Some causes and consequences of dispersal in real and model systems

EVERYTHING DISPERSES TO MIAMI

THE ROLE OF MOVEMENT AND DISPERSAL IN SPATIAL ECOLOGY, EPIDEMIOLOGY AND ENVIRONMENTAL SCIENCE

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2007-2008 IPY-API

Natural Resources Canada

NSERC CRSNG

Lakehead UNIVERSITY

UNIVERSITÉ LAVAL

INTERNATIONAL POLAR YEAR 2007-2008

Dispersal is a solution to the struggle for existence in heterogeneous environments

Dispersal depends on density

Dispersal is contingent on habitat

Dispersal is a solution to the struggle for existence in heterogeneous environments

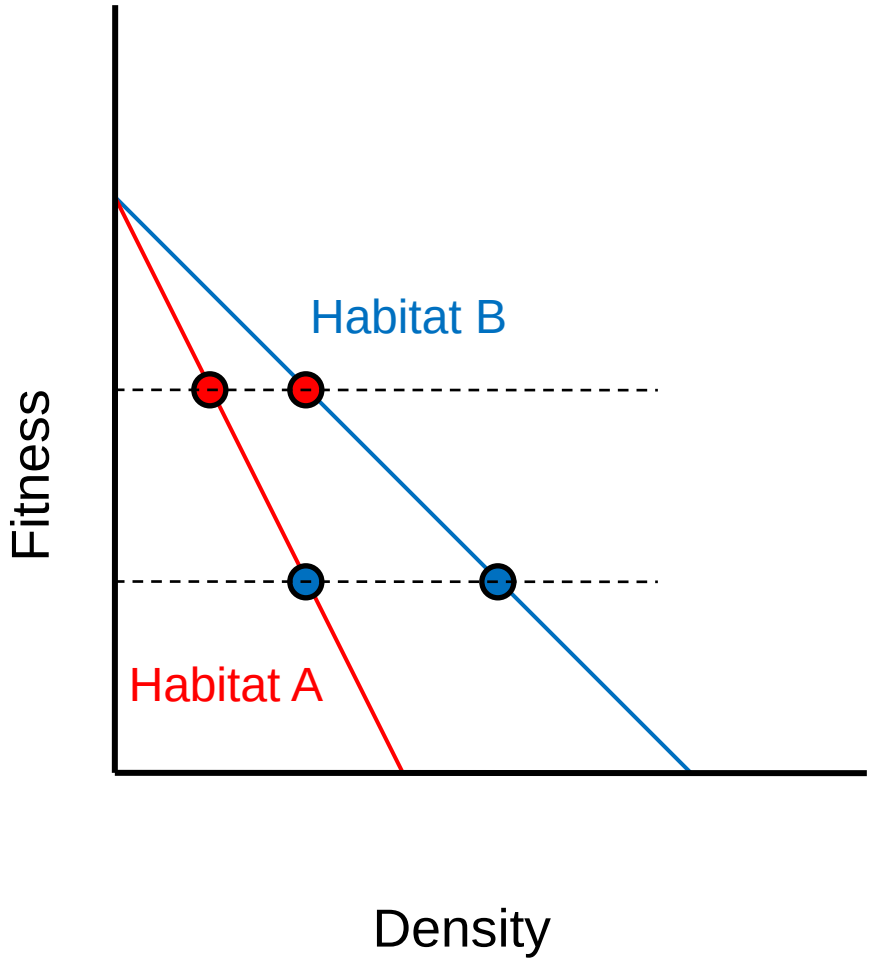
- Can we use habitat selection to predict evolutionary futures?
  (Arctic lemmings)

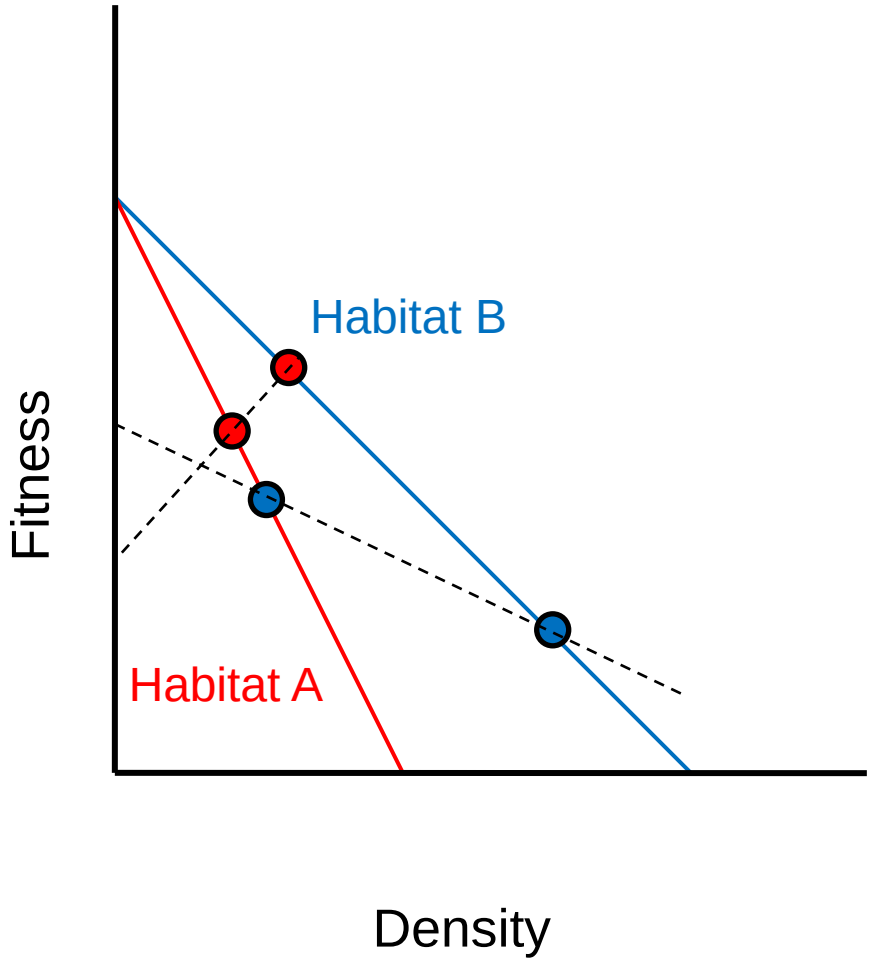
- Do different habitat-selection strategies coexist in the same population?
  (Simulated habitat selection)

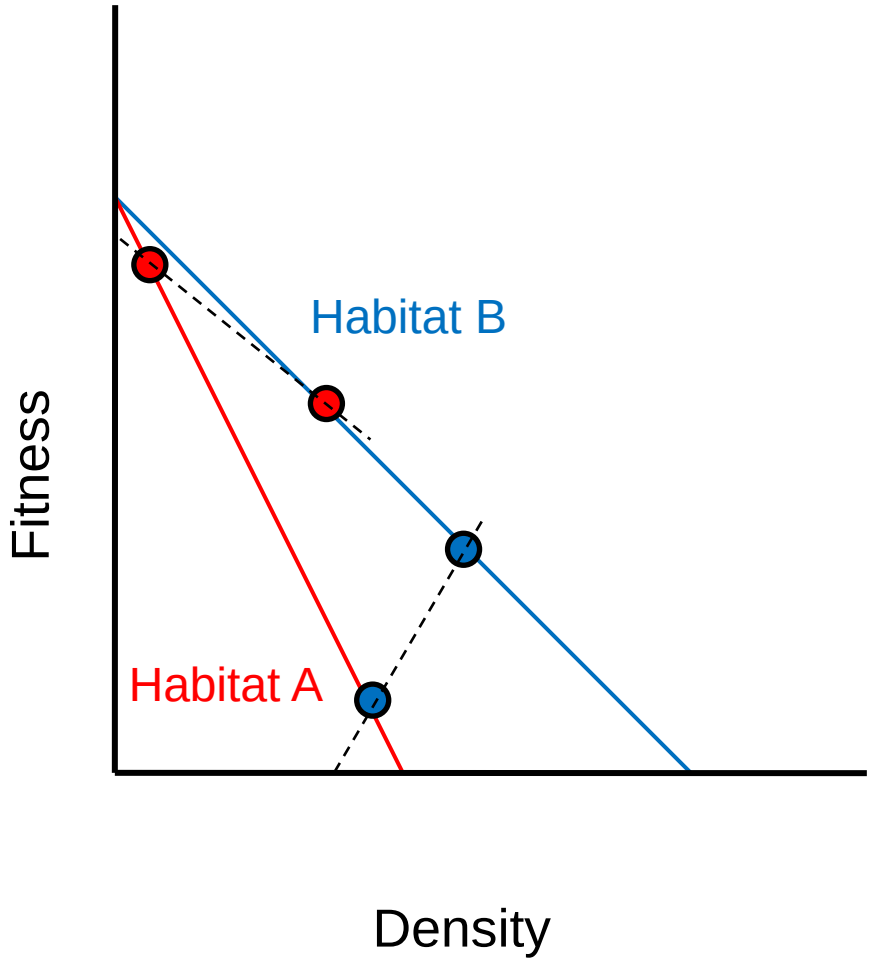
- What are the necessary and sufficient conditions for adaptive movement?
  (Model organisms)

Habitat A

Habitat B

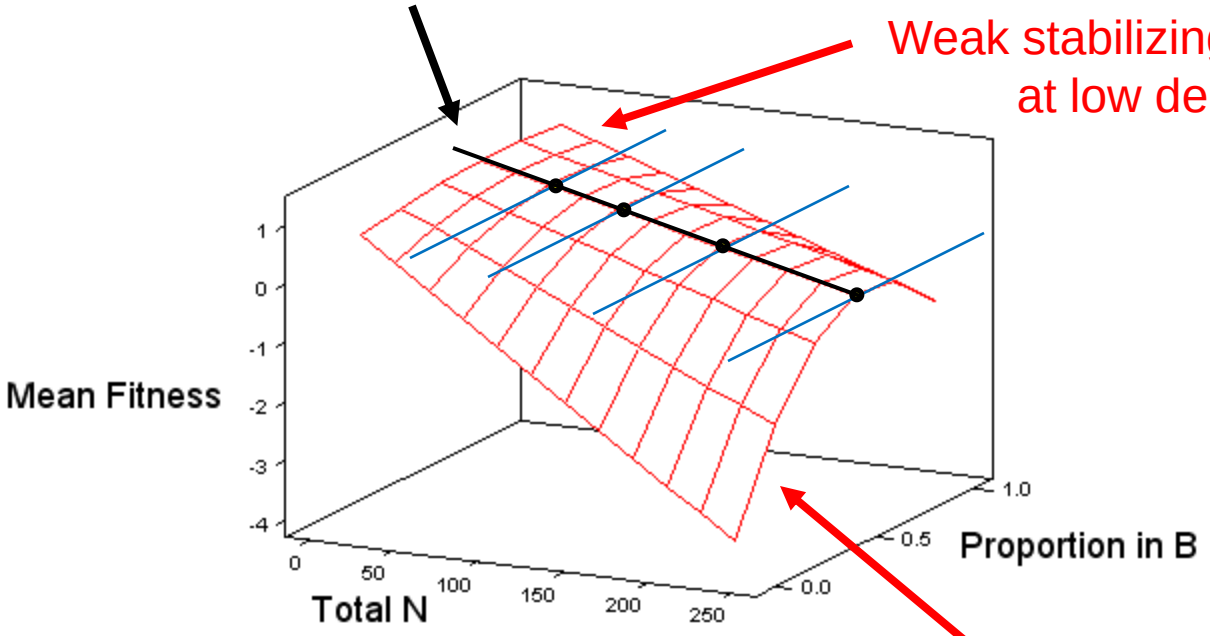

Habitat B
Habitat A
Fitness
Density

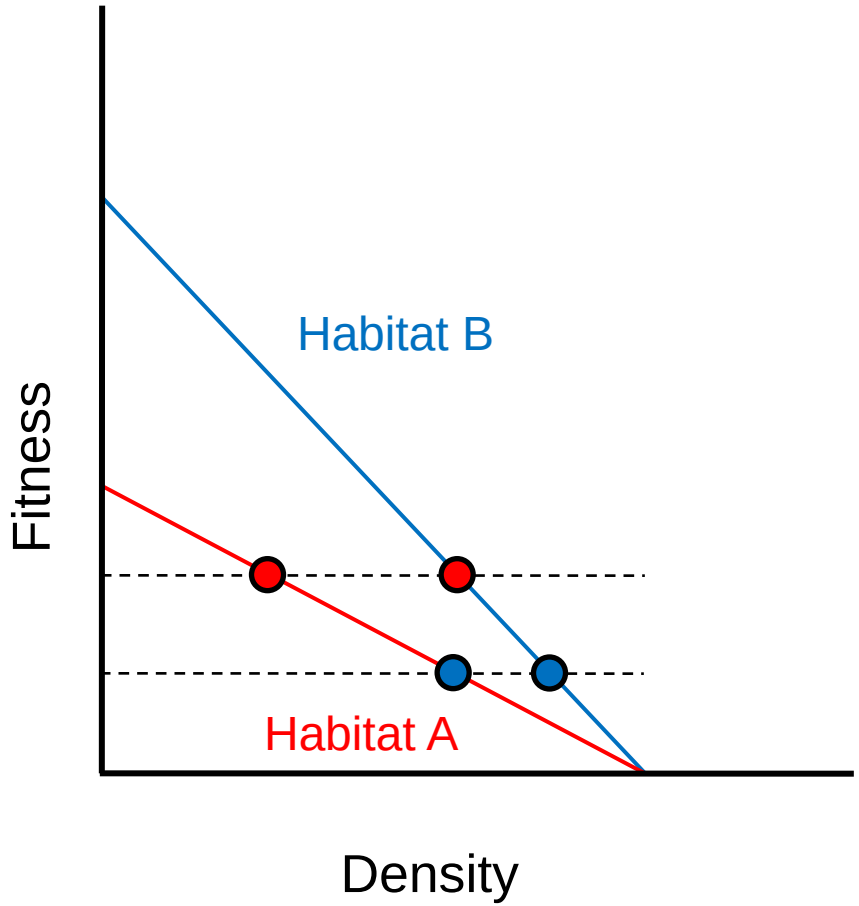

Habitat B
Fitness
Habitat A
Density


Habitat B
Habitat A
Fitness
Density

Divergent Population Regulation
(qualitatively different habitats)

Single strategy of density-dependent habitat selection
(no directional selection)

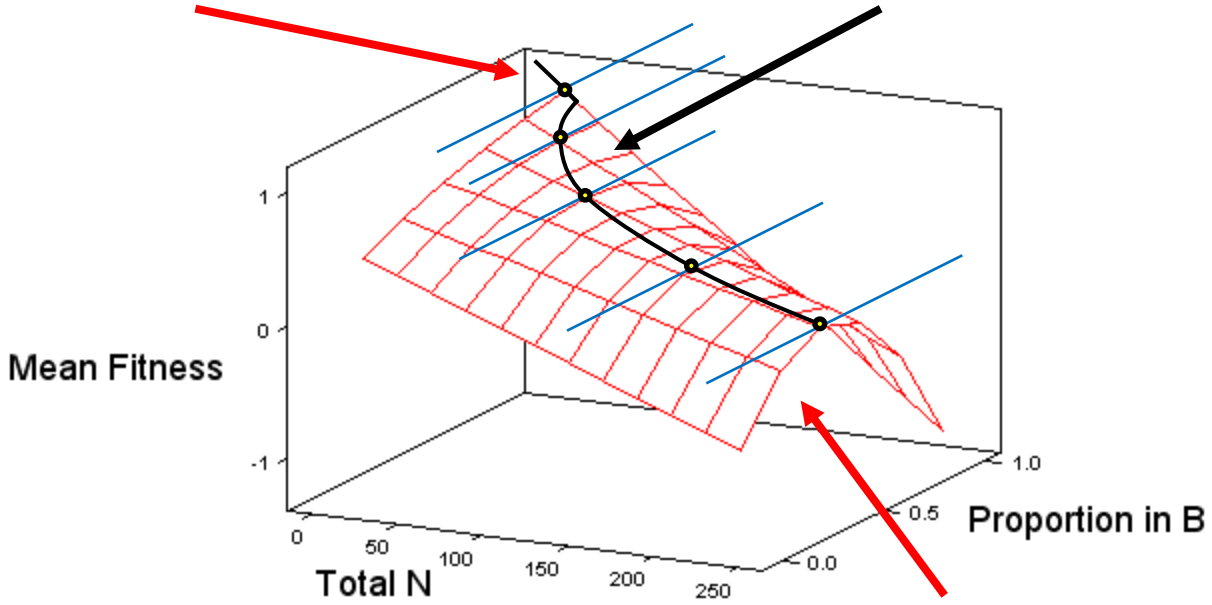



Habitat B
Fitness
Habitat A
Density

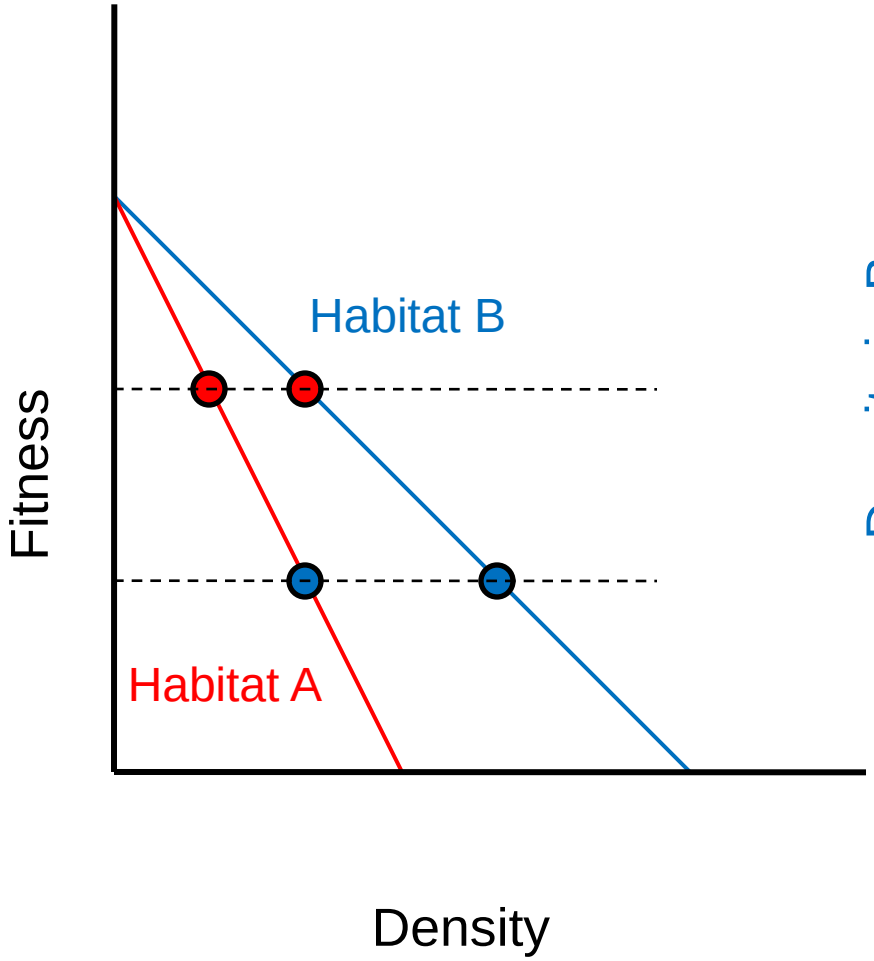
Convergent Population Regulation
(quantitatively different habitats)

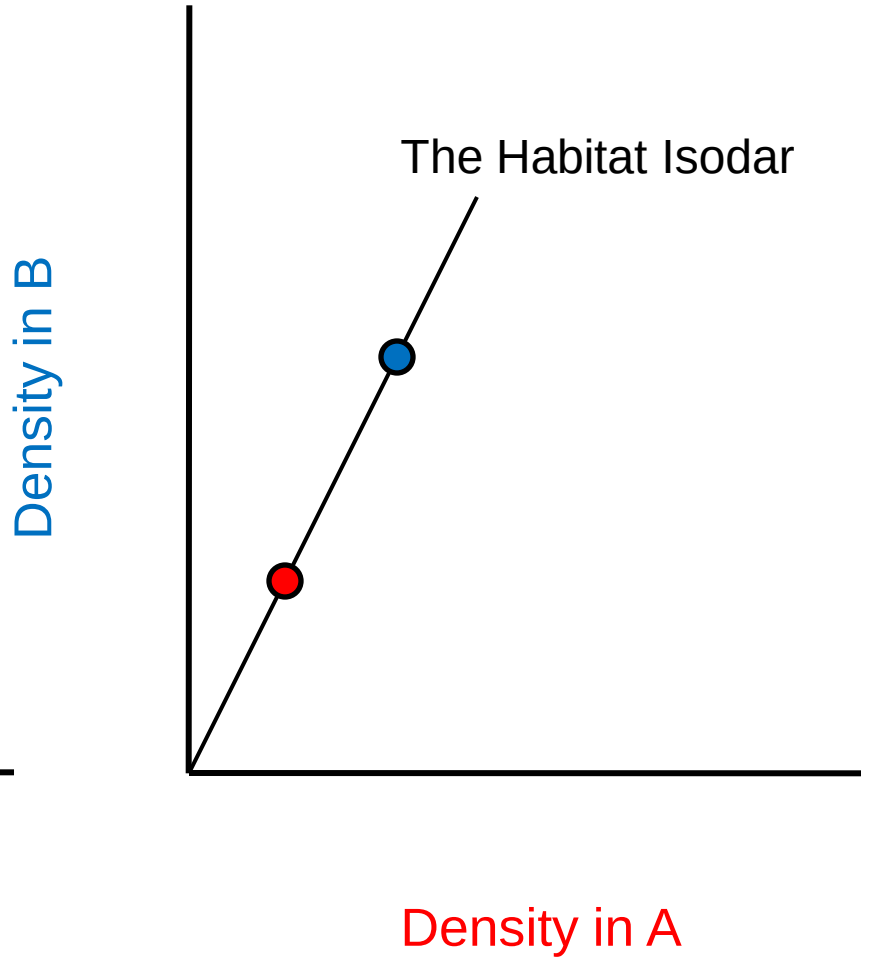
Weak stabilizing selection
at low density (fixed)

Strong directional selection
at intermediate density



Strong stabilizing selection
at high density


Habitat B
Habitat A
Fitness
Density

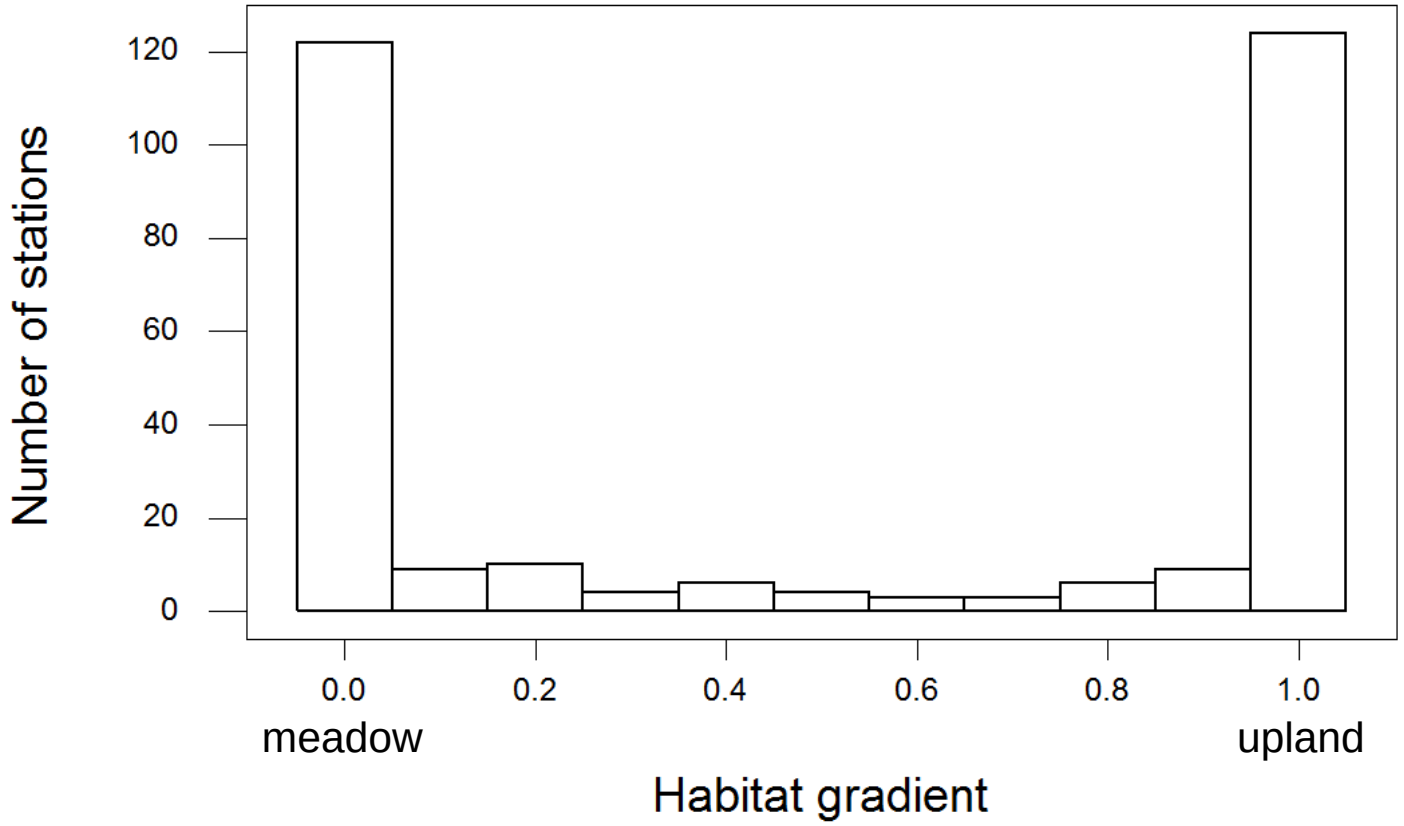

The Habitat Isodar
Density in B
Density in A

Arctic Ocean
Queen Elizabeth Islands
Axel Heiberg Island
Ellesmere Island
Sverdrup Islands
Prince Gustaf Adolf Sea
Peary Channel
Borden I.
Brock I.
Isachsen
Ellef Ringnes I.
Amund Ringnes I.
Mackenzie King I.
Satellite Bay
Prince Patrick Island
Mould Bay
Emerald Isle
Lougheed I.
Hazen Strait
Maclean Strait
King Christian I.
Cornwall I.
Graham I.
Norwegian Bay
Eglinton I.
Parry Islands
Byam Martin Channel
M'Clure Strait
Banks Island
Melville Island
Bathurst Island
Byam Martin I.
Polaris
Cornwallis Island
Resolute
Jones Sound
Devon Island
Dundas Harbour
Viscount Melville Sound
Parry Channel
Thesiger Bay
Amundsen Gulf
Fort Collinson (abandoned)
Stefansson Island
M'Clintock Channel
Ommanney Bay
Peel Sound
Somerset Island
Prince Regent Inlet
Bylot Island
Baffin Bay
Nanisivik
Paulatuk
Holman
Prince of Wales Island
Franklin Strait
Victoria Island
Quunnguq Lake
Washburn
Mary River
Clyde River
Neergaard Lake
Lake Gillian
Baffin Island
Kugluktuk
Cambridge Bay
Victoria Strait
King William Island
Gulf of Boothia
Igloolik
Queen Maud Gulf
Gjoa Harbour
Pelly Bay
Hall Lake
Prince Charles Island
Auyuittuq National Park
Port Radium
Coppermine R.
Kealekavig Lake
Bathurst Inlet
Burnside R.
Hornaday R.
Arctic Ocean
RUSSIA
Greenland (DENMARK)
QUEEN ELIZABETH ISLANDS
UNITED STATES
CANADA
ROCKY MOUNTAINS
North Pacific Ocean
UNITED STATES
North Atlantic Ocean
MEXICO

Collared Lemming, http://users.iab.uaf.edu

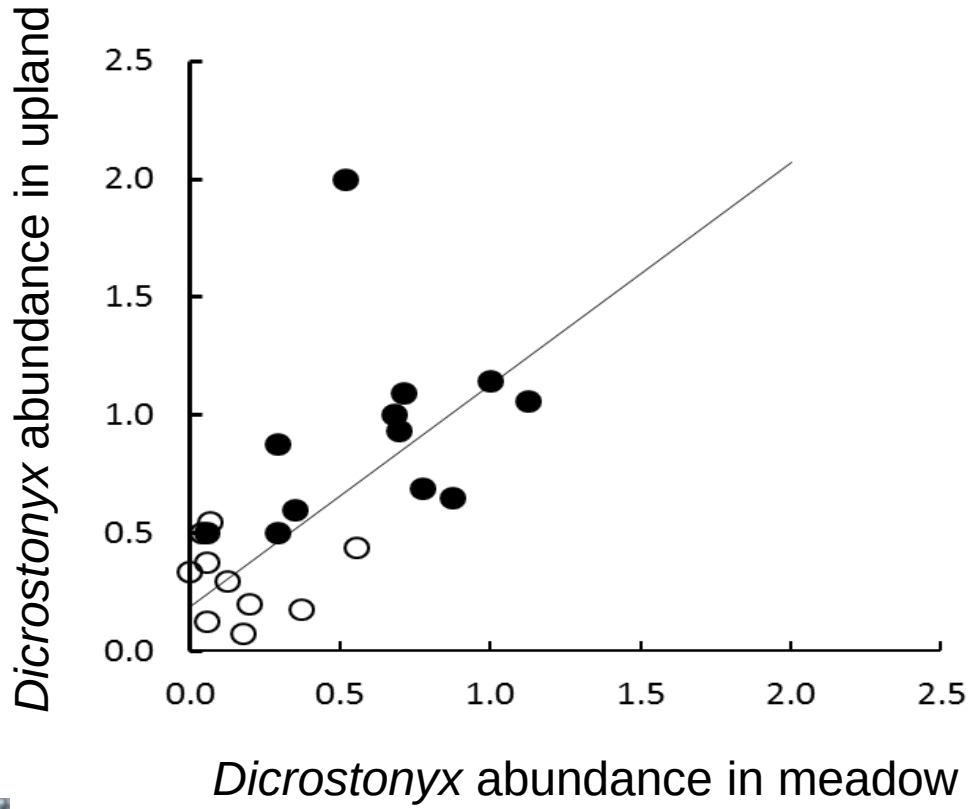
Brown Lemming, http://users.iab.uaf.edu

Two Habitat Classes at Walker Bay



Morris, Davidson & Krebs, EER 2:41-67

In 2011, *Dicrostonyx* preference for upland depended only on intra-specific competition



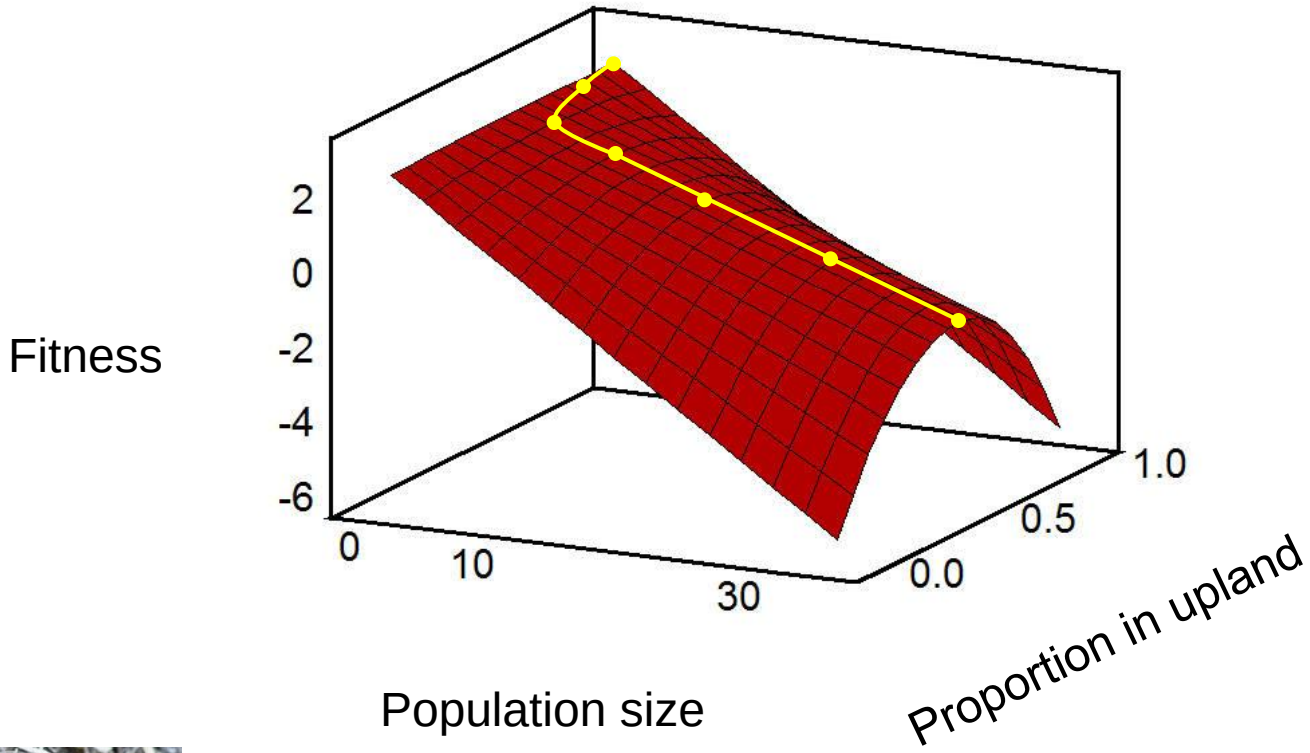
$Du = 0.19 + 0.94\ Dm$

$p < 0.001$, $R^2 = 0.54$

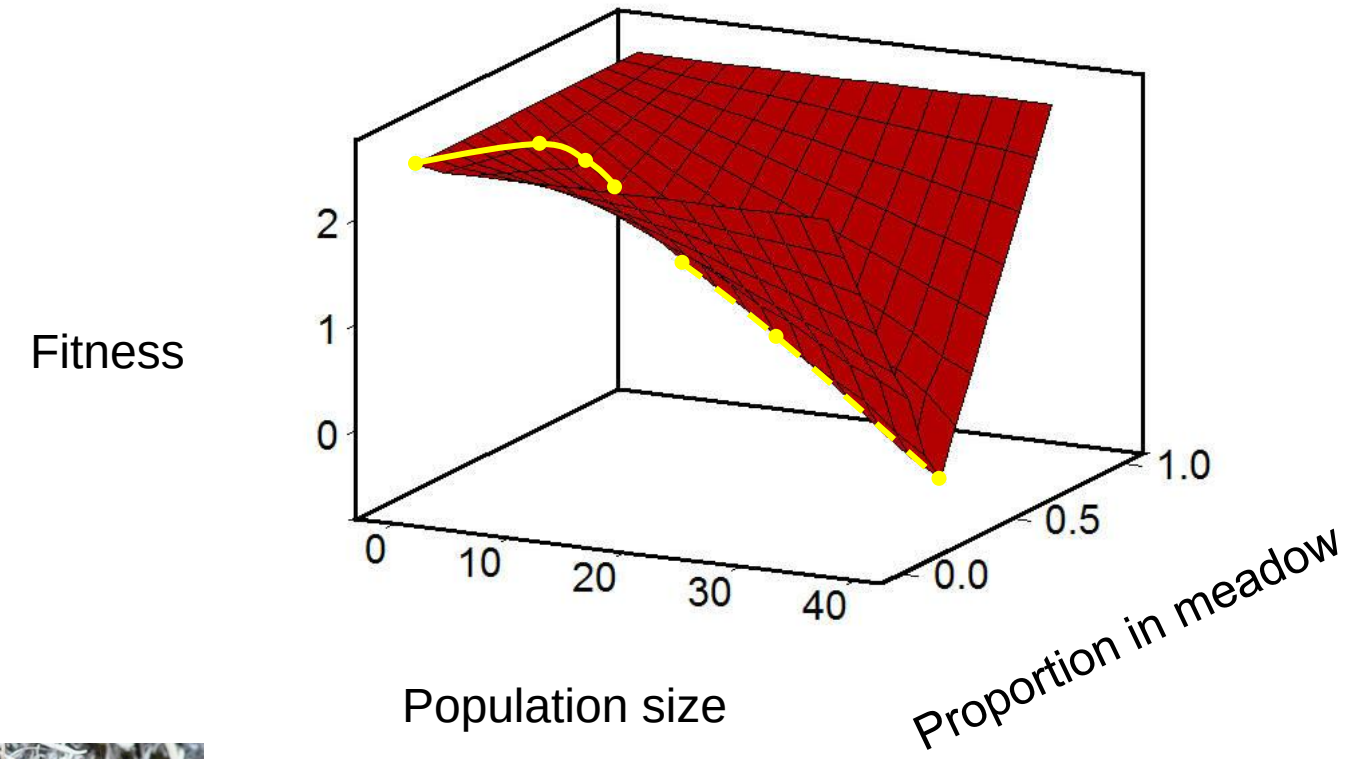
Collared Lemming, http://users.rcn.com/...

Morris, Dupuch & Halliday, EER In Press

Dicrostonyx fitness landscape



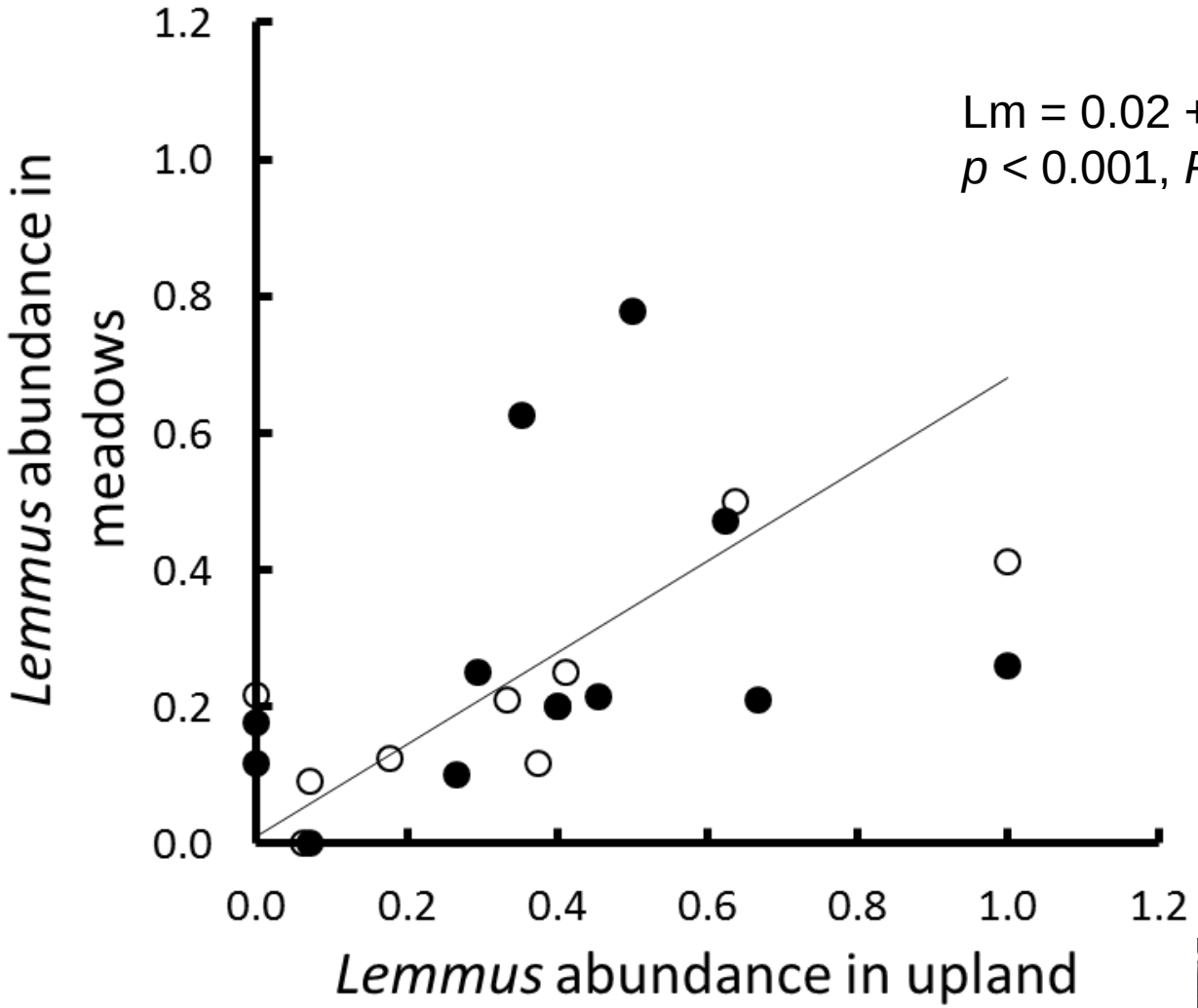
Dicrostonyx fitness invasion landscape



Collared Lemming. http://usersnab.uaf.edu/

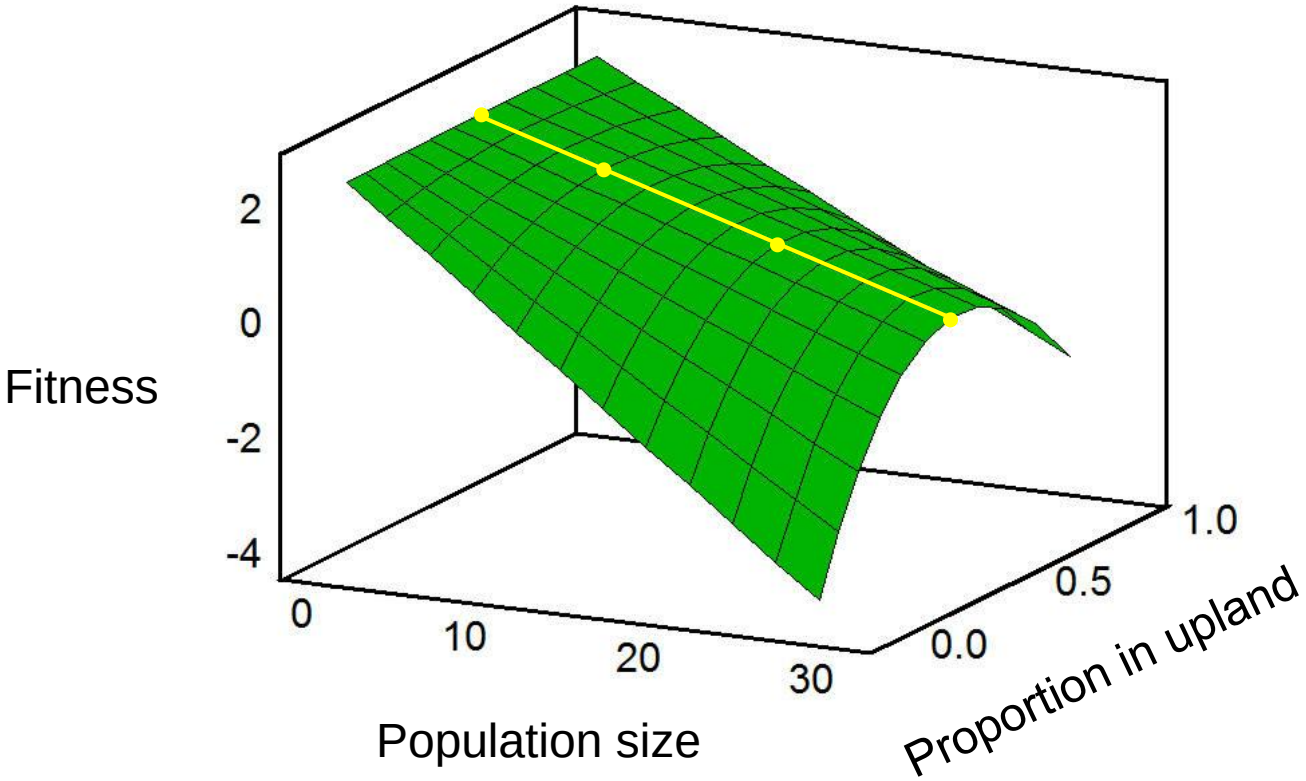
Morris, Dupuch & Halliday, EER In Press

In 2011, *Lemmus* preference for meadows depended only on intra-specific competition



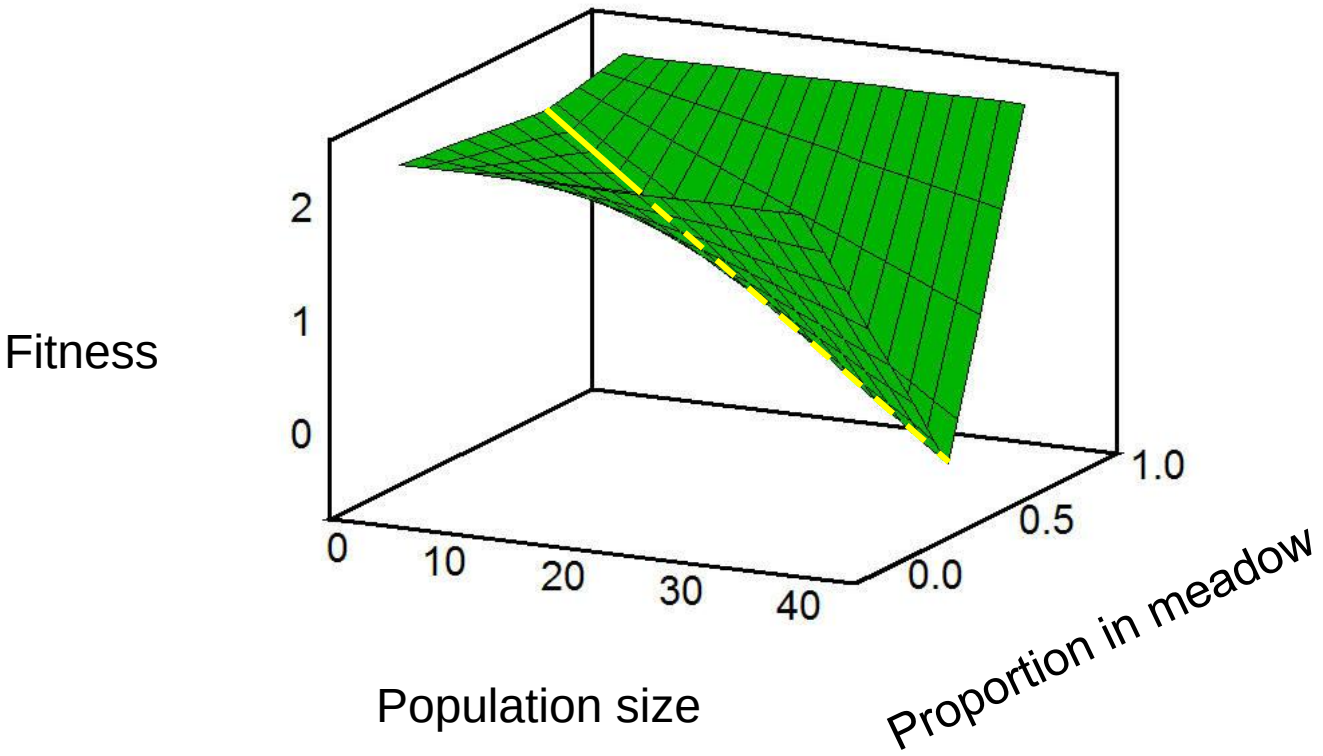
Morris, Dupuch & Halliday, EER In Press

Lemmus fitness landscape



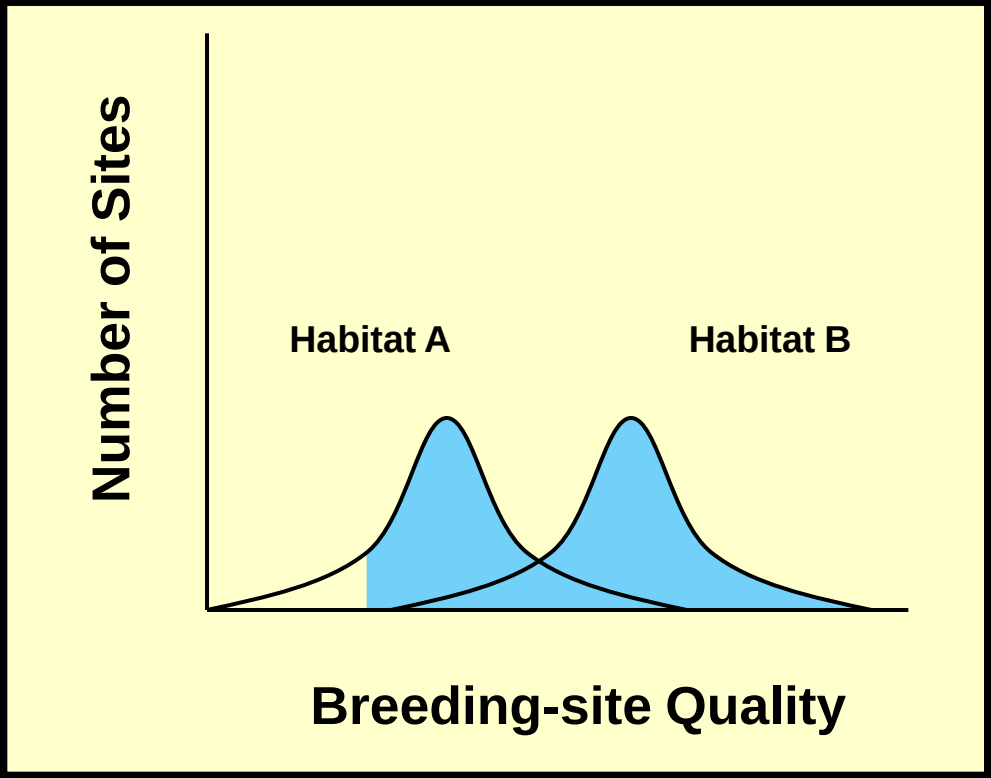

Brown Lemming, http://users.iab.uaf.edu

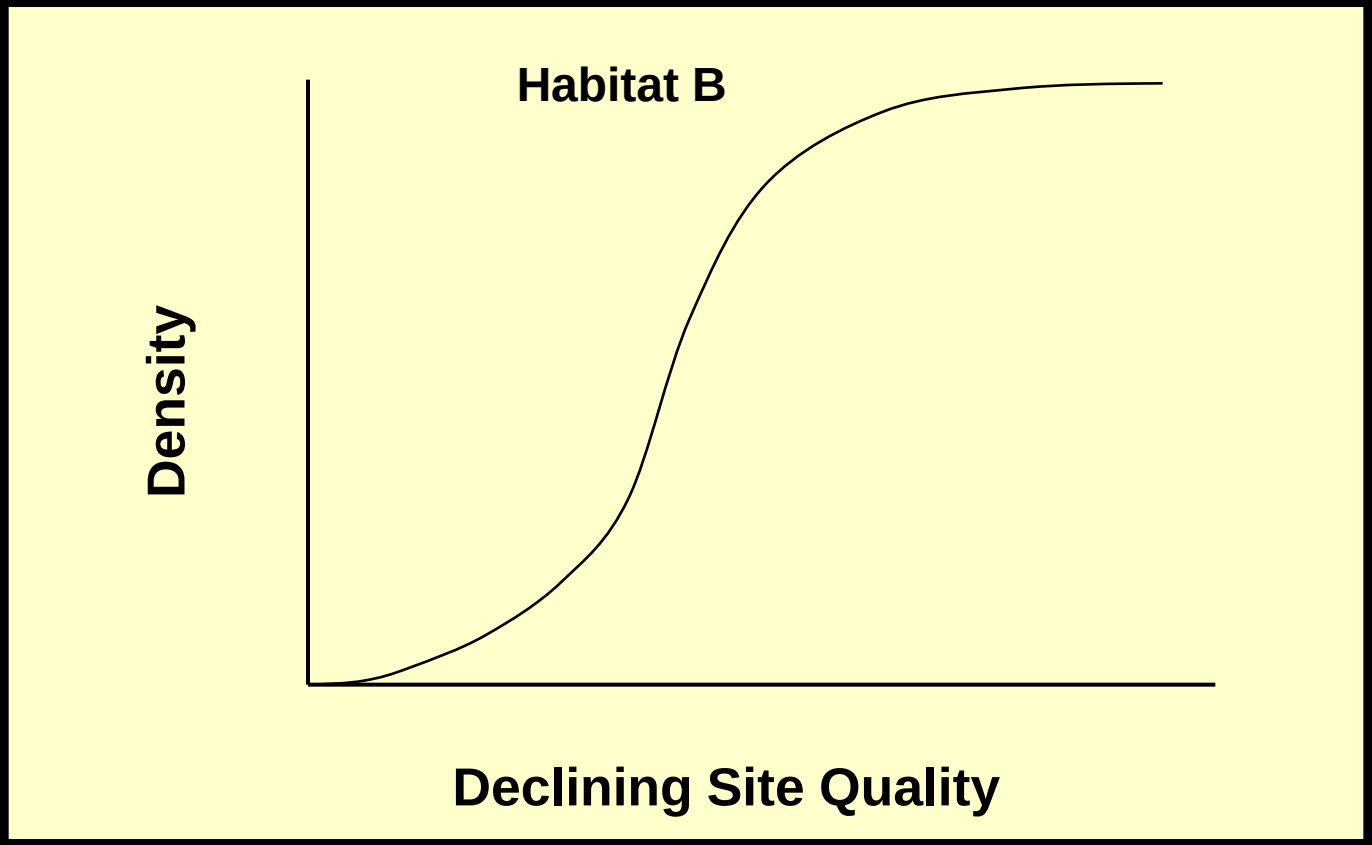
Lemmus fitness invasion landscape

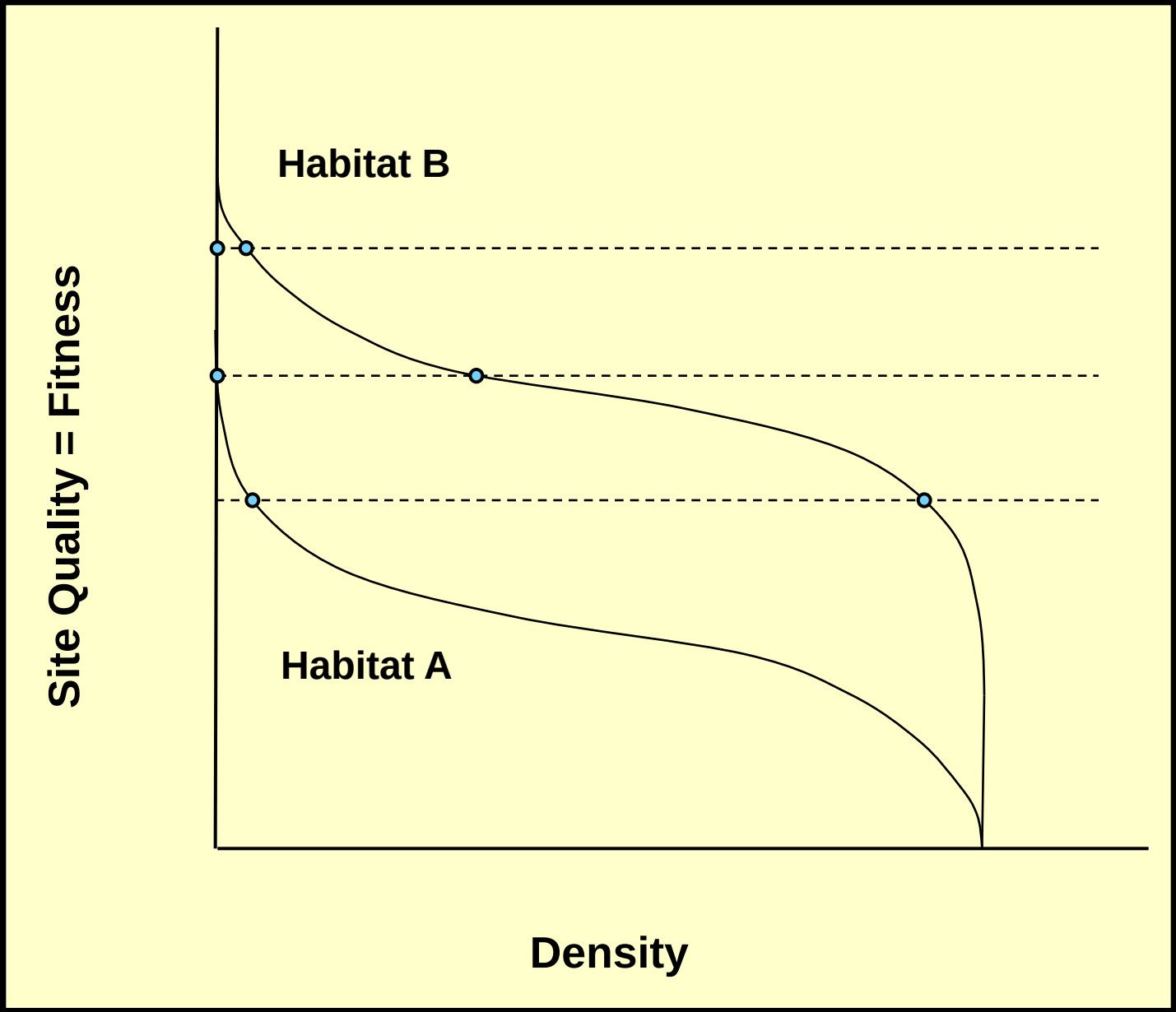


Morris, Dupuch & Halliday, EER In Press

Ideal Pre-emptive Habitat Selection

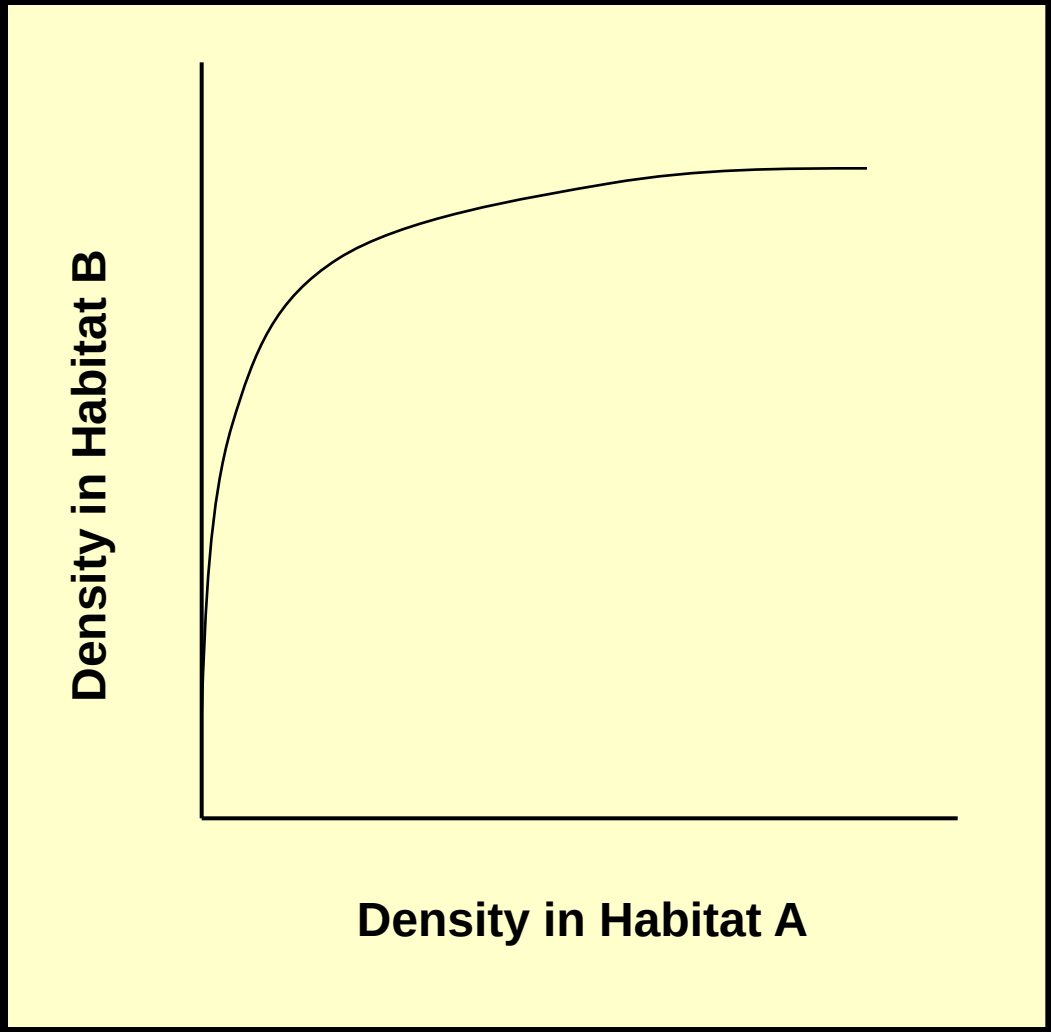


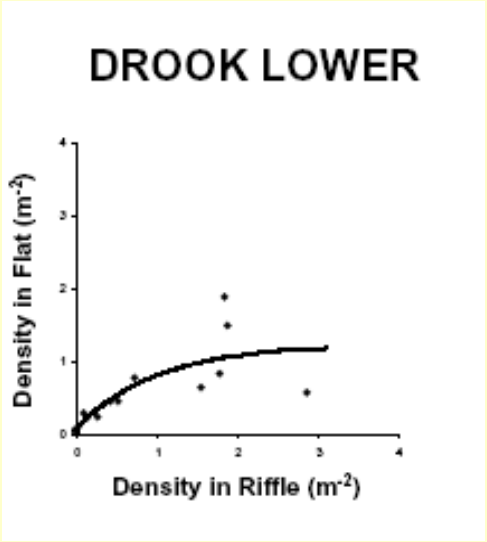

Habitat B
Density
Declining Site Quality

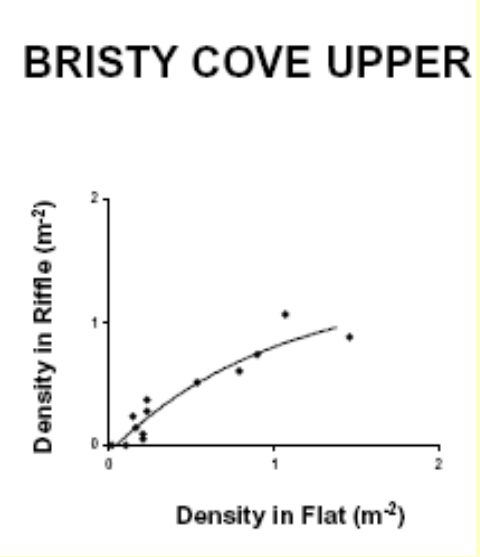


e.g., Morris, Evol. Ecol. 8:387-406

An Ideal Pre-emptive Isodar







Knight, Morris & Haedrich, IJEE 54:345-360

Question: Under what conditions will ideal pre-emptive (site dependent) habitat selection outperform despotic habitat choice?

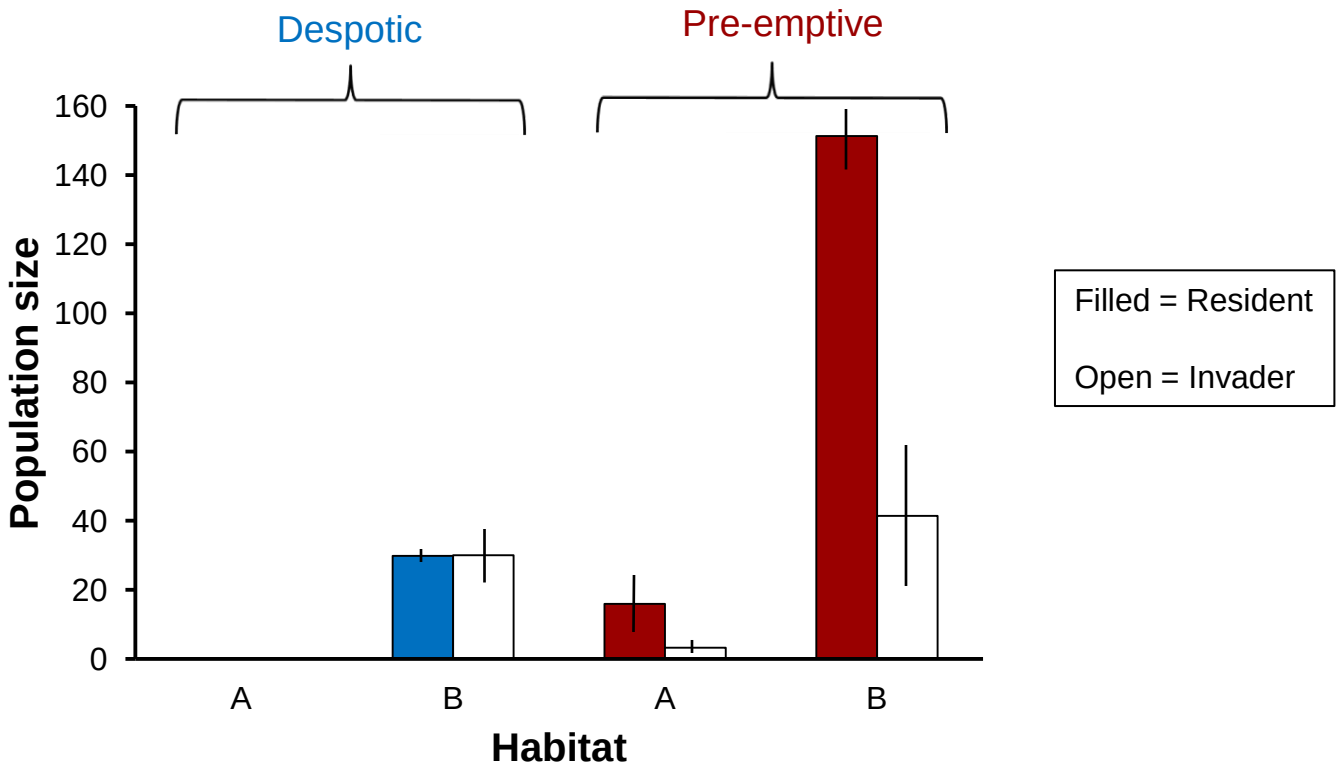
Answer: Clearly not when territoriality is cost free.

Surprise?

1. The two strategies coexist across a broad range of parameter values.

2. Priority effects determine the frequency of the pre-emptive strategy.

An example of priority effects when costs of territoriality are low



When despotism is the resident strategy, high-quality territories are occupied and unavailable to pre-emptive individuals.

When pre-emption is the resident strategy, the population maintains itself in territories of low (replacement) quality.

Motility and sensory capability are necessary traits for adaptive movement.

But are they sufficient?

Chlamydomonas reinhardtii

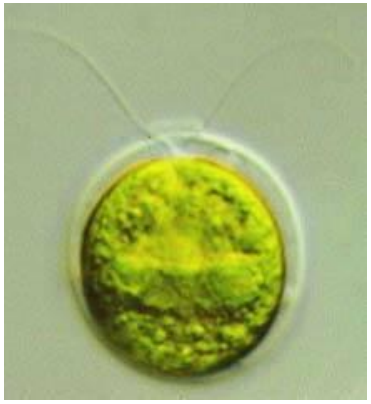
Single-celled haploid algae

Possess two flagellae

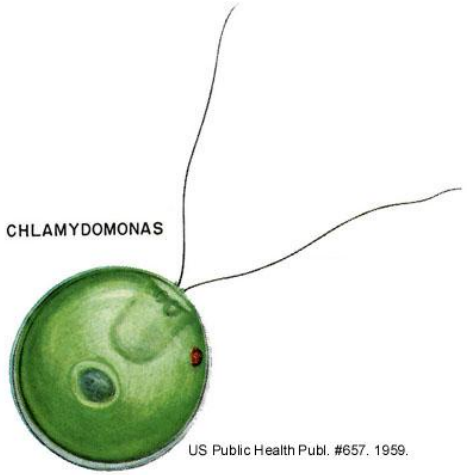
Are both chemotactic and phototactic (eyespot)

Physiology and genetics are well known

Easily cultured in the lab



From: http://2.bp.blogspot.com/_DZH2cmCoois/Rw-OYR_zsKI/AAAAAAAADaM/LtXdx_Wo3W4/s400/chlamydomonas.jpg, Accessed 4 November 2011



From: http://www.botany.hawaii.edu/BOT201/Algae/Bot%20201%20Chlamydomonas.jpg, accessed 4 November 2011

Experimental Design

Many Thanks

Robert Bromley
Robert Buchkowski
Todd Burnside
Ian Clarke
Victoria Danco
Douglas Davidson
Benjamin Dippo
Mathieu Dumond
Gilles Gauthier
William Halliday
Robert Harmer

Charles Krebs
Jody MacEachern
Debra Moore
Kelly Morris
Michael Oatway
Wensheng Qin
Donald Reid
Shane Sather
Douglas Stern
Vijayan Sundararaj
Debra Wilson