Status Review of the Bliss Rapids Snail, *Taylorconcha serpenticola* in the Mid-Snake River, Idaho

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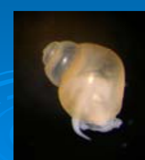

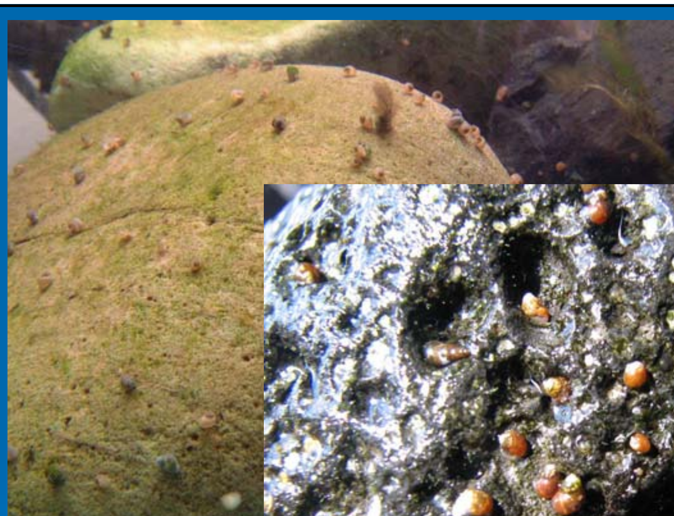

Blond morph

Photo: ECAS, Bozeman, MT

Orange morph

Photo courtesy: Dr. Peter Bowler

Density Dependence and Competition with NZMS

NZMS

BRS

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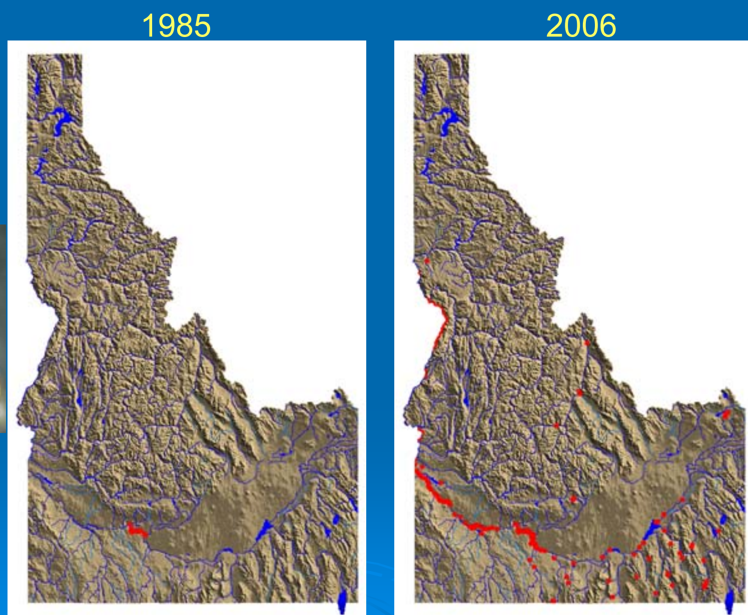

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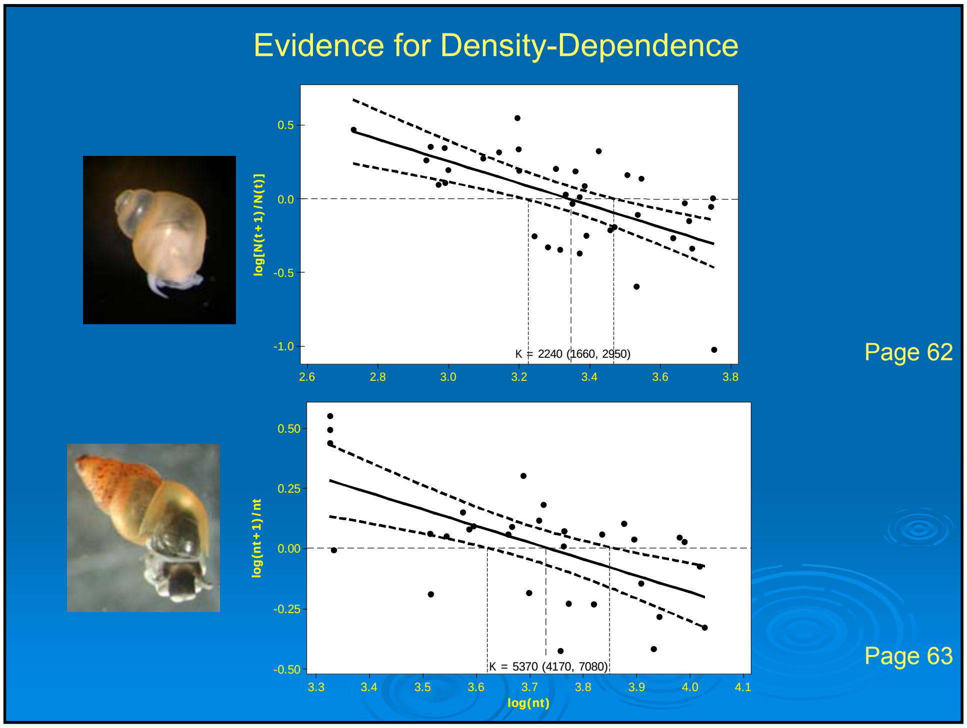
BRS and NZMS Density Dependence

- Growth rates log (Nt+1/Nt) plotted at densities at t, log Nt from Banbury Springs data
- A negative linear fit strongly suggests density dependence (Akcakaya 1999, Baguette and Schitickzelle 2006,Gotellie 1998)


Evidence for Density-Dependence
log[N(t+1)/N(t)]
0.5
0.0
-0.5
-1.0
2.6 2.8 3.0 3.2 3.4 3.6 3.8
K = 2240 (1660, 2950)
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log(nt+1)/nt
0.50
0.25
0.00
-0.25
-0.50
3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0 4.1
log(nt)
K = 5370 (4170, 7080)
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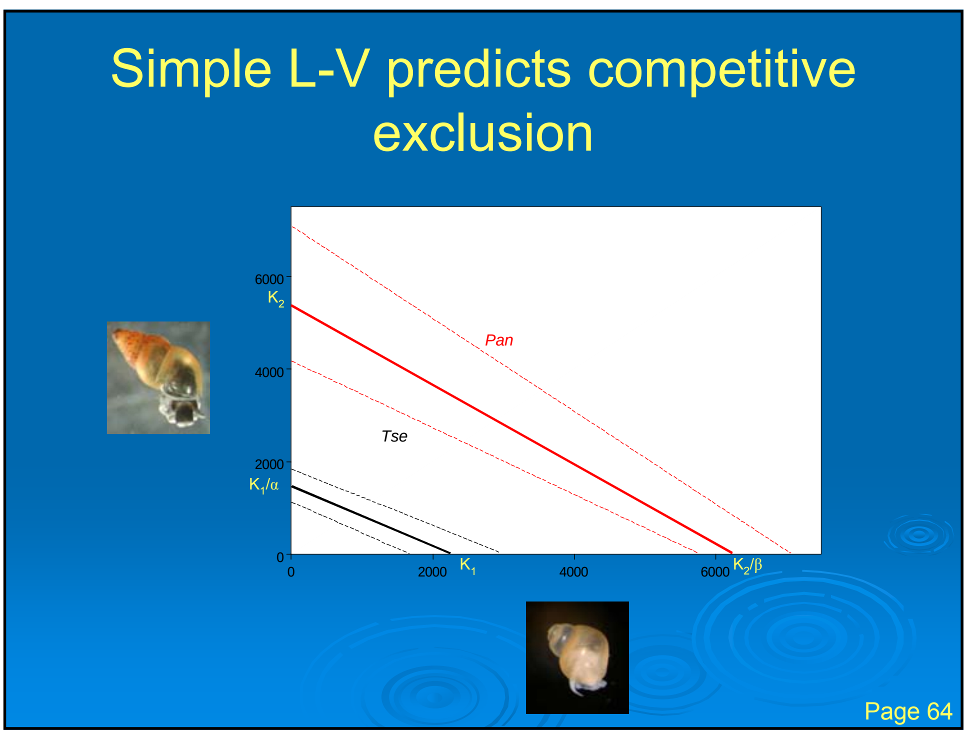
Simple L-V predicts competitive exclusion
6000
K2
4000
2000
K1/α
0
0 2000 4000 6000
K1
K2/β
Pan
Tse
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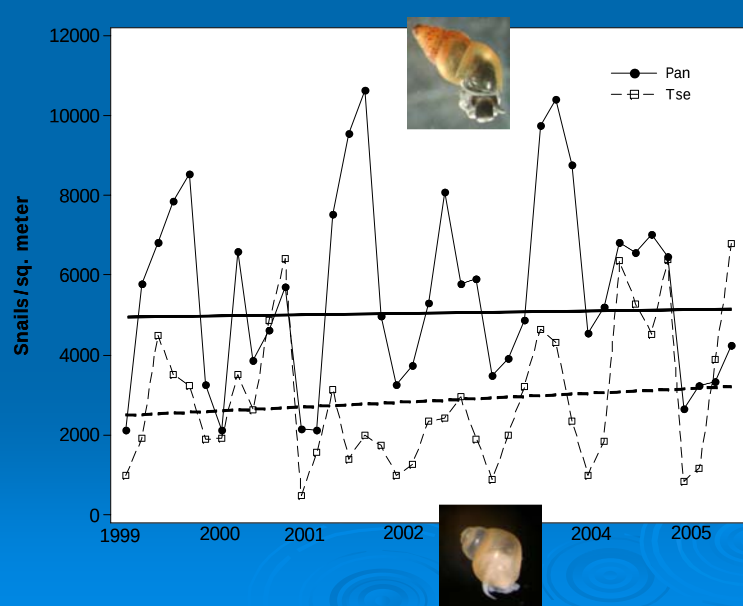
However……

Time series at Banbury Springs outlet



D-D/Competition Conclusion….

- Both BRS and NZMS appear to be D-D
- NZMS may compete strongly with BRS under certain conditions (i.e. food limited)
- BRS and NZMS are coexisting at outlet of Banbury Springs
- NZMS doesn't compete with BRS in headwater spring locations

Putting probabilities on 'threatened and 'foreseeable future'

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What does the federal listing
‘**threatened**’
under the
Endangered Species Act
(ESA 1973) mean?

“any species that was likely to become an ‘**endangered species**’ within the ‘**foreseeable future**’ throughout all or a significant portion of its range”

Endangered species

any species which is “in danger of extinction throughout all or a significant portion of its range"

What does ‘threatened’ and ‘foreseeable future’ mean?

Congress in all of its wisdom probably intentionally left these definitions vague to give the Judicial Branch something to do (and cause headaches for USFWS).

IUCN Section E in the Redbook

The IUCN specifically sets extinction probabilities and time frames for three classes of species viability:

- *Critically endangered* = probability of extinction > 50% within 10 years
- *Endangered* = probability of extinction is 20% within 20 years
- *Vulnerable* = probability of extinction is 10% within 100 years

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YCT

Unfortunately, USFWS did not attach a probability to their 20 to 30 year “foreseeable future” criteria which doesn’t help if we want to conduct a ‘precise, exact, & true viability analysis’

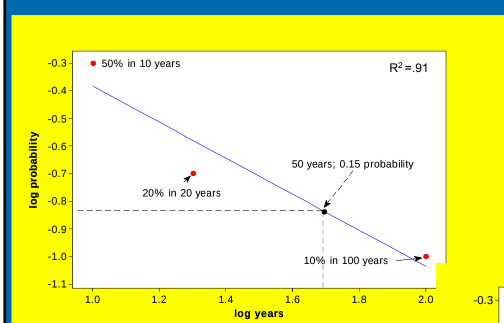
WSCT

USFWS working criteria for “threatened” = 30 years “foreseeable future”

IUCN definition “endangered” probability of extinction = 20 years

Our working model interpretation:
30 years (USFWS) + 20 years (IUCN)
= **50 years**

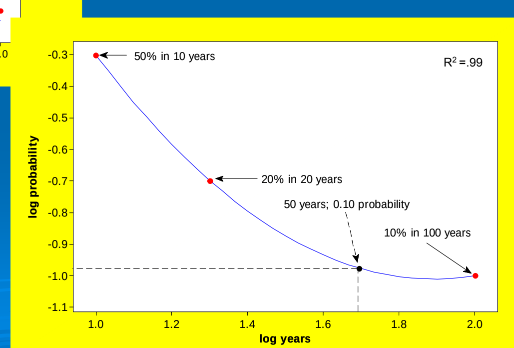
What about probability?



Linear

50 years; 0.10 - 0.15 probability

Quadratic



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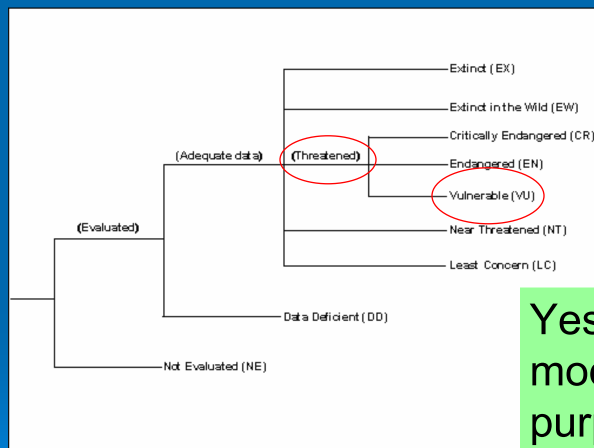
Does ‘threatened’ = ‘vulnerable’?



Yes, for our modeling purposes

Structure of IUCN Red List categories

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Population Trends

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Methods

- Four long-term monitoring sites
  - Thousand Springs
  - Banbury Springs
  - Frank Lloyd Wright
  - Bancroft Springs
- Time series analysis
- Non-equivalence tests

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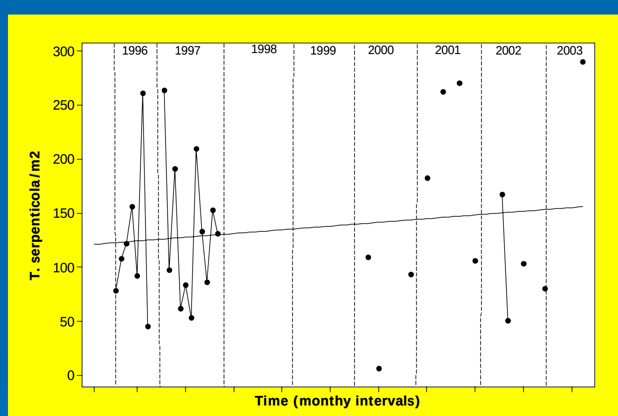
Thousand Springs



Dixon and Pechmann (2005) 'non-equivalence' test suggested that there was **insufficient evidence to conclude that BRS at Thousand Springs was not 'vulnerable'**

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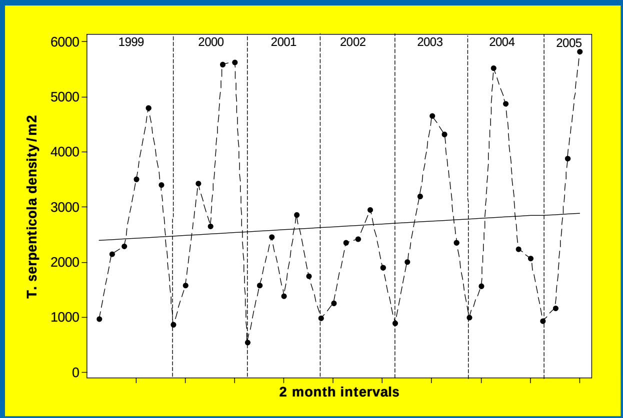
?

I thought Thousand Springs had lots of BRS?

Answer: this analysis was based on population trends not abundances. If we consider abundance as a measure of viability, then the Thousand Springs population would be more viable than the following….

Banbury Springs



Dixon and Pechmann (2005) 'non-equivalence' test suggested that **there was significant evidence that BRS at the outlet of Banbury Springs was not 'vulnerable'**

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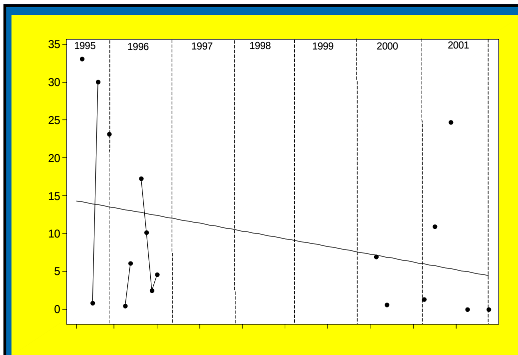
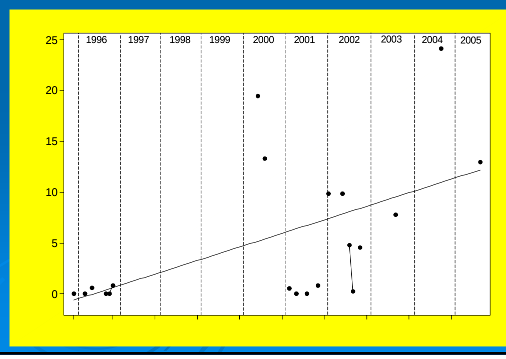


Frank Lloyd Wright

Not vulnerable

Bancroft Springs

Not vulnerable



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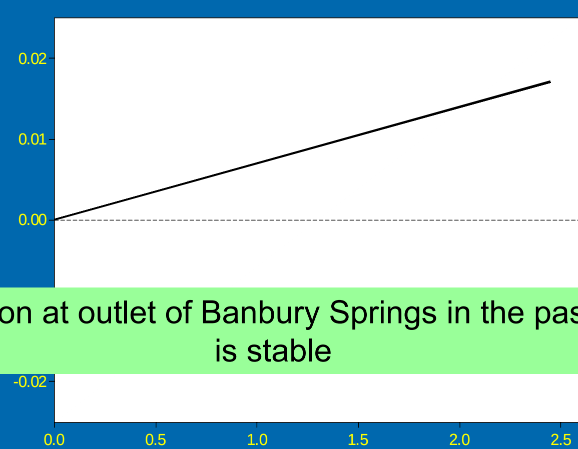
Population Growth Rates

Methods

- Estimated population growth rates of BRS at the outlet of Banbury Springs
- Refer to pages 103 and 104 for methods and Dennis et al. (1991)



$\ln(N_j/N_i)/\sqrt{t_j - t_i}$

$\sqrt{t(j)-t(i)}$

BRS population at outlet of Banbury Springs in the past 6 + years is stable

$\hat{\lambda}$, the estimated finite rate of increase; $e^{\mu+1/2\sigma^2}$ at the outlet of Banbury Springs

$\hat{\lambda}$ = 1.07 (0.80, 1.43)

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Effect of Environmental Stochasticity (σ) on a single BRS Population

Method 1

- Estimated yearly environmental stochasticity (σ) needed to cause BRS extinction in 10, 20, and 30 years
- Decreasing population growth rate, λ =.90 and stable growth rate λ =1.00
- Three initial population densities (N_0), 100, 500, and 1000/m^2

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Results

	10 years[1]		20 years[2]		30 years[3]	
	N_o	σ	N_o	σ	N_o	σ
Decreasing (λ= 0.90)	100	0.54	100	0.26	100	0.30
	500	0.57	500	0.33	500	0.36
	1000	0.58	1000	0.35	1000	0.38
Stable (λ= 1.00)	100	0.63	100	0.38	100	0.42
	500	0.65	500	0.41	500	0.47
	1000	0.66	1000	0.42	1000	0.48

[1] IUCN criteria for 'critically endangered' = 50% probability of extinction within 10 years

[2] IUCN criteria for 'endangered' = 20% probability of extinction within 20 years

[3] USFWS proposed criteria of 20-30 years 'foreseeable future' (USFWS 2003, USFWS 2006)

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Method 2

- Initial density = 900/m^2, (winter lows at Banbury) λ = 1.00 (method 1)
- σ at 0.18, 0.25, 0.30, 0.40, 0.50 (0.18 winter low at Banbury)
- Replicated 10,000 X
- Reported as Interval Extinction Risk (IER)
- IERs calculated for 10, 20, 30, 50, and 100 years (95%CIs for 50 years)
- Used RAMAS METAPOP (Applied Biomathematics 1998)

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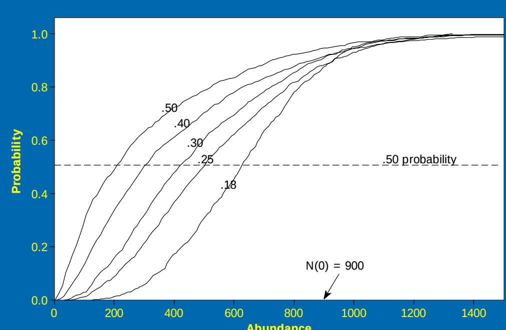
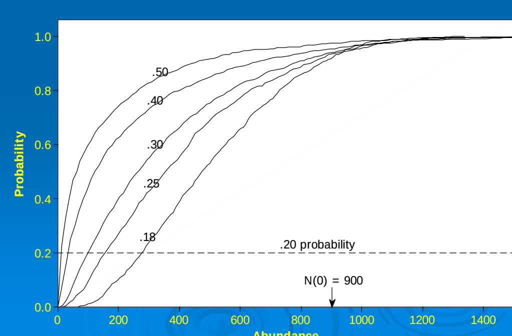
Interval Extinction Risk (IER)

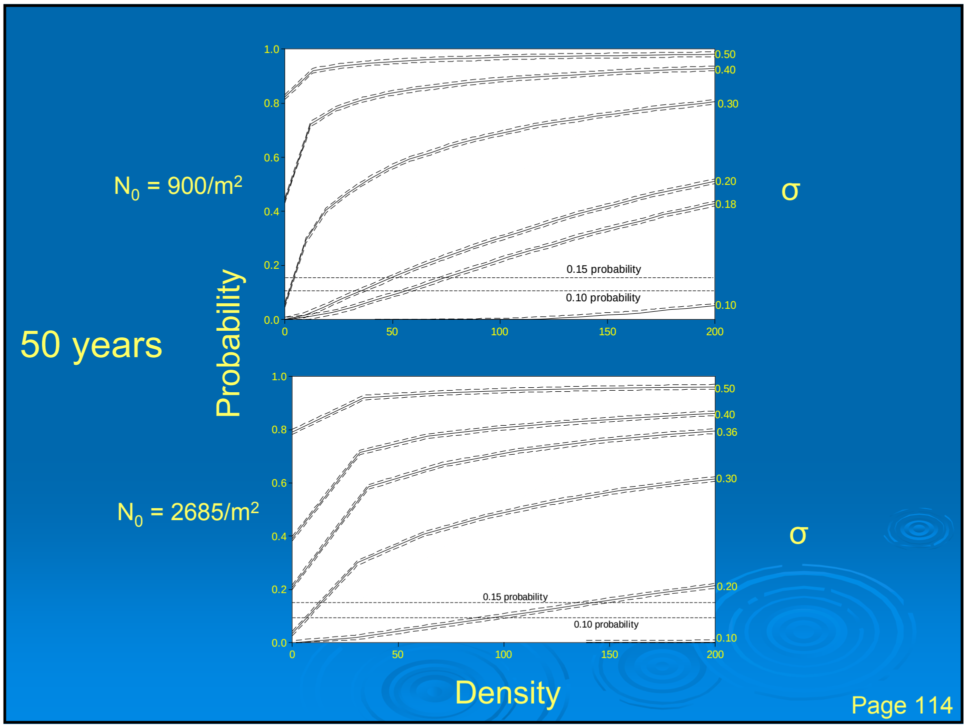
Probability BRS population abundance will fall below a range of abundances at least once during the next ‘X’ years

10 years



20 years





50 years
N0 = 900/m2
N0 = 2685/m2
Probability
Density
σ
σ
0.15 probability
0.10 probability
0.15 probability
0.10 probability
0.50
0.40
0.30
0.20
0.18
0.10
0.50
0.40
0.36
0.30
0.20
0.10
0
50
100
150
200
0.0
0.2
0.4
0.6
0.8
1.0
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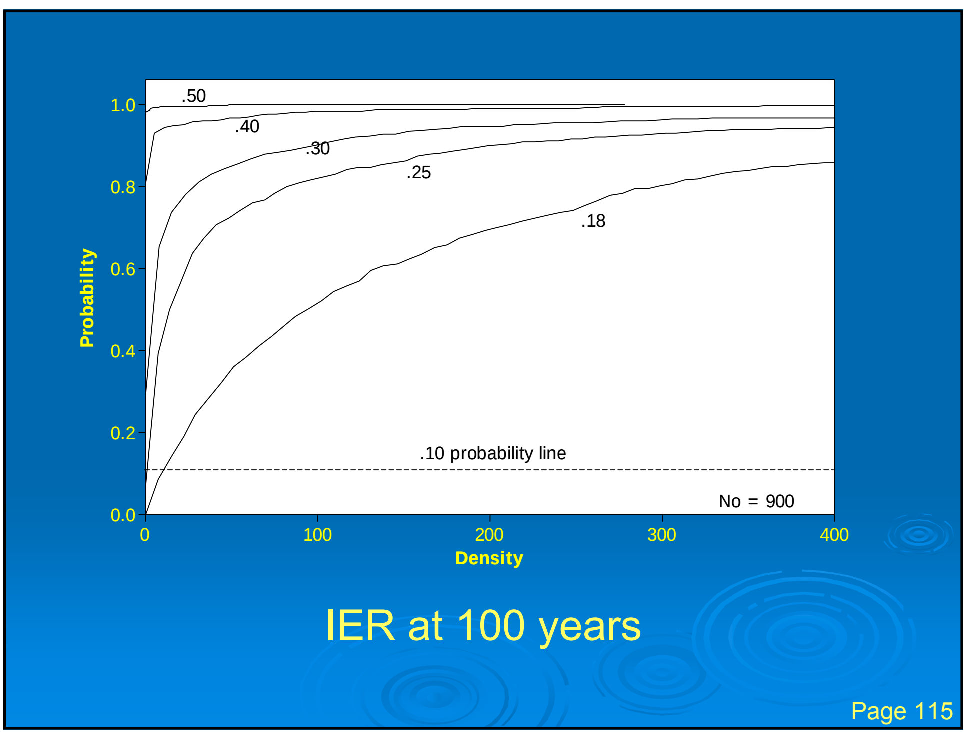

Probability
Density
.50
.40
.30
.25
.18
.10 probability line
No = 900
0.0
0.2
0.4
0.6
0.8
1.0
0
100
200
300
400
IER at 100 years
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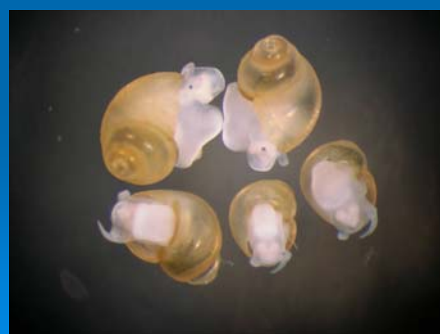
What if we modeled using abundance and not density?



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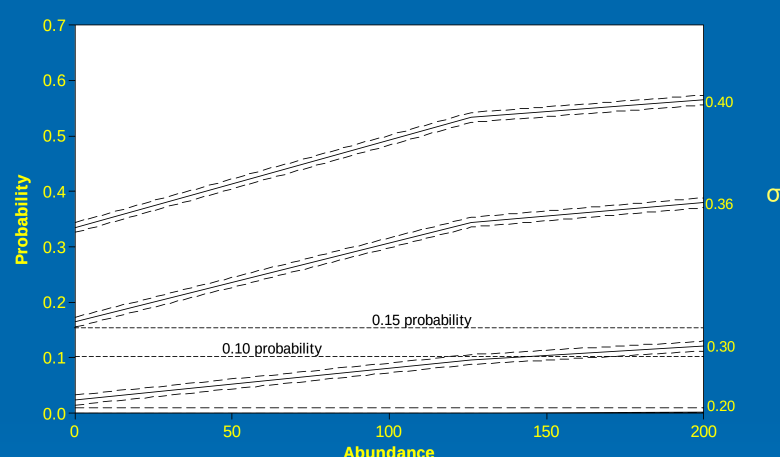

IER (±95% CIs) for a single BRS population with a steady growth rate of λ =1.0 in 50 years N_0 of 100,000

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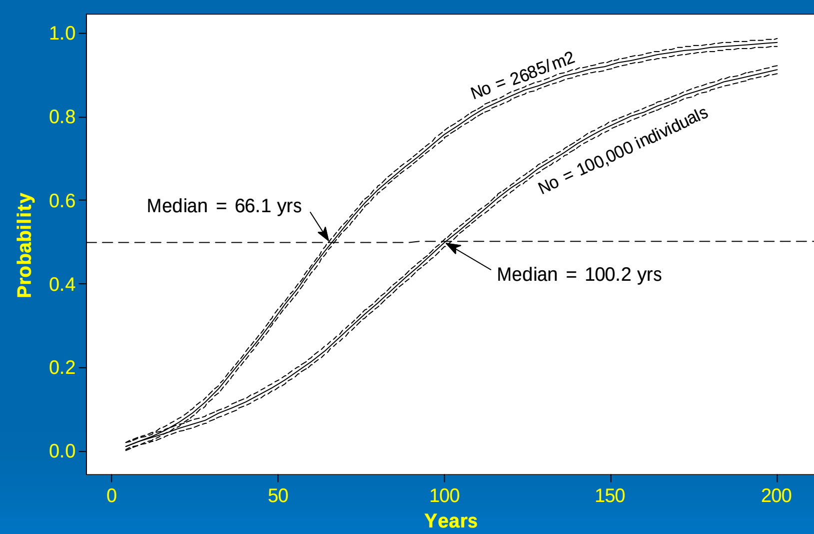

Median time to extinction for a single BRS population using N_0 = annual mean density of 2685/m^2 or N_0 = 100,000 individuals

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σ Conclusion

- Amount of environmental stochasticity (σ) affects BRS viability
- Single BRS population models suggest not ‘vulnerable’ (threatened)
- Modeling density vs. abundance causes different results
- Abundance more accurate but more difficult to estimate, however
- Density is more conservative estimator

What if we are not dealing with a single BRS population?

(which we are not)

Metapopulation Dynamics

Metapopulation Theory Review

Metapopulation theory is the current paradigm for fragmented populations (Hanski and Gilpin 1997, Hanski 1999)

Metapopulations are a network of fragmented populations with
- low migration rates and
- extinction rates of individual populations are stochastically uncorrelated

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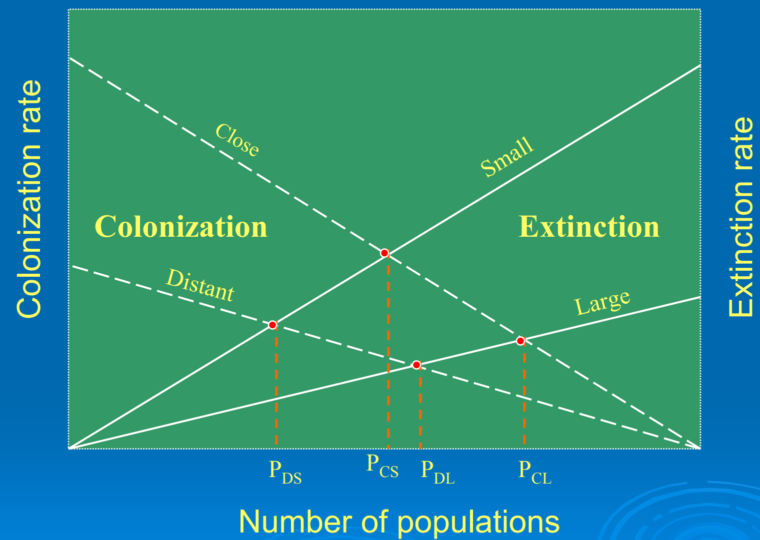
Metapopulation Theory based on Theory of Island Biogeography

(MacArthur and Wilson 1967)

Rate of Extinction and Colonization



Equilibrium theory of island biogeography (MacArthur and Wilson 1967)

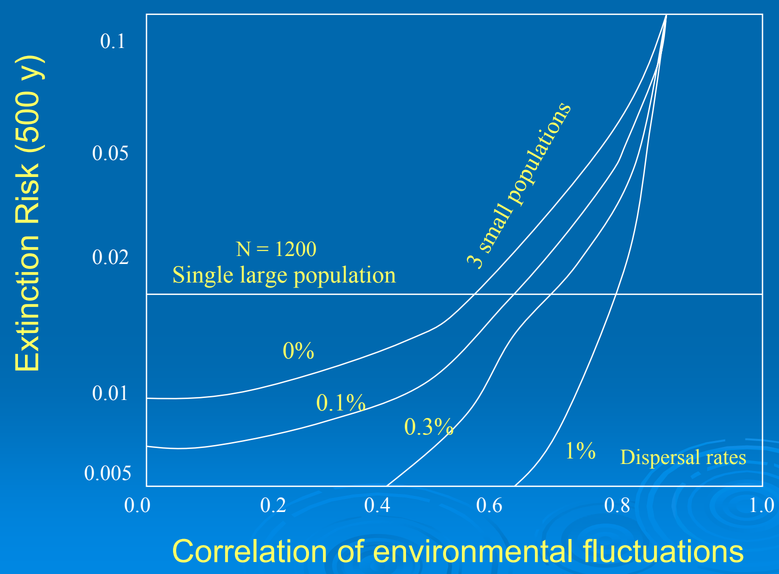
Interaction between dispersal (d) and habitat correlation (er)

In general:

$$E \int (d,er)$$

where E = extinction risk

Relationship between dispersal and correlation



One large BRS population or many small populations in a metapopulation?

- Historically, thought to be one continuous population
- Now thought to be discontinuous populations or a metapopulation

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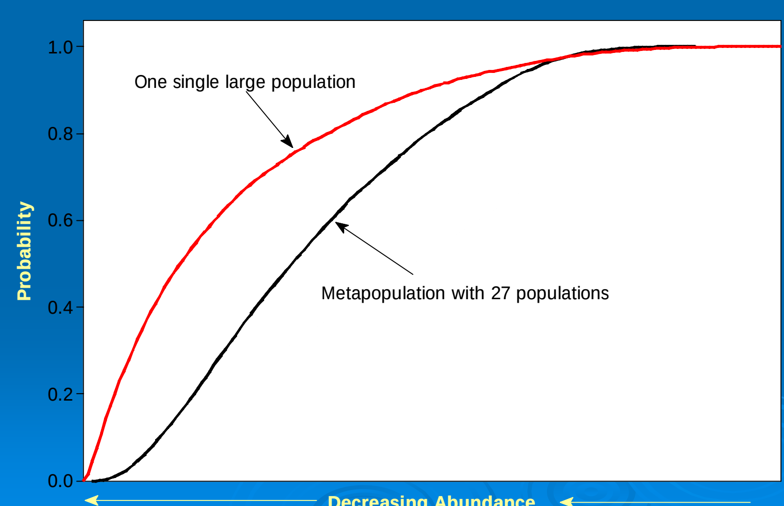
What if we modeled BRS as one continuous population with no:

environmental stochasticity (σ),
local extinction
recolonization

vs.
metapopulation?

See appendices 3,4, and 5

IER in 50 years for BRS, modeled as one single large population vs. 27 separate populations in a metapopulation



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Interval extinction risks (IER) (± 95% CIs) in 100 years for BRS metapopulations as reported in 1992 (n=19) and 2006 (n=27)

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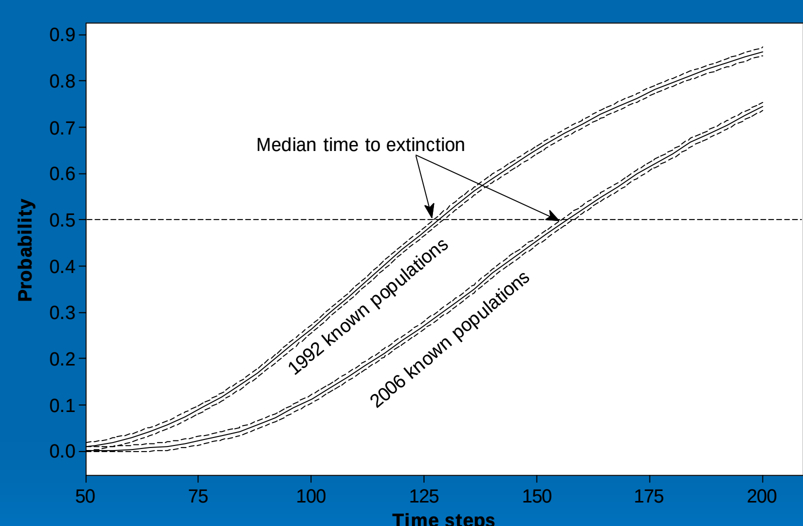

Median time to extinction for BRS metapopulations as reported in 1992 and 2006

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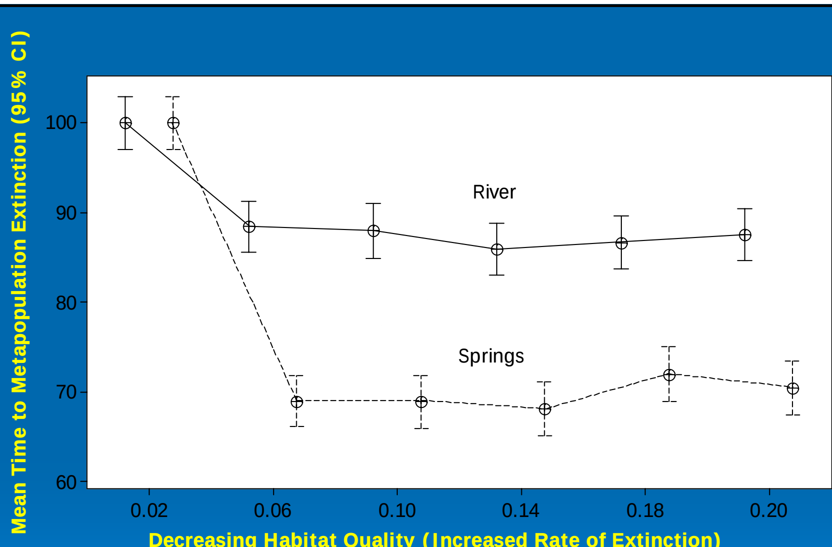
River vs. Spring habitats

- Set baseline extinction rates = 0.02 (50 years)
- Increased from 0.02, 0.06, 0.10, 0.14, 0.18, and 0.20 (5 years) for river populations and held constant for spring populations to simulate decreased habitat quality
- Repeated for spring habitats



Relative importance of spring/spring-influenced habitat populations vs. river habitat populations to BRS metapopulation viability

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Effects of ‘load following’ on metapopulation viability

- Harvested (removed) 0, 10, 20, 30% of river populations while maintaining spring populations
- Simulated at 5 river populations vs. 21 river populations

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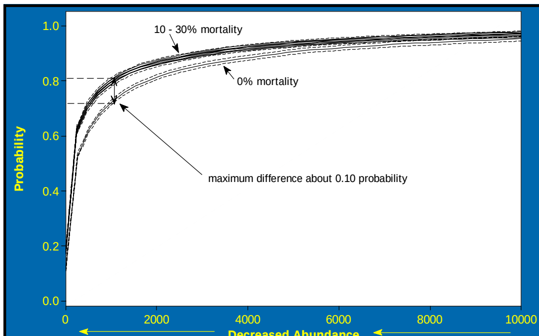
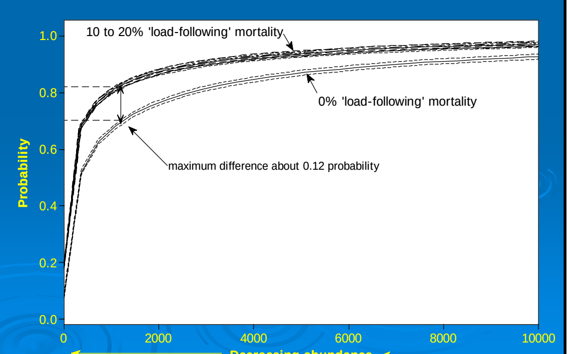


IERs in 100 years for BRS modeled with losses (mortality) of 0,10, 20, and 30% of individuals from river populations

2 populations in the Wiley and Bliss Reach



10 populations in the Wiley and Bliss Reach

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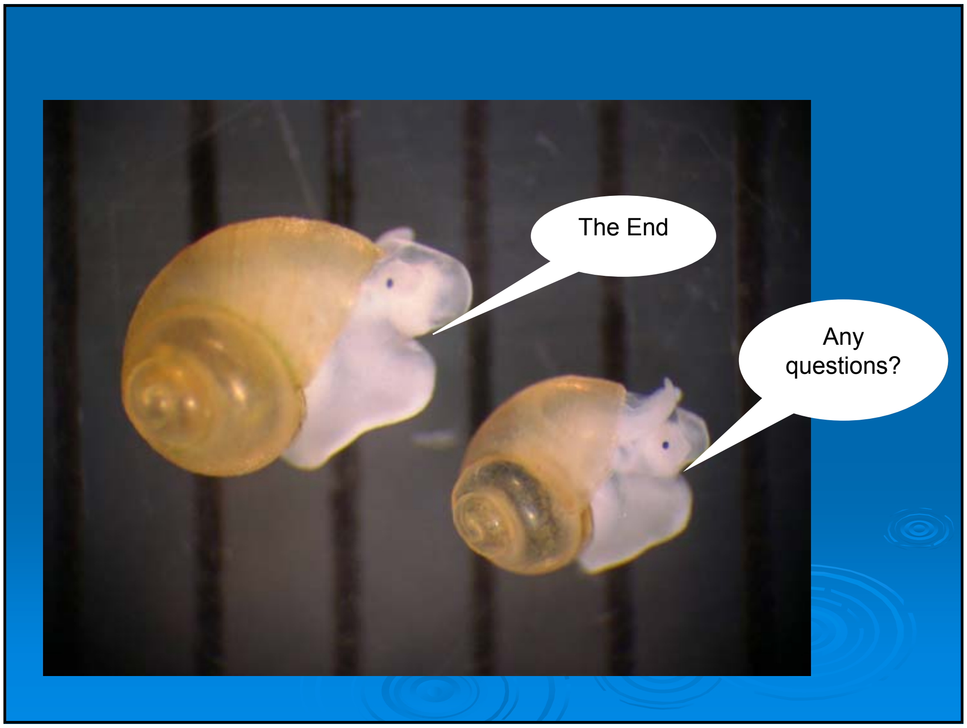
The End
Any questions?