Specialising on Change Part 1: Migration

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Biol 417: Evolutionary Ecology

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Review

Last lecture we covered the idea that organisms track environmental change over evolutionary timescales but fast/large environmental change will always challenge survival and fitness.

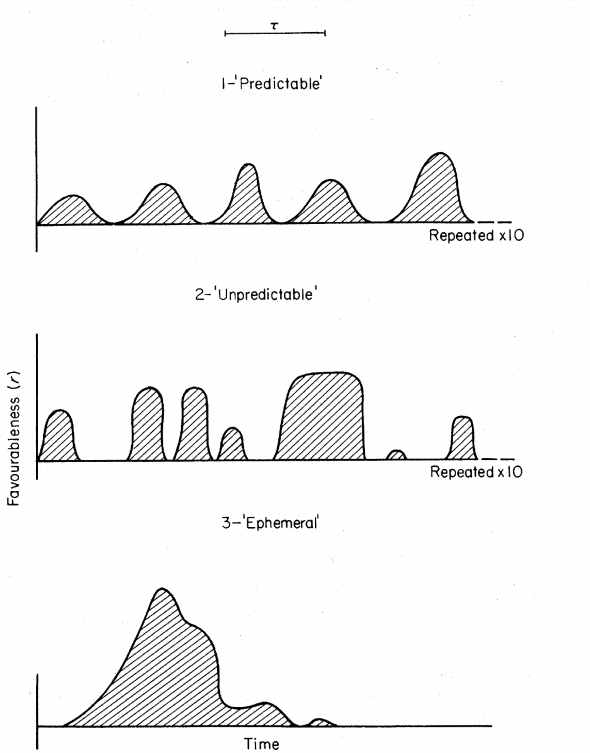
Species need to balance decisions to reproduce against spatio-temporal differences in reproductive rates.

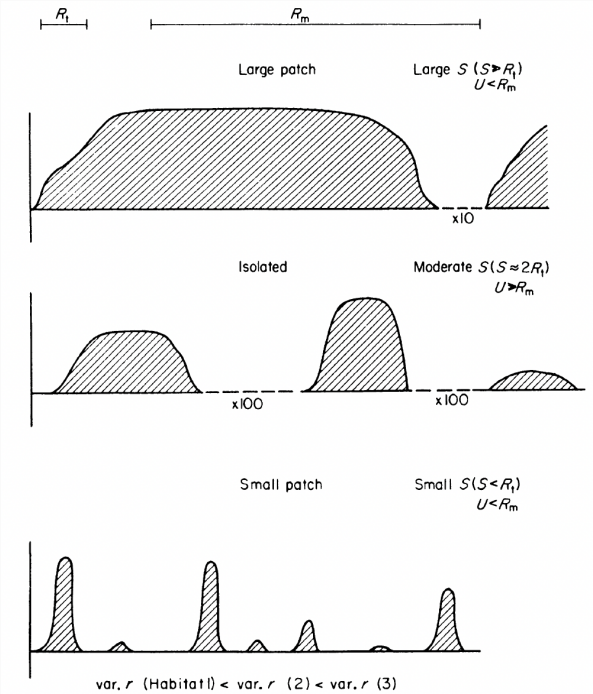
		Time	
		Now	Later
Space	Here	$r_a \pm \sigma_a^2$	$r_b \pm \sigma_b^2$
	Elsewhere	$r_c \pm \sigma_c^2$	$r_d \pm \sigma_d^2$

Southwood (1977)

Review cont.

We also saw how the predictabiliity of the (un)favourable conditions in space and time, relative to organisms' lifespans (τ) and vagility (R_t and R_m) is also critical in determining how much change species can cope with.





Southwood (1977)

Specialising on change

We mostly viewed change as being negative, and that species should try to avoid environmental stochasticity if at all possible.

If we only consider abiotic change, this is a logical way to think about change, but environmental change can open up niche space by modifying competition, predation, parasitisation, etc...

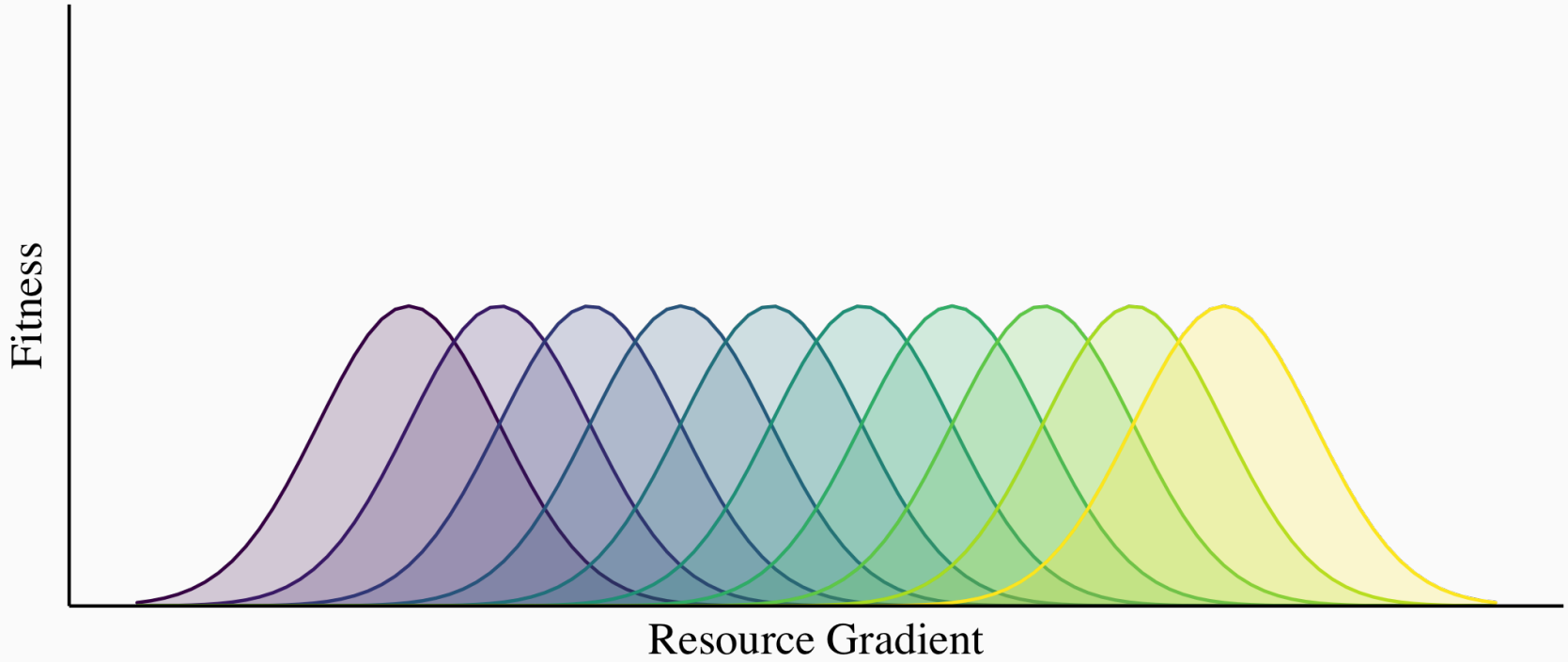
... and anything that opens up niche space can (and will) be exploited.

Today we will start exploring some ecology phenomena that are governed by specialising on change.

Environmental Change and Niche Space

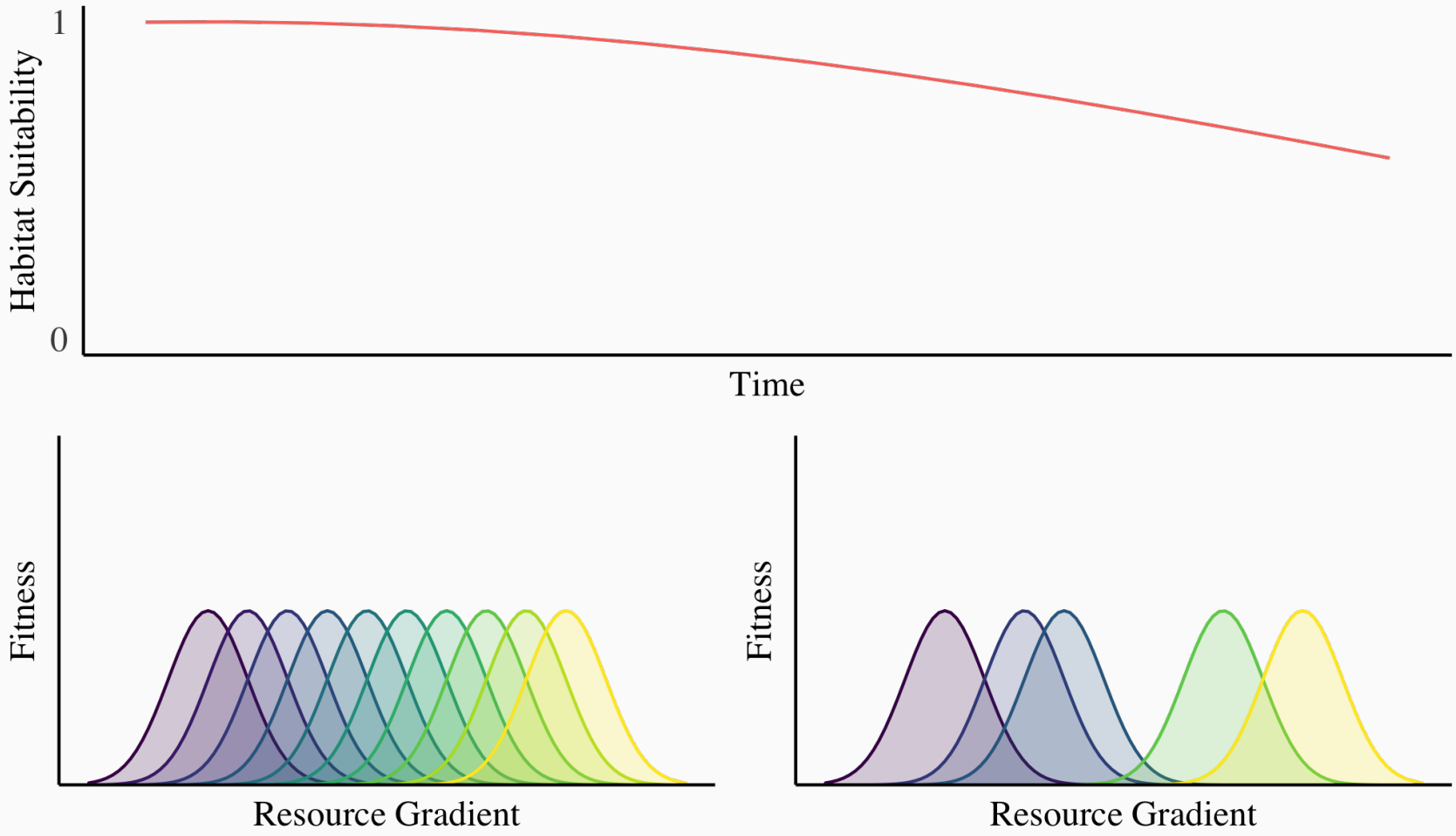
Env. Change and Niche Space

Stable, productive habitats tend to be saturated and highly competitive.



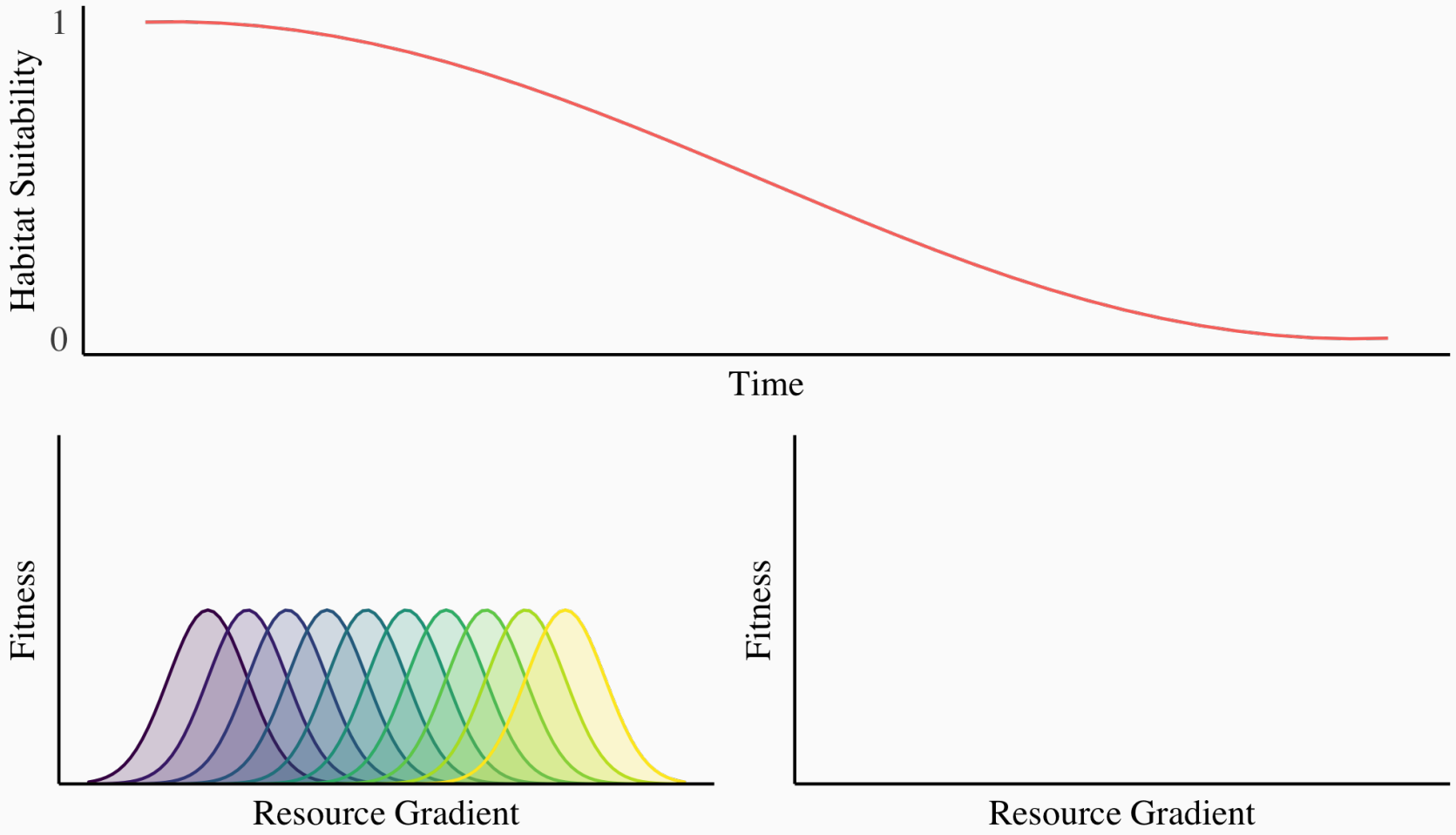
Env. Change and Niche Space cont.

Environmental change will open up niche space.



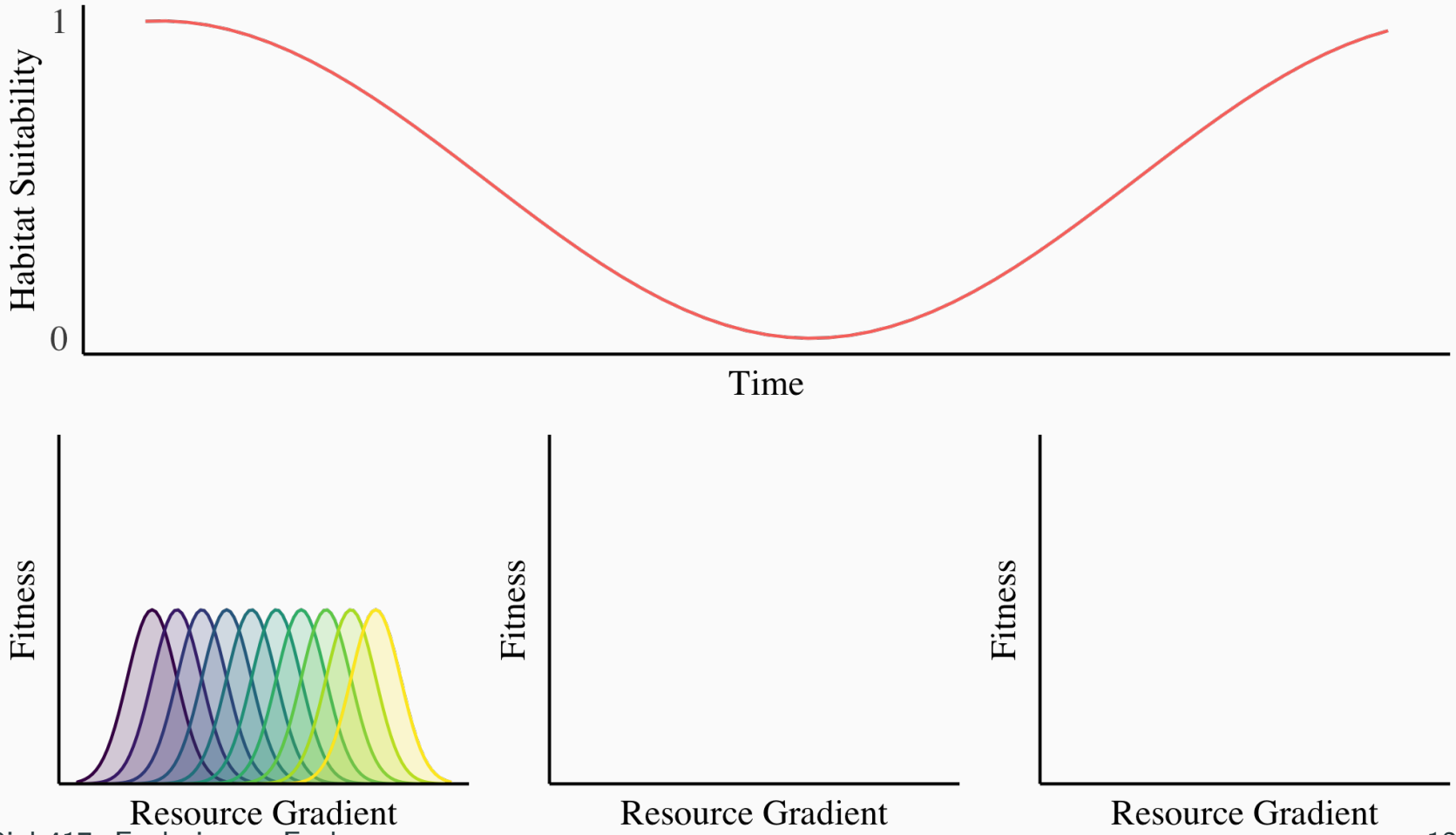
Env. Change and Niche Space cont.

A large environmental change will open up a lot of niche space.



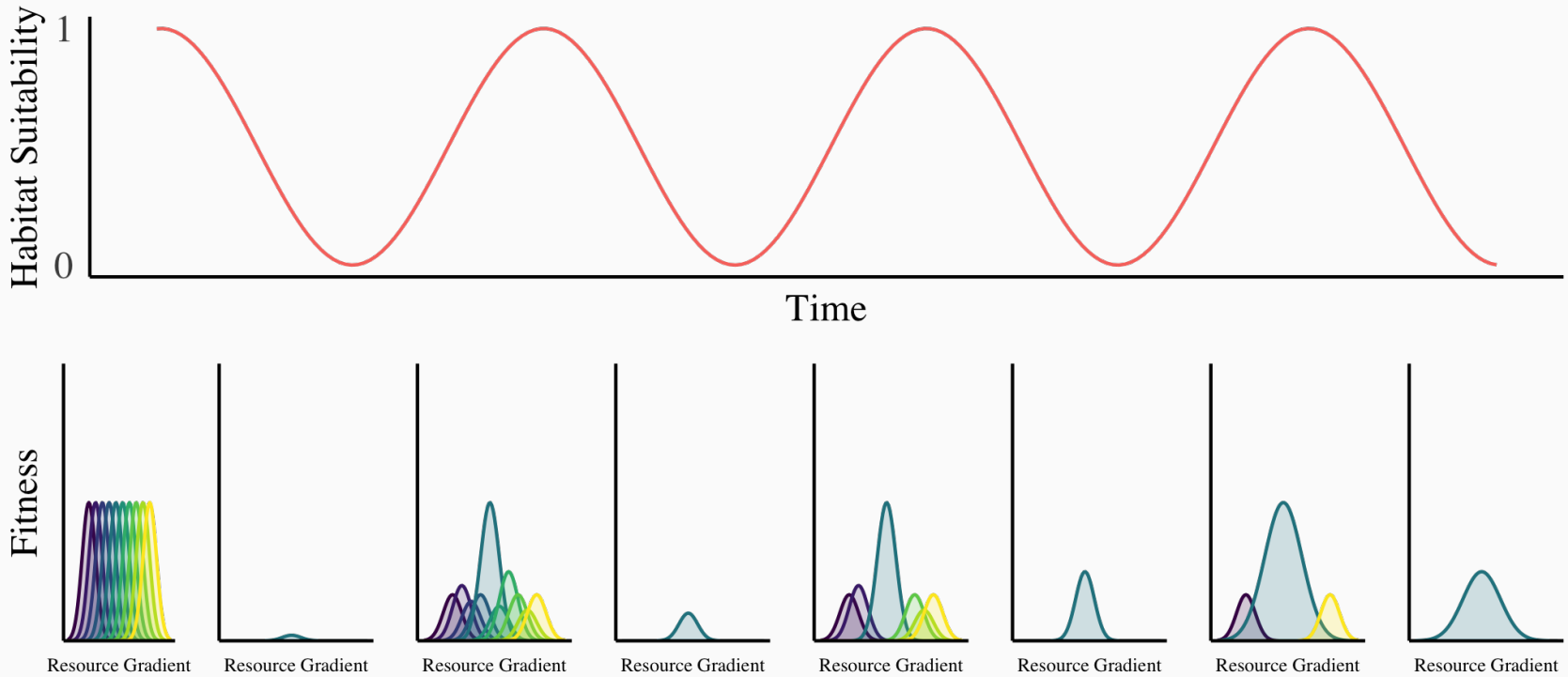
Env. Change and Niche Space cont.

If suitability eventually improves there's a vacuum ready for exploitation... but there's nothing left alive to take advantage of that vacuum.



Env. Change and Niche Space cont.

One-off events are unlikely to drive adaptation, but if the changes in suitability are predictable in time (or space) then species have something to work with.



Env. Change and Niche Space cont.

Can you think of any large, predictable environmental change?

Source: http://skierbob.ca

Can you think of any adaptations to seasonality?

- Migration
- Hibernation/Torpor
- Food caching
- Leaf loss
- Burrowing
- Changes in fur colour/thickness
- etc...

Adaptations to Change

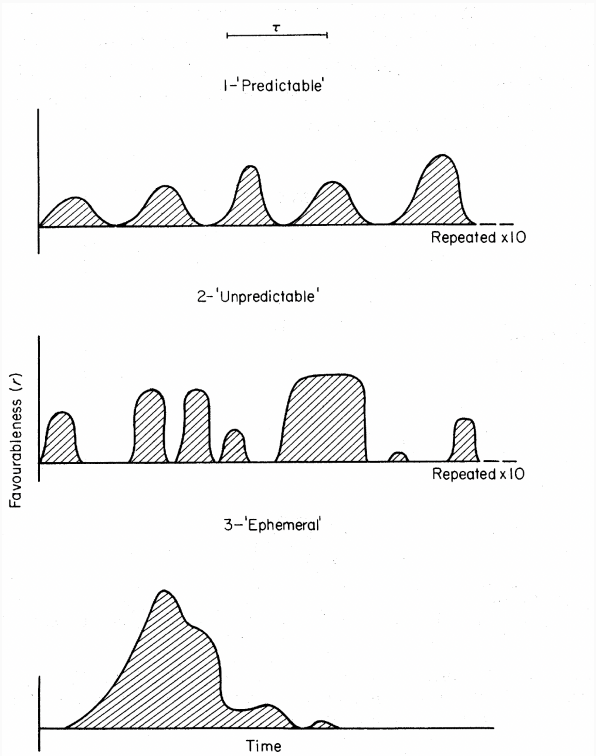
Species respond to change over two timescales:

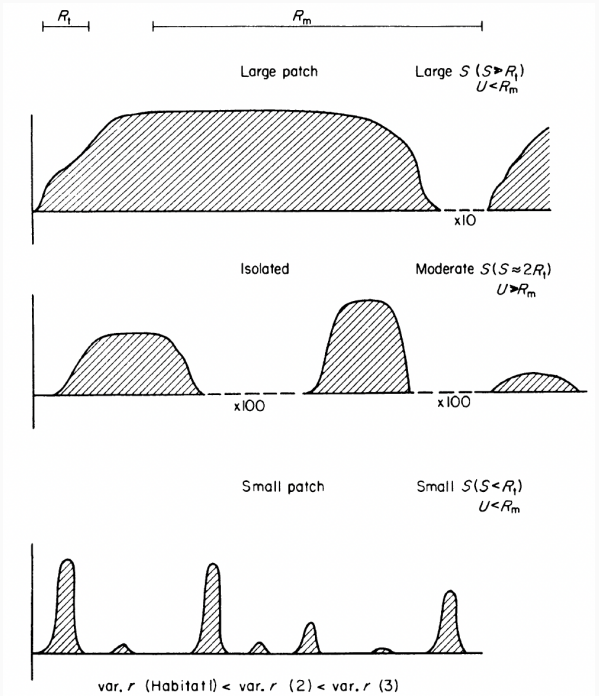
Ecological	Evolutionary
Leverage behavioural plasticity to overcome challenges.	Modify genomes to better match new conditions.
More immediately accessible, better suited to short term stochasticity.	Takes generations to occur, can allow adaptations out of the range of behavioural plasticity.

Behavioural Adaptations to Environmental Change

Southwood (1977)

The predictabiliity of the (un)favourable conditions in space and time need to be considered in relation to organisms' lifespans (τ) and vagility (R_t and R_m)

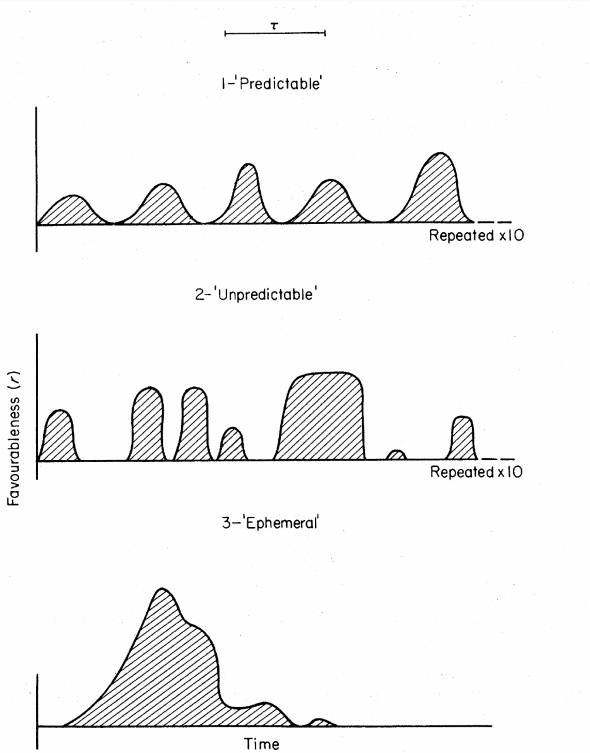


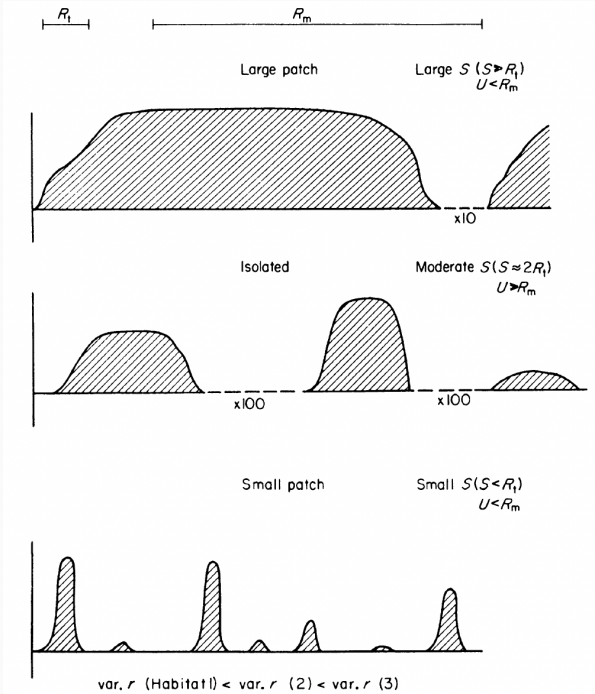


Southwood (1977)

Southwood (1977)

If (un)favourablility is heterogeneous in space, R_m is larger than U, and τ is long enough to allow the travel, then migration is a viable strategy that doesn't necessarily require evolutionary adaptations.

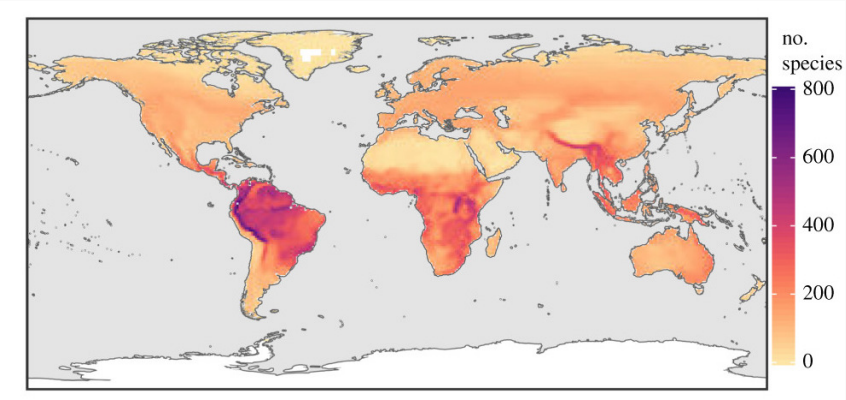




Southwood (1977)

Birds in the Americas

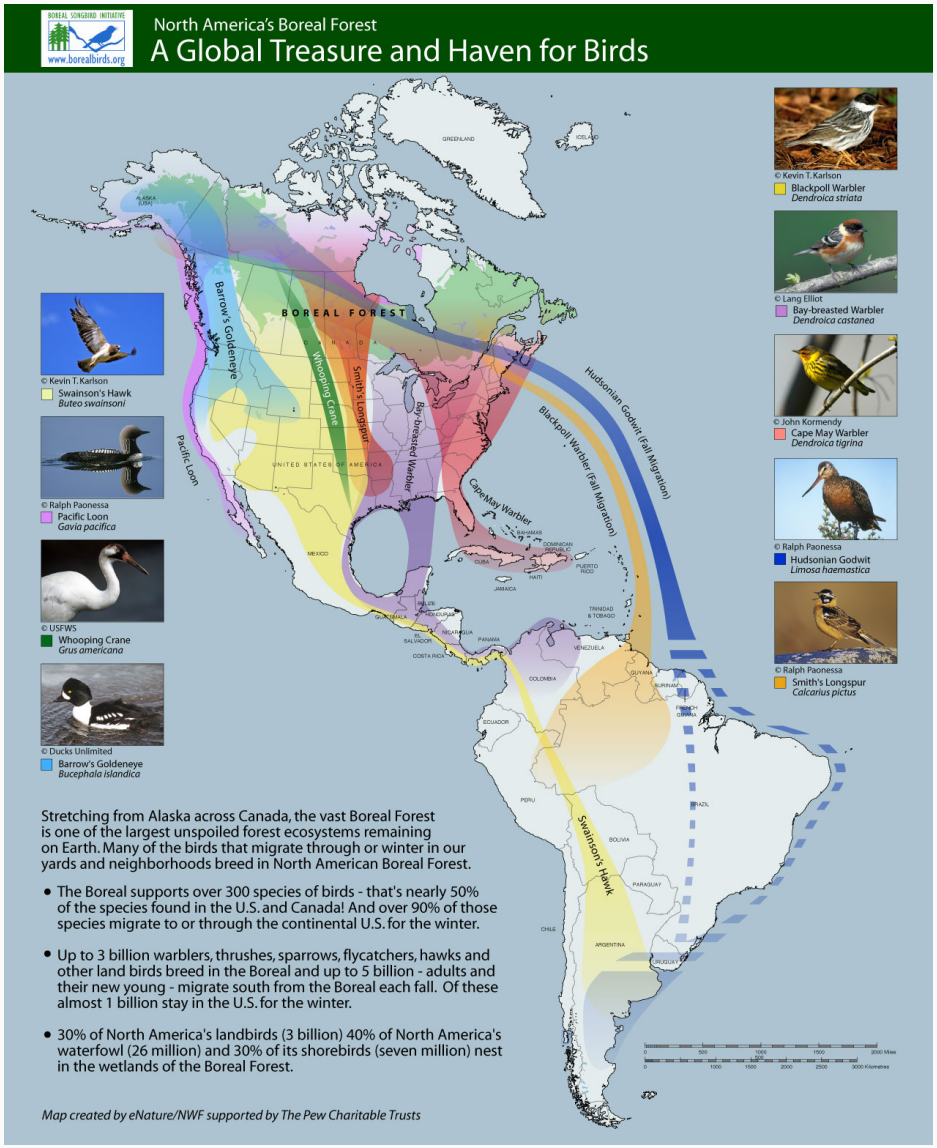
For birds, breeding in the tropics is constrained by intense competition and predation.



Schumm *et al.* (2019)

Source: roaring.earth

Birds in the Americas



Source: www.borealbirds.org

In the Americas, ∼600 bird spp. move way from the equator in spring (pre-breeding), and towards it in fall (post-breeding).

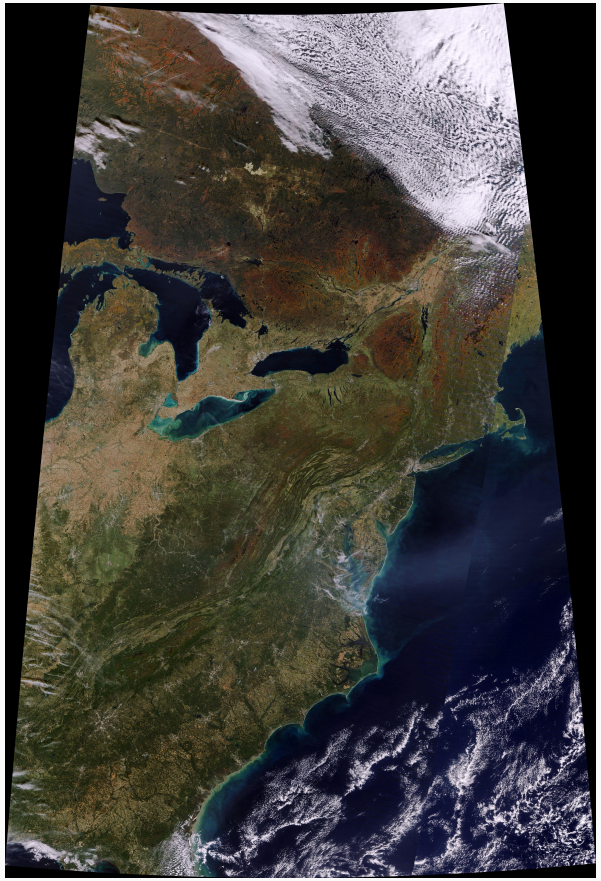
...the consensus is that many species breeding in the temperate zone and overwintering in the tropics evolved from tropical ancestors ... (Jahn *et al.*, 2004)

Seasonal migration allows them to capitalise on conditions in less favourable regions.

Green wave surfing

Ungulates in NA experience seasonal changes in food availability.

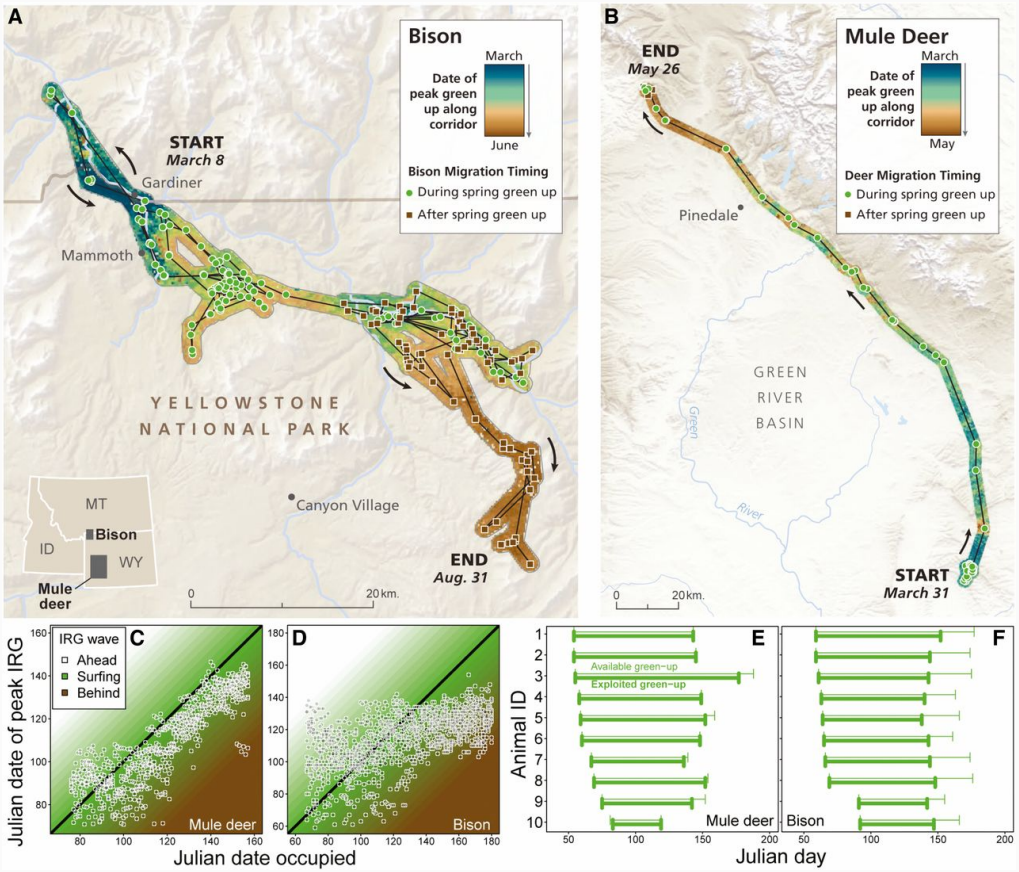
Source: http://skierbob.ca



Source: NASA

Green wave surfing cont

Ungulates 'surf' landscape scale waves of spring green ups and autumn die offs, resulting in mostly North-South seasonal migrations (Merkle *et al.*, 2016).



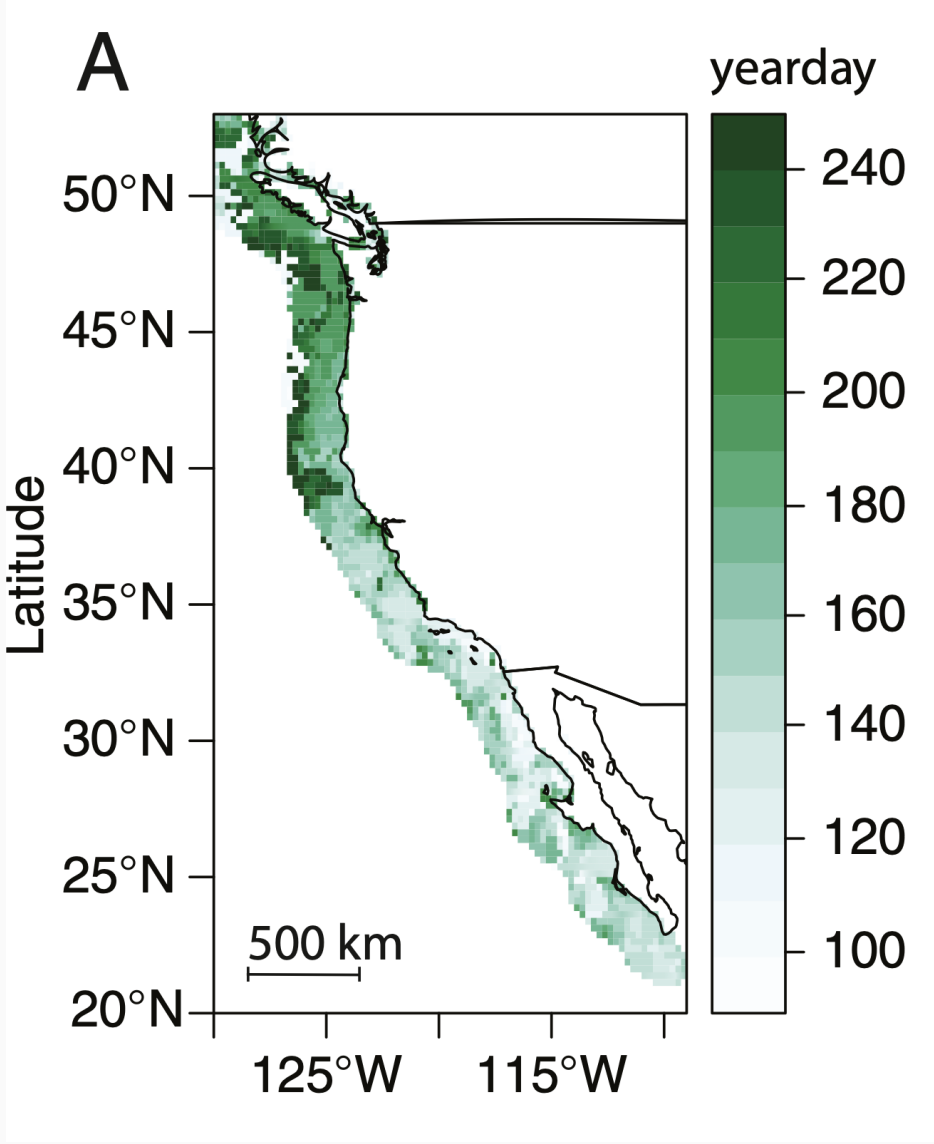
Geremia *et al.* (2019)

Migration

It is possible for migration to arise over ecological timescales purely via behavioural mechanisms (e.g., green wave surfing), but that doesn't mean that it's efficient.

Maintaining the benefits of migration over evolutionary timescales is facilitated by evolutionary adaptations (e.g., memory, navigation, learning, etc.).

Memory



(Abrahms *et al.*, 2019)

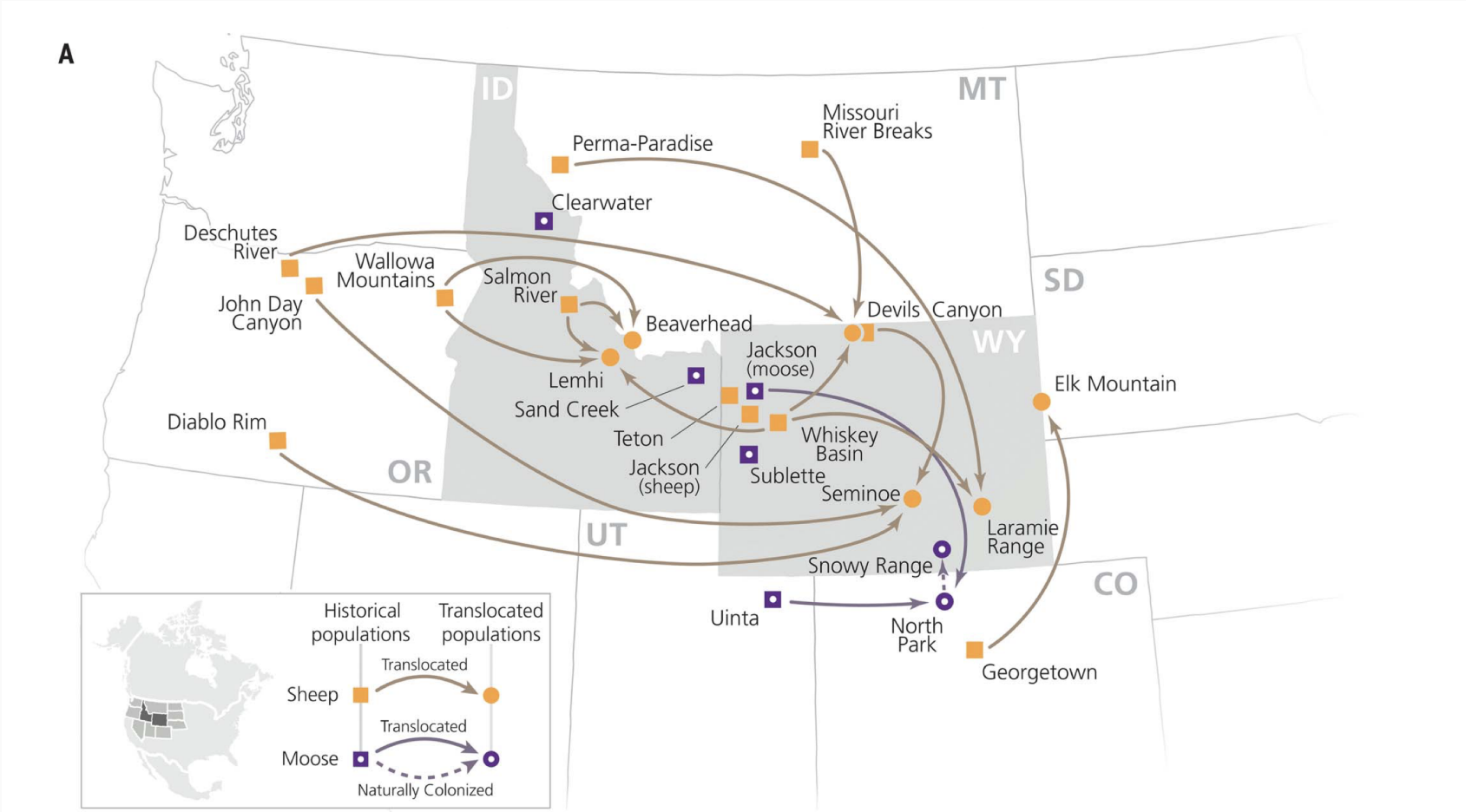
In the Pacific Ocean, blue whales surf seasonal green ups in chlorophyl (krill).

Abrahms *et al.* (2019) used a decade worth of tracking data and computer simulations to show that surfing alone wasn't efficient (can follow noise instead of signal).

Only when she included memory were the whales were able to optimally migrate along the spatio-temporal gradient in productivity.

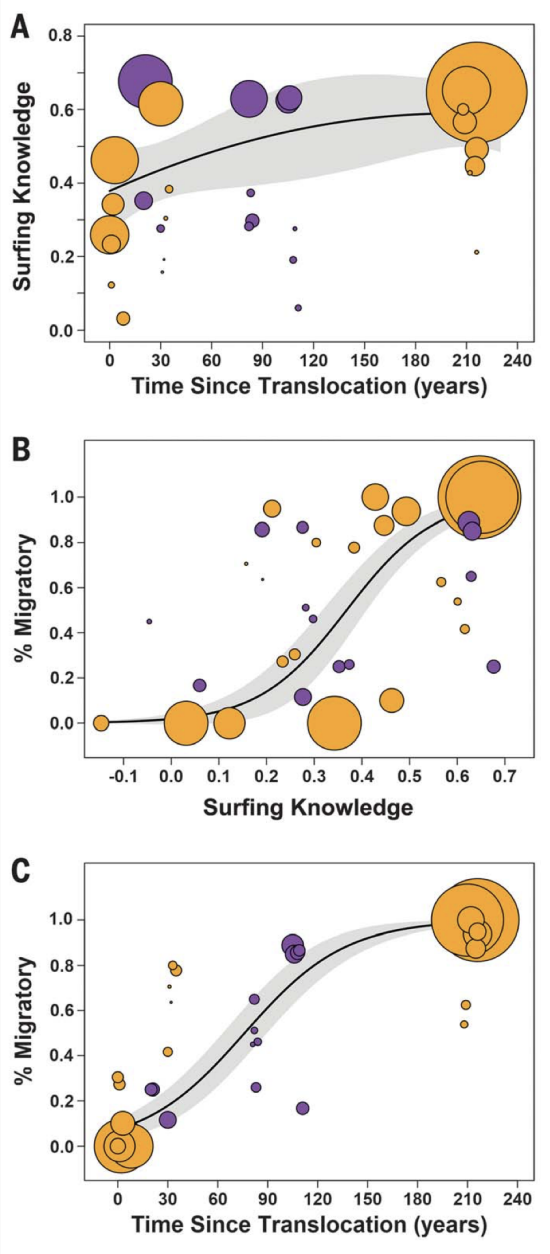
Cultural transmission

Jesmer *et al.* (2018) used data on translocated vs. untranslocated animals to tease apart genetic vs. learned aspects of migration.



Jesmer *et al.* (2018)

Cultural transmission cont.



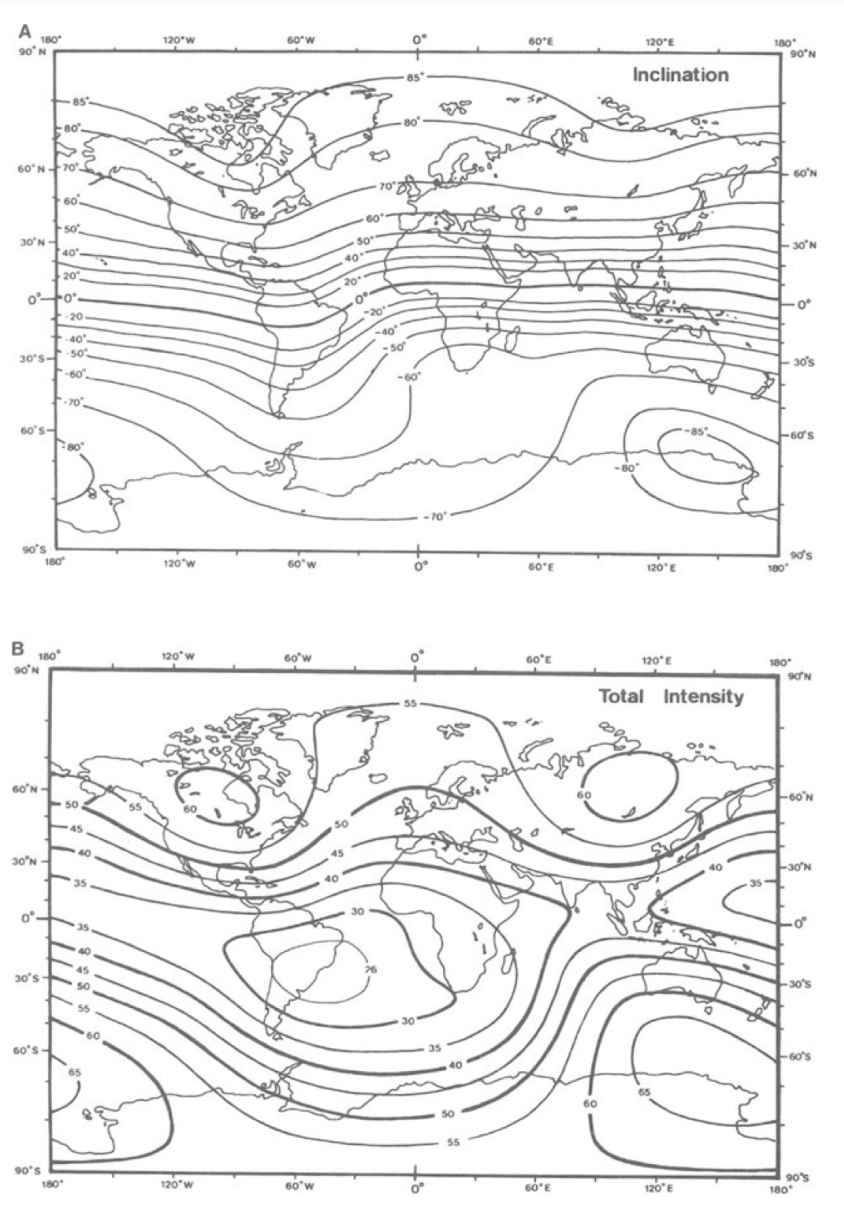
(Jesmer *et al.*, 2018)

Newly translocated populations don't migrate (no purely genetic effect).

Populations with a collective knowledge on how to surf local green waves will migrate.

It takes generations to build up that knowledge, which can only happen if learning is passed on from generation to generation.

Navigation



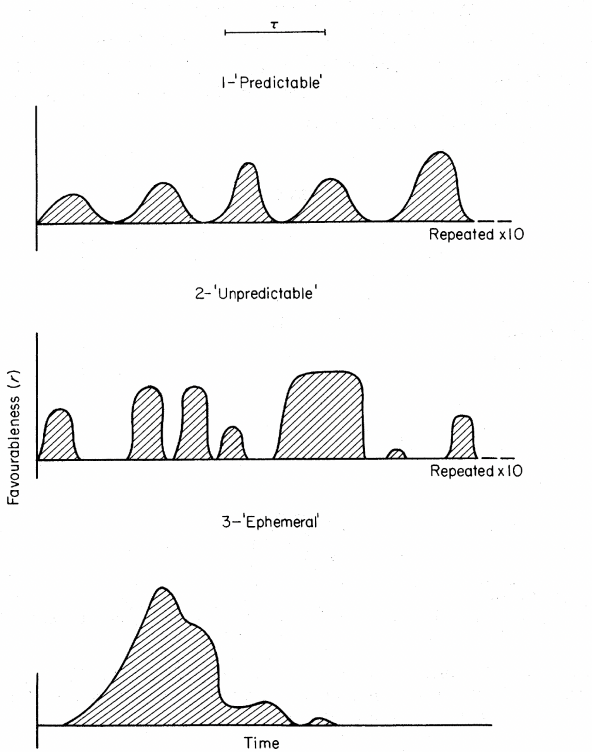
(Wiltschko & Wiltschko, 1988)

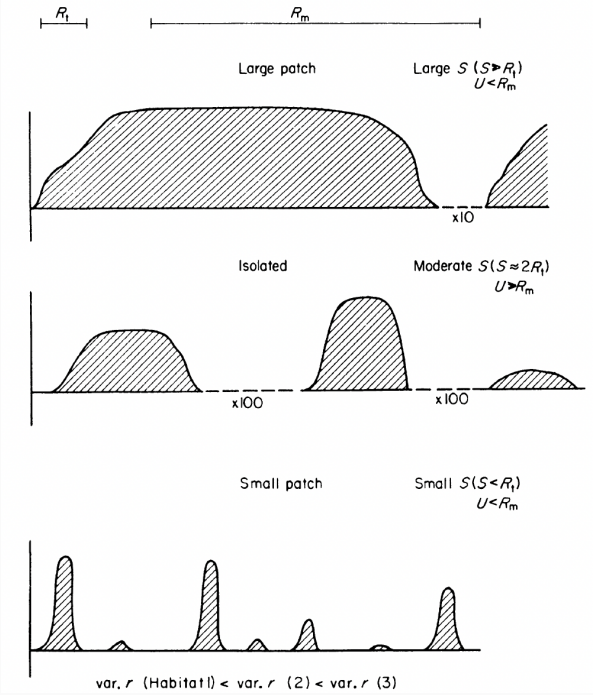
Birds rely on local changes in the earth's magnetic field to orient themselves.

Over evolutionary timescales they have evolved mechanisms for making their migrations more efficient (faster, further, more efficient routes).

Southwood (1977)

In general, adaptations that increase $\frac{R_m}{U}$ should be favoured by selection (faster, further, more efficient, etc...).

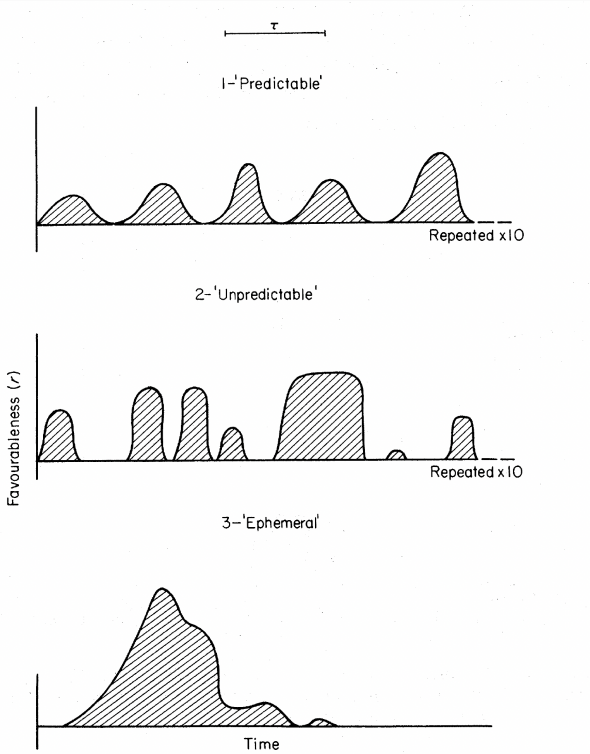


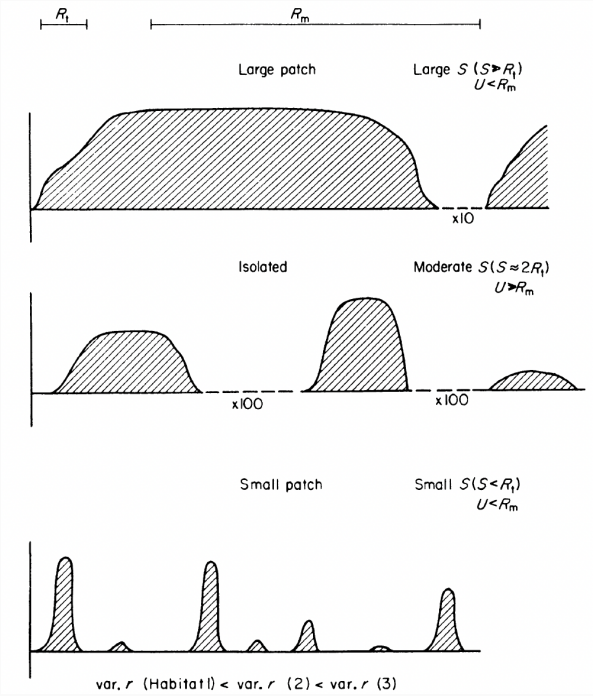


Southwood (1977)

Southwood (1977)

What about τ? Hasn't been studied yet...





Southwood (1977)

Take home messages

Environmental change challenges survival/fitness, but it also opens up niche space.

If the changes are predictable in space and/or time, species can specialise on this change, and this can happen over evolutionary or ecological timescales.

Over ecological timescales, behavioural adaptations to change are immediately accessible and can provide a boost to fitness, but they're not necessarily efficient and can be refined over evolutionary timescales.

We will continue along this path next lecture.

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