Habitat fragmentation and landscape change: Using experiments to investigate processes occurring at large spatial scales

Thomas AH Smith

Feb 14th, 2023

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Landscape change is a global threat to biodiversity
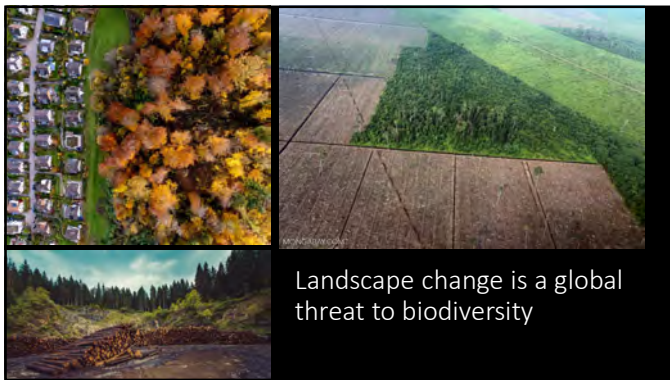
2

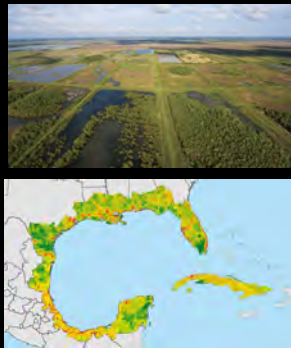Habitat relegated to small and/or disjointed patches

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Landscape ecology

Interested in large spatial scale phenomena

How do we replicate:

Processes that occur over great distances?
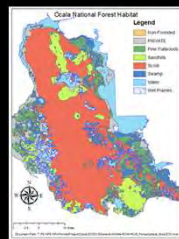Unique landscapes

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Landscape ecology

Interested in large spatial scale phenomena

How do we replicate:

Processes that occur over great distances?
Unique landscapes
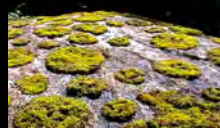
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Experimental studies of landscape processes

Biological Dynamics of Forest Fragments Project

Moss Fragmentation Experiment

Wog Wog Fragmentation Experiment

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Experiments in landscape ecology

Trade-off:
- Spatial extent
- Number of patches
- Number of Landscapes

Small scale *in situ* model systems allow for replication without loss of realism

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Model Systems

Manageable but realistic scale

Photos Berg Lab UW

Easily manipulated

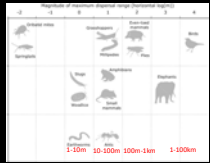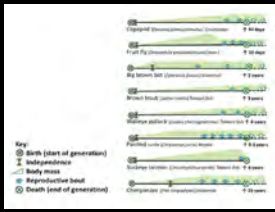Complex mechanisms of the system understood

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Model System Scale

Scale of processes of interest line up with natural history of organism of interest

Spatial Extent:
    Dispersal biology of species
    Population density/home range size

Temporal Extent:
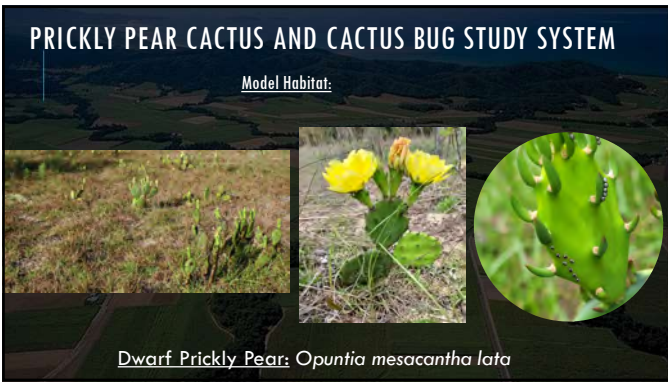   Generation Time
    Longevity and "extinction debt"

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Model System for Landscape Ecology

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PRICKLY PEAR CACTUS AND CACTUS BUG STUDY SYSTEM

Model Habitat:

Dwarf Prickly Pear: *Opuntia mesacantha lata*

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PRICKLY PEAR CACTUS AND CACTUS BUG STUDY SYSTEM

Model Wildlife Species:
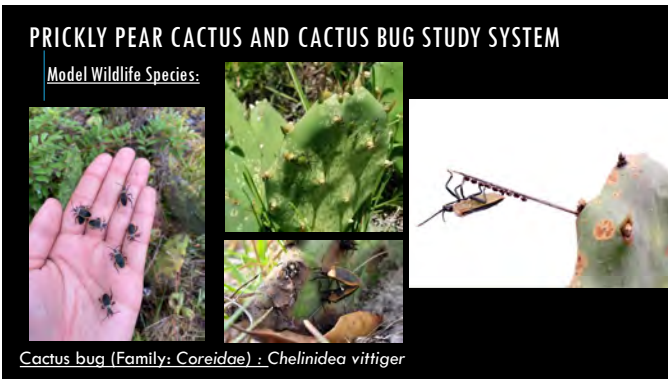
Cactus bug (Family: Coreidae) : *Chelinidea vittiger*

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PRICKLY PEAR CACTUS AND CACTUS BUG STUDY SYSTEM
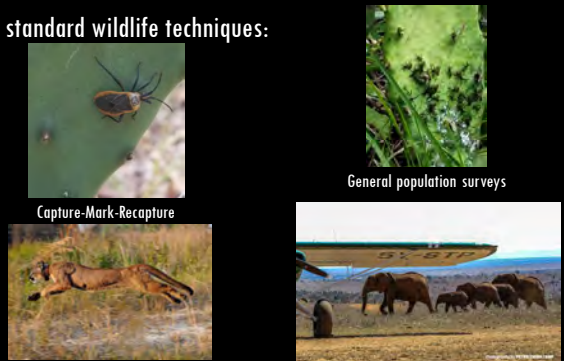
Model Wildlife Species:

Cactus bug (Family: Coreidae) : *Chelinidea vittiger*

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Use standard wildlife techniques:

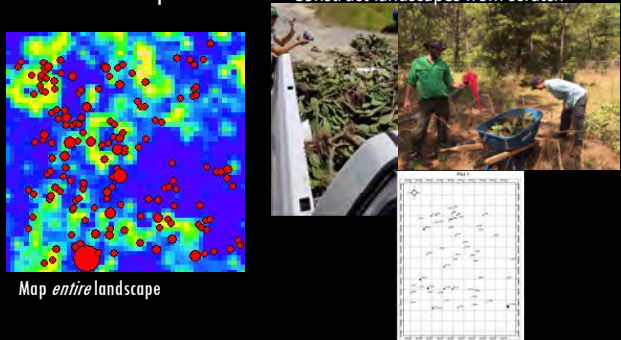General population surveys

Capture-Mark-Recapture

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Control the landscape

Construct landscapes from scratch

Map *entire* landscape

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Experimental Landscapes:
50m by 50m
Approximately 4000-5000x body length

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Why is it needed?

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Landscape change 3 fundamental processes:

Habitat Loss | Habitat Fragmentation | Land use conversion (changes in non-habitat)

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Habitat loss is bad

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Debate: Degree and importance
(1) fragmentation
(2) *non-habitat conversion*

fragmentation →

← *loss*

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Non-habitat in the landscape — The Matrix

Matrix

Patch

Organisms interact with land between patches

Embedded in non-habitat "matrix"

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The matrix matters

Edge effects at patch-matrix boundaries

A Site
Meadow
Willow
Conifer
Aspen

(Ricketts 2001)

Shown to affect movement rates

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Scales of Matrix Effects

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The Landscape Matrix

Local effects:
Matrix affects populations within patches

Landscape effects:
Matrix affects populations across entire landscapes

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Scale of the Matrix

Previous research has considered these together

Which is most important?
Do they interact?

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Why is matrix scale important?

Does modifying non-habitat next to a patch matter more or less than away from patch?

Does modification at one scale affect the interpretation at the other?

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Why matrix matters:

Conservation needs to know were to focus efforts.

There is a lot more non-habitat than habitat in fragmented landscapes:

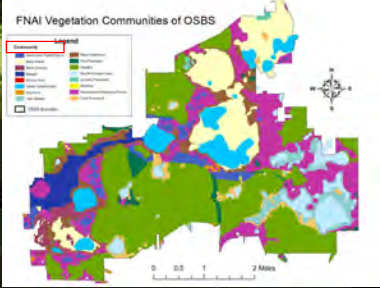Q1: Does local *matrix* affect populations more than regional *matrix*?

Q2: Does the local *matrix* effect depend on the landscape *matrix*?

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Experiment location: OSBS
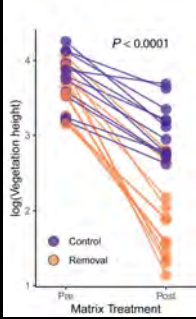
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Matrix Treatments

Pre treatment

Post treatment

$P < 0.0001$

Control
Removal

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Control | Mowed

Local treatment

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Control

Landscape treatment

Mowed

Figure 3-1

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Local Patch Treatments

Identical patch placements between paired landscapes

Pair 1:Landscape A | Pair 1: Landscape B

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AR1   Need to add patch pictures

Anonymous, 4/11/2021

Replication:
12 total landscapes
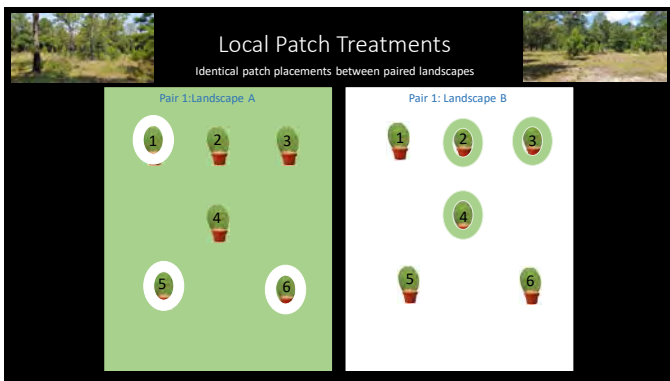40 patches per landscape
- 20 local mowed
- 20 local control

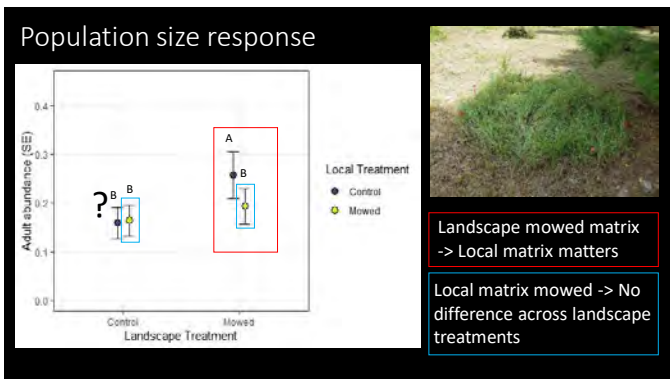**Sampled:**
Population #s of adults and nymphs
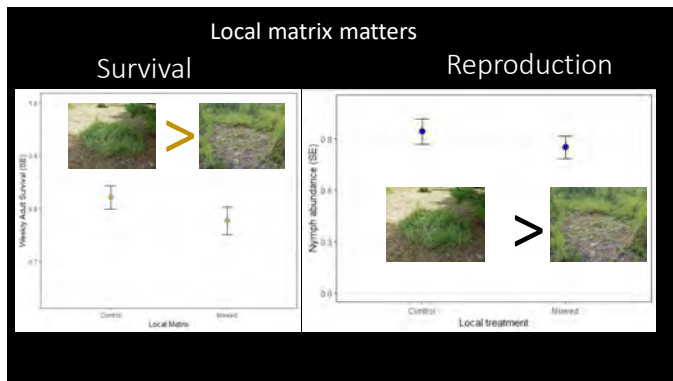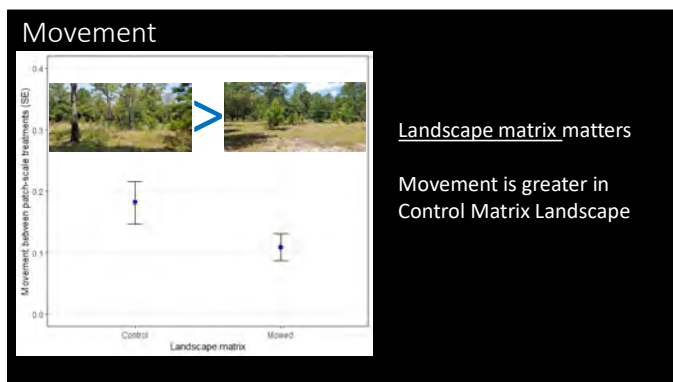Mark-recapture on adults

X   12

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Results

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Population size response

Landscape mowed matrix
-> Local matrix matters

Local matrix mowed -> No difference across landscape treatments

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Local matrix matters

Survival

Reproduction

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Movement

<u>Landscape matrix</u> matters

Movement is greater in Control Matrix Landscape

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Putting this together:

Mowing the landscape decreased movements between patches, but increased abundance in local control patches

<u>Local Effects:</u>
Survival
Reproduction

<u>Landscape Effects:</u>
Movement

Dispersal is risky

High dispersal can lead to the averaging of local conditions

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Take aways

- The quality of the local matrix is important, but landscape matrix context is key for understanding entire population

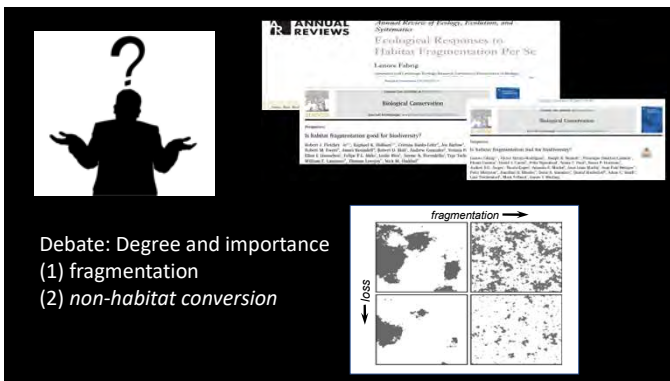- High movement in landscapes can be detrimental if high variability in local conditions.
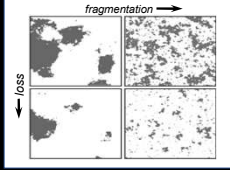
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Incorporating the Matrix into Fragmentation

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Debate: Degree and importance
(1) fragmentation
(2) *non-habitat conversion*

fragmentation

loss

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QUESTIONS

1) How do habitat loss, fragmentation, and matrix conditions alter populations?

2) How does the matrix inform our interpretation of large-scale processes?
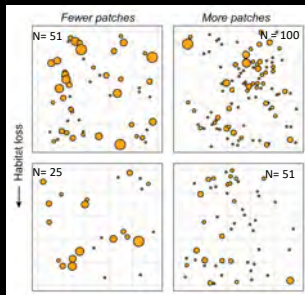
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The experiment

Fragmentation treatment: Preferentially remove large or small patches

| | Low | High |

27 landscapes

35% Loss

Loss treatment: removal of total area

70% loss

Fewer patches — N= 51 / More patches — N = 100

Habitat loss

N= 25 / N= 51

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Matrix treatment

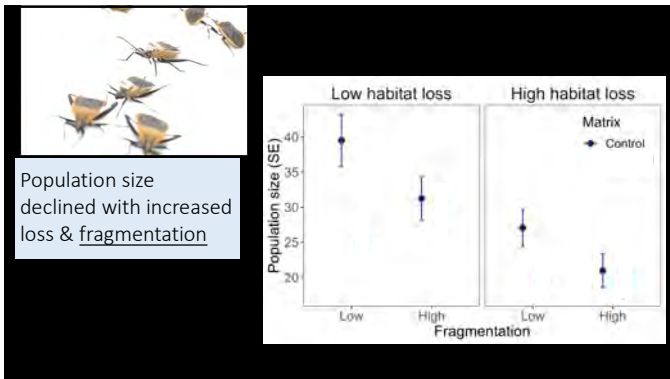Control

X 27

Removed

45

Population size declined with increased loss & fragmentation

Low habitat loss High habitat loss

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A reduction in matrix quality obscured fragmentation effects

Low fragmentation functionally equivalent to high when matrix quality declined

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Complex demographic effects:
Lower survival with increasing fragmentation

Matrix effects in high, but not low, habitat loss
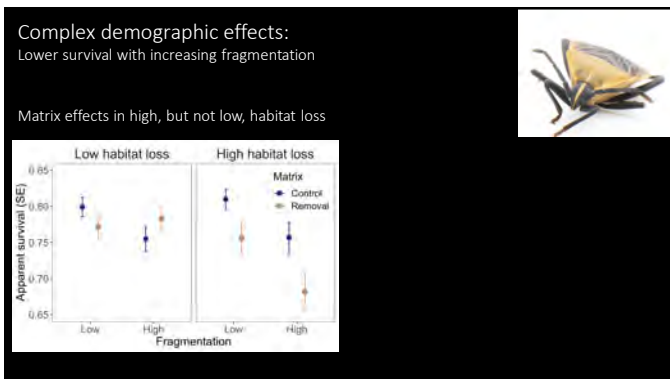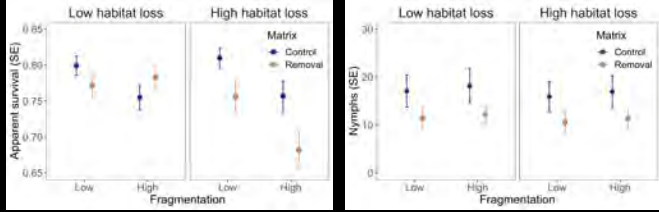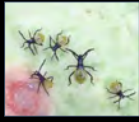

48

16
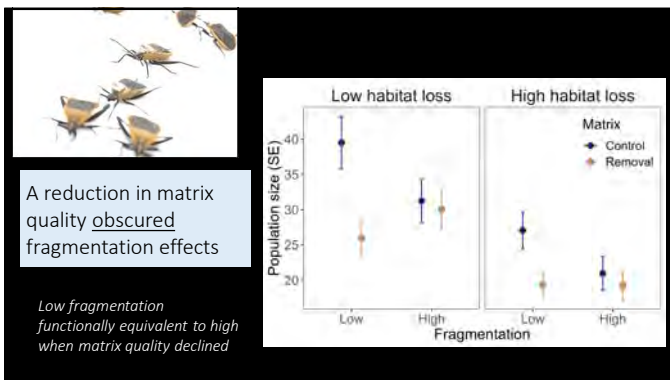
Complex demographic effects:
Reduction in *matrix quality* reduced reproductive output by 65%, but not loss or fragmentation

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Take-home points

Both loss AND fragmentation can have considerable negative effects

Matrix decay can have effects just as large as losing habitat & can mask effects of fragmentation

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Landscape change is multi-faceted

Non-habitat is important both at local and landscape scales

Absence of local matrix effects due to movement and/or landscape context

The non-habitat in a landscape can mask effects of fragmentation

BIG PICTURE

Any future fragmentation studies and experiments should control for or incorporate difference in the matrix

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