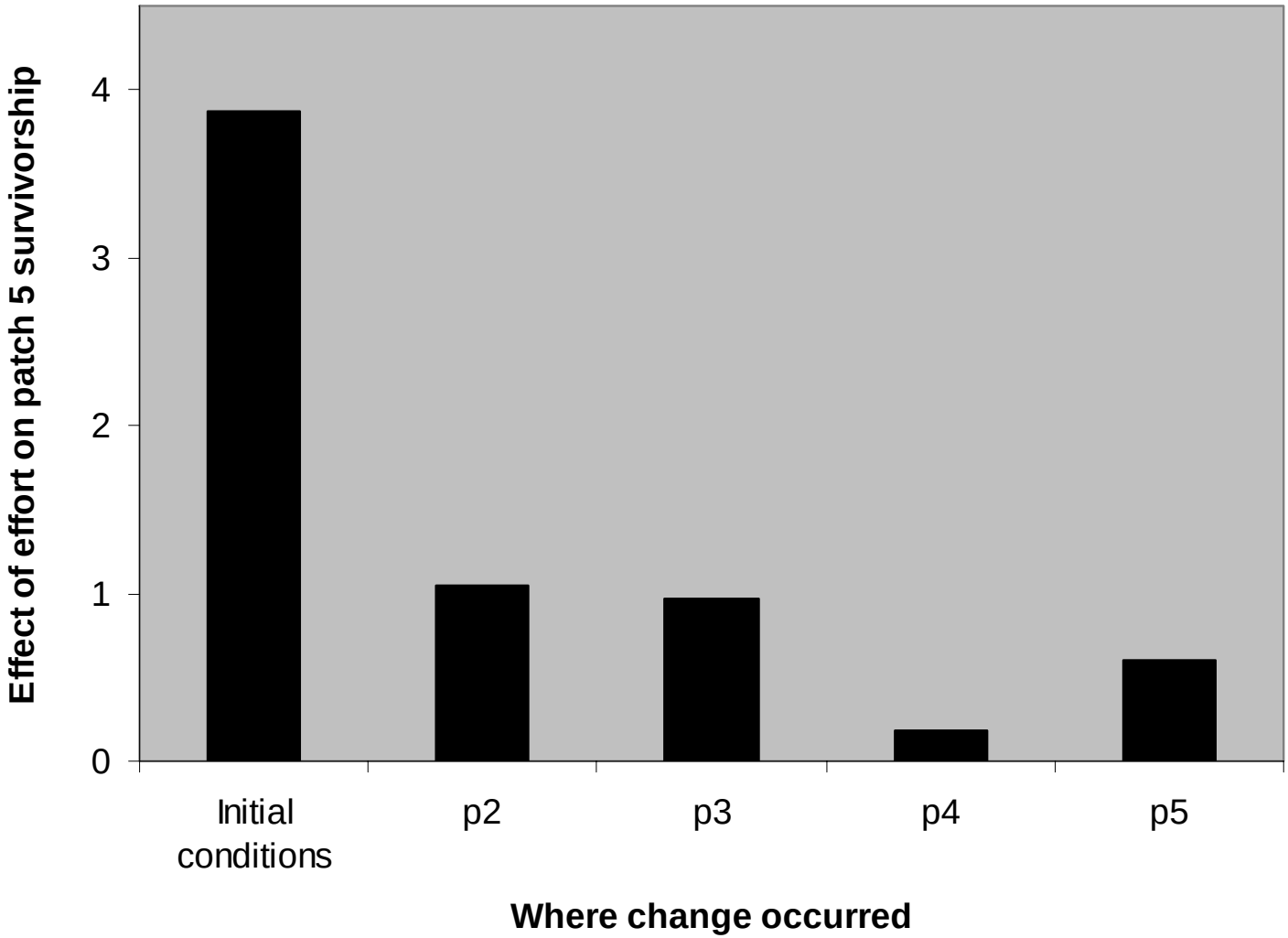


Minimum Spanning Tree

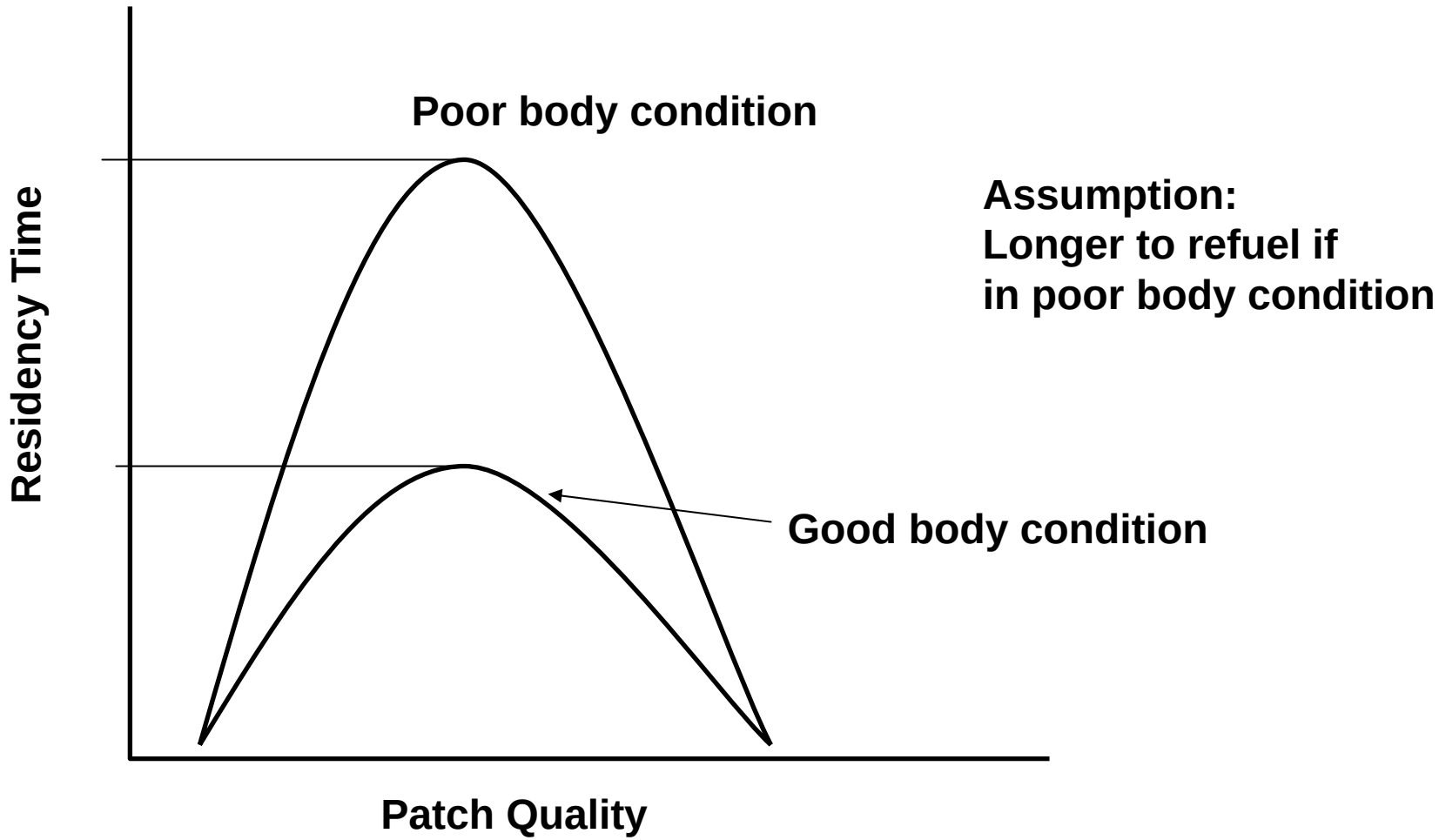
Species variation in response to landscape



Canvasback Integrated Flyway Management



Relationship between body condition, patch quality and residency time



Management Implications

- **Management response:**
  - **Increase patch quality (increase forage quality, lower disturbance)**
  - **Increase patch density**
- **Challenge is to optimize recruitment or non-breeding survival via these two options**

Next Steps

- **Determine if objective is achievable**
  - **Potential outcome of refining the model to inform management (regional and patch perspective)**
- **What will it take to make it happen?**
- **If the above two are affirmative, develop action plan to move forward**
- **Is our accomplishment to this point of value in itself?**
  - **Develop manuscript**
- **Is the rapid prototyping process applicable to other issues in our daily work?**

Future Needs

- **Quantitative measures ot 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 identifed 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