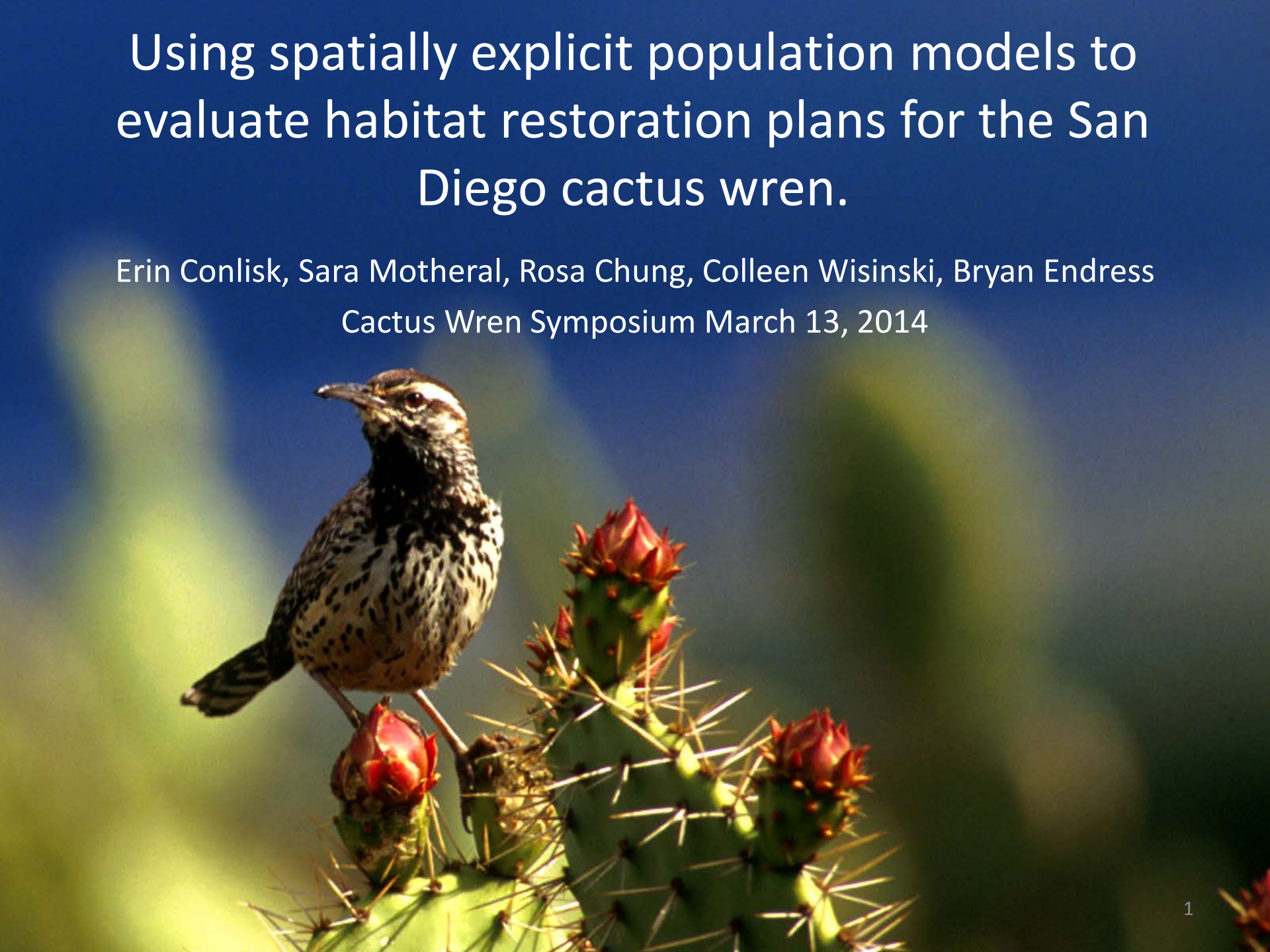
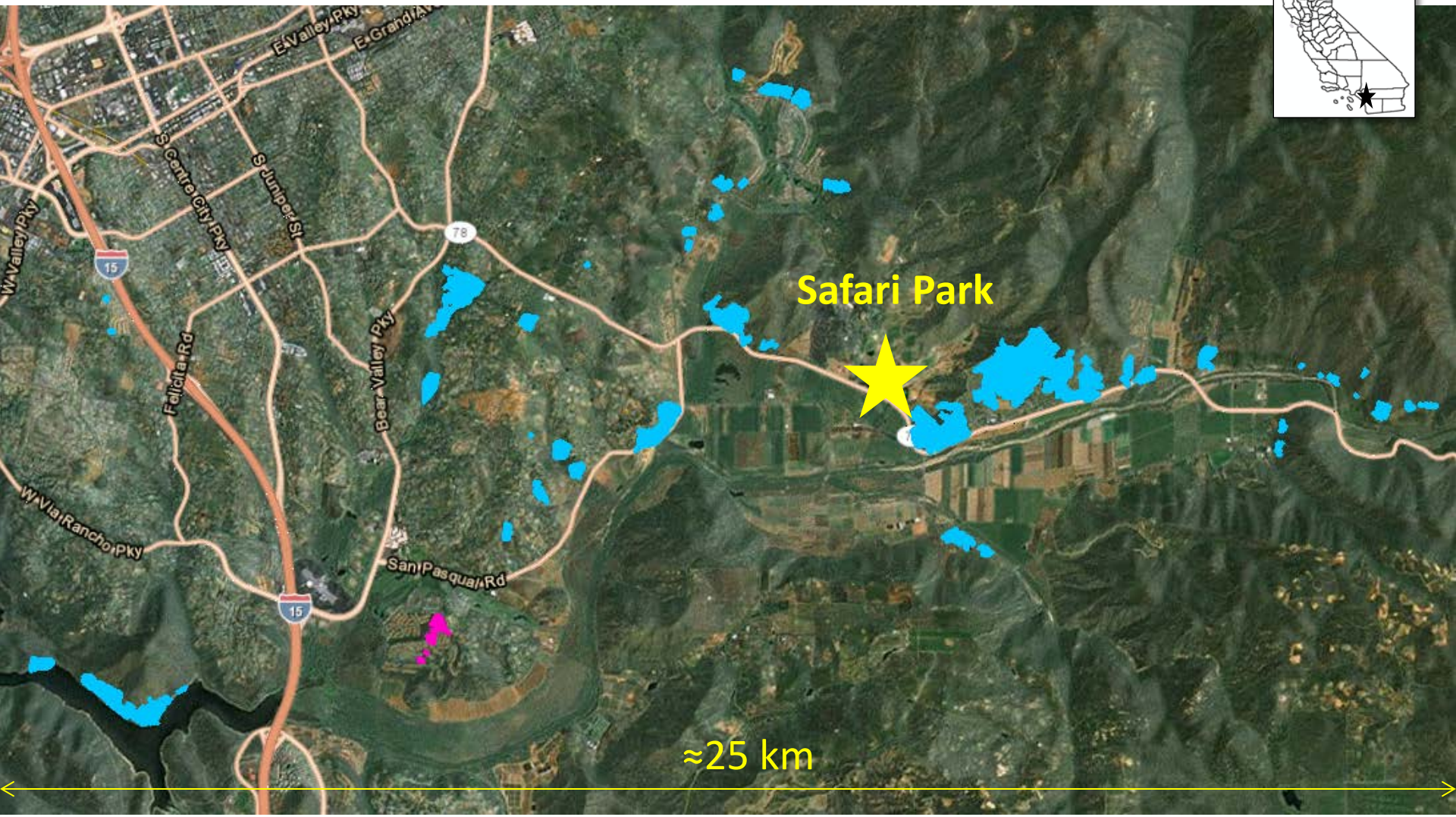
Using spatially explicit population models to evaluate habitat restoration plans for the San Diego cactus wren.

Erin Conlisk, Sara Motheral, Rosa Chung, Colleen Wisinski, Bryan Endress

Cactus Wren Symposium March 13, 2014



Current Cactus Wren Habitat



Unoccupied cactus

Occupied habitat

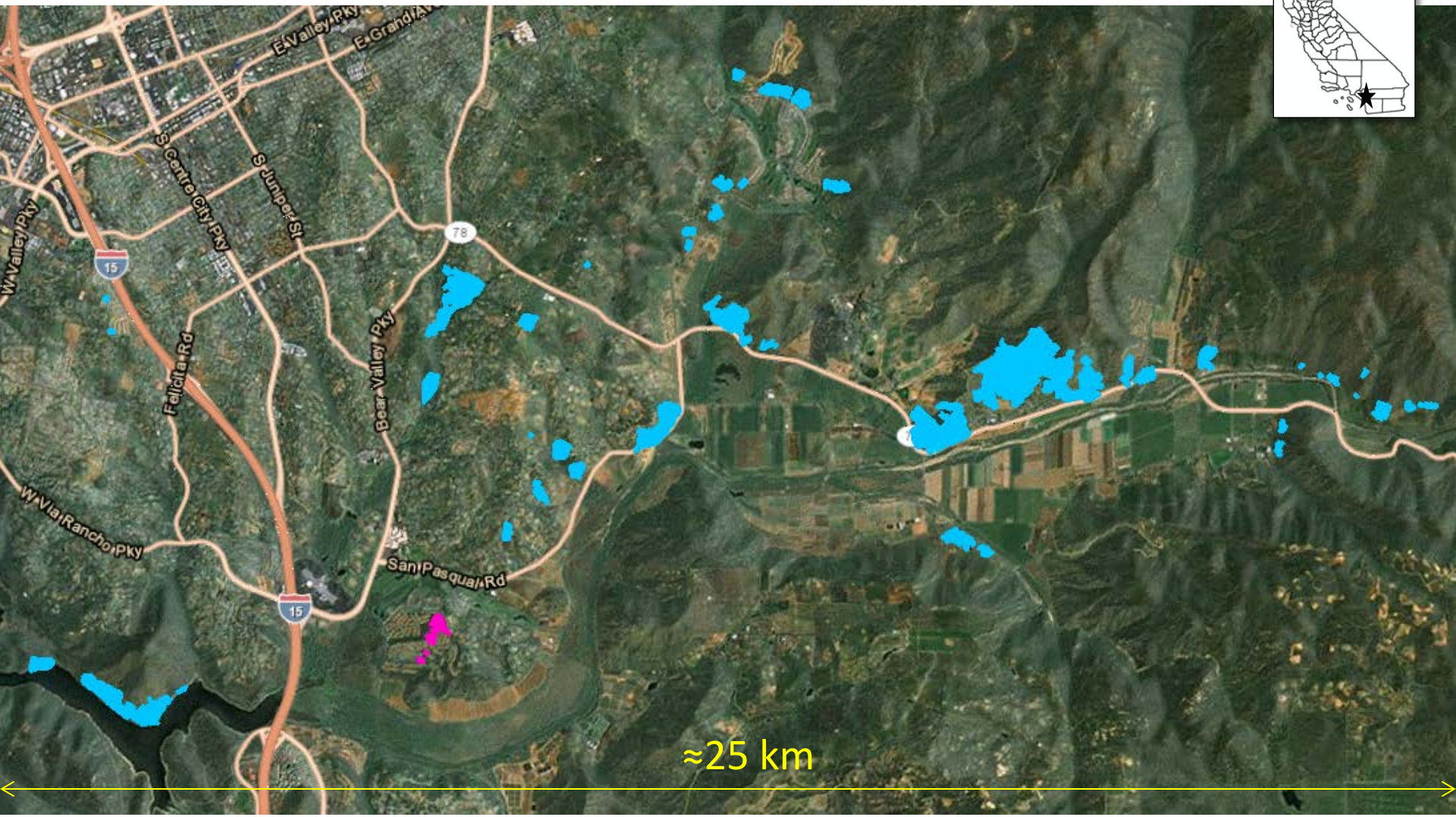
In response to the 2007 Witch Creek Fire, where should we focus restoration efforts?

When thinking about ideal cactus wren habitat, consider primary threats:

- Fragmented habitat patches are genetically isolated
- Small patches are demographically vulnerable
- Connectivity allows for re-colonization

- Fragmentation protects patches from single catastrophic fire
- Good habitat often occurs in fire-prone areas

Current Cactus Wren Habitat



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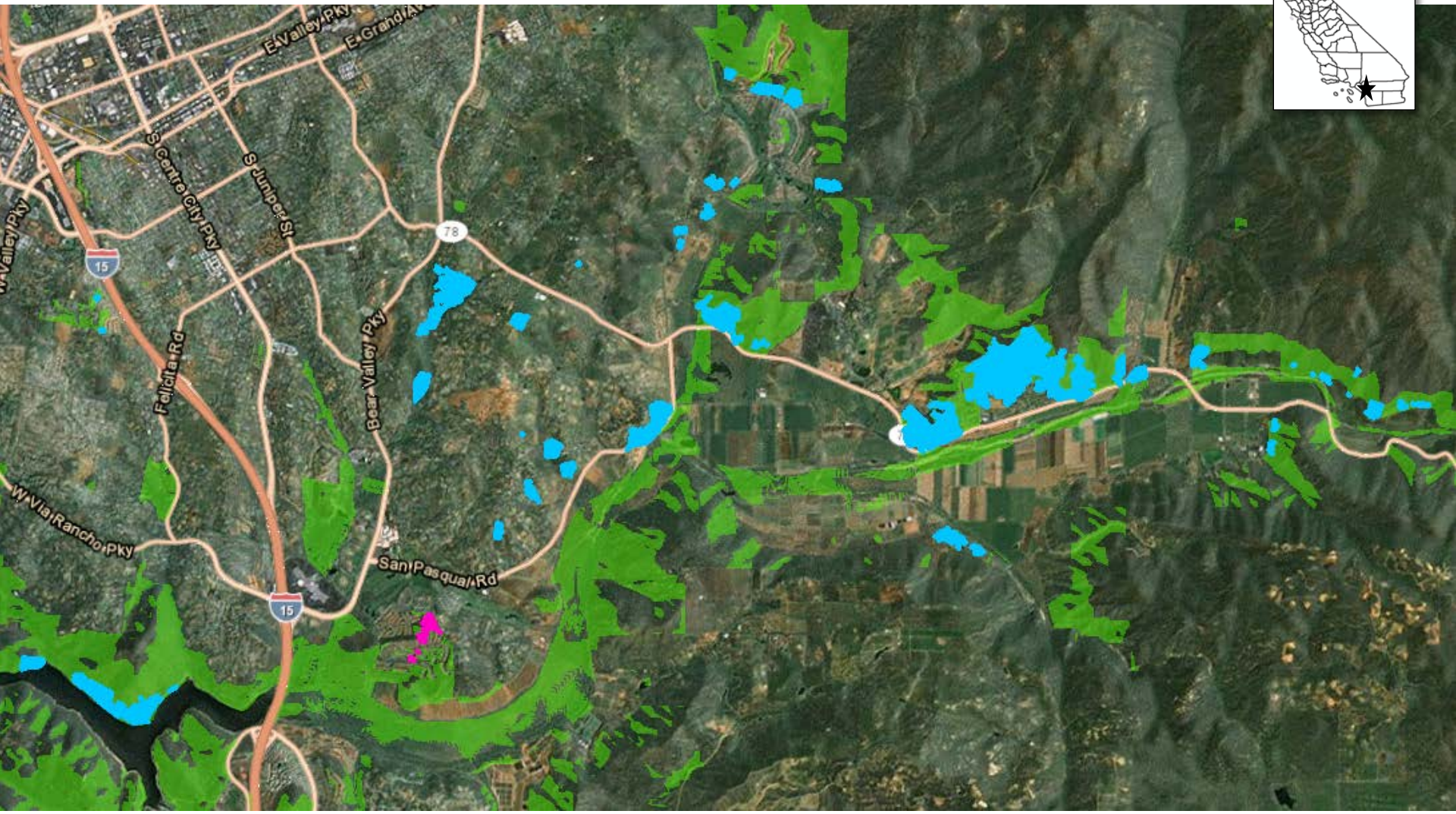
Current Cactus Wren Habitat

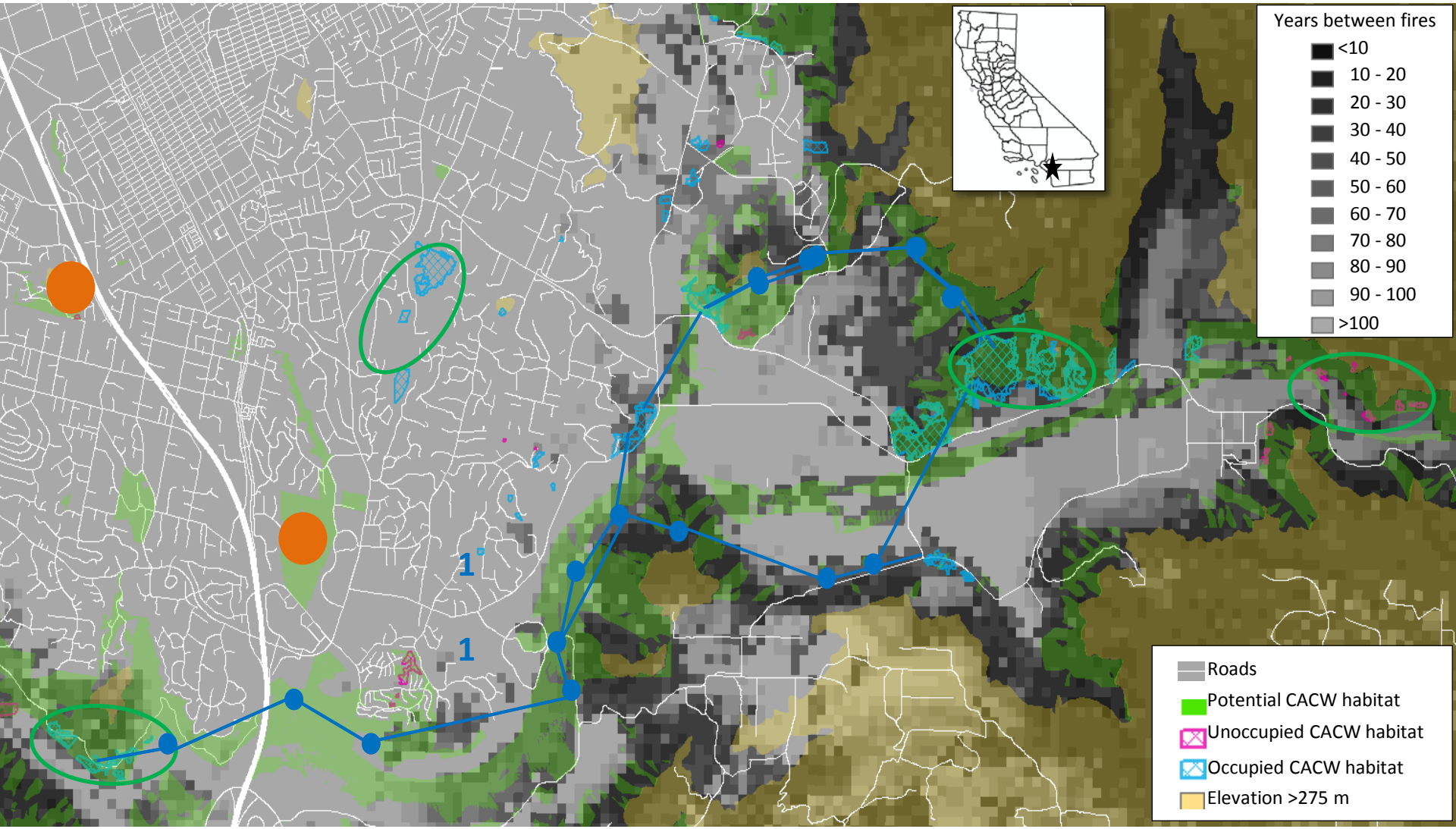


Unoccupied cactus

Occupied habitat

Potential habitat (south facing, coastal sage, preserved, low elevation)

Potential Cactus Enhancement Sites and Strategies



Unoccupied cactus

Occupied habitat

Potential habitat

Stepping stone corridor

Augment existing habitat

Fire refuge

To choose a restoration site, we need a meta-population model that:

Incorporates risk due to fragmentation and isolation

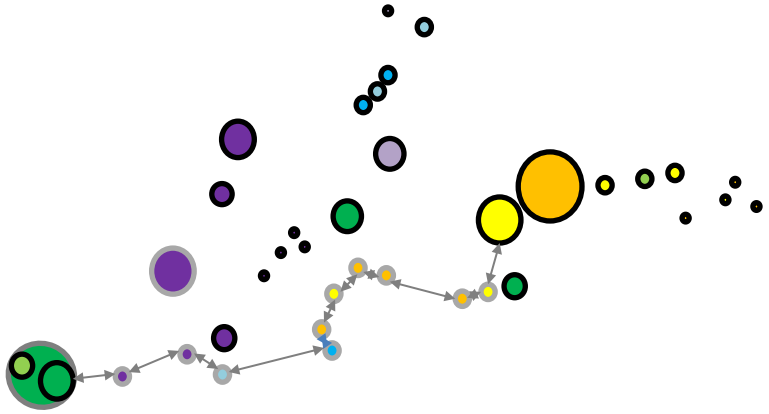
- Population, or patch, size
- Annual adult survival
- Annual juvenile survival
- Fecundity
- Dispersal

Incorporates risks due to fire

- Fire frequency
- Impact of fire
- Dispersal

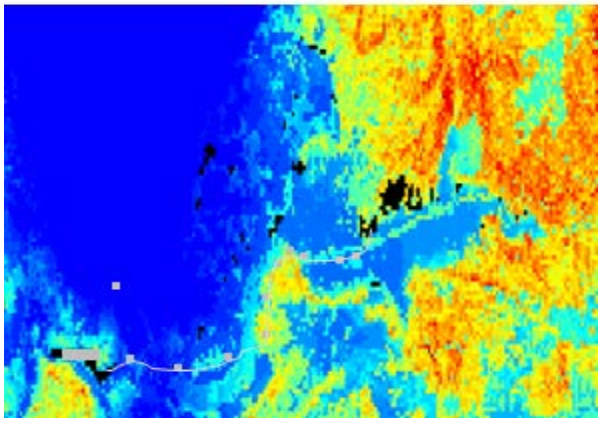
Compare two modeling techniques

RAMAS – matrix metapopulation model



versus

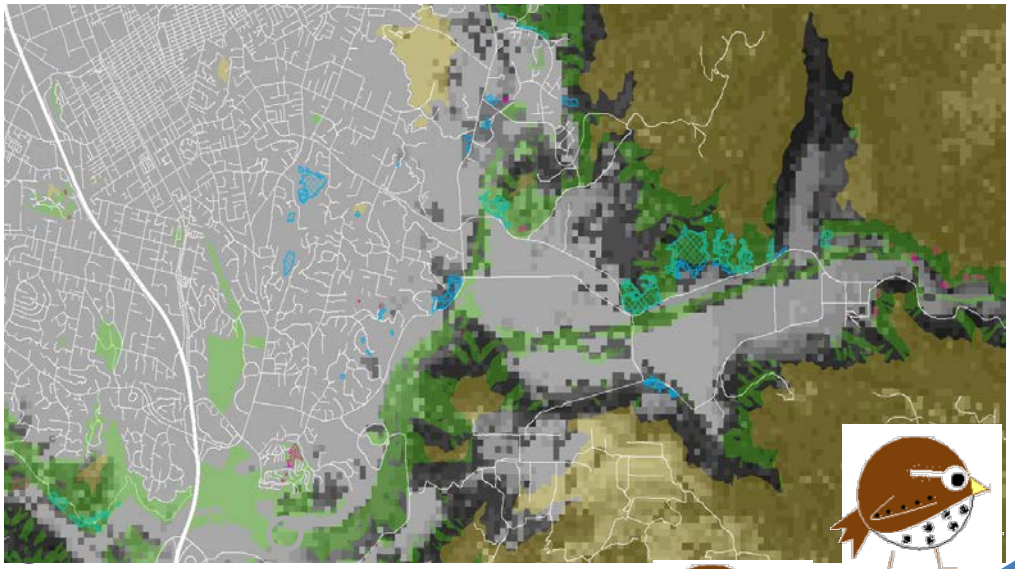
Individual model



These models differ primarily in how they treat the space between habitat patches.

Forecast 50 years into the future and compare outcomes under different strategies for restoring 20 and 200 hectares of cactus wren habitat.

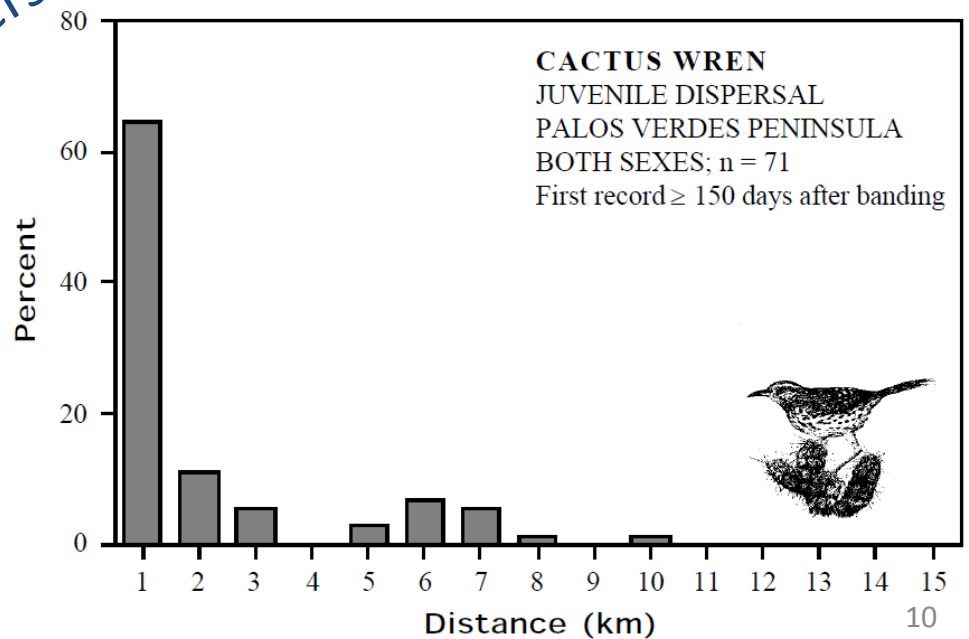
Model 1: RAMAS matrix metapopulation



In each year and patch, the vital rates change subject to these averages.

$$\begin{bmatrix} n_{juv}(t) \\ n_{adult}(t) \end{bmatrix} = \begin{bmatrix} 0.394 & 0.804 \\ 0.311 & 0.623 \end{bmatrix} \begin{bmatrix} n_{juv}(t-1) \\ n_{adult}(t-1) \end{bmatrix}$$

Dispersal



Model 1: Limitations

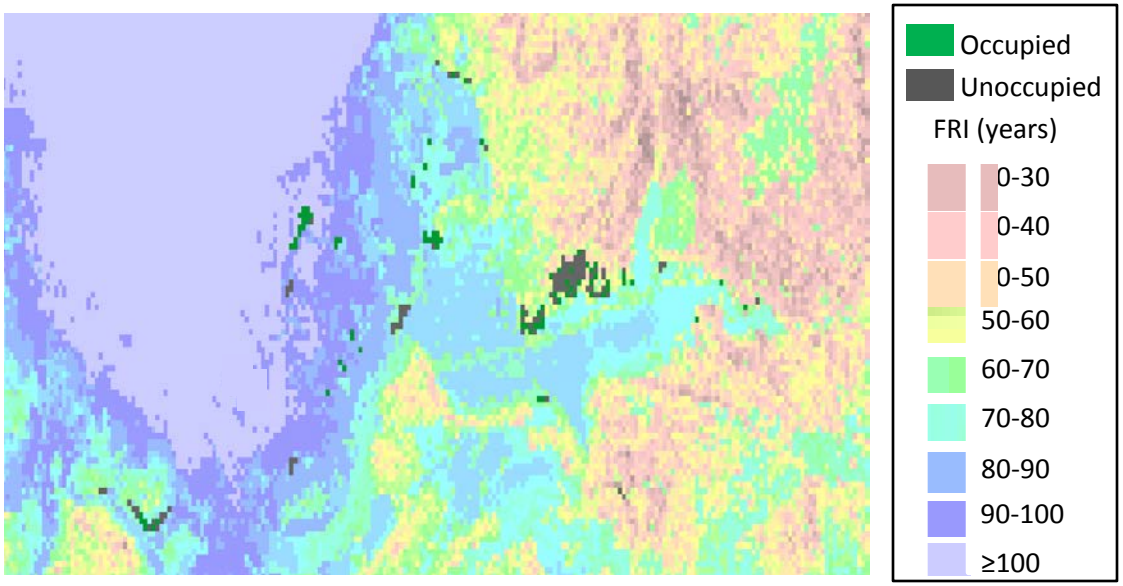
Simple interpretation of the landscape

- Patch or no patch
- No “matrix” in between patches
- No edge effects
- No fire spread
- Dispersal is probabilistic, not deliberate
- No cost to dispersal
- Cannot consider patch geometry

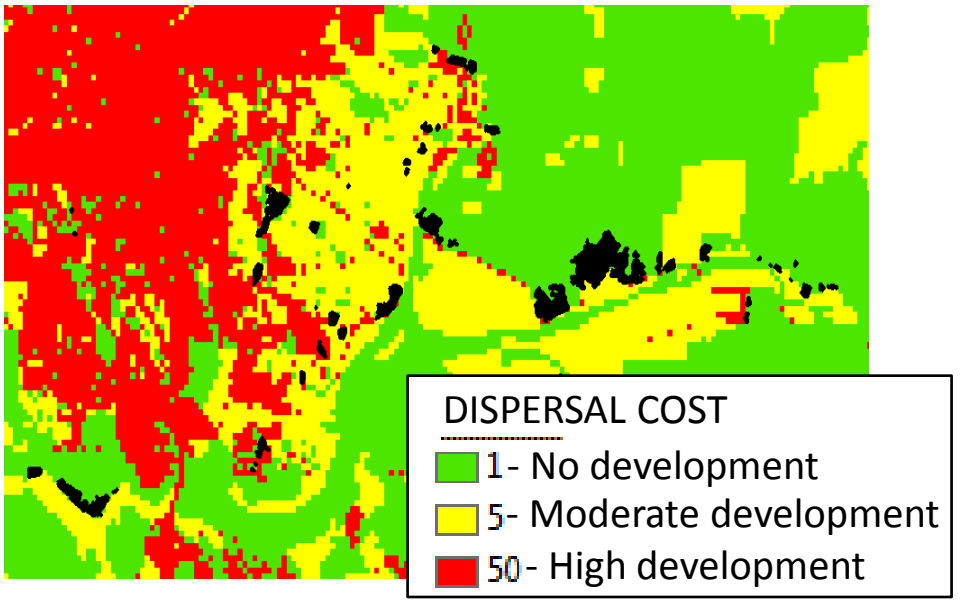
Model 2: Individual model

The entire landscape is considered, impacting:

(i) how fire is modeled,

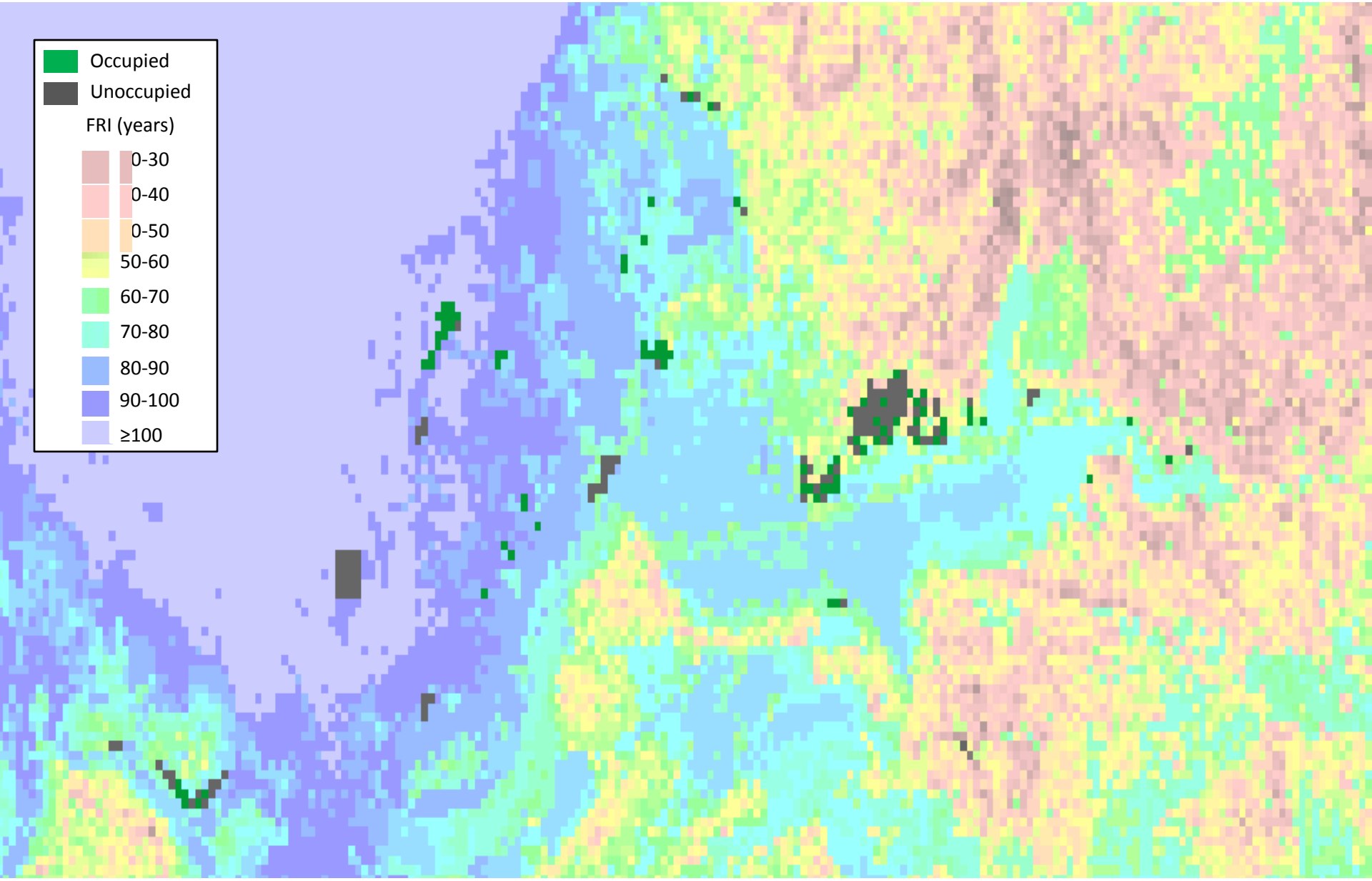


(ii) how dispersal is modeled.



Wren adult and juvenile survival and fecundity are the same between the two models.

Model 2: Fires in the individual model



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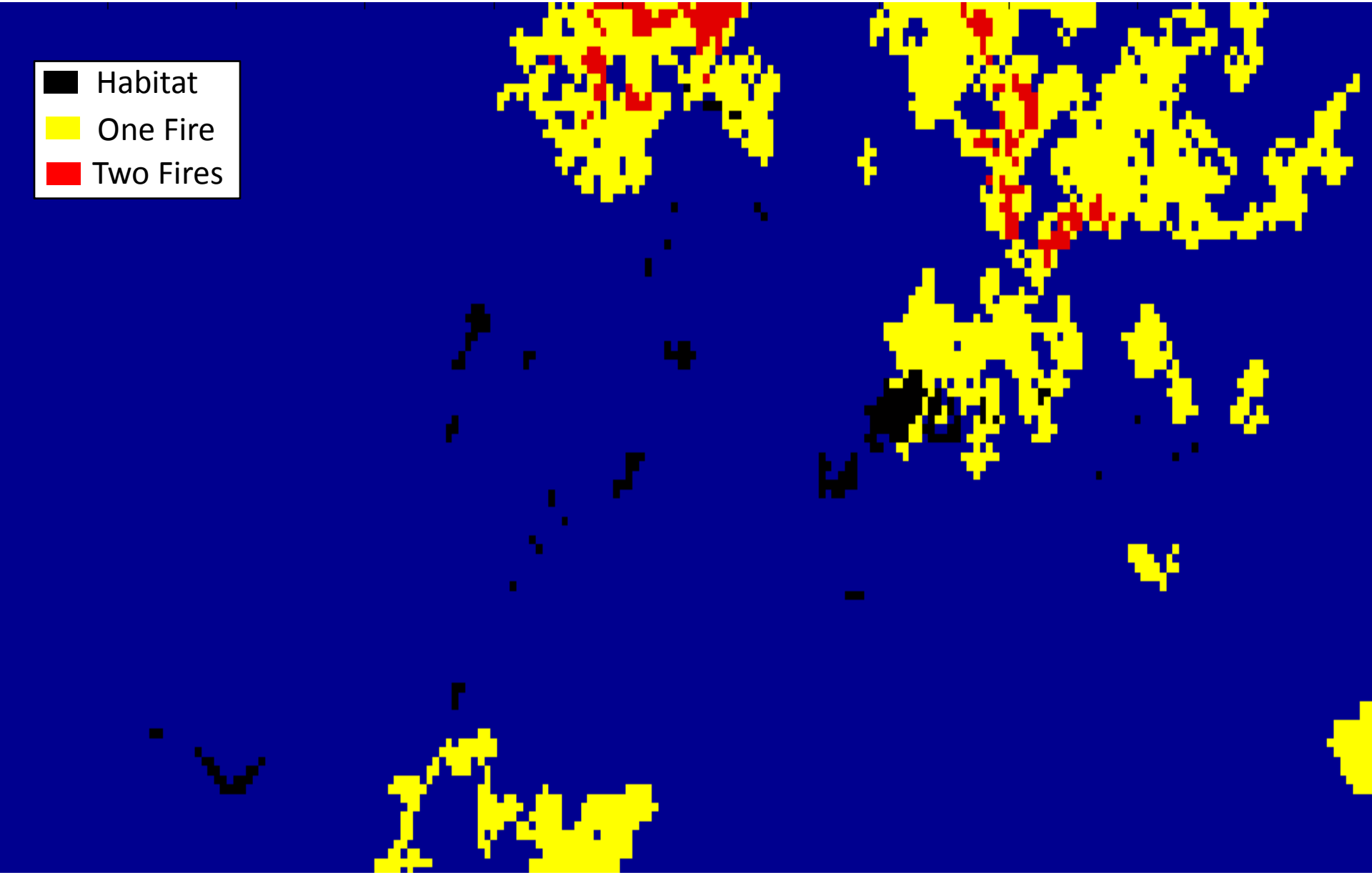
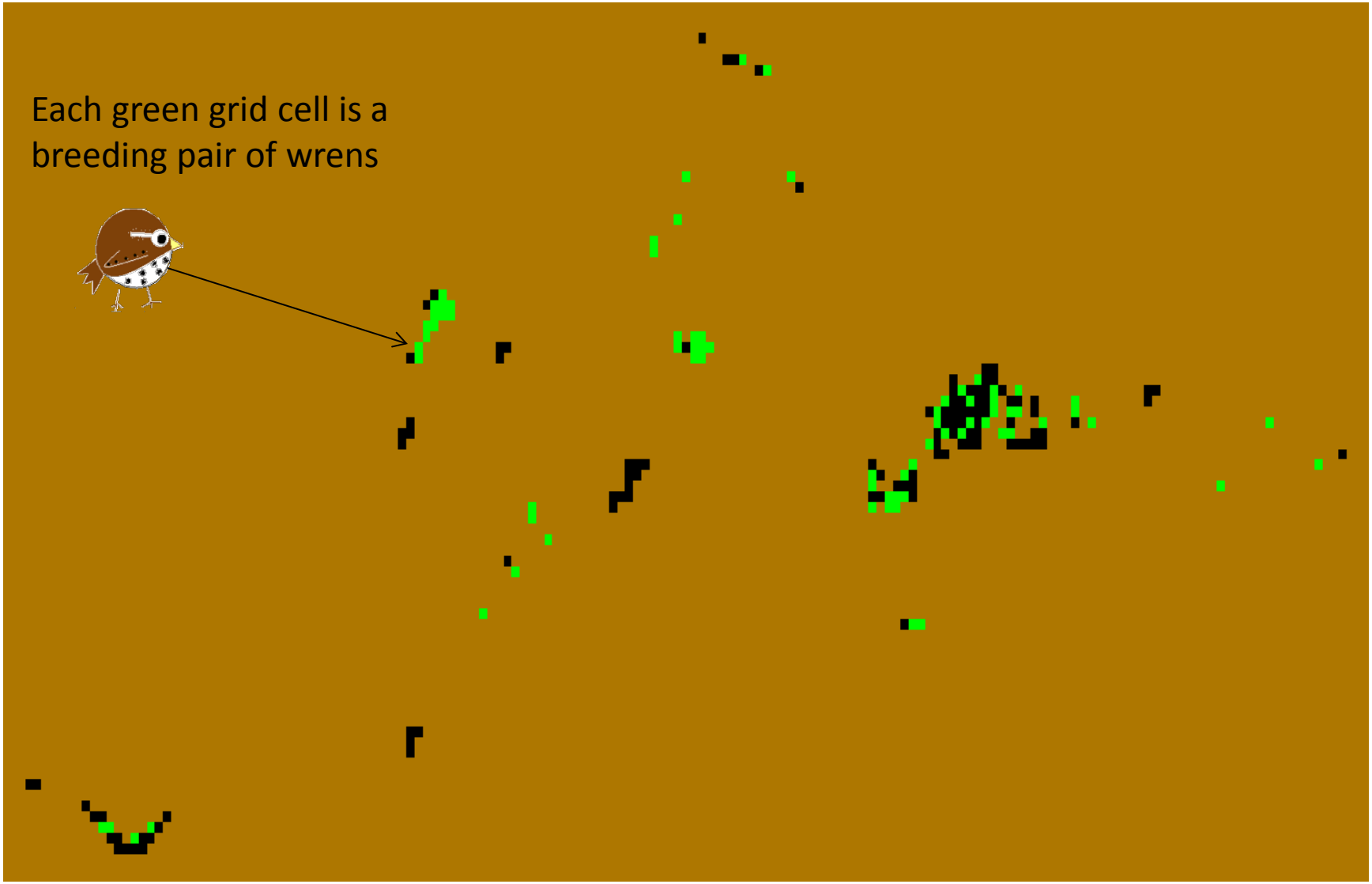


Model 2: Births and deaths in the individual model



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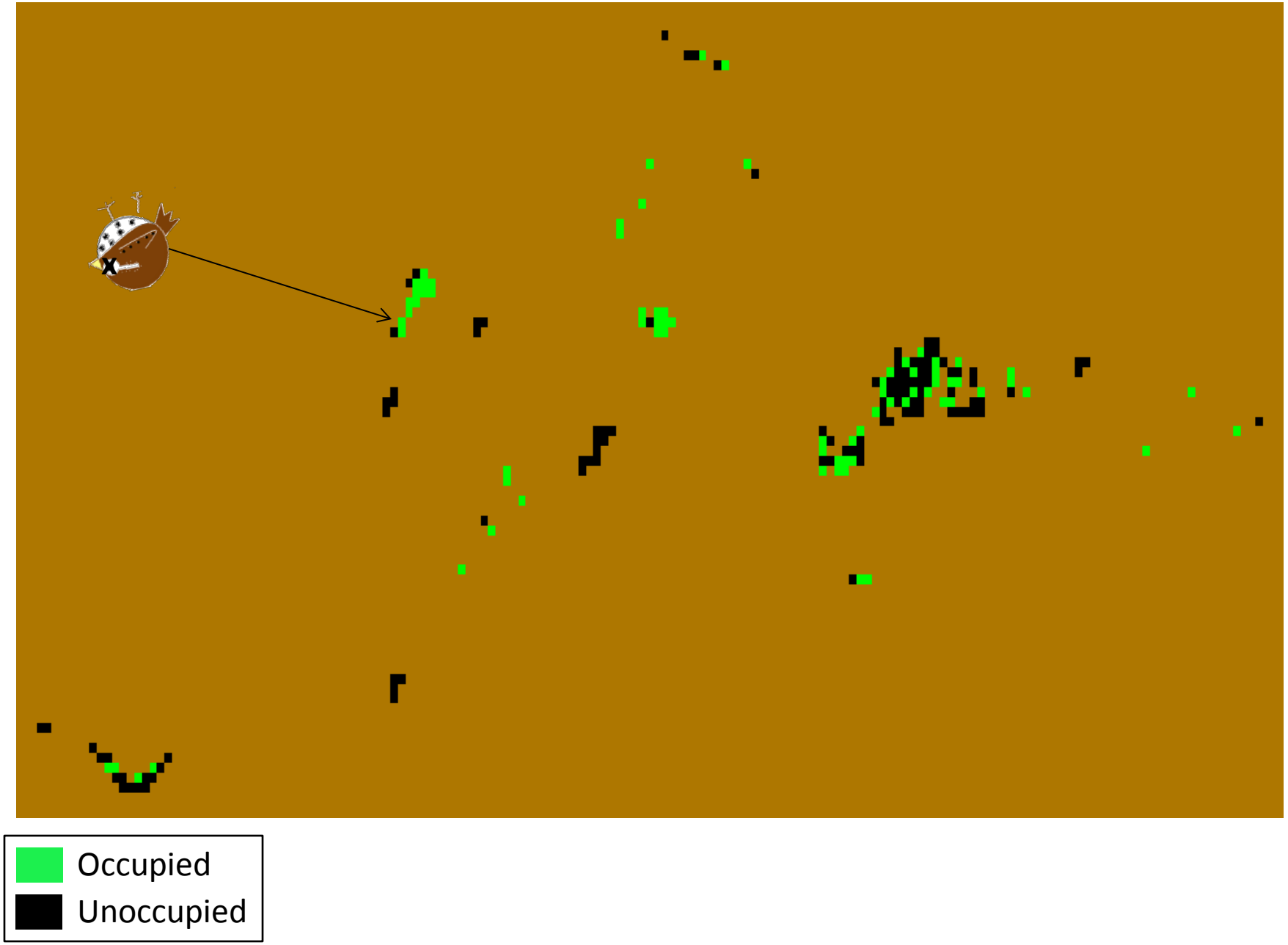

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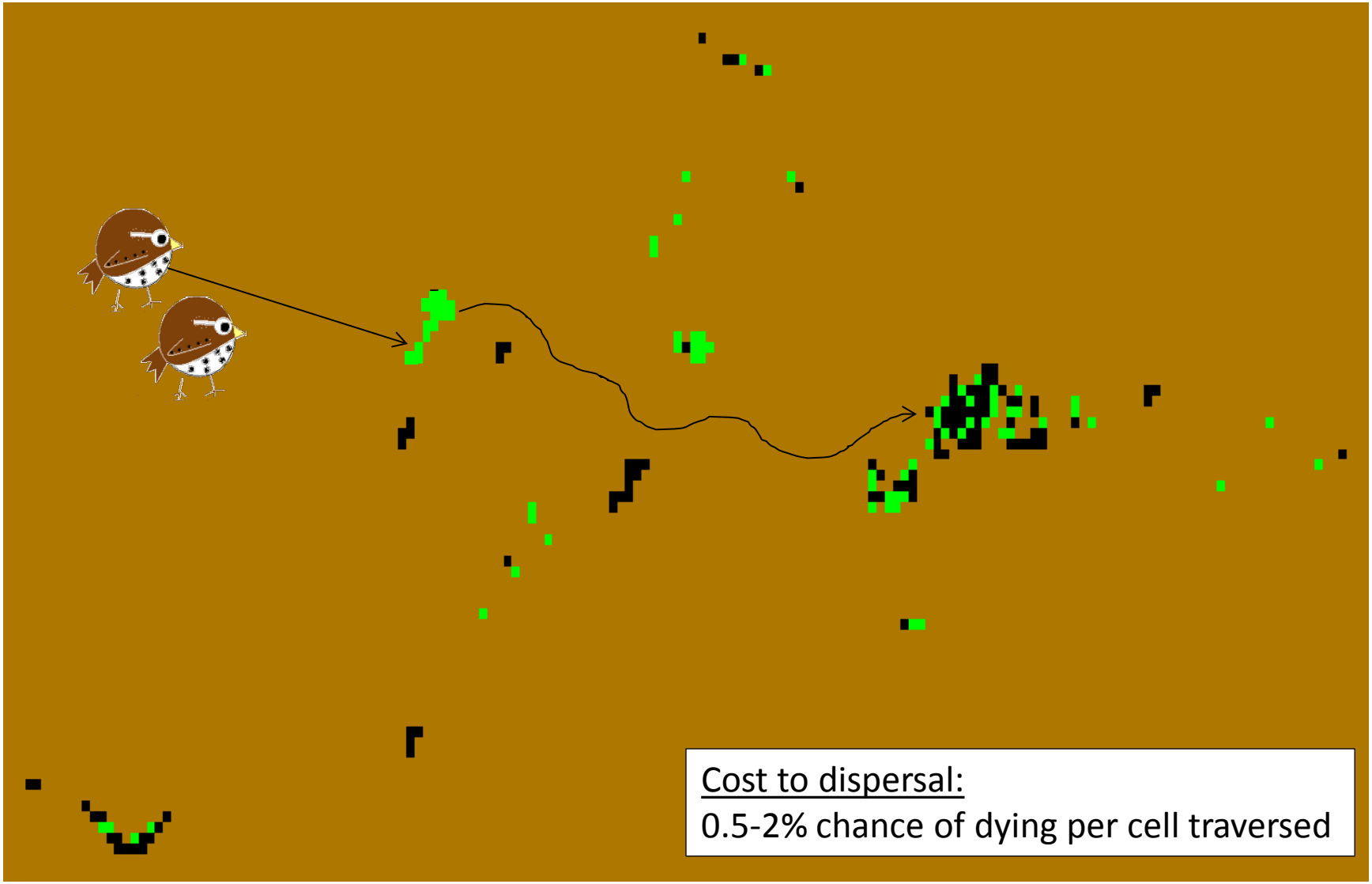
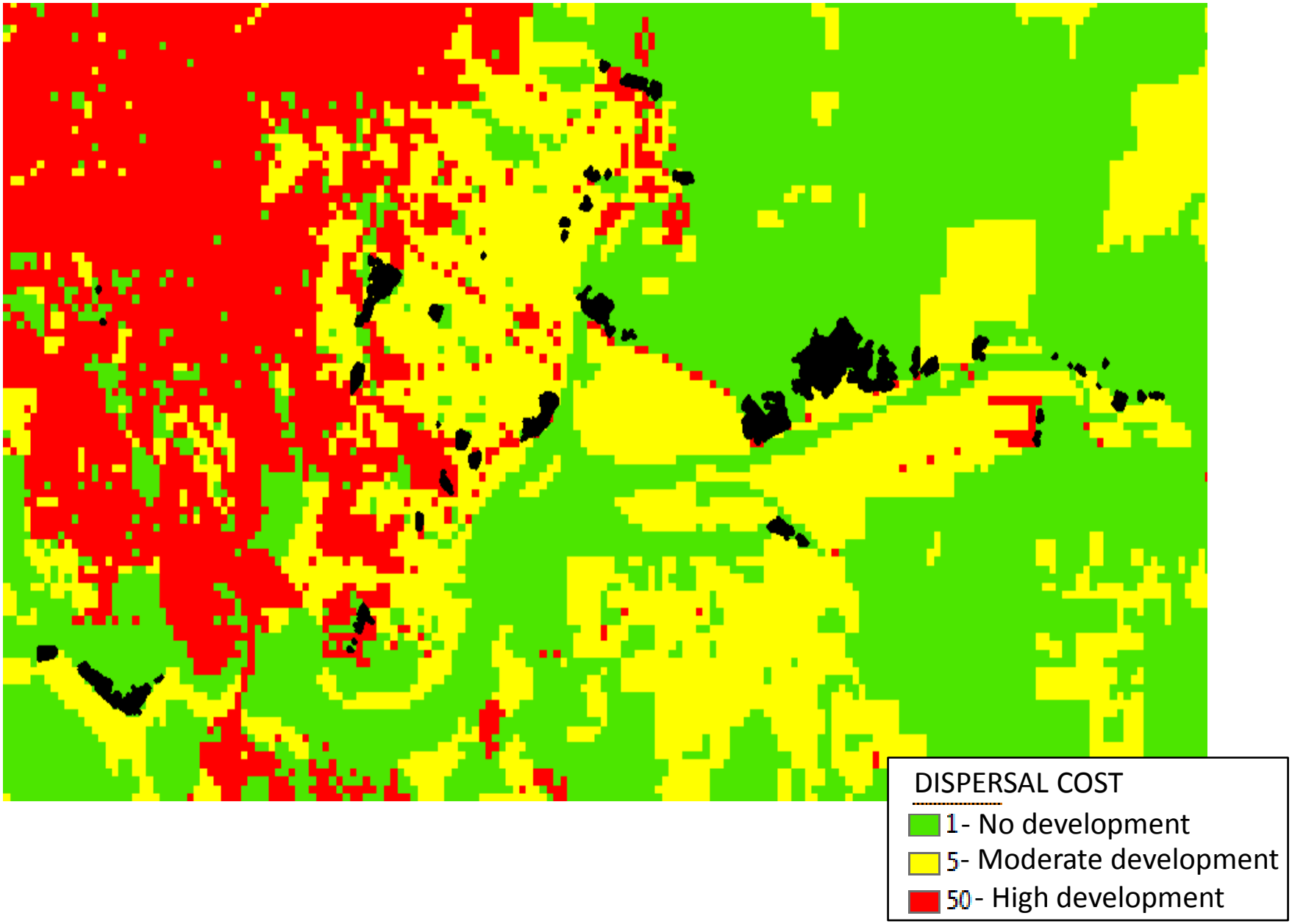
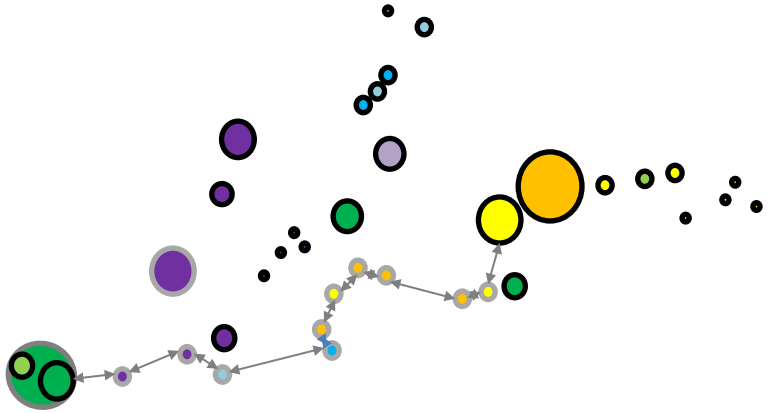


Model 2: Individual model



Model Comparison

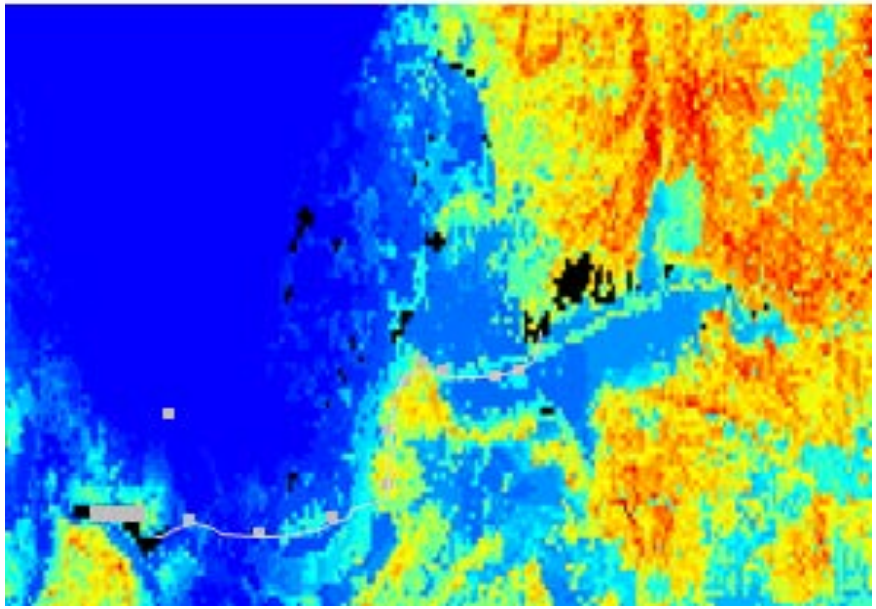
RAMAS – matrix metapopulation model



Advantages:

- Simpler
- Developed methods and software
- Short computation times

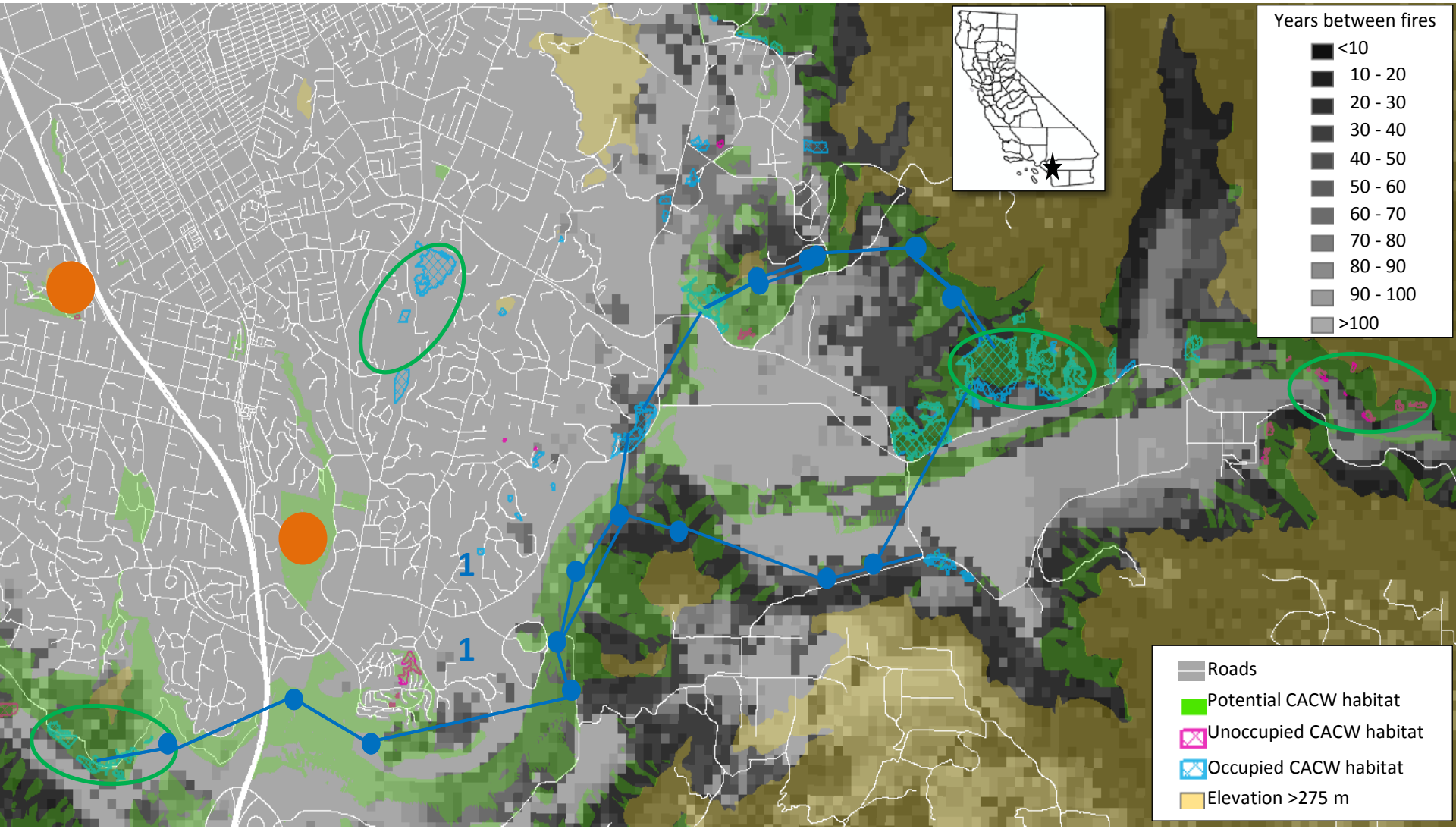
Individual model



Advantages:

- Realistic fire spread
- No loss of habitat geometry
- Cost to dispersal

Potential Cactus Enhancement Sites and Strategies



Unoccupied cactus

Occupied habitat

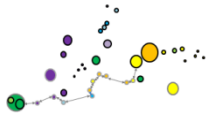
Potential habitat

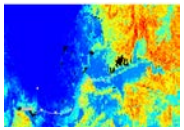
Stepping stone corridor

Augment existing habitat

Fire refuge

Results (20 ha of suitable habitat added)

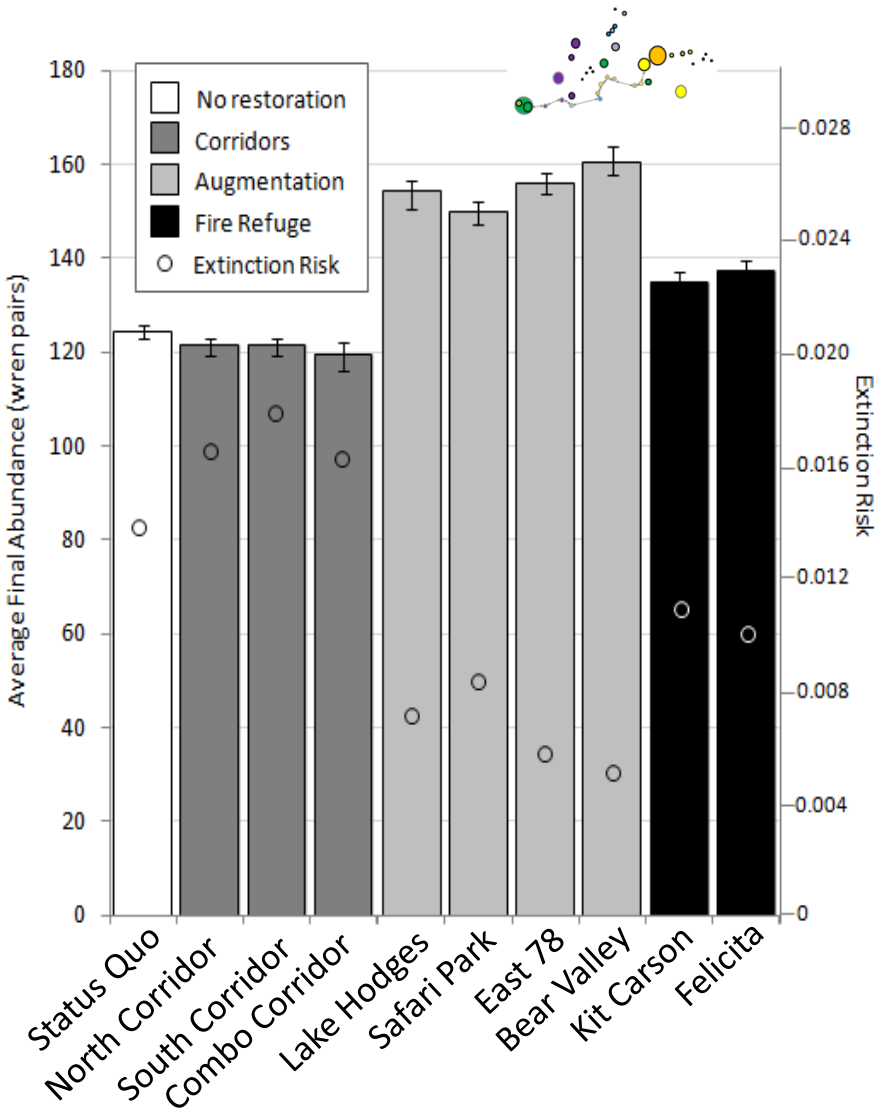




RAMAS matrix Model

Individual-based Model

Results (20 ha of suitable habitat added)



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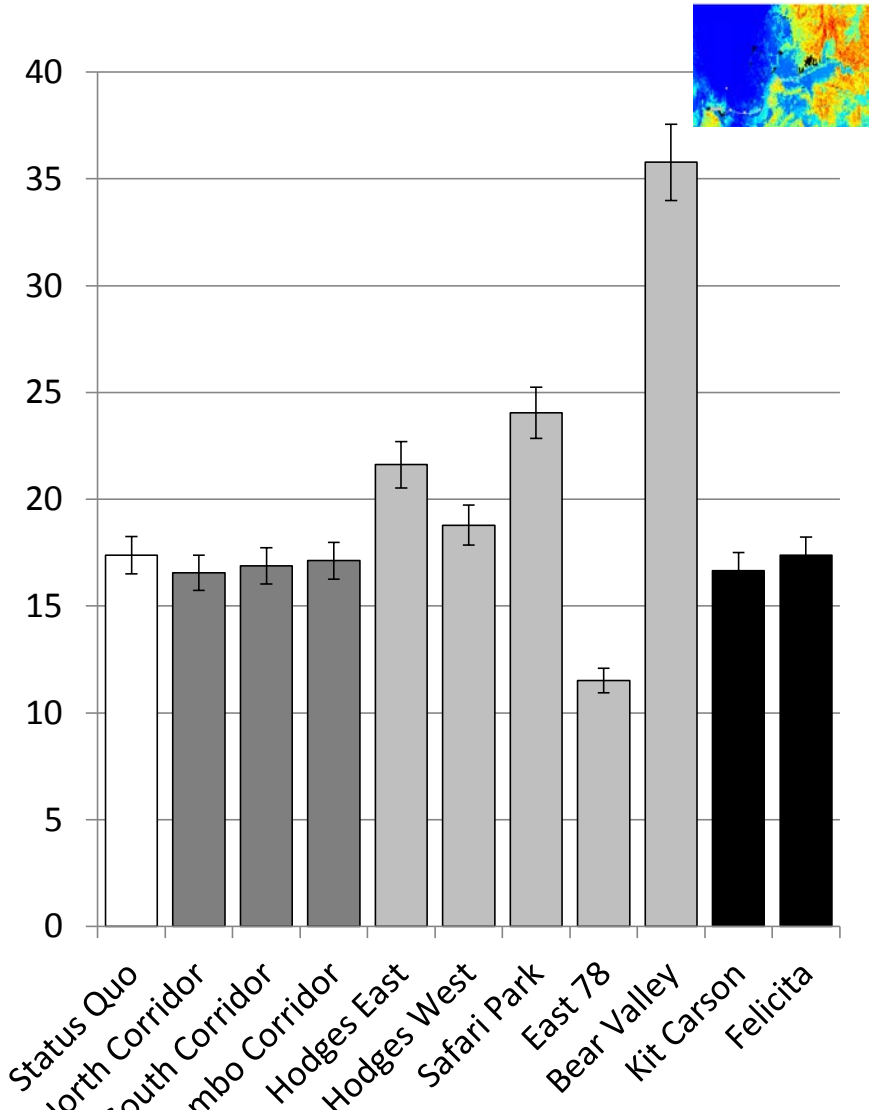

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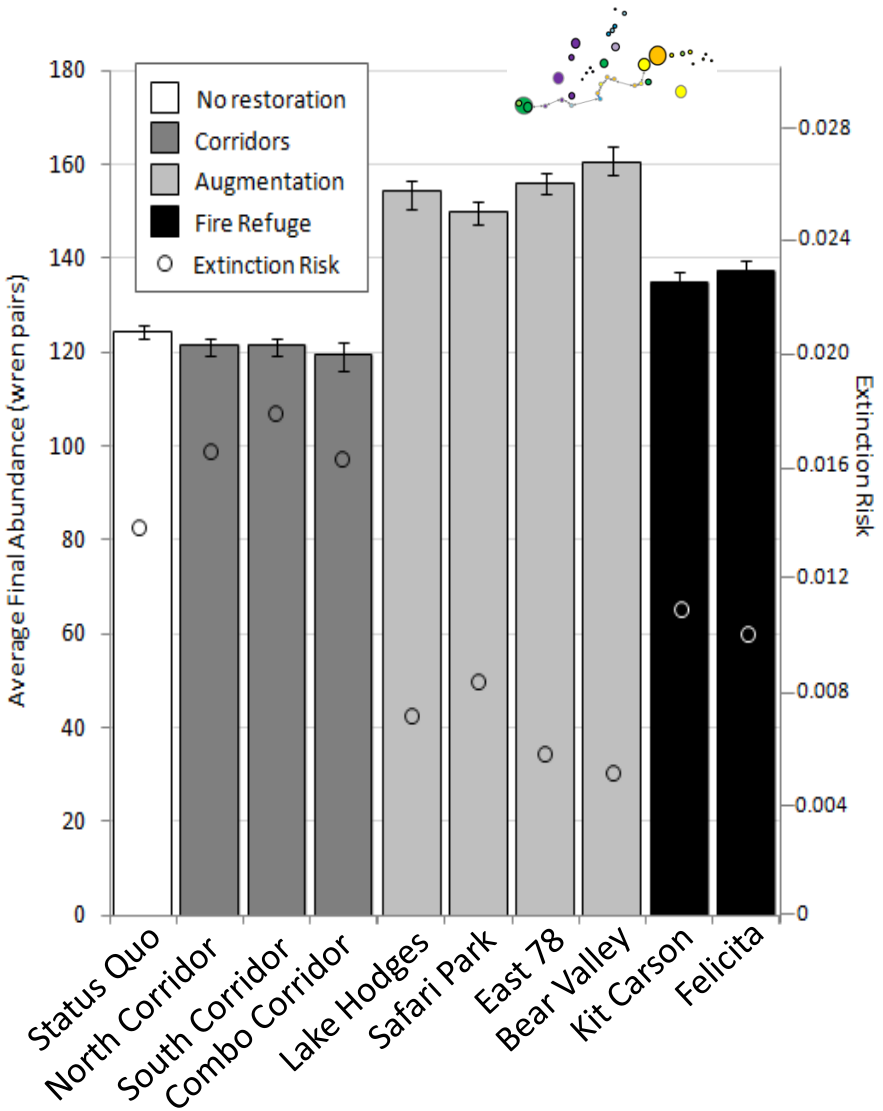

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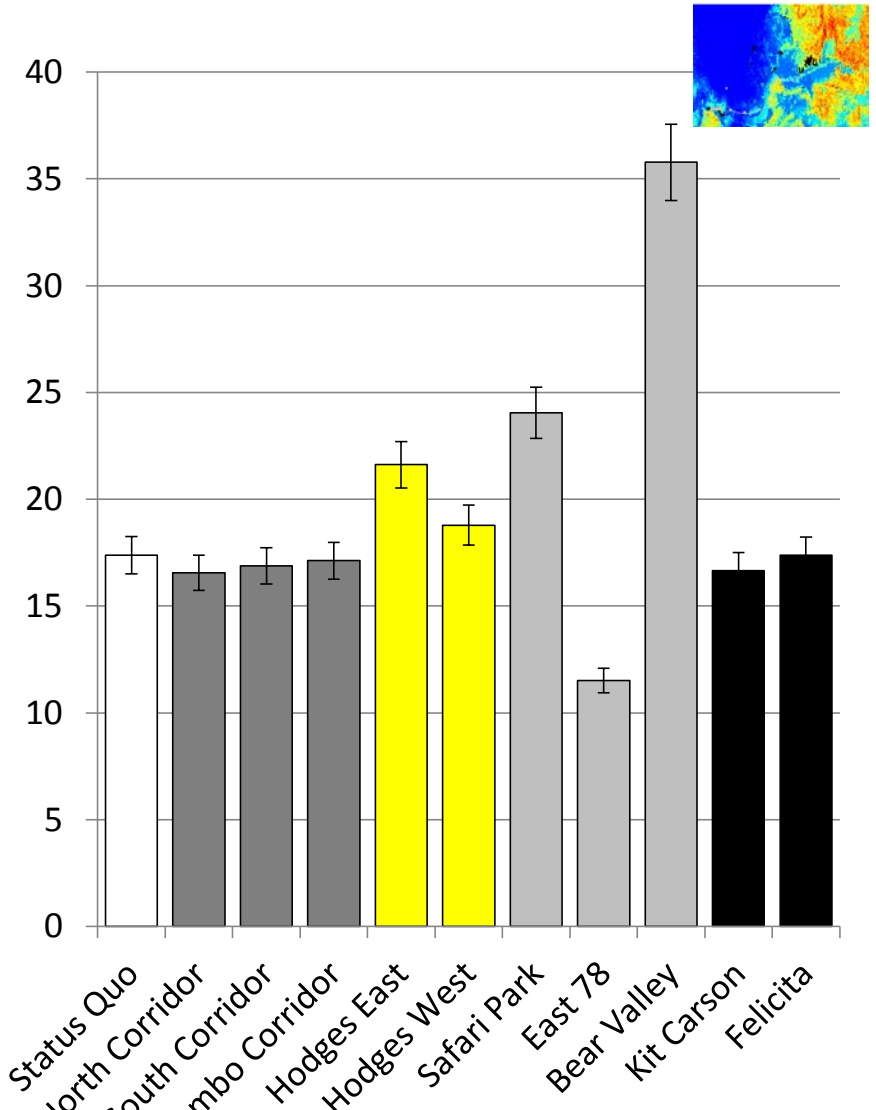
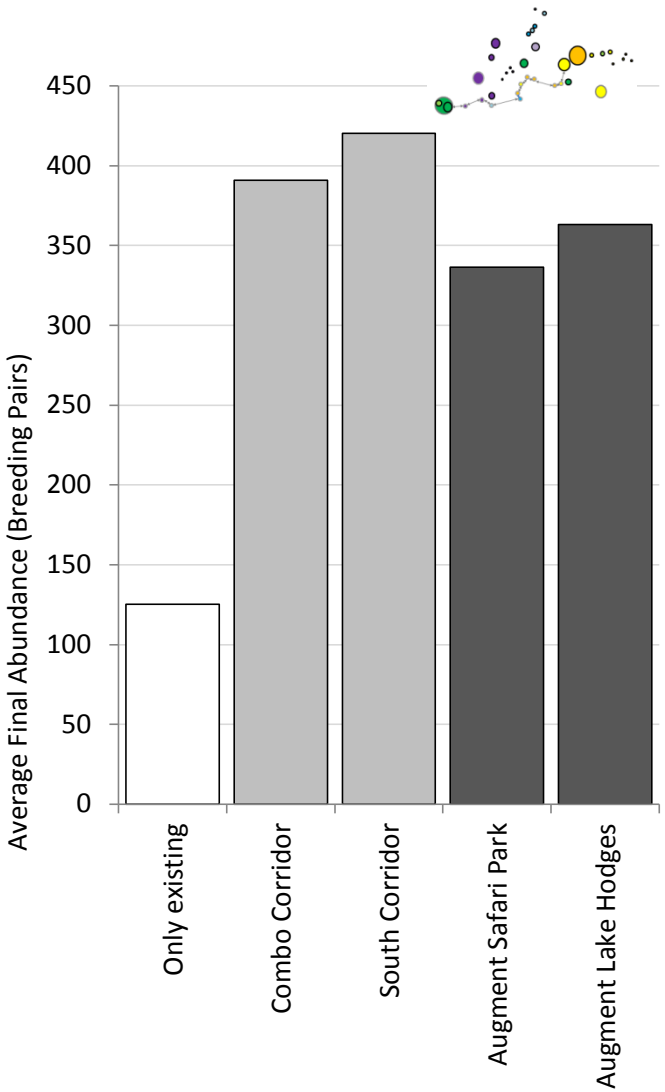
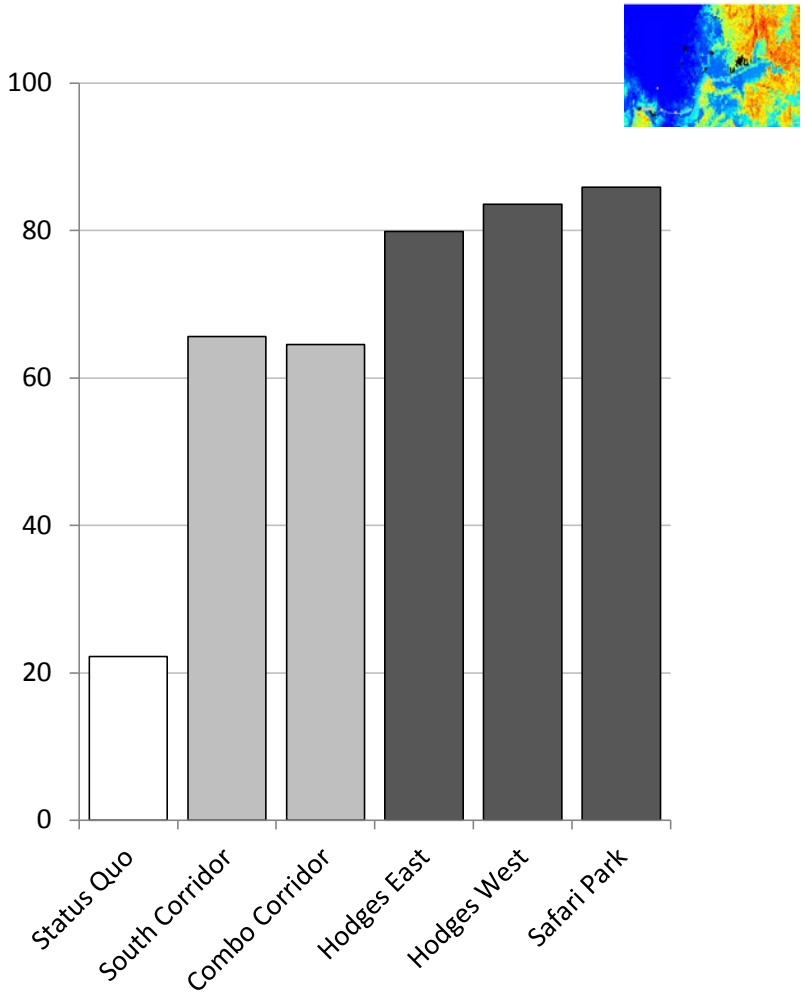


Individual-based Model

Results (200 ha of suitable habitat added)

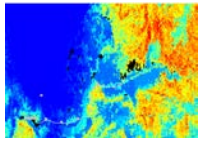


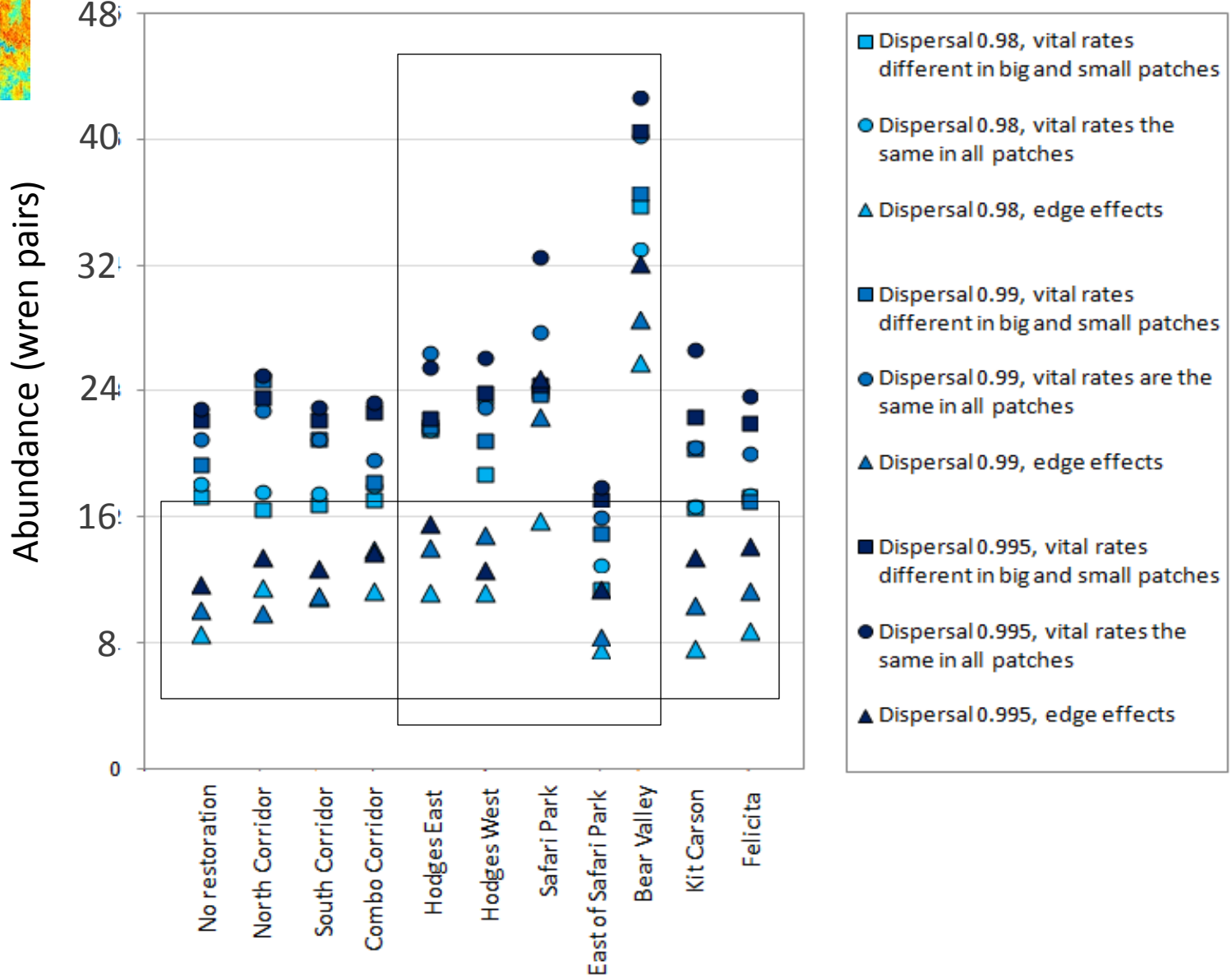
RAMAS matrix Model



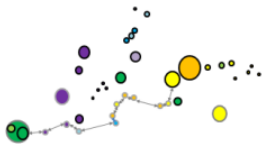
Individual-based Model

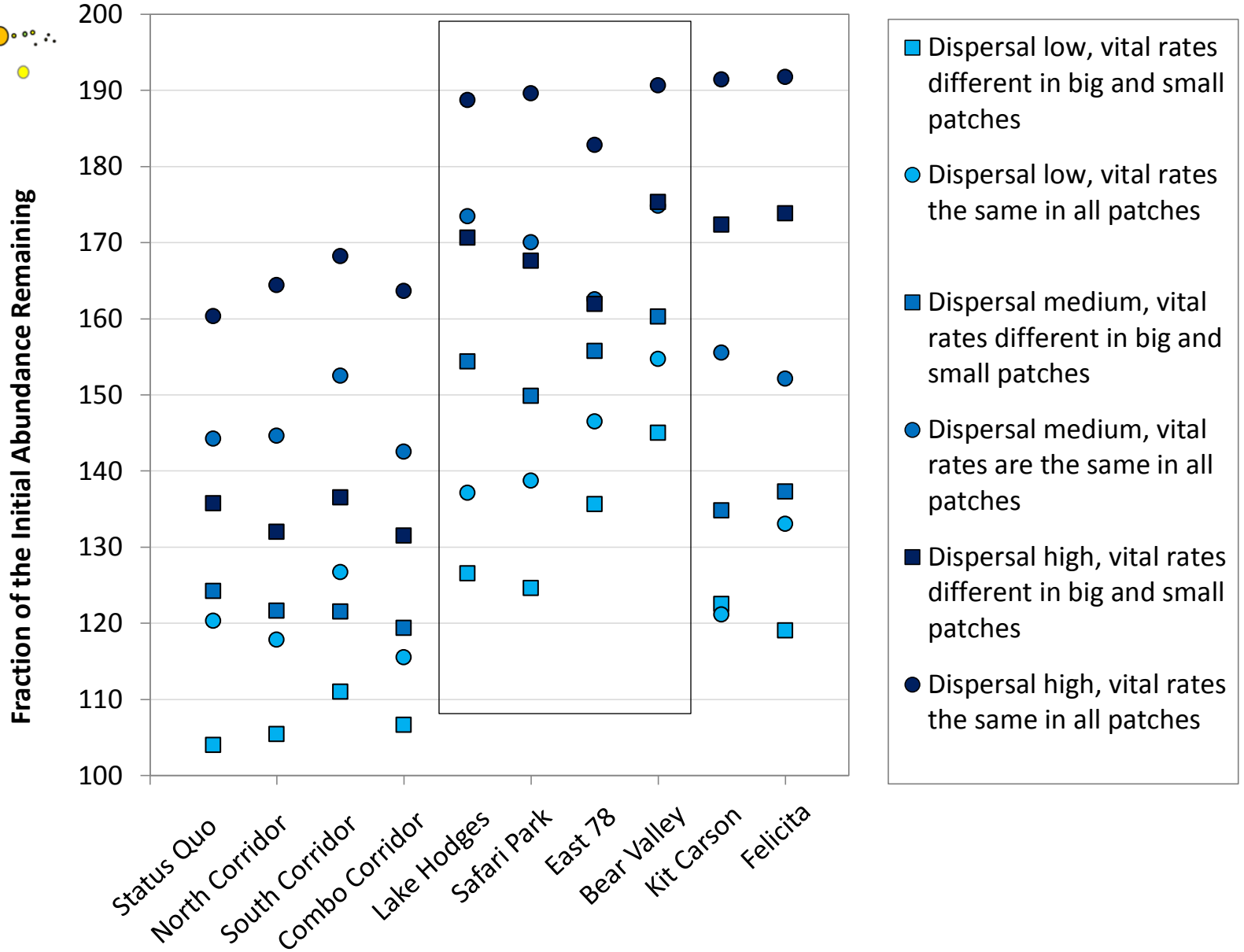
Sensitivity of individual-based model, adding 20 ha





Sensitivity of RAMAS matrix model, adding 20 ha





Summary

- When 20 ha are restored, habitat augmentation is best
- When 200 ha are added the models recommend different strategies
- Cost of dispersal is important
- Edge effects matter
- Geometry of the landscape is predicted not to be important at our site

Acknowledgements

Bryan Endress

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Rosa Chung

Colleen Wisinski

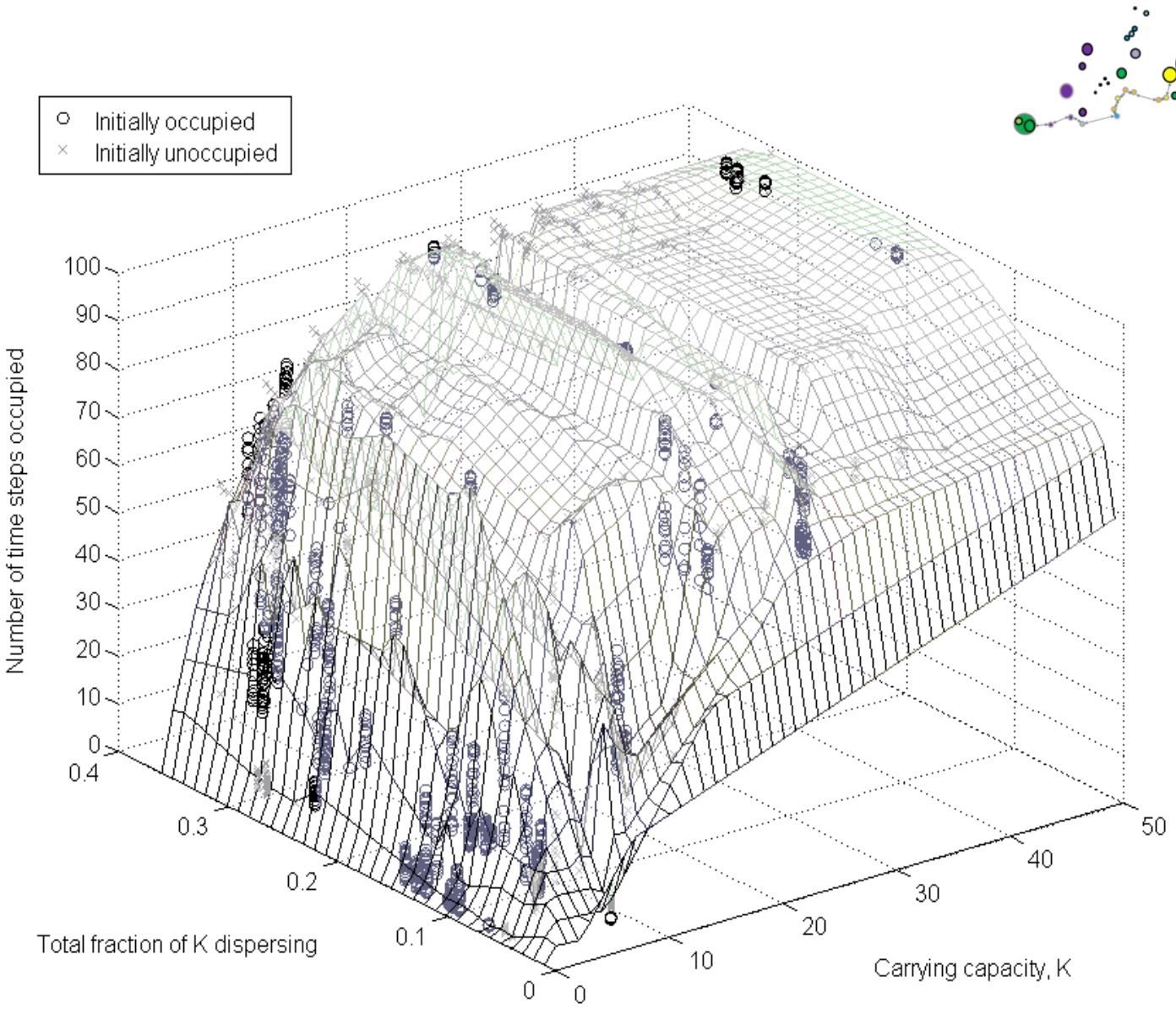
SAN DIEGO ZOO
INSTITUTE FOR
CONSERVATION
RESEARCH.

SANDAG

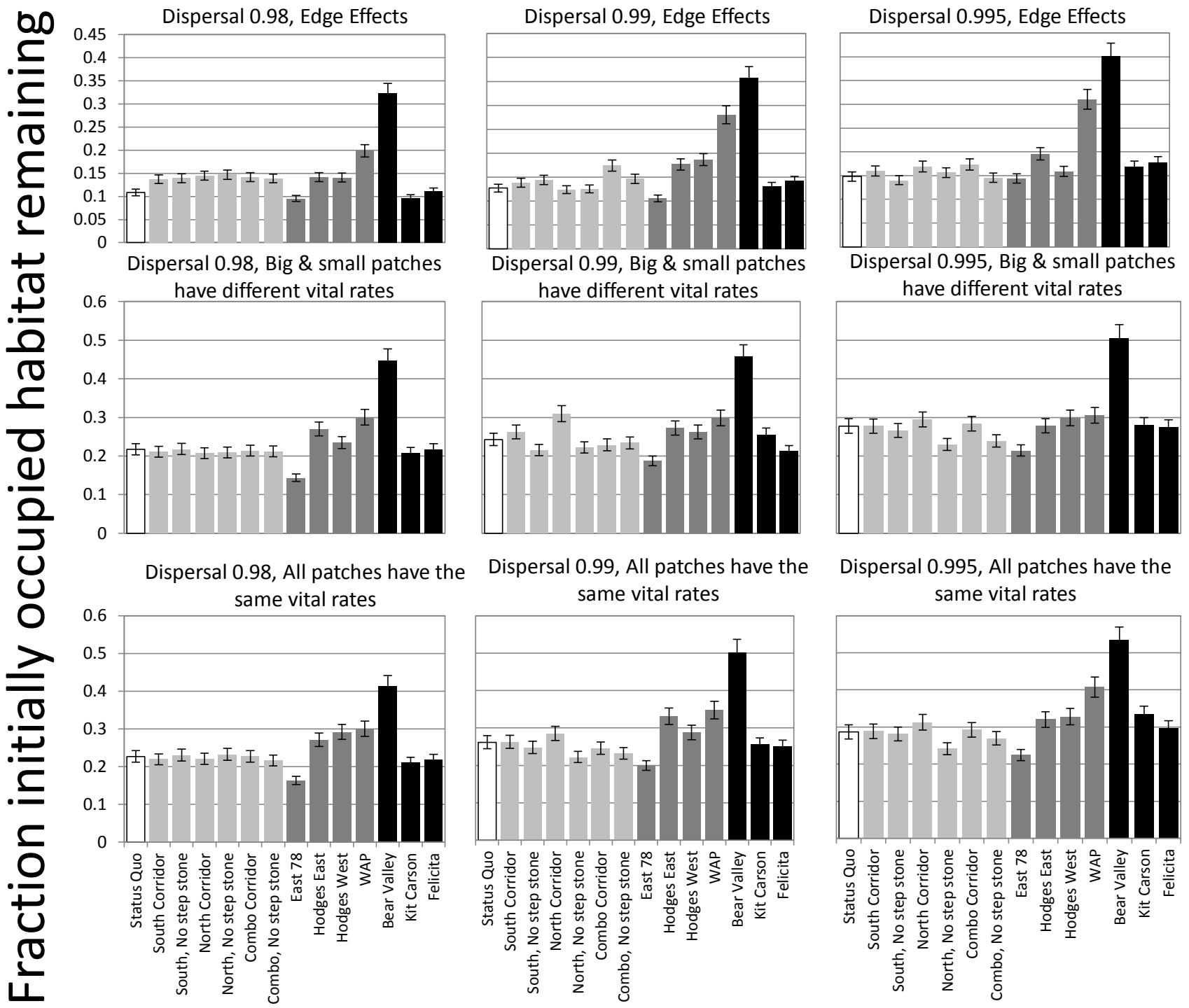
Bud C. Heller Fellowship

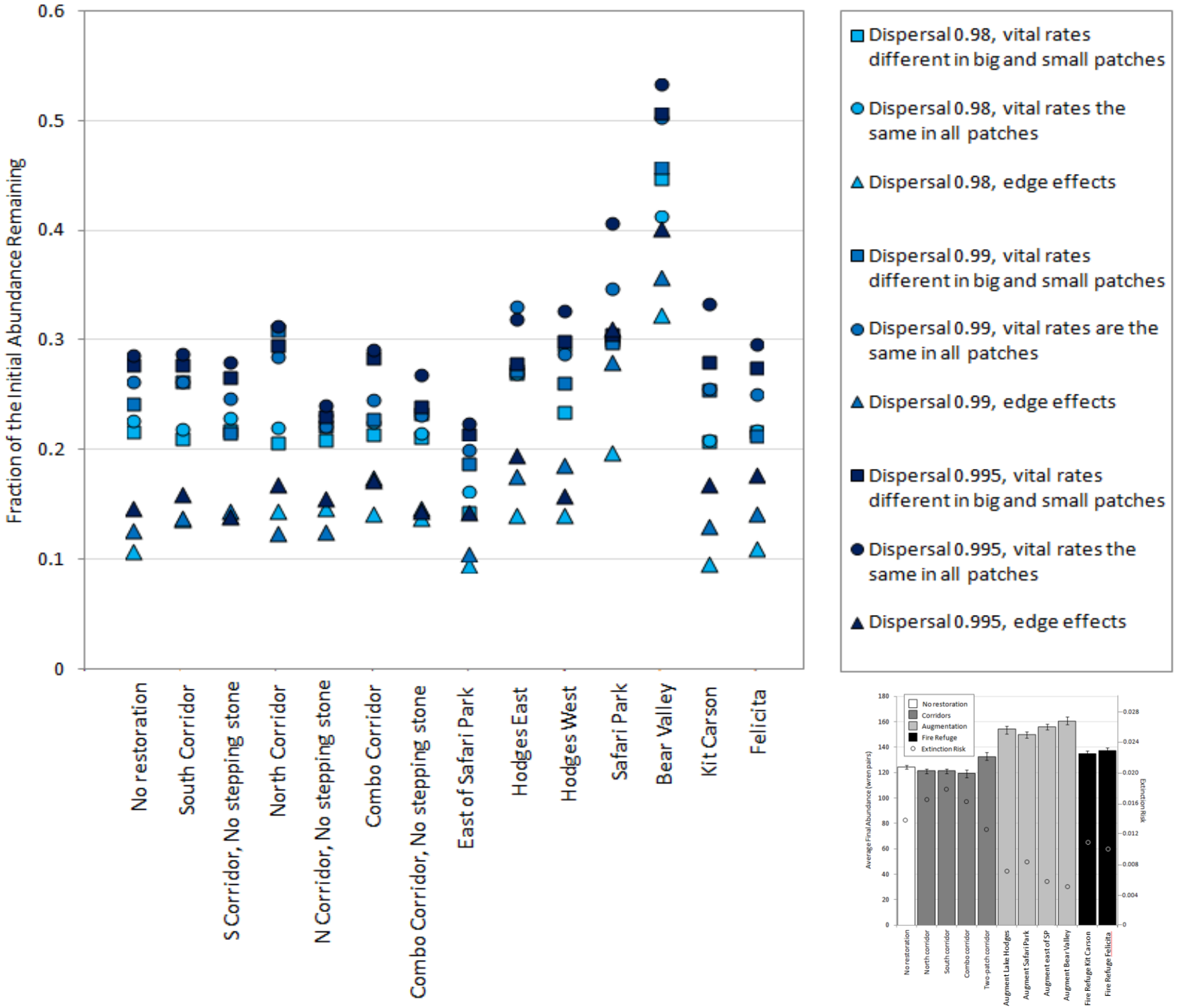

Thanks!

Results: Isolation versus occupancy



Results from the individual model (200 ha)




Fraction of the Initial Abundance Remaining
0.6
0.5
0.4
0.3
0.2
0.1
0
No restoration
South Corridor
S Corridor, No stepping stone
North Corridor
N Corridor, No stepping stone
Combo Corridor
Combo Corridor, No stepping stone
East of Safari Park
Hodges East
Hodges West
Safari Park
Bear Valley
Kit Carson
Felicita
Dispersal 0.98, vital rates different in big and small patches
Dispersal 0.98, vital rates the same in all patches
Dispersal 0.98, edge effects
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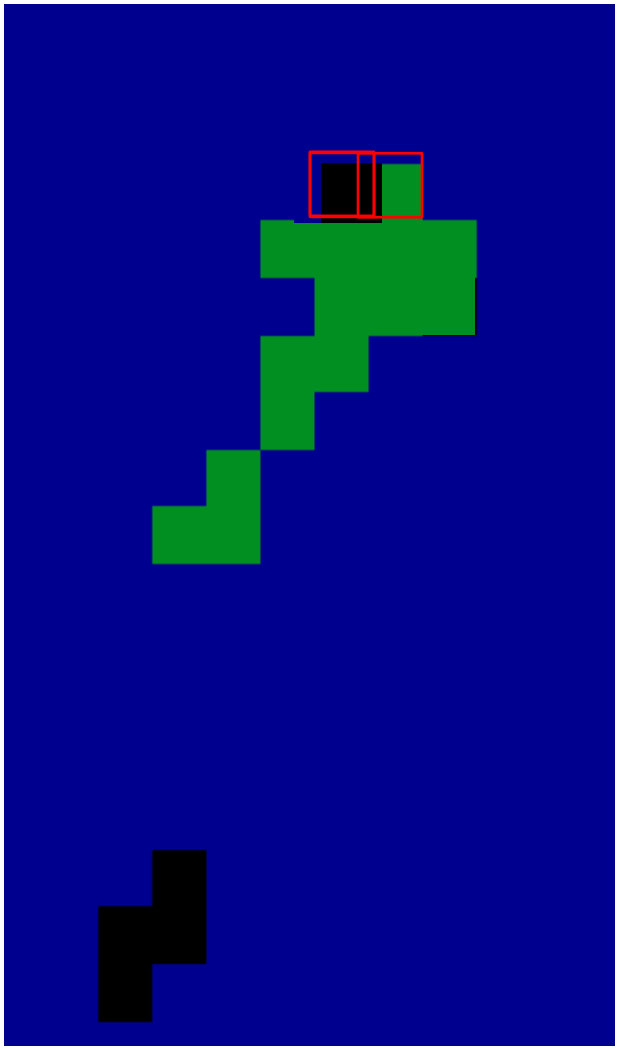
Dispersal 0.99, vital rates are the same in all patches
Dispersal 0.99, edge effects
Dispersal 0.995, vital rates different in big and small patches
Dispersal 0.995, vital rates the same in all patches
Dispersal 0.995, edge effects

No restoration
Corridors
Augmentation
Fire Refuge
Extinction Risk
Average Final Abundance (wren pairs)
Extinction Risk
No restoration
North corridor
South corridor
Combo corridor
Two-patch corridor
Augment Lake Hodges
Augment Safari Park
Augment east of SP
Augment Bear Valley
Fire Refuge Kit Carson
Fire Refuge Felicita

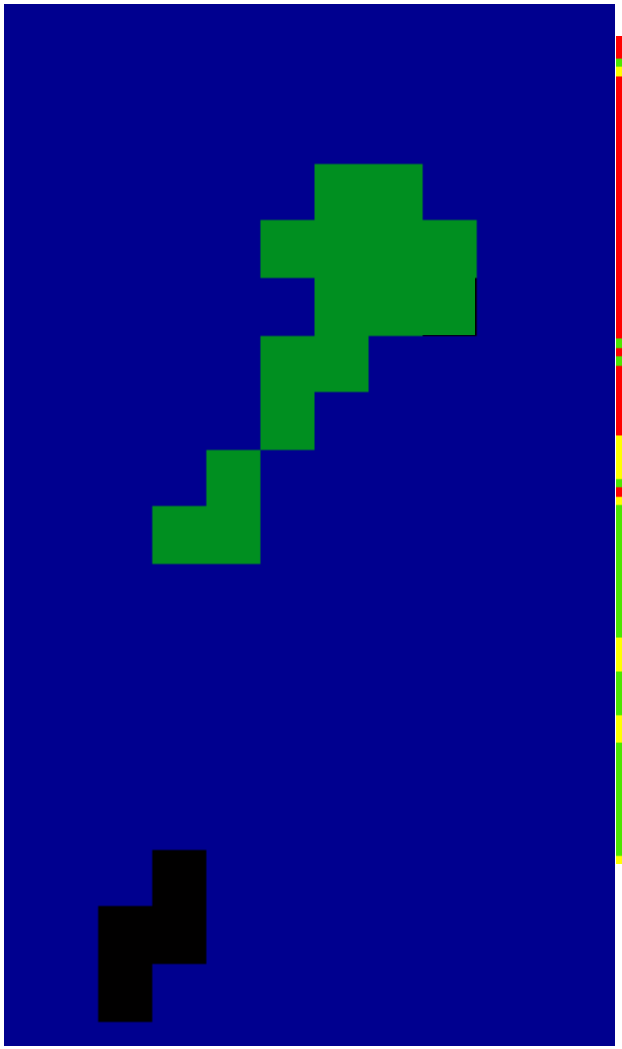
Model 2: Births and deaths in the individual model



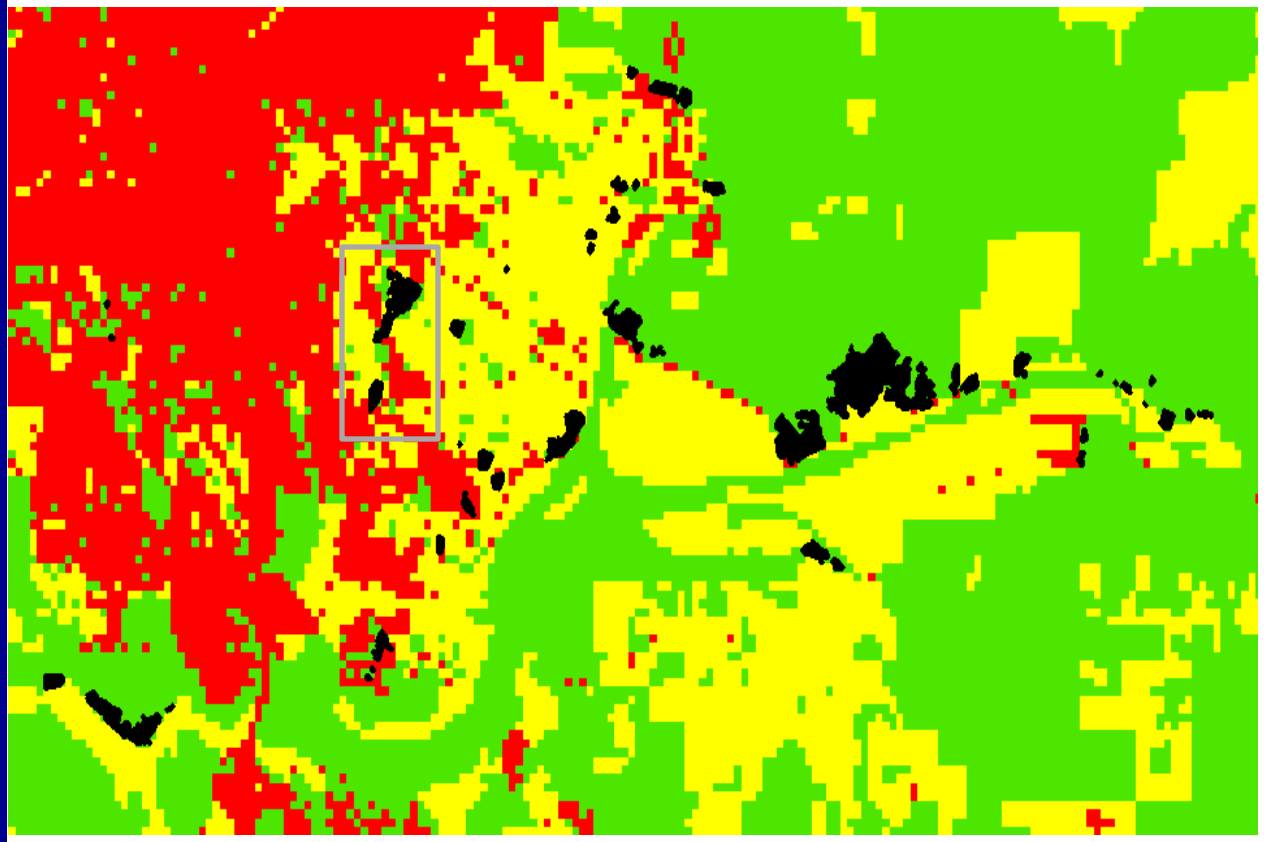
Each occupied grid cell represents a breeding pair.

Occupied
Unoccupied

Model 2: Dispersal in the individual model

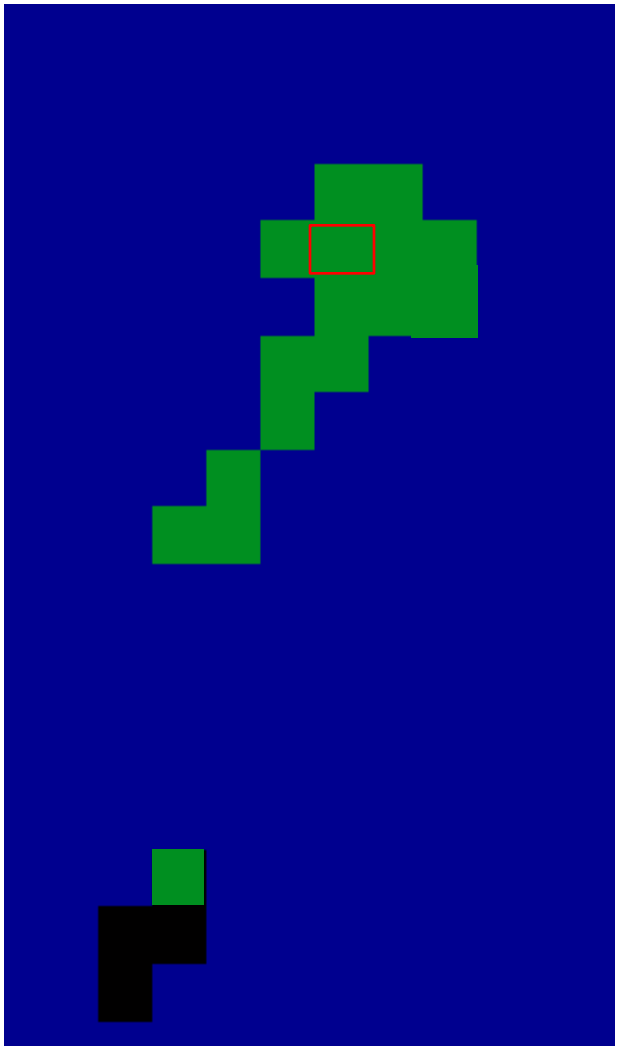


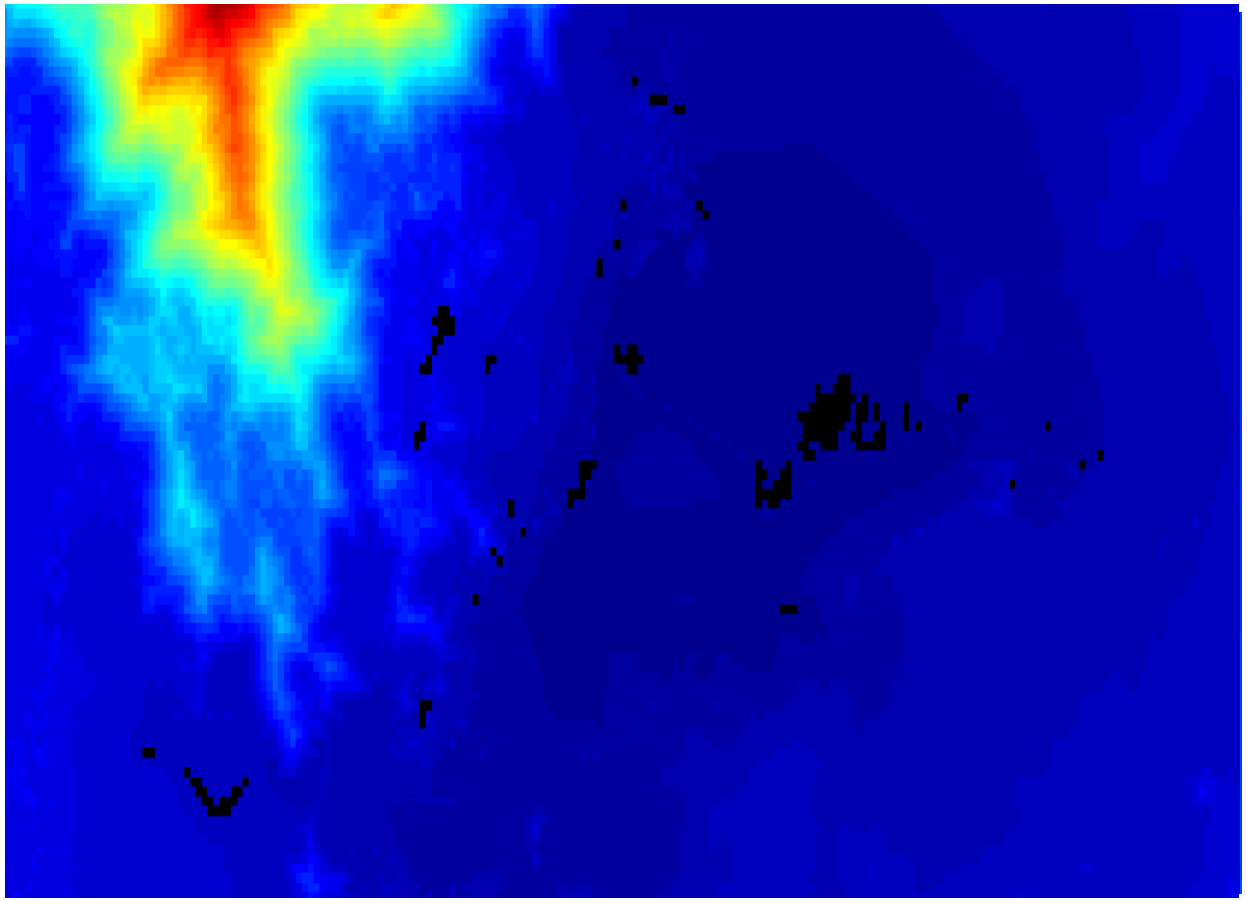
Occupied
Unoccupied



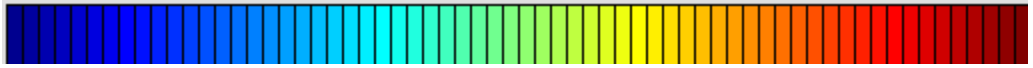
DISPERSAL COST
1- No development
5 - Moderate development
50 - High development

Model 2: Dispersal in the individual model





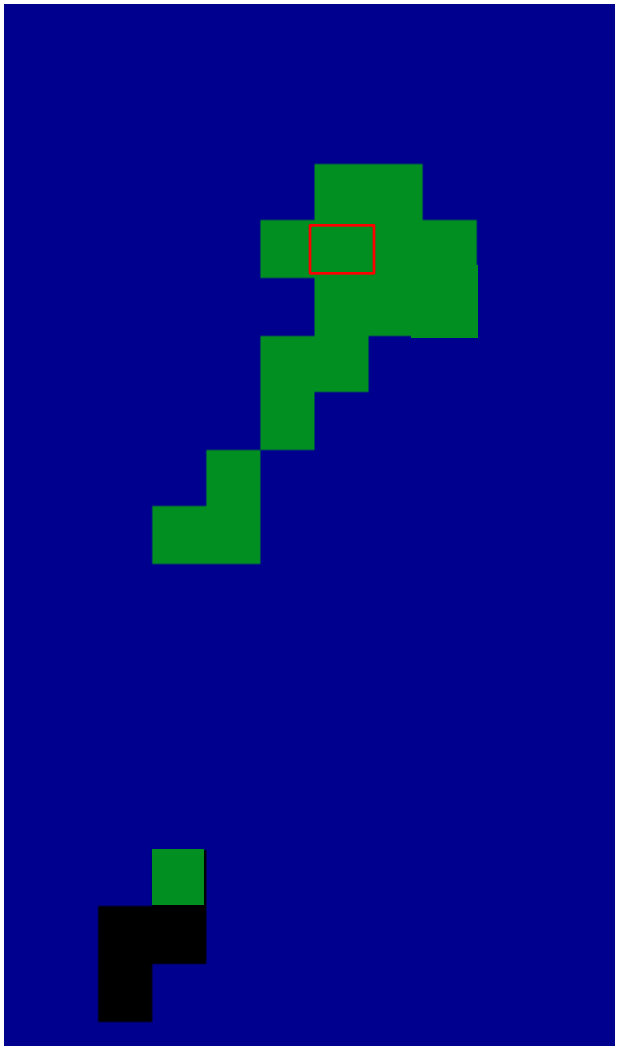
Low COST DISTANCE High

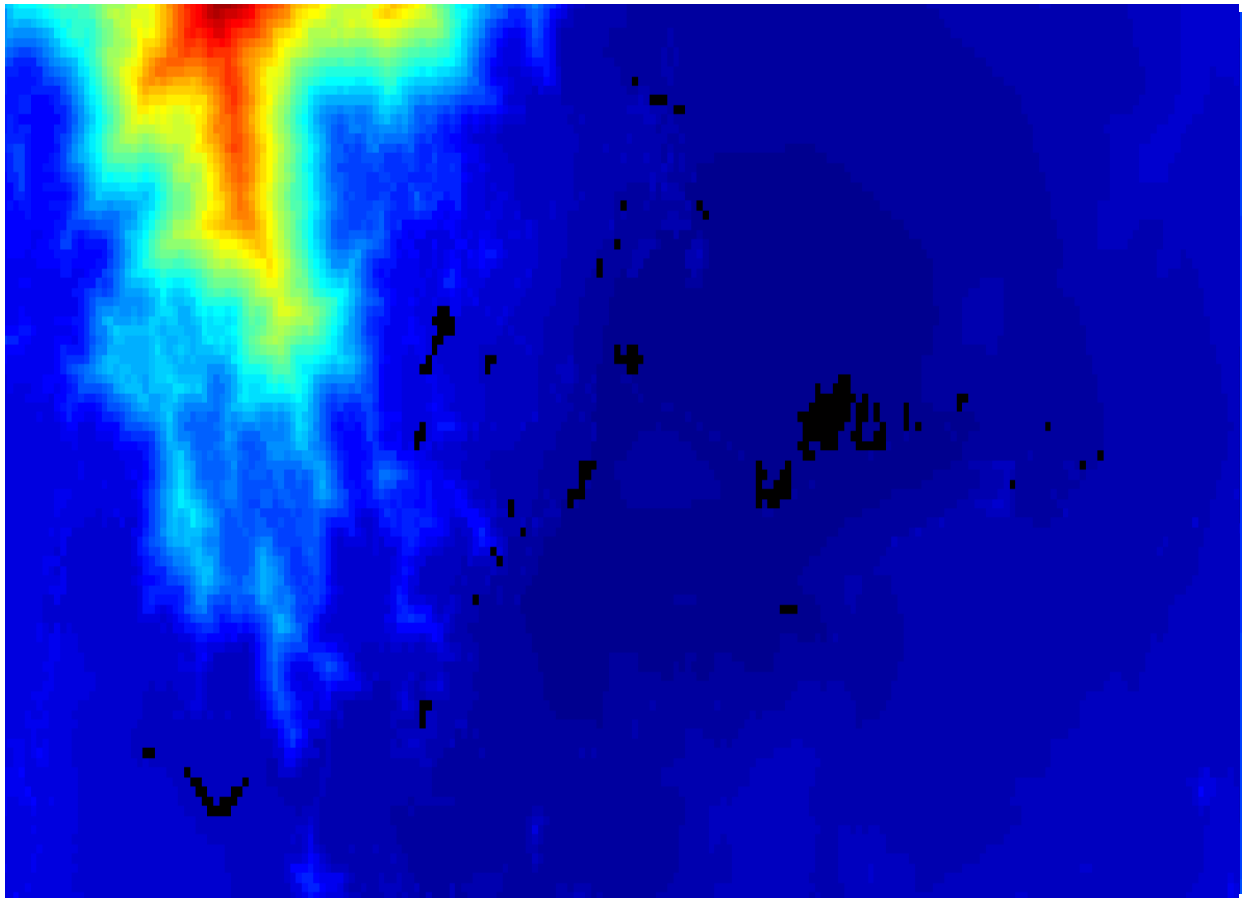


High PROBABILITY OF DISPERSING TO CELL Low

Occupied
Unoccupied

Model 2: Dispersal in the individual model





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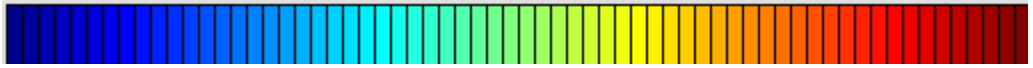
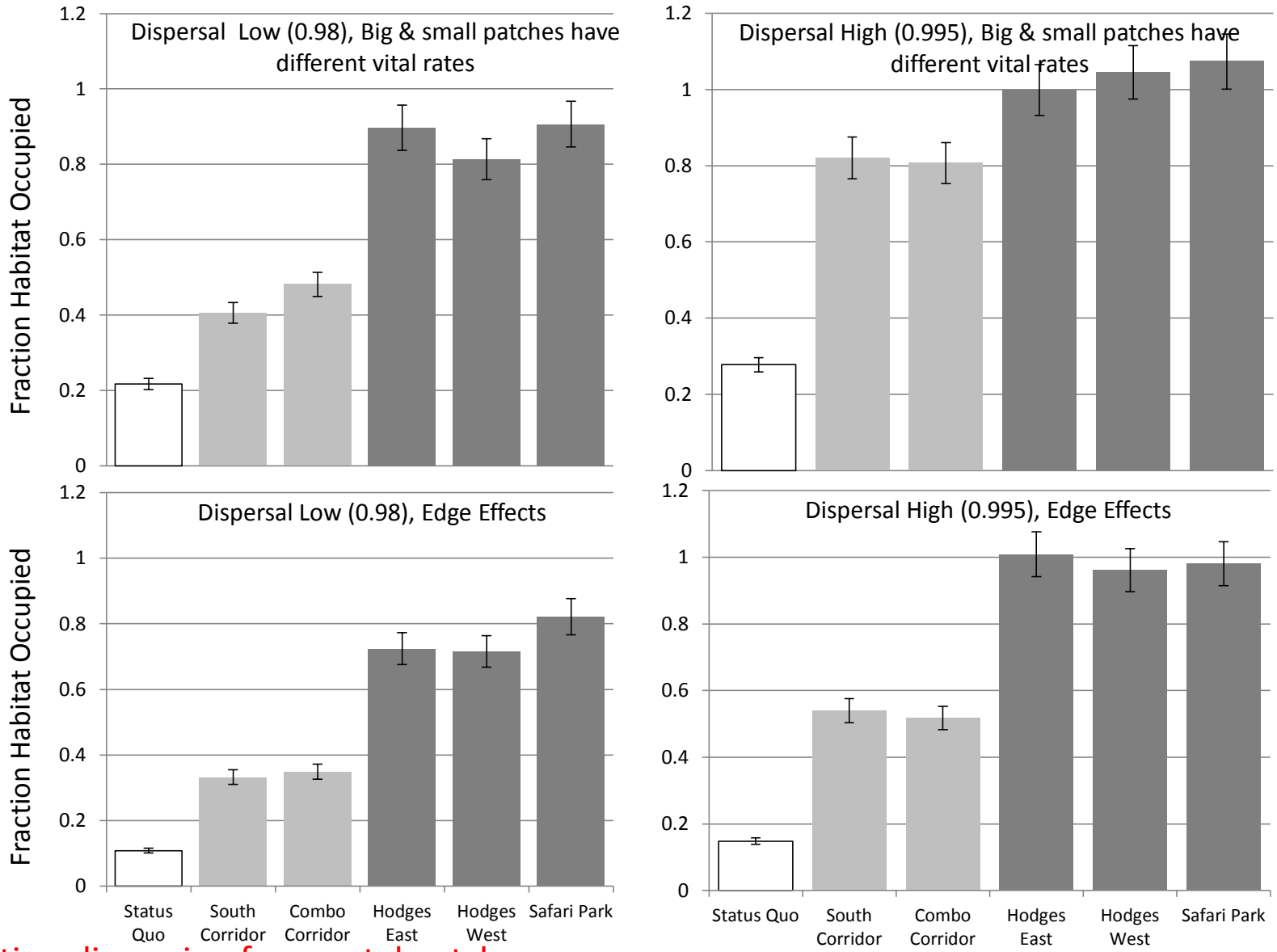


High PROBABILITY OF DISPERSING TO CELL Low

Occupied
Unoccupied

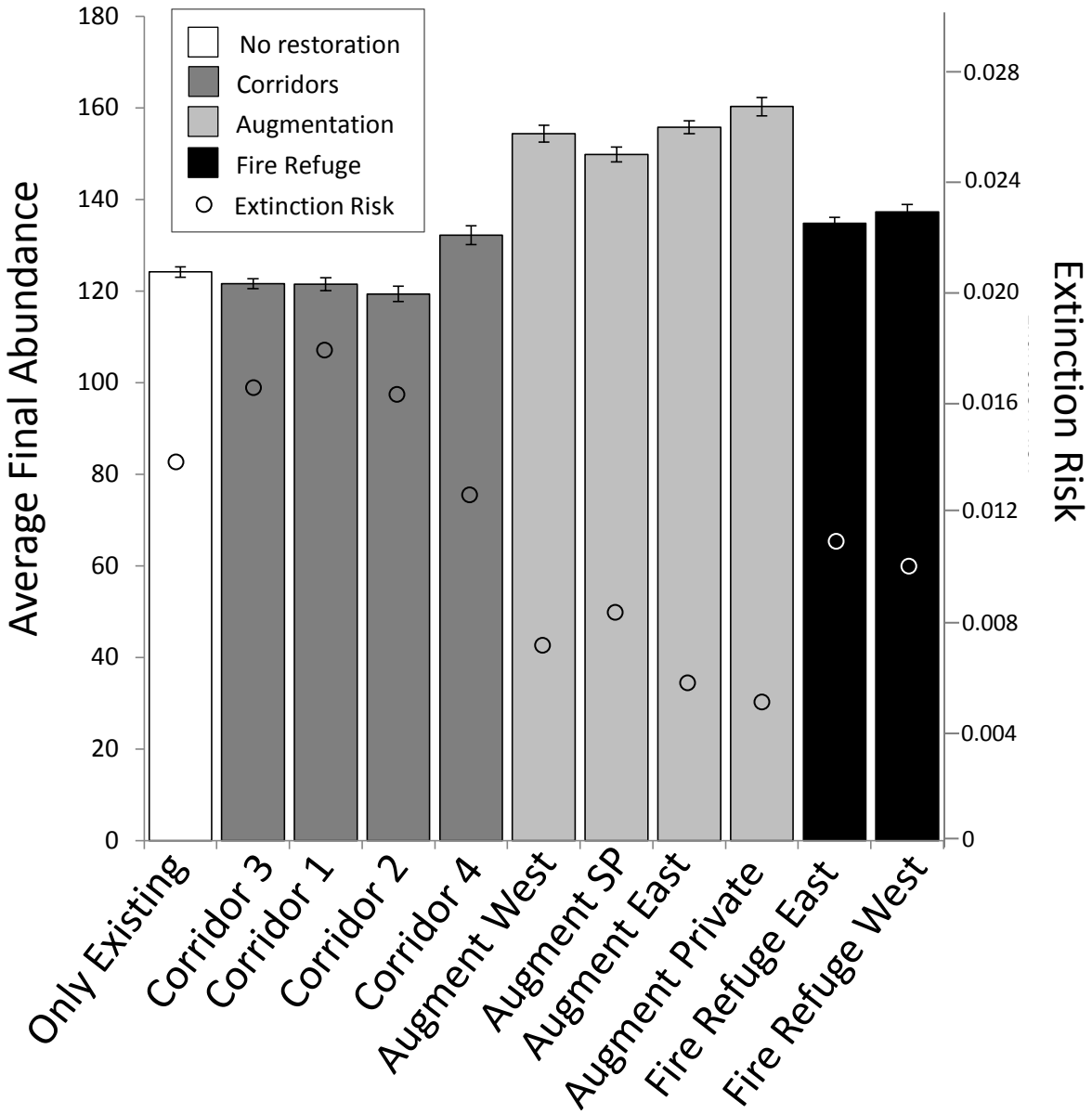
Results (200 ha) – Individual-based model



Fraction dispersing from natal patch

In non-corridor scenario:	~ 5.5%	~8%
In corridor scenario:	~ 8%	~14%

Results: Adding 20 hectares



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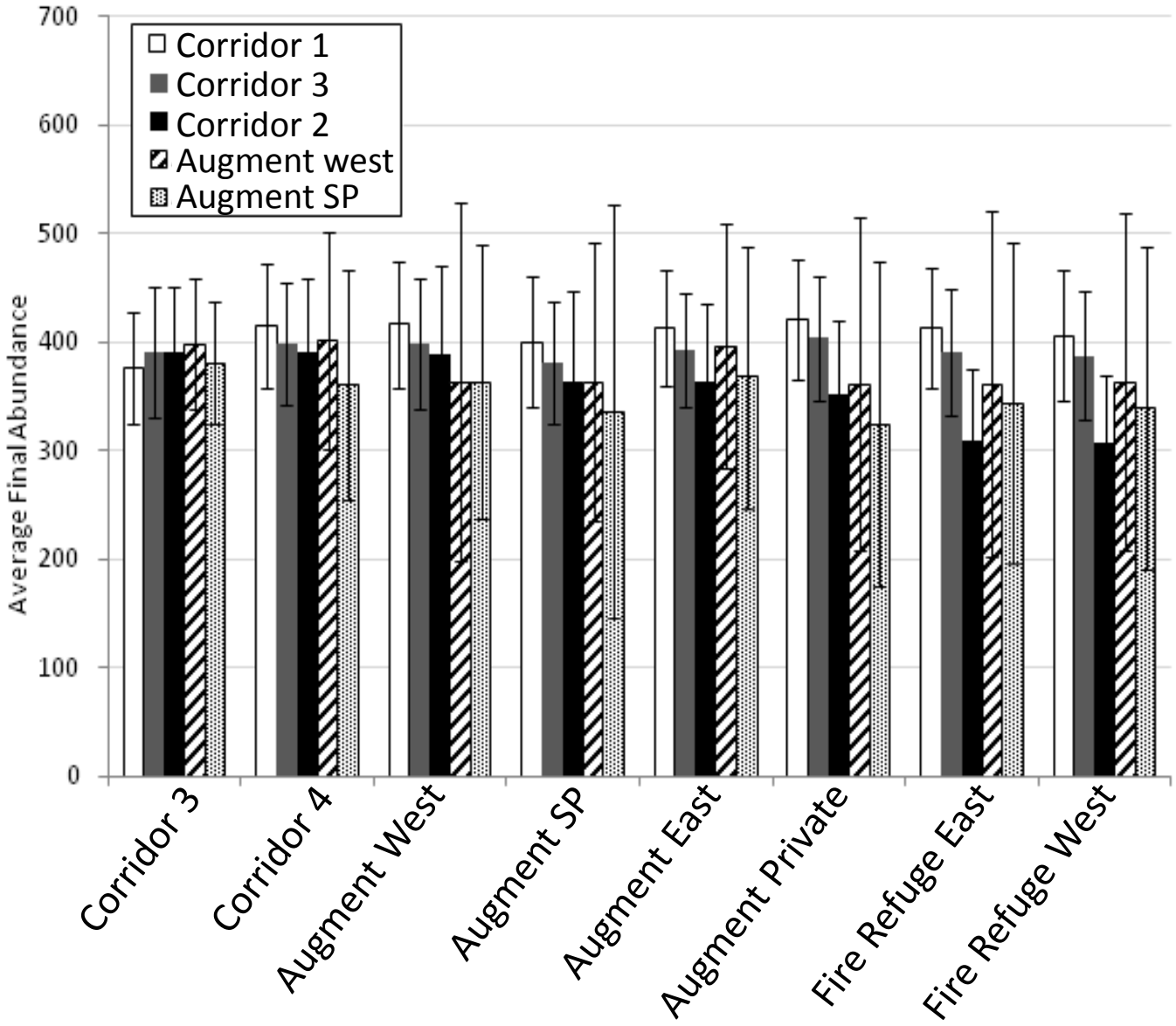
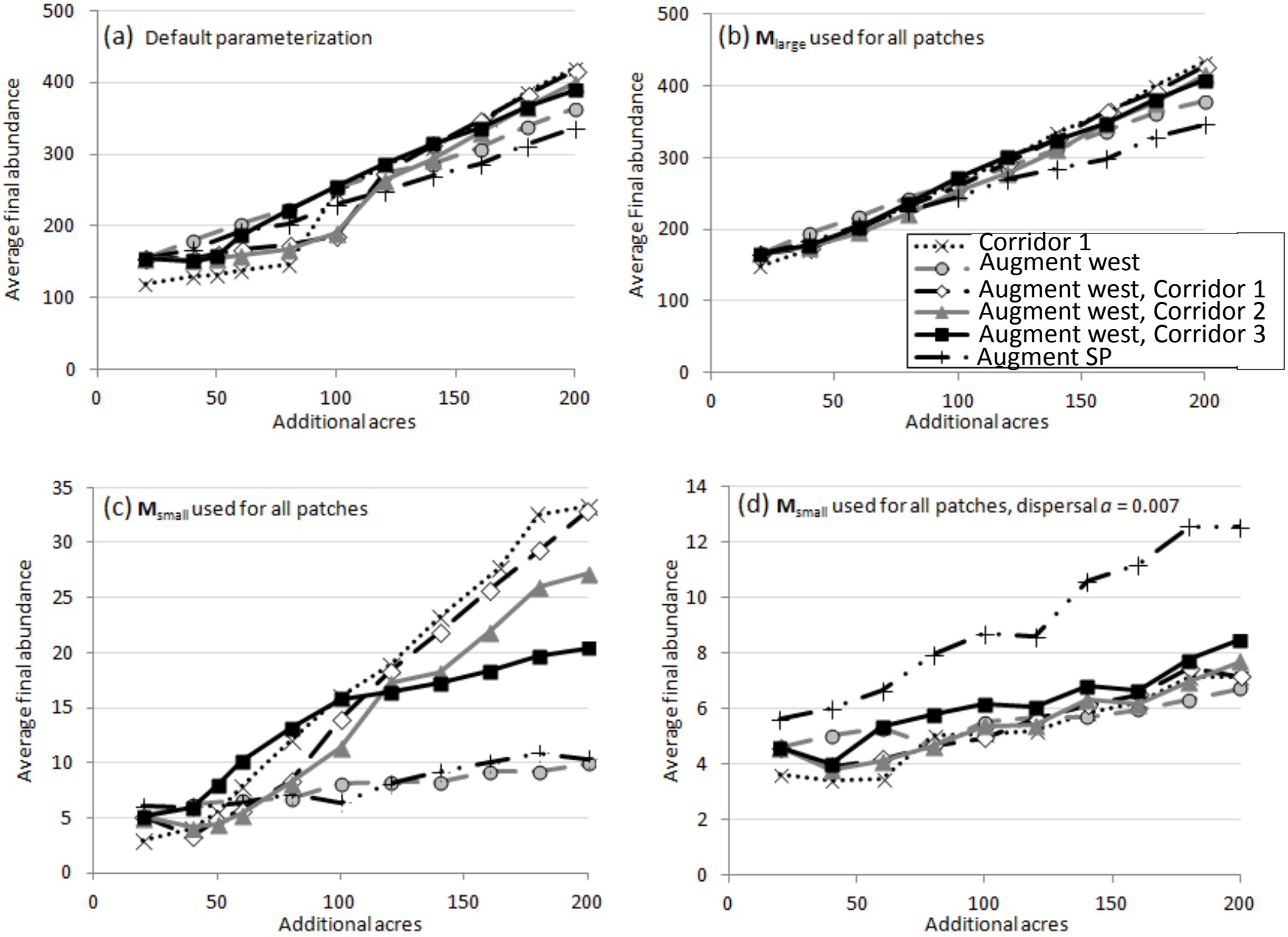
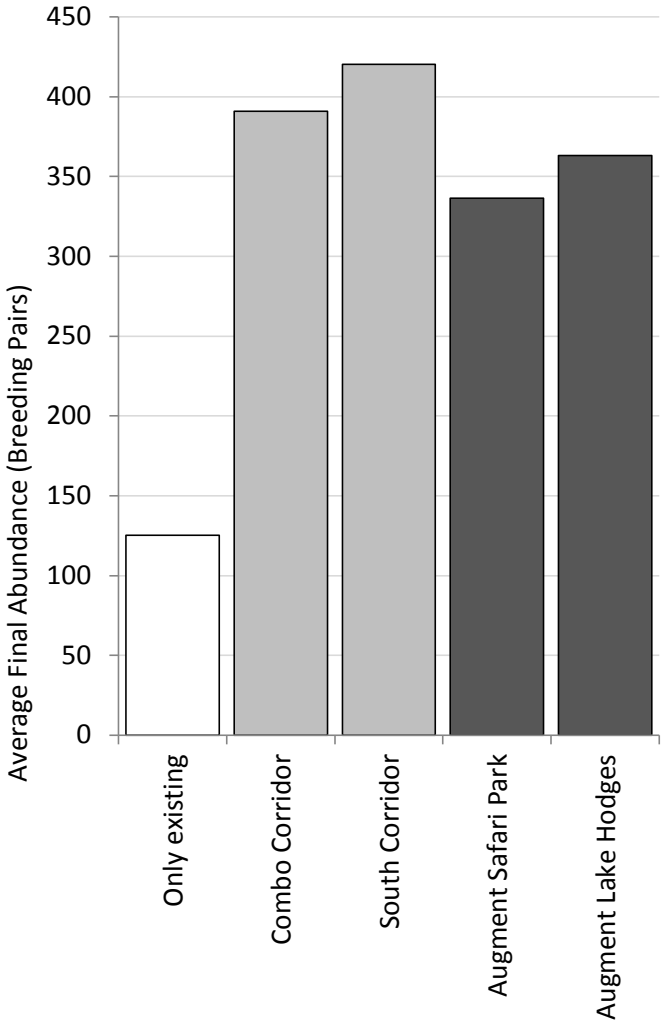


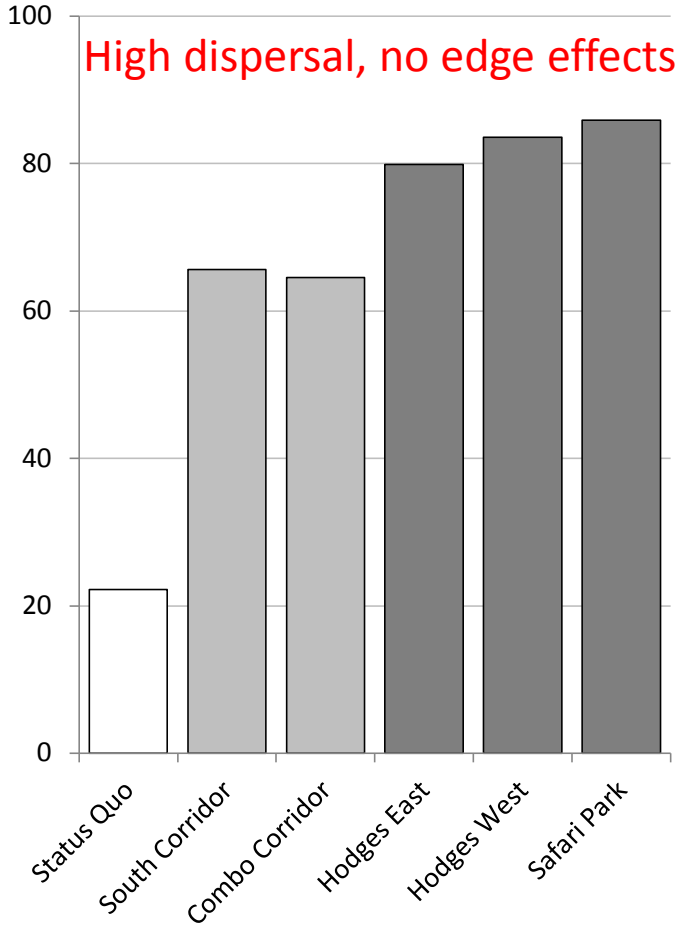
Results: Sensitivity tests



Results (200 ha of suitable habitat added)



Meta-population Model



Individual-based Model

Fraction dispersing from natal patch

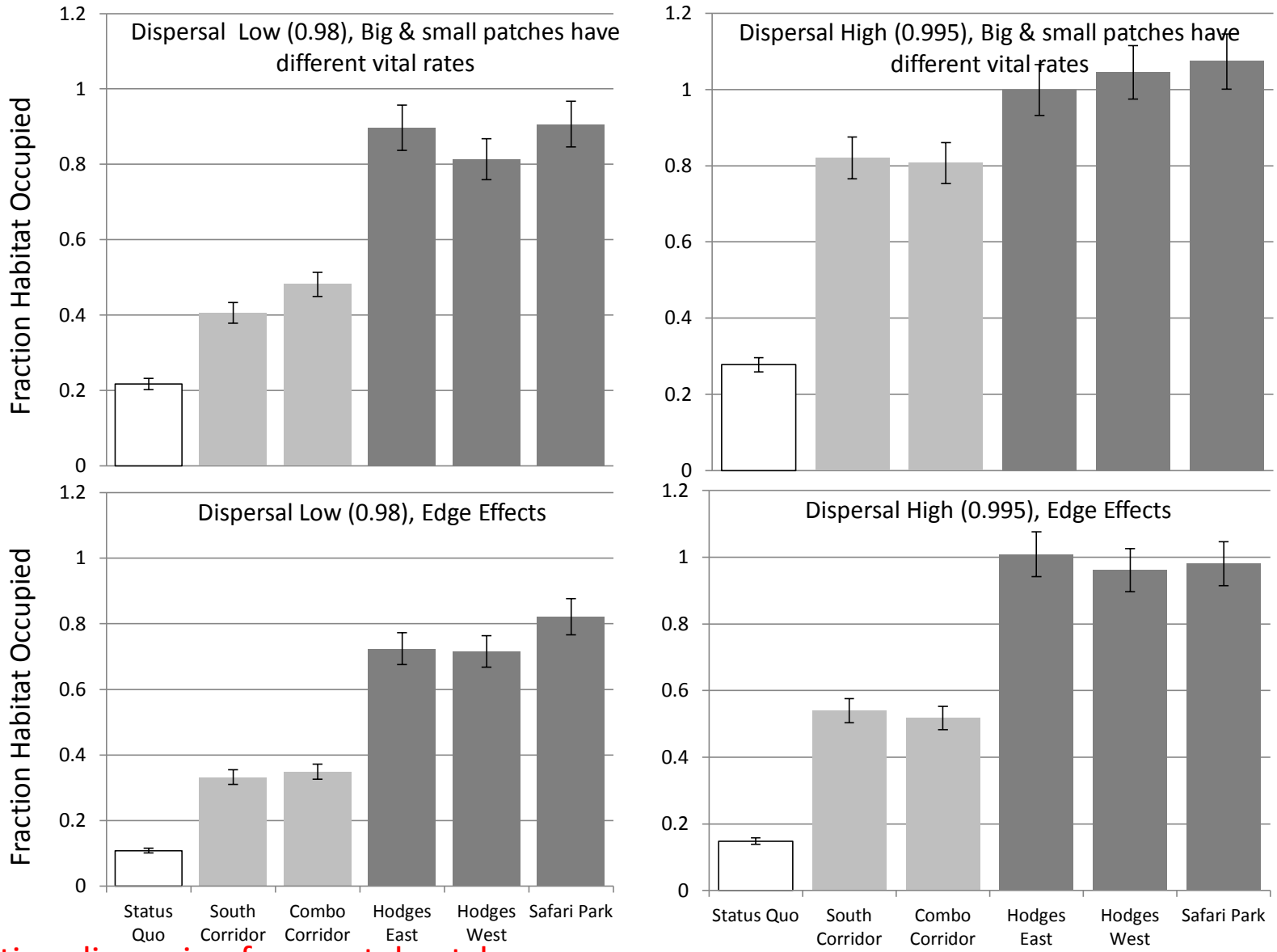
In non-corridor scenario: ~4%

In corridor scenario: ~10%

~8%

~14%

Results (200 ha) – Individual-based model



Fraction dispersing from natal patch

In non-corridor scenario:	~ 5.5%	~8%
In corridor scenario:	~ 8%	~14%

Results: Isolation versus occupancy