Vulnerability to Climate Change in Amphibians and Reptiles

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Possible Effects of Climate Change

- Physiological stress
- Mobility
- Earlier phenology
  - Shorter hibernation
  - Longer aestivation
- Changes in community ecology
  - prey, predators, parasites, competitors

Possible Effects of Climate Change

- Habitat changes
  - range limit changes
  - loss and fragmentation
  - new habitats
- Extirpations, extinctions
- Changes in management strategies

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Assessing Response to Climate Change

- Milsap et al. (1990)
  - Florida wildlife
  - Scoring system for general vulnerability and climatic sensitivity
- Herman & Scott (1992)
  - Nova Scotia amphibians
- Ovaska (1997)
  - Adapted Herman & Scott for all Canadian amphibians
  - Considered sensitivity to UV light

Scoring System

- Biological variables
  - Demographics, range, reproductive potential, specializations, etc.
- State of knowledge variables
  - Distribution, trends, limiting factors, management activities

Scoring System

- Climatic sensitivity variables
  - Temperature, precipitation, stream flow, snow and ice cover, flooding
- Supplemental variables
  - systematic significance, total range area, harvest pressures

Conclusions – Herman & Scott (Nova Scotia)

- Amphibian scores fairly uniform, reptiles uneven
- Relatively high vulnerability for newts and four-toed salamanders
- Recommended developing methodology further
- Management can mitigate some impacts

Conclusions – Ovaska (Canada)

- Potentially high UV impacts for frogs, less for salamanders
- Suggested that many amphibian species may be tolerant of climate change in Canada
- Terrestrial salamanders and tailed frogs are most vulnerable

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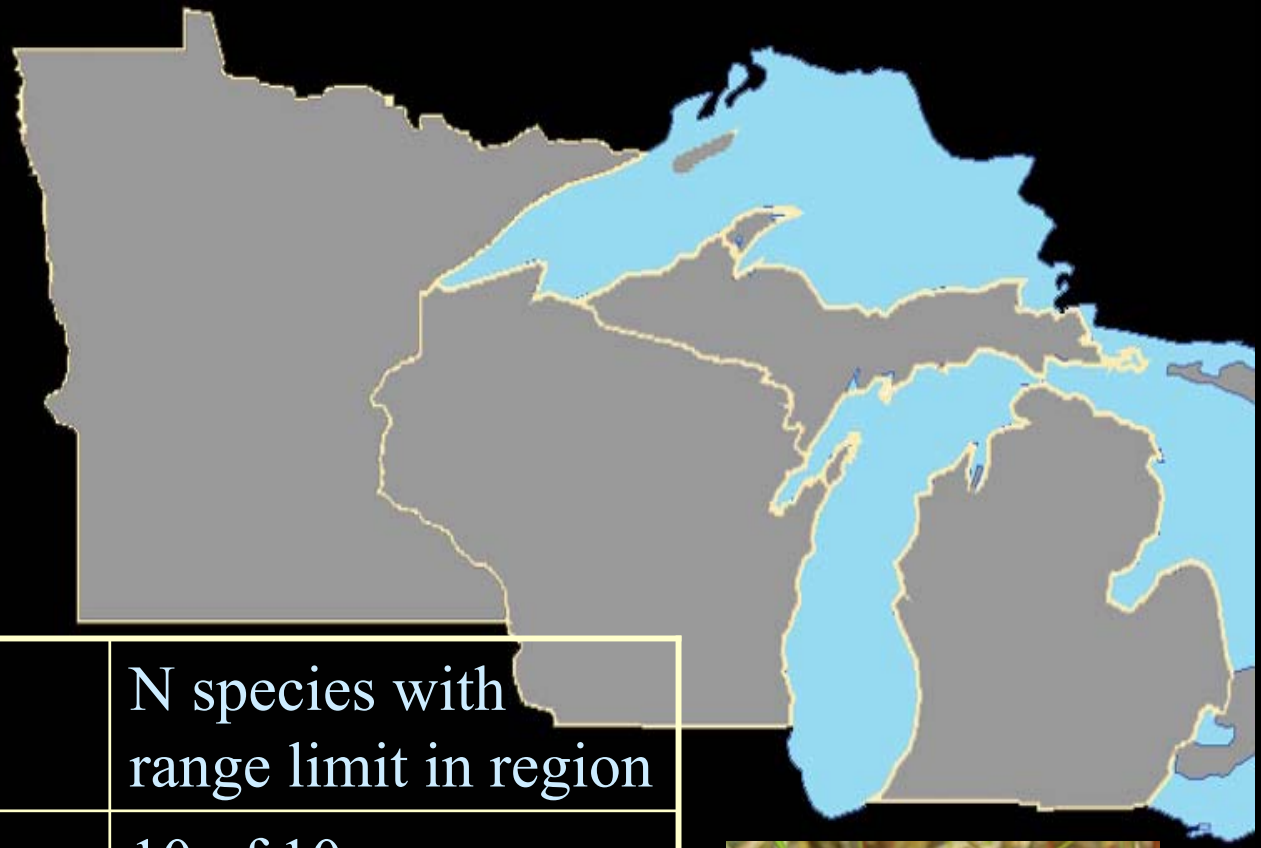
Scoring System – This Study

- Study area = MN, WI, MI
- Did not consider solar UV radiation
- Added consideration of range limits
  - a tolerance limit sensitive to climate change (physiological, ecological, or geographic)
- Further refined climate change variables

Study Area: MN-WI-MI



Group	N species with range limit in region
Salamanders	10 of 10
Frogs and Toads	13 of 15
Lizards and Snakes	29 of 30
Turtles	10 of 12

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Glacial History

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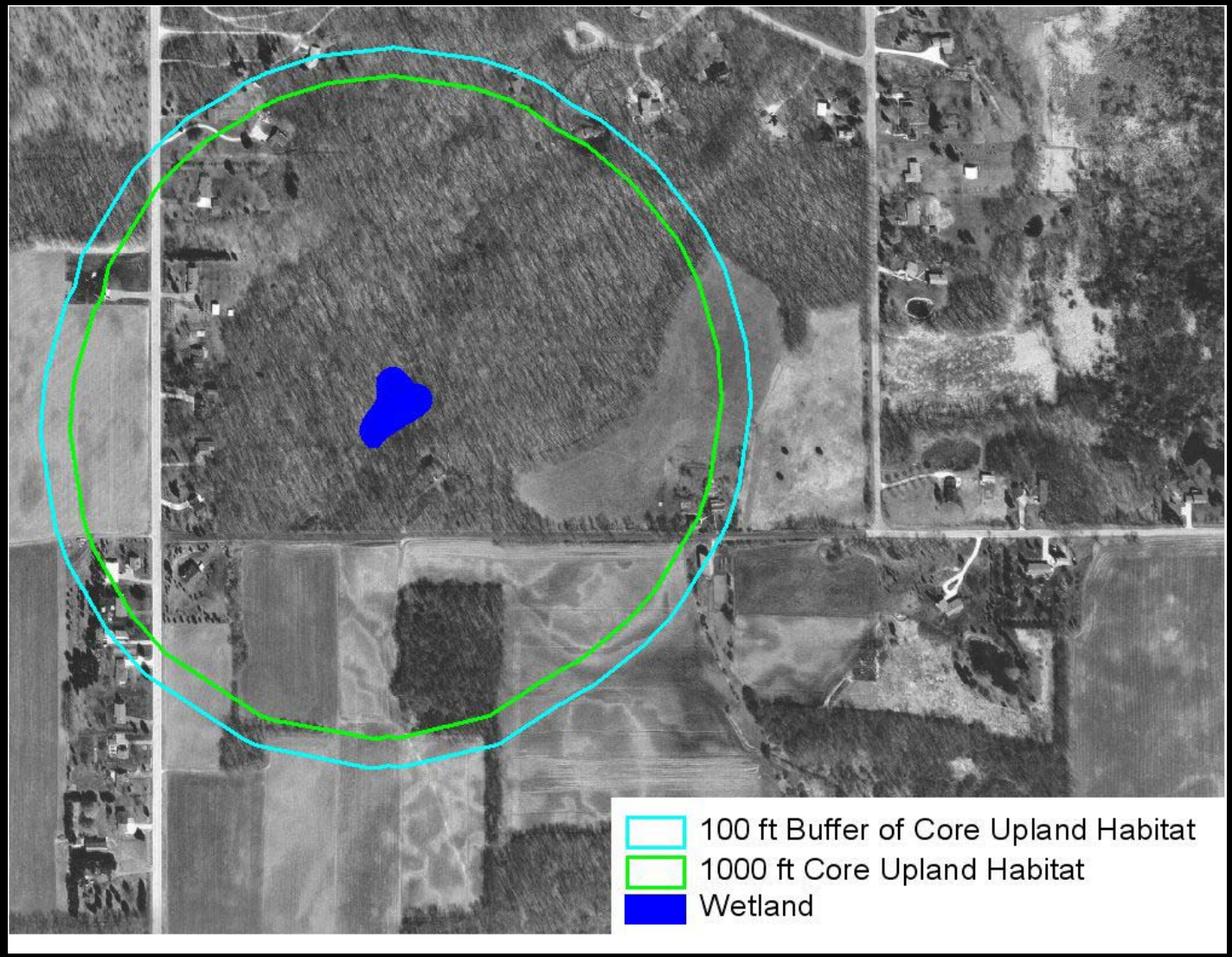
Modern Dispersal Problems



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Three Scoring Categories

- General vulnerability – 145 pts
  - Biological criteria
- Sensitivity to climate change – 150 pts
  - Effects of expected climate change
- Regional importance – 100 pts
  - % of total range within region

General Vulnerability Variables

- Population and Distribution
  - Trend within region
  - Area of region occupied
  - Fragmentation of distribution
  - Patchiness of habitats
  - Range limit within region

General Vulnerability Variables

- Life History
  - Number of distinct habitat types required
  - Seasonal population concentrations (mating, nesting, denning)
  - Length of oviposition season
  - Reproductive specialization (breeding or rearing young)
  - Habitat specialization
  - Dietary specialization
  - Average clutch size (recovery potential)
  - Average age of female at first reproduction (recovery potential)

Scoring System

	Measures of general vulnerability w/in Region	Scoring	Max Score
	Population and Distribution Variables		
1	Population or distribution trend within region	known to be stable or inc. = 0, unknown but widespread and abundant = 15, no data or local decreases or habitat loss over <20% of region = 30, unknown but decrease suspected or past declines known but recovered = 40, decrease known over >20% of region = 5	50
2	Area of region occupied (MN, WI, MI)	>75% = 0, 75-50% = 2, 50-25% = 6, <25% = 10	10
3	Fragmentation of distribution (disjunct pops)	contiguous 0, at least one disjunct pop 10	10
4	Patchiness of habitats within regional range (degree of fragmentation)	limited = 0, low = 3, moderate = 6, great = 10	10
5	Range limit within region	No = 0, Yes = 20	20
	Life History Variables		
1	N distinct habitat types required	1 = 0, 2 = 3, 3 = 5	5
2	Seasonal population concentrations (mating, nesting, denning)	0 no, 10 yes	10
3	Length of oviposition season	prolonged 0, explosive 5	5
4	Reproductive specialization (for breeding or rearing young)	limited 0, moderate 3, highly 5	5
5	Habitat specialization	limited 0, moderate 3, highly 5	5
6	Dietary specialization	limited 0, moderate 3, highly 5	5
7	Average clutch size (recovery potential)	5000+ = 0, 1000-4999 = 2, 100-999 = 3, 30-99 = 4, <30 = 5	5
8	Average age of female at first reproduction (recovery potential)	1-3 yr = 0, 4-5 yr = 3, 6+ yrs = 5	5
		subtotal	**145**

Salamander Vulnerability (10 species)
mean 95, range 80 - 120

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Anuran Vulnerability (15 species)
mean = 82, range 39 - 120

Range limits and known declines

Index

0
20
40
60
80
100
120
140

American Toad
Canadian Toad
Great Plains Toad
Fowler's Toad
Northern Cricket Frog
Cope's Gray Treefrog
Gray Treefrog
Spring Peeper
Chorus Frog sp.
American Bullfrog
Northern Green Frog
Pickerel Frog
Northern Leopard Frog
Mink Frog
Wood Frog

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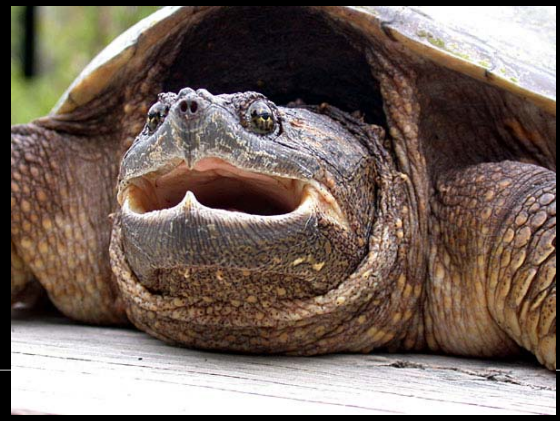
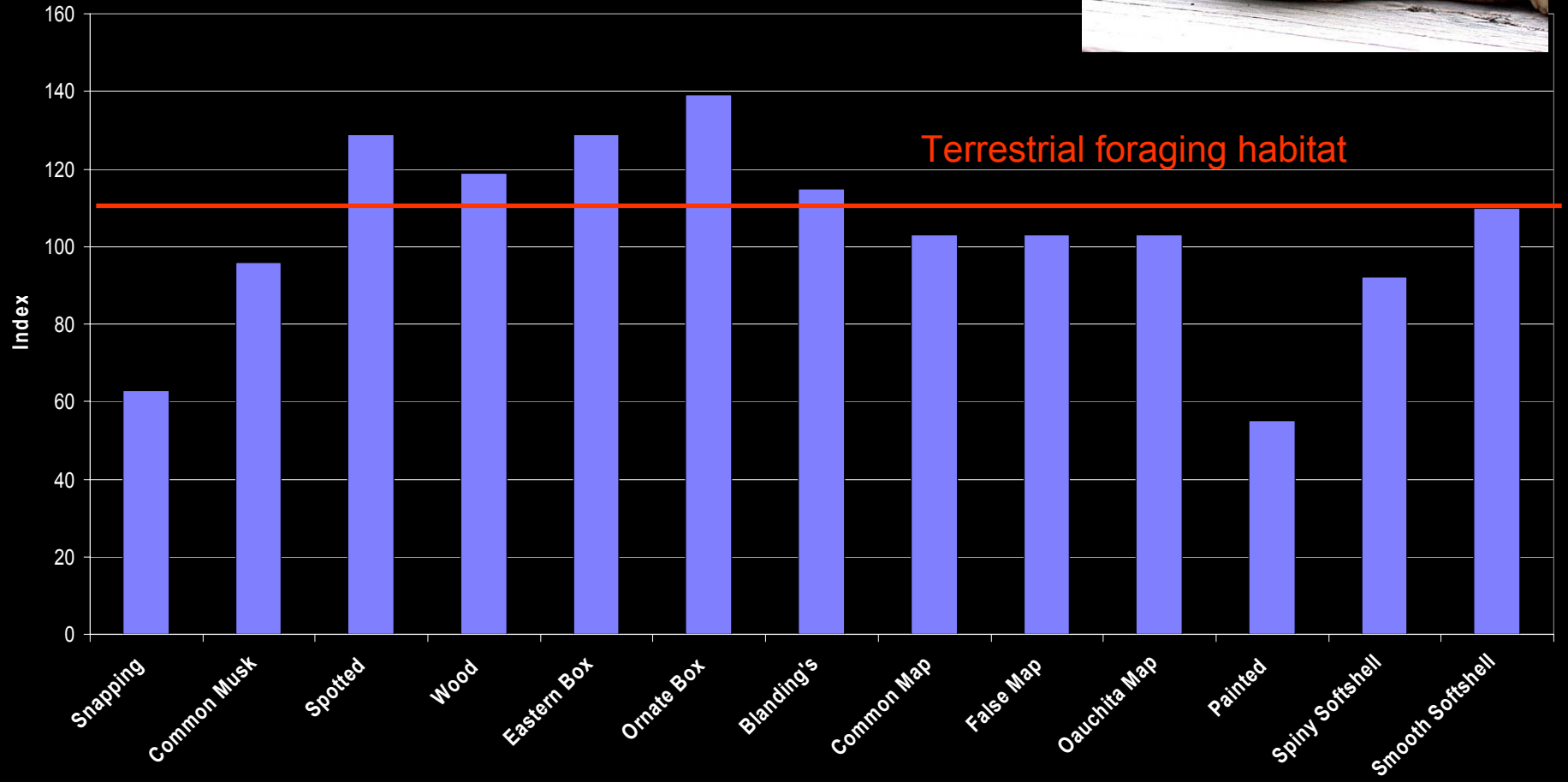
Turtle Vulnerability (13 species)
mean 104, range 55 - 139





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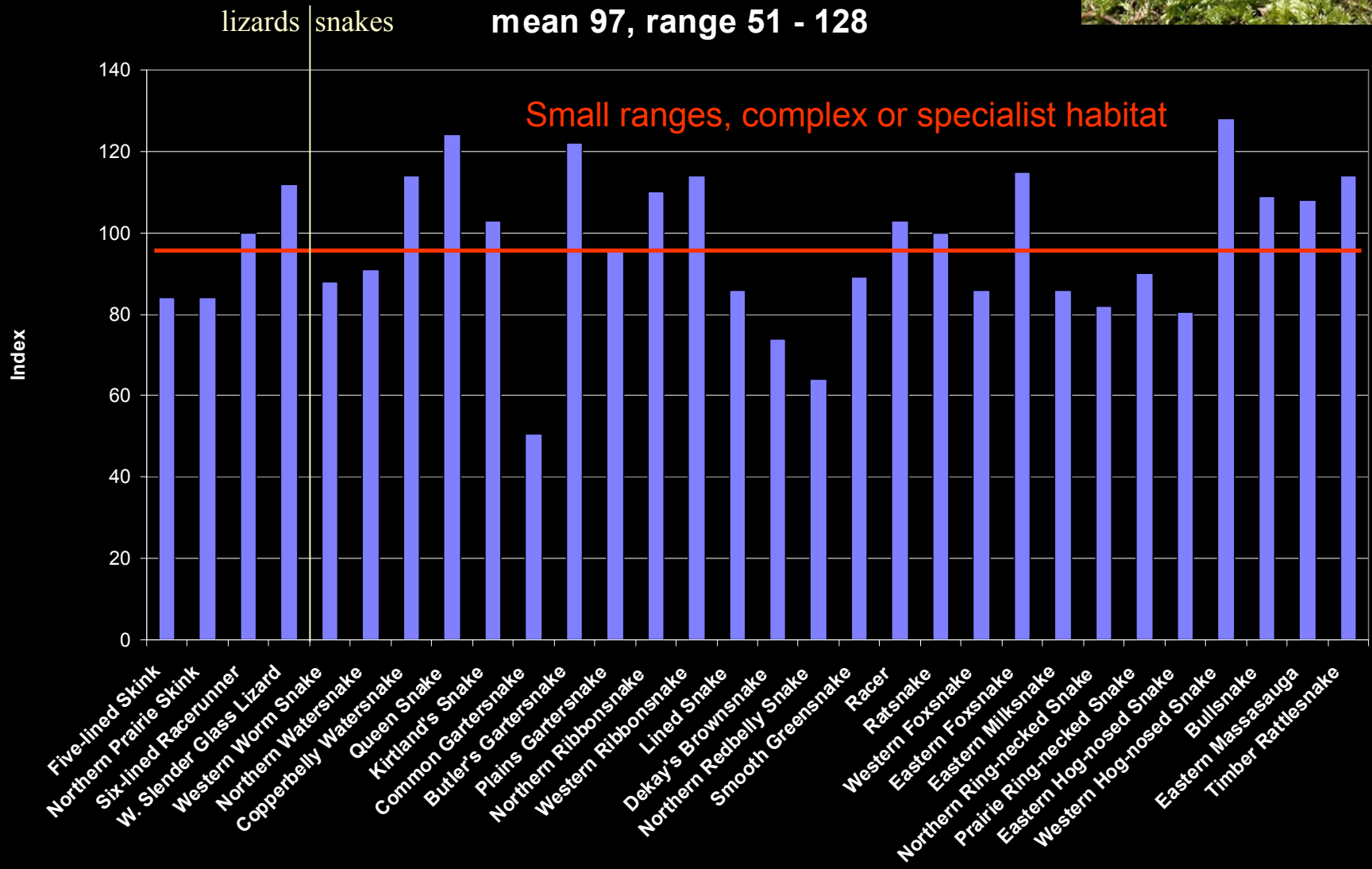
Squamate Vulnerability (30 species)
mean 97, range 51 - 128



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Sensitivity to Climate Change Variables

- Warmer drier summer soils (lower water tables)
- Reduced summer rainfall (shorter hydroperiod, lower stream flow)
- Increased winter water temperature (less ice cover)
- Reduced soil frost duration (longer growing season)
- Amplified climate extremes (increased incidence of deep frosts and extreme drought)
- Increased winter/spring flooding

Climate Change Sensitivity Scoring

- Each variable scored for how it would effect:
  - Food supply and access
  - Dispersal mobility
  - Habitat reduction (area or quality)
  - Exposure to predation
  - Physiological stress (including skewed sex ratios)

Snow Cover and Frost

- Models predict warmer, wetter winters
  - Less ice and snow cover on average
  - Reduced soil frost duration
  - Longer growing seasons
- **But also** amplified climate extremes
  - increased incidence of deep frosts and extreme droughts

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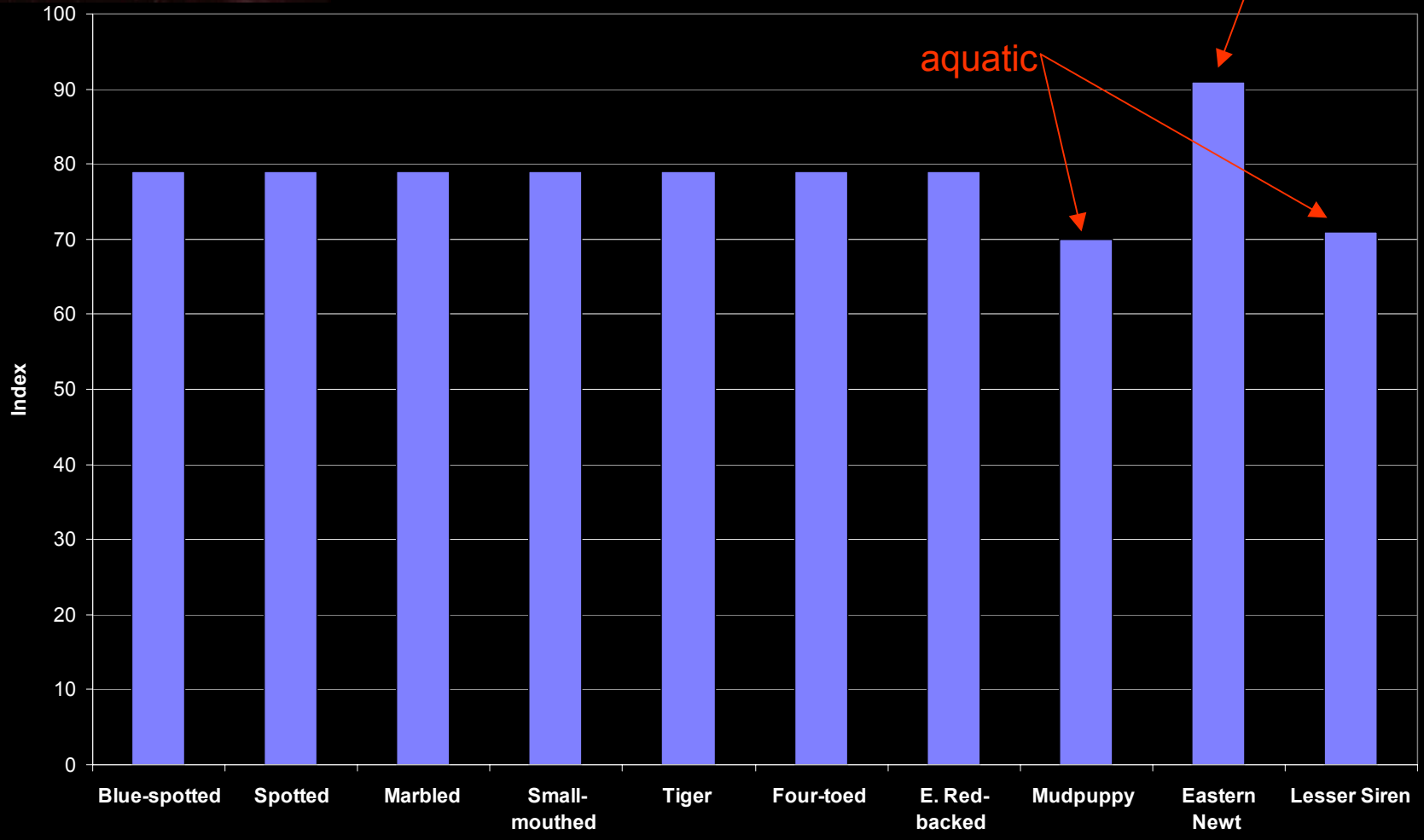
Scoring System

- Advantages
  - Systematic approach to assessing relative vulnerability
  - Flexibility in variables used
  - Variables and scoring can be adjusted as data improves
  - Adaptable to different organismal groups and regions
- Disadvantages
  - Relative, not absolute, measure
  - Subject to errors in scoring based on knowledge gaps
  - Needs truthing

Scoring System

Sensitivity to Climate Change Variables			
A	Warmer drier summer soils (lower water tables)		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress (inc. skewing sex ratios)	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25
B	Reduced summer rainfall (inc. shorter pond hydroperiod, lower stream flow)		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress (low oxygen, thermal stress)	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25
C	Increased winter water temperature (less ice cover)		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25
D	Reduced average frost duration (longer growing season)		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25
E	Amplified climate extremes (increased incidence of deep frosts and extreme drought)		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25
F	Increased winter/spring flooding		
	1. Food supply and access	NA or low = 0, moderate = 3, high = 5	5
	2. Dispersal mobility	NA or low = 0, moderate = 3, high = 5	5
	3. Habitat reduction (area or quality)	NA or low = 0, moderate = 3, high = 5	5
	4. Exposure to predation	NA or low = 0, moderate = 3, high = 5	5
	5. Physiological stress	NA or low = 0, moderate = 3, high = 5	5
	subtotal		25

Salamander Sensitivity (10 species)
mean 79, range 70 - 91



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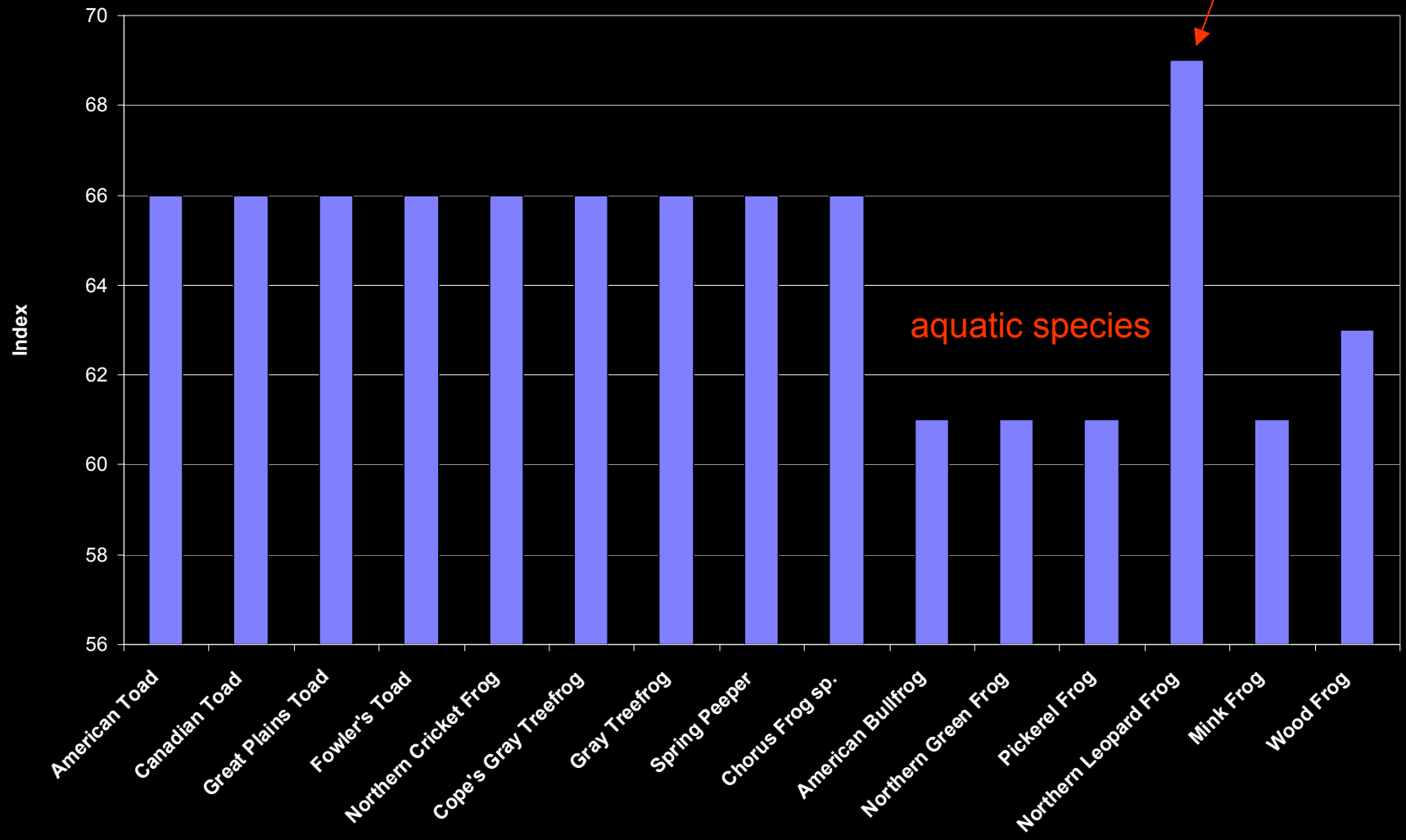
Anuran Sensitivity (15 species)
mean = 65, range 61 - 69



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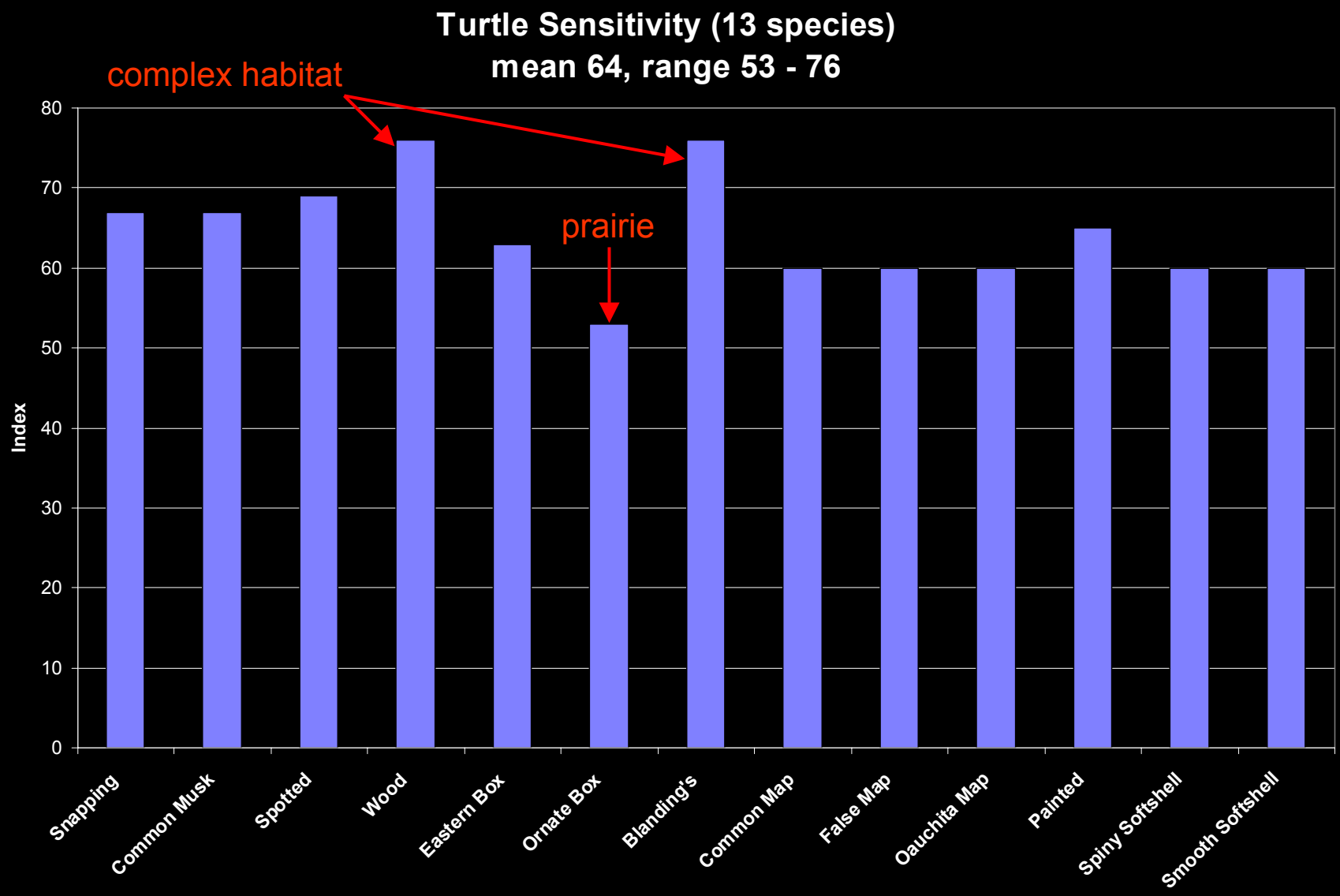

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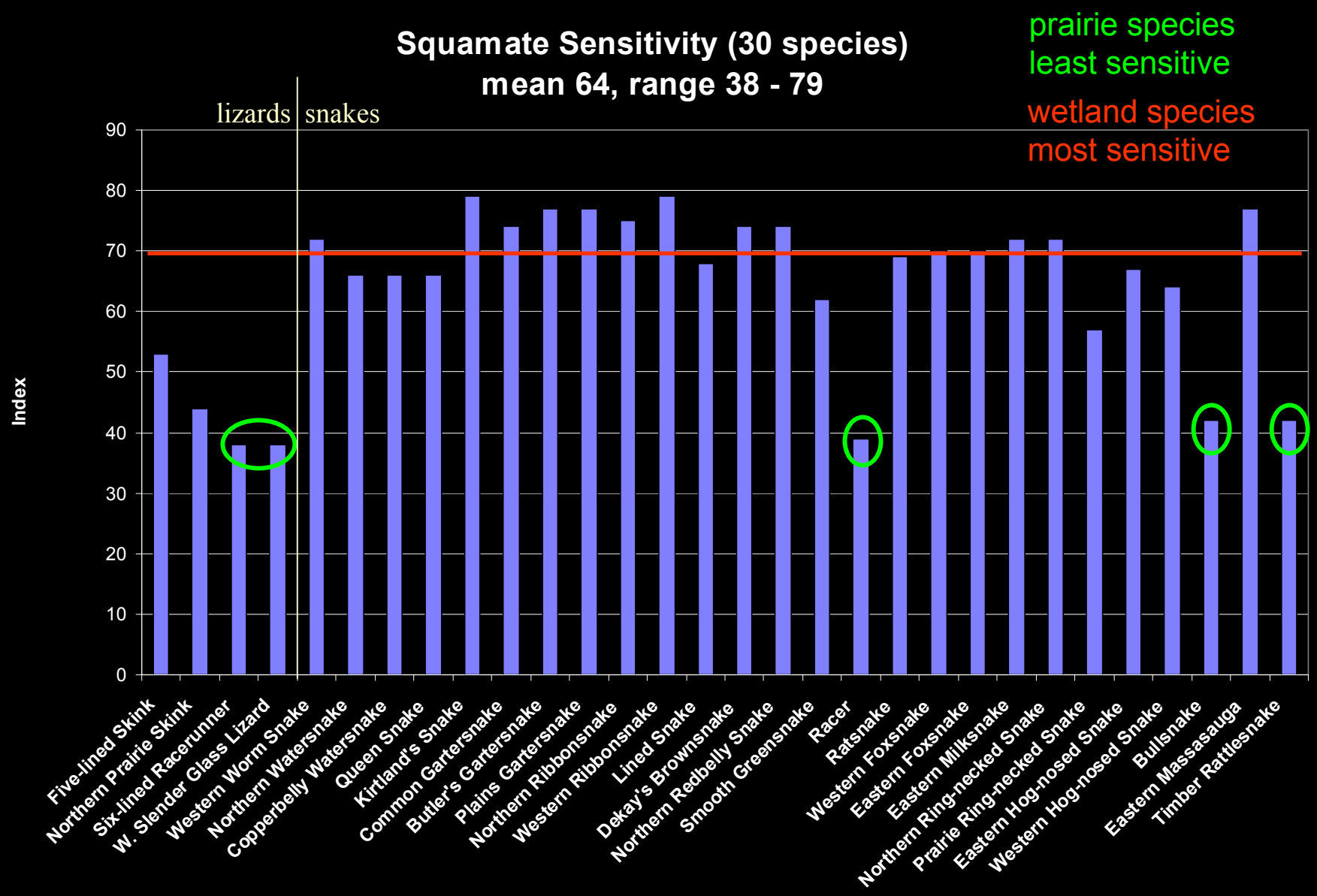

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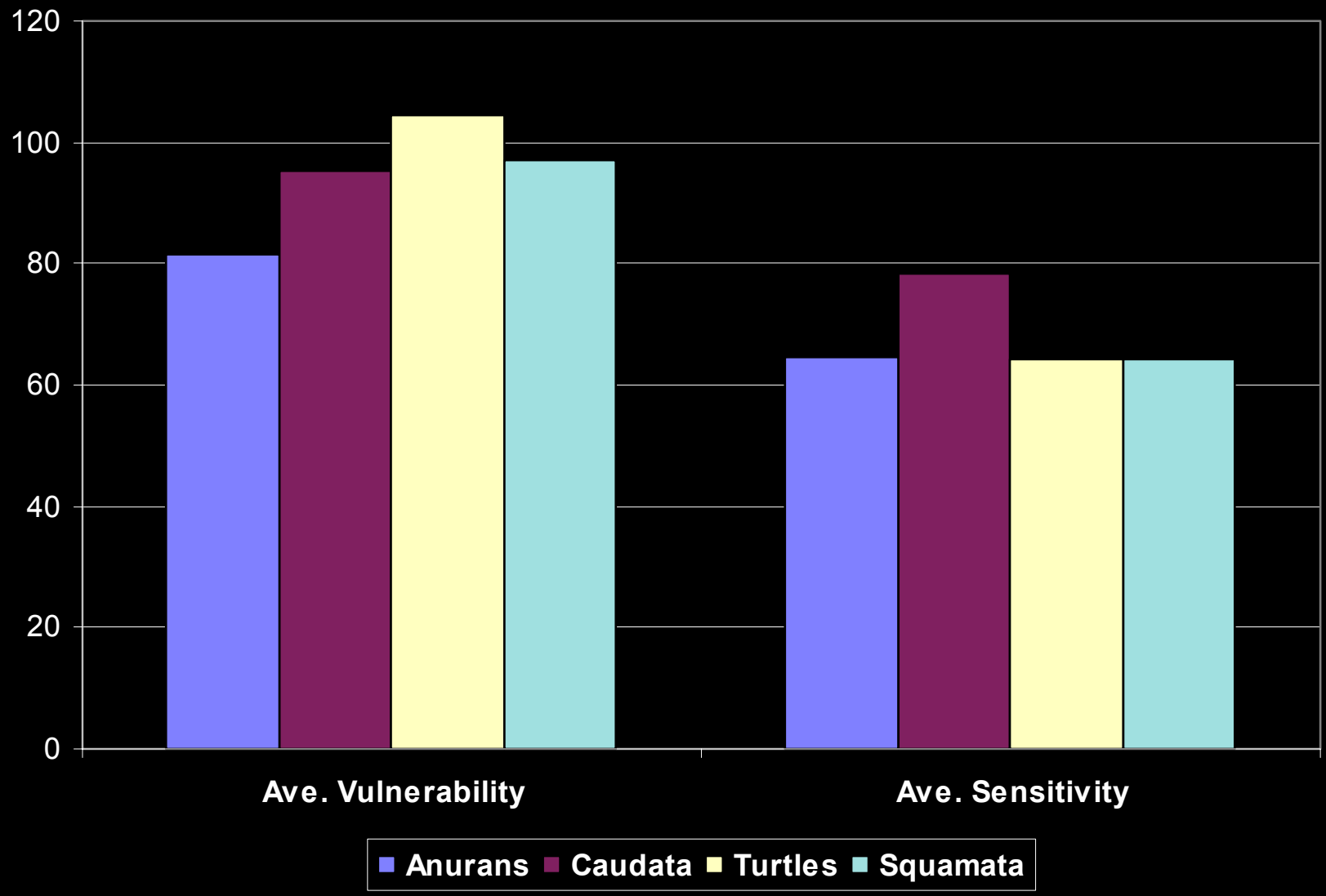
Average Scores



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Conclusions: vulnerability

- Species with limited ranges, complex habitats, specialist needs, and known declines are most vulnerable
- Turtles most vulnerable overall
  - especially more terrestrial species (spotted, wood, box, Blanding's)

Conclusions: vulnerability

- Snake vulnerability is most variable
  - range 51- 128
- Amphibian vulnerability increases for more terrestrial species and for salamanders in general

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Conclusions: sensitivity to climate change

- Salamanders are most sensitive overall and the newt scores highest
  - more aquatic species are slightly less sensitive
- Frogs and toads are uniformly sensitive
  - leopard frogs more so, aquatic species less so
- Turtles somewhat less sensitive overall
  - species with complex habitats most sensitive (Blanding's, wood)

Conclusions: sensitivity to climate change

- Prairie reptiles are less sensitive (box turtle, glass lizard, bullsnake), and may benefit.
- More sensitive reptiles have complex habitat requirements, especially species utilizing ephemeral wetlands.

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What To Expect?

- Northern species will surely retract range limits northward (i.e. mink frog, wood turtle)
- Southern species may or may not expand range limits northward (mobility problems)
- Prairie and grassland species may flourish in warmer drier conditions, if exploitable
- Widespread extirpations as systems are stressed, especially for the most vulnerable and sensitive species

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