Everything must go

predator-prey dynamics and biological control

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Outline

- Background
  - Biological control
  - The importance of plant structure
- Modelling plant structure
- Linking plant structure & predator-prey models
- Characterising plant canopies
- Summary

Biological control

A multitrophic system

Pests

Mites

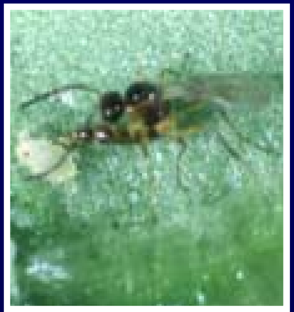
Aphids

Whitefly

Thrips

Natural Enemies

A. colemani



E. formosa

P. persimilis

Specialist

I. degenerans

O. laevigatus

N. cucumeris

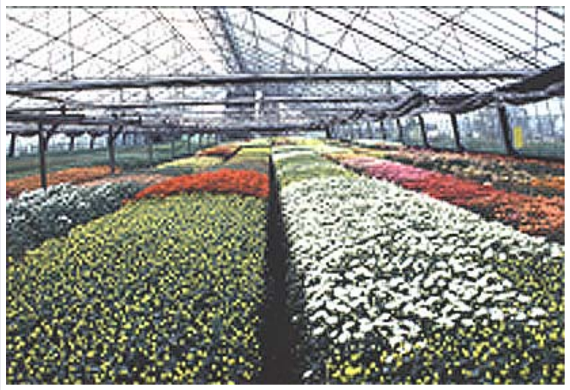
Generalist

Crops

Cut flowers

Nursery Stock

Pot plants



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Biological Control

- Spectrum of complexity
- Multiple approaches
  - Conservation
  - Augmentation
  - Preventative
- Multiple natural enemies used

Modelling for biological control

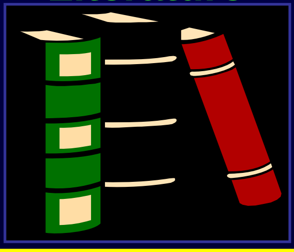
Simulation Model

Manages Information

Subroutine library

Data from Experiments

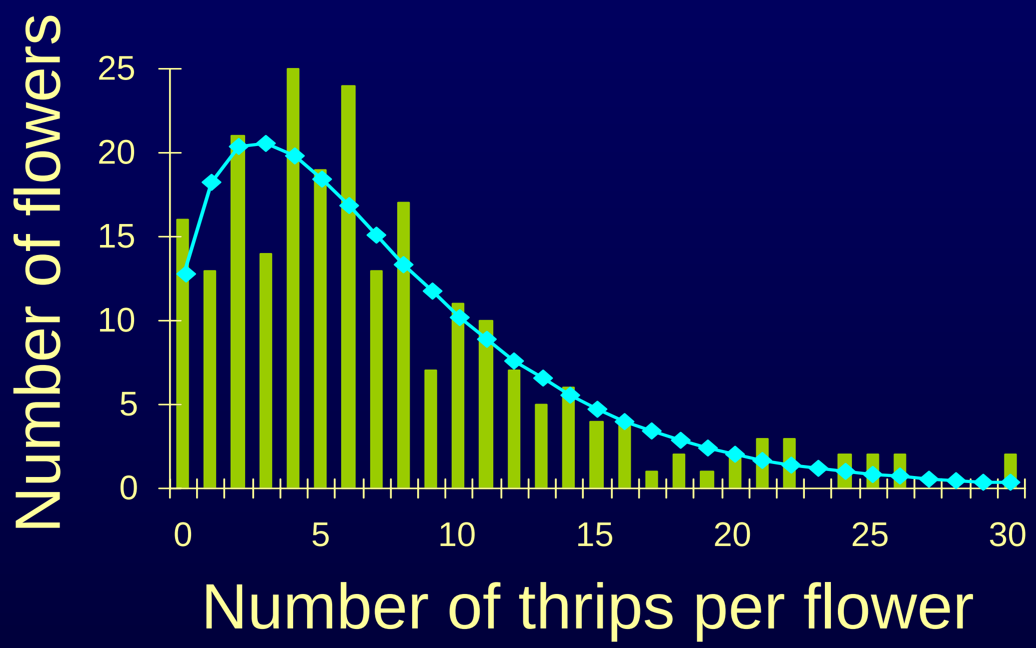
Data from Literature



Experimental Protocols

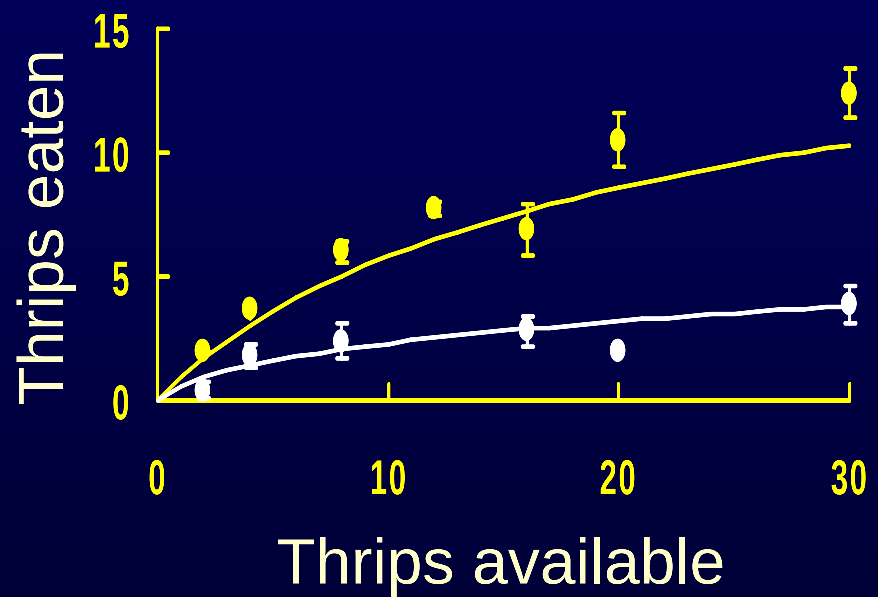
Key processes

- spatial distribution of pest and natural enemies



Key processes

- spatial distribution of pest and natural enemies
- predatory capability of natural enemies

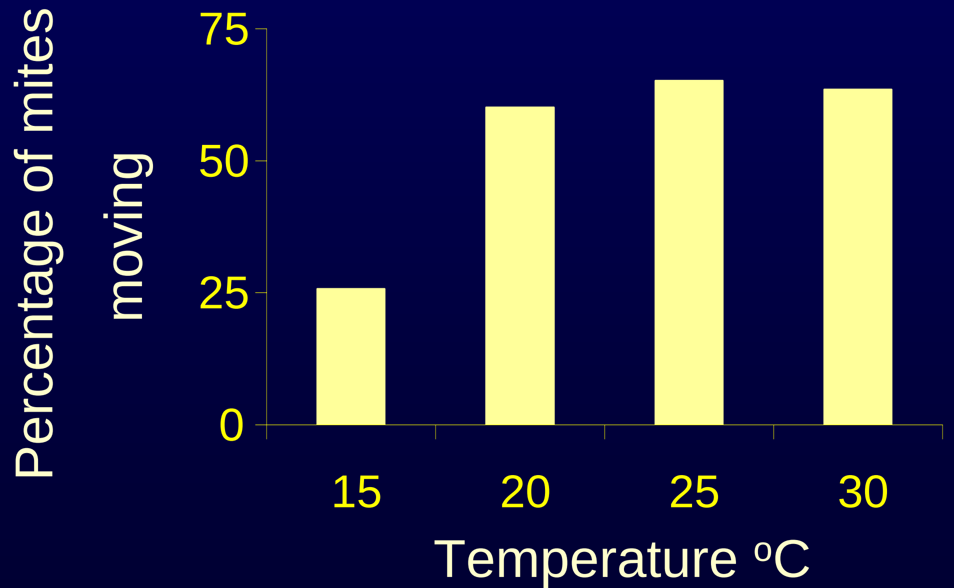


New Guinea impatiens flowers

Chrysanthemum flowers

Key processes

- spatial distribution of pest and natural enemies
- predatory capability of natural enemies
- movement of natural enemies



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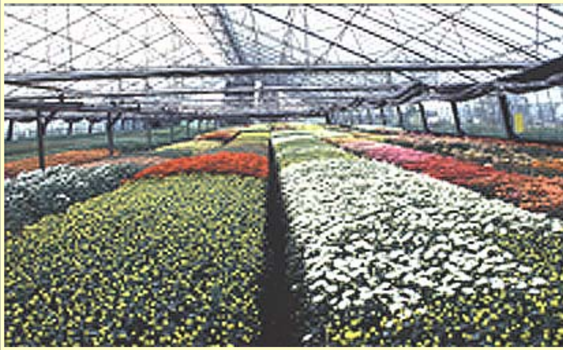
Importance of plant architecture

- leaf and flower morphology impacts on:
  - prey spatial distribution
  - natural enemy movement and predation
  - environmental conditions (boundary layer)

- canopy structure (plant touching):
  - prey spatial distribution
  - natural enemy movement



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Modelling plant canopies

- L-systems approach
  - requires only info on changes
- Can be stochastic or conditional
- Link easily to other models

Modelling plant canopies

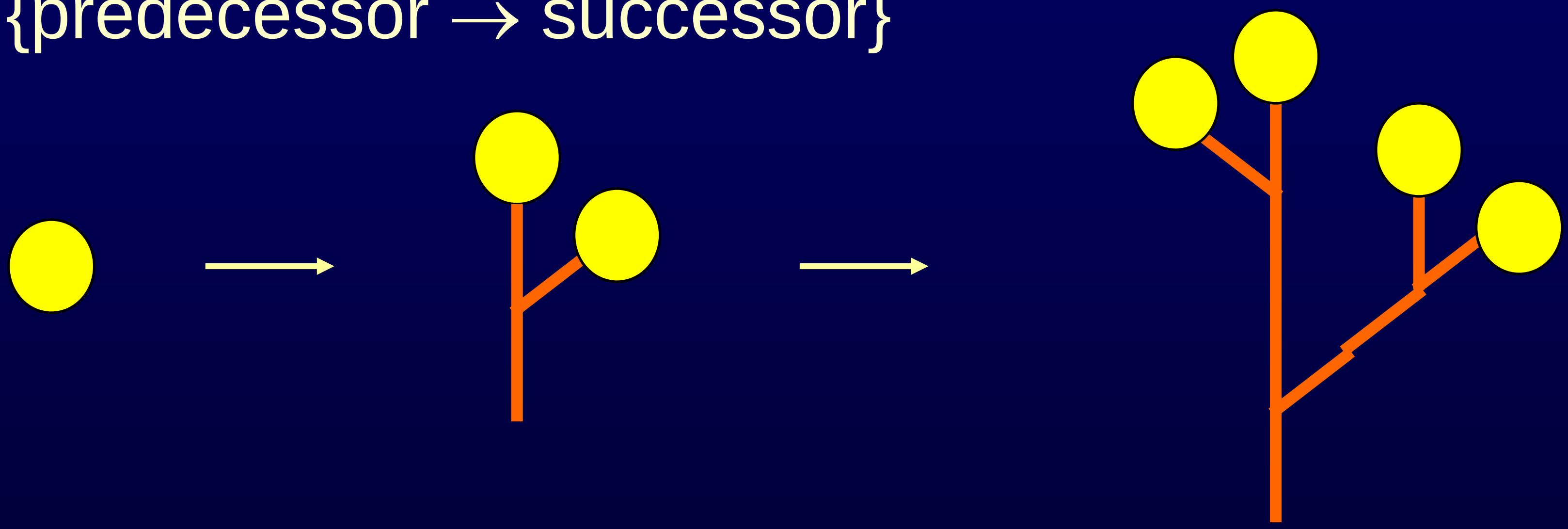
L-systems

- General format is:
  Left context < predecessor > right context: condition →successor
- predecessor can contain information about structure being described
  - L(4,1.4) = Leaf (age, length)
- Allows flow of information in any direction

Modelling plant canopies

Axiom: A

Production: A $\rightarrow$ I[IA]IA
{predecessor $\rightarrow$ successor}



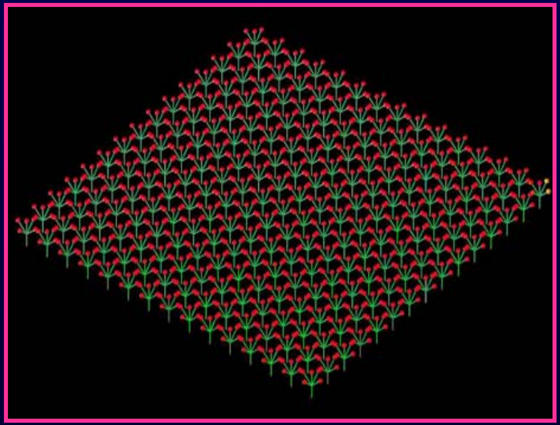
A   I [IA] IA   I [I I [IA] IA] II [IA] IA

Where A = apex, I = internode, [ ] indicates a branch

Modelling plant canopies

- Digitise real plant structures
- Model and quantify canopy structure

QuickTime™ and a
Microsoft Video 1 decompressor
are needed to see this picture.



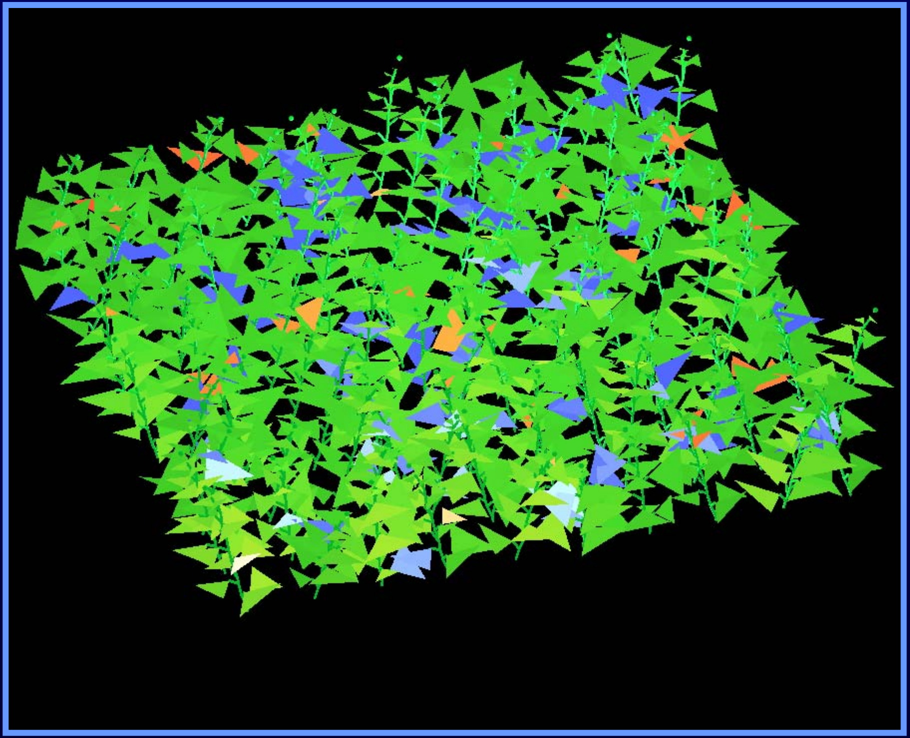
Linking canopies and insects

- Combine with models of natural enemy movement
- Use models to derive biological control strategies

QuickTime™ and a
Microsoft Video 1 decompressor
are needed to see this picture.

Linking canopies and insects

- Where and when to release predators?
- Canopy structure is crucially important



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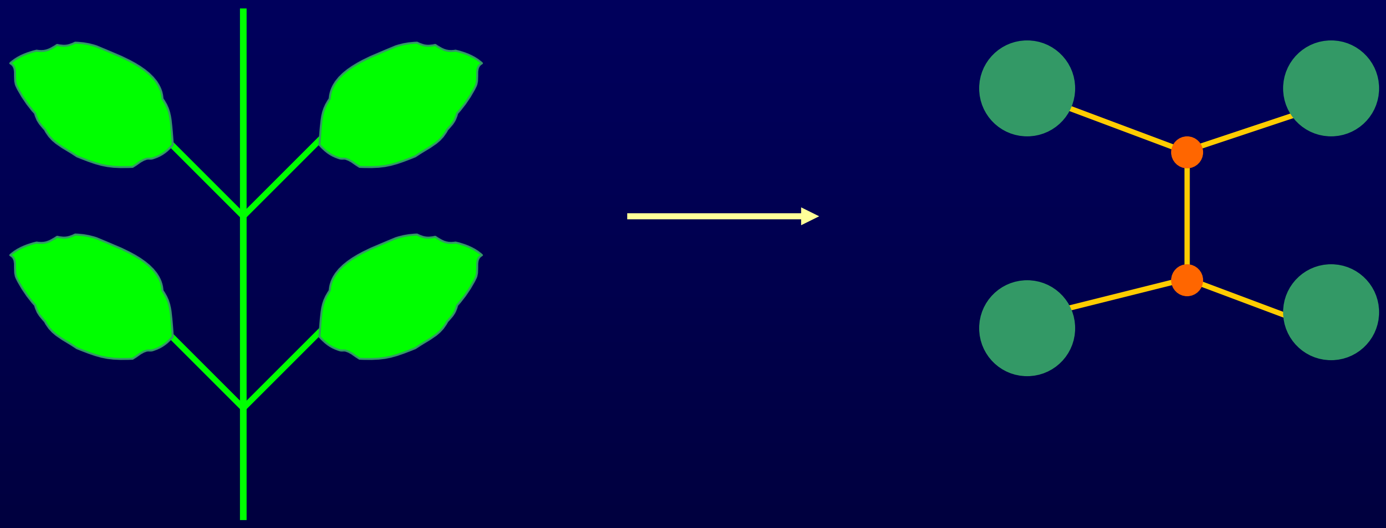
A plant as a network



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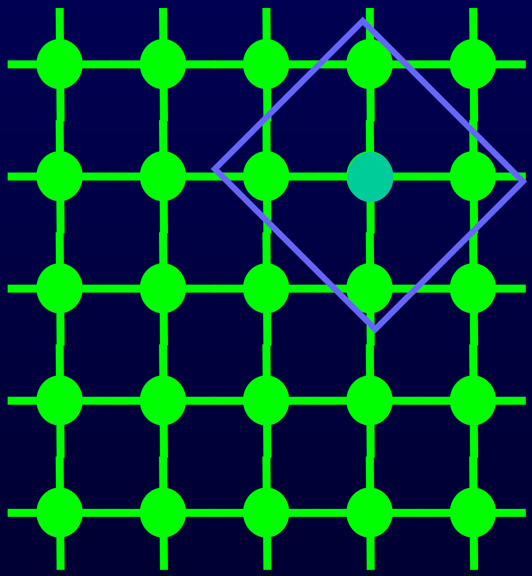
Linking canopies and searching

- 3 types of searching
  - Random
  - Directed
  - Semi-directed
- Detection distance important
- Simulations in progress

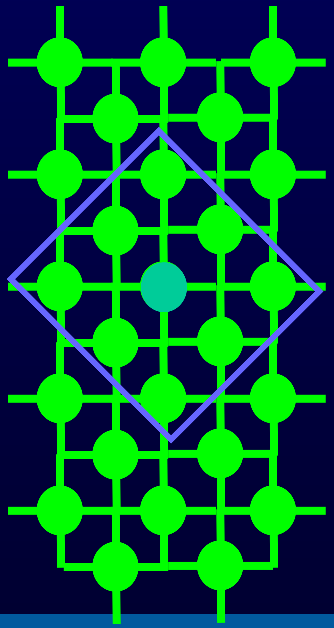
Linking canopies and insect movement

- Effect of grid size
- Effect of canopy connectedness

Regular grid



Offset grid



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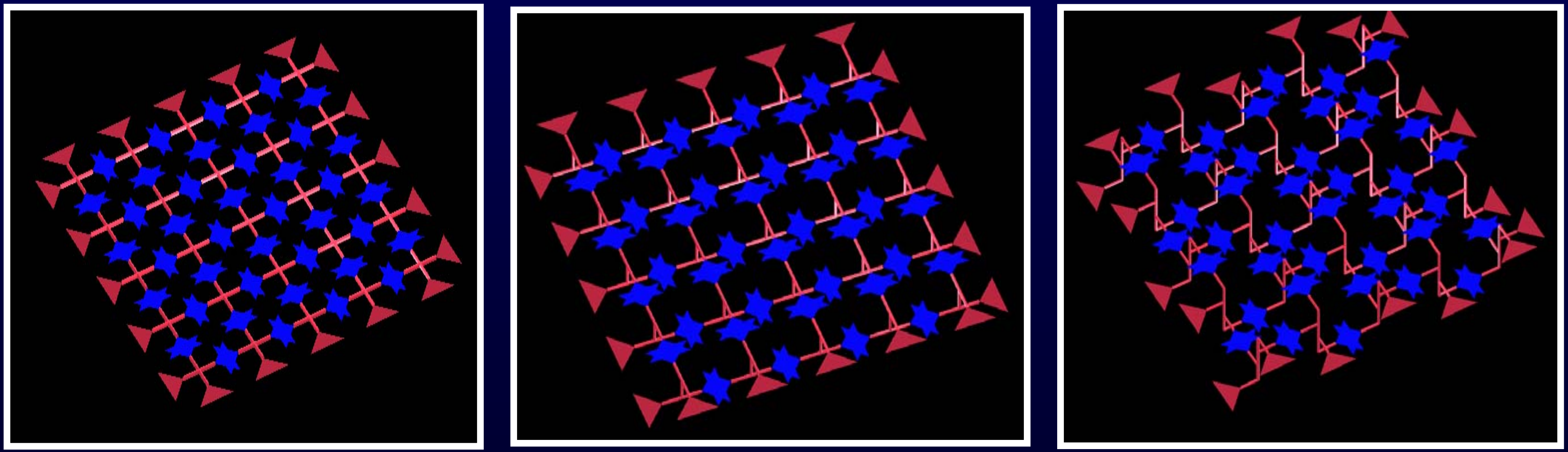
Linking canopies and insect movement

- Effect of grid size
- Effect of canopy connectedness
- Effect of canopy complexity



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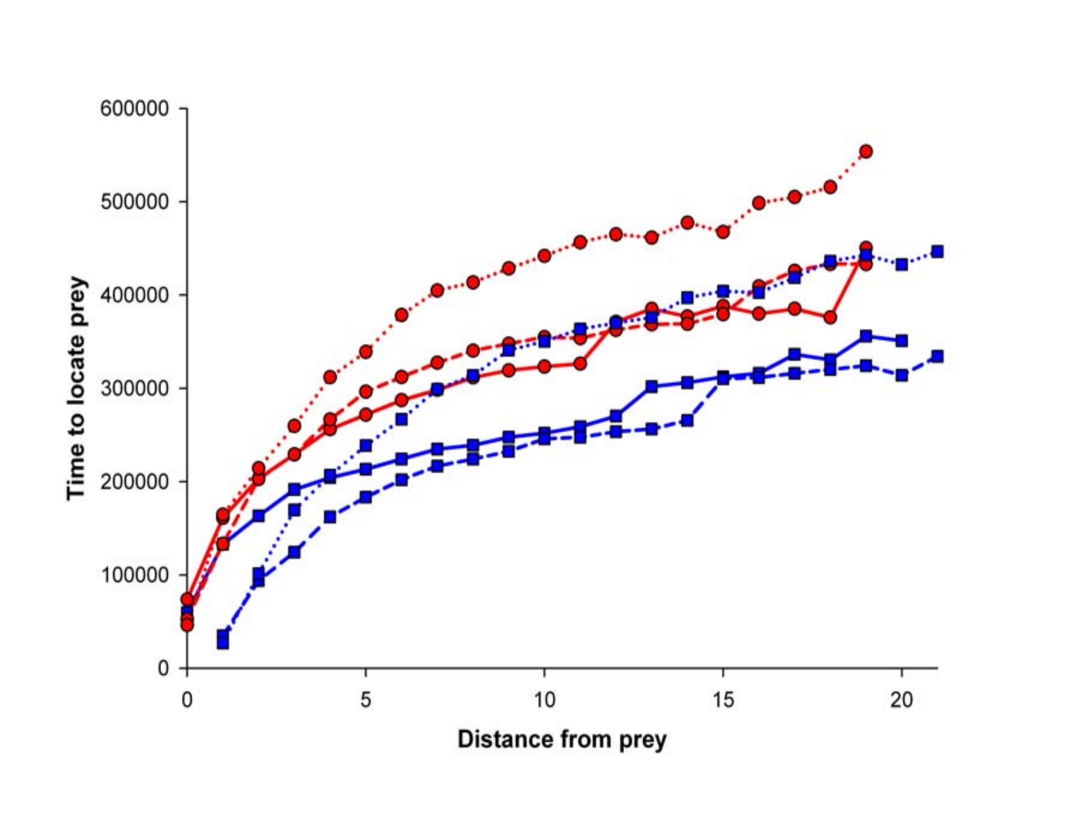
Time to prey location



4 nodes

2 nodes

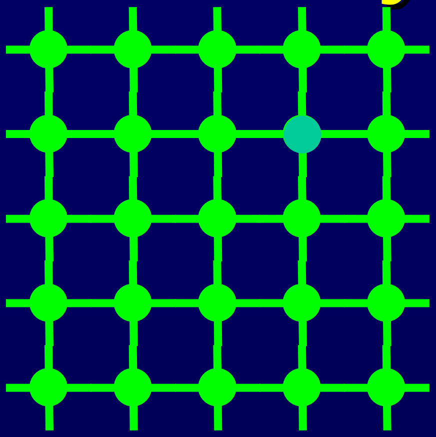
1 node

How different are the canopies?

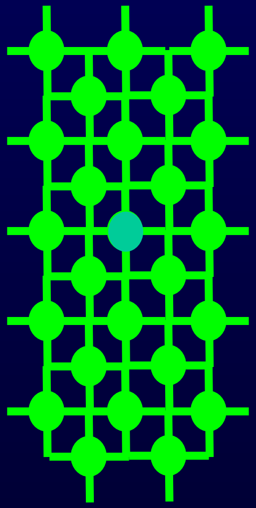
- Network matrices
- Comparison of:
  - Connectivity
  - Distance

Network Connectivity

- Regular Grid
  - 1 node = 1840
  - 2 nodes = 1840
  - 4 nodes = 1840

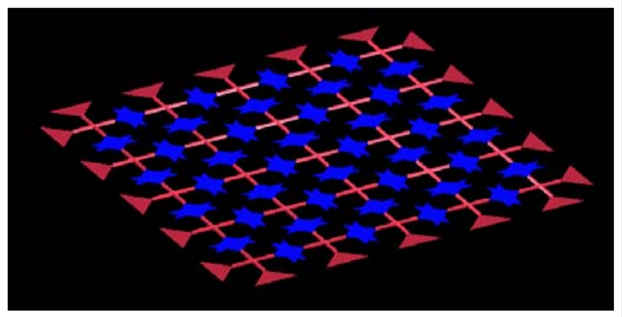
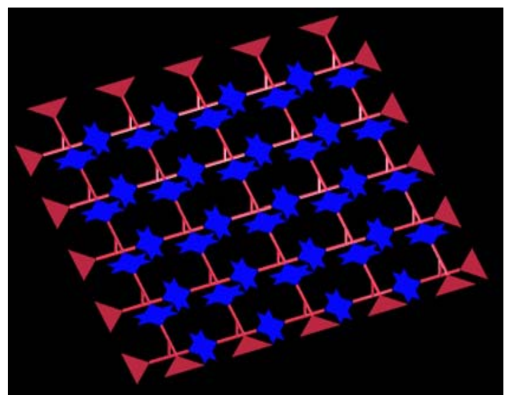
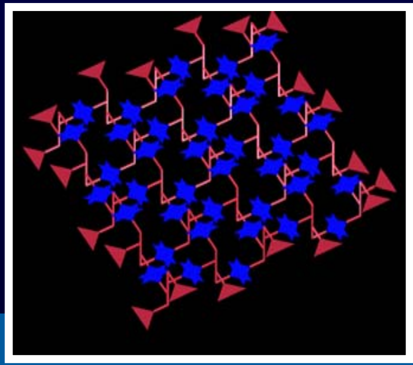


- Offset Grid
  - 1 node = 3266
  - 2 nodes = 3266
  - 4 nodes = 3266

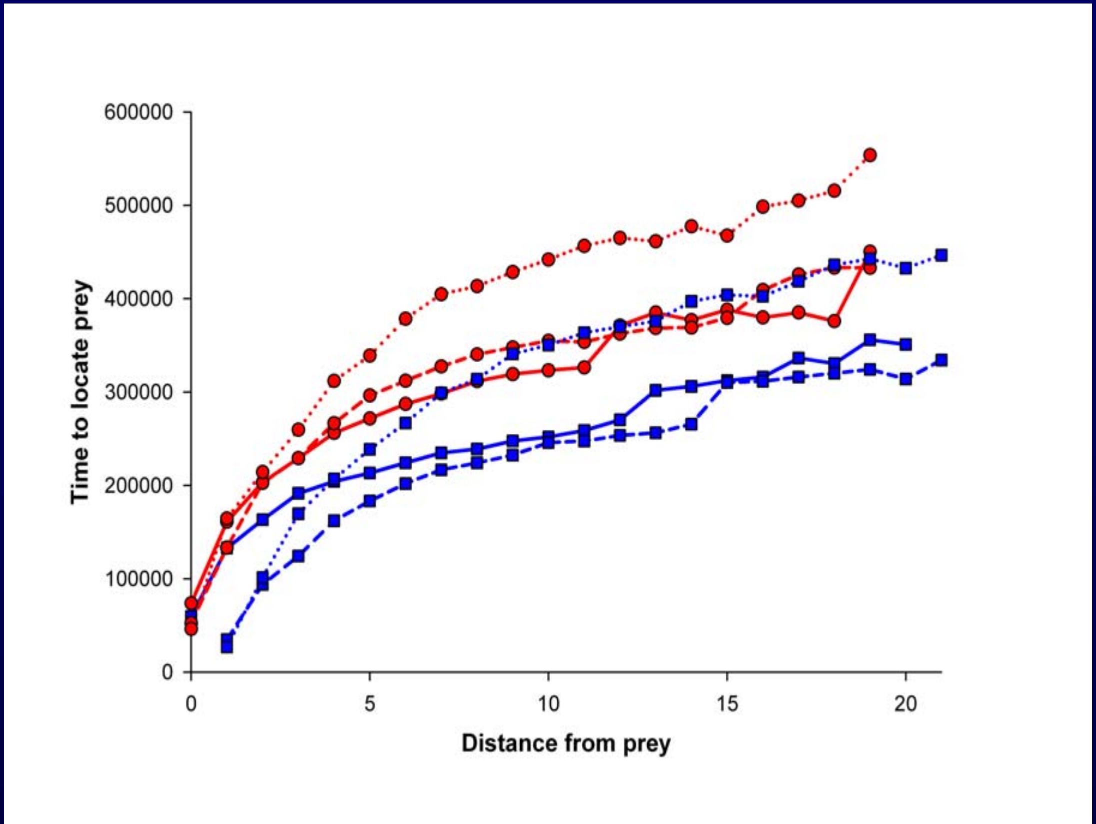


Network Distance

- Regular Grid
  - 1 node = 243
  - 2 nodes = 302
  - 4 nodes = 352
- Offset Grid
  - 1 node = 196
  - 2 nodes = 207
  - 4 nodes = 280

Network Distance



4 nodes

2 nodes

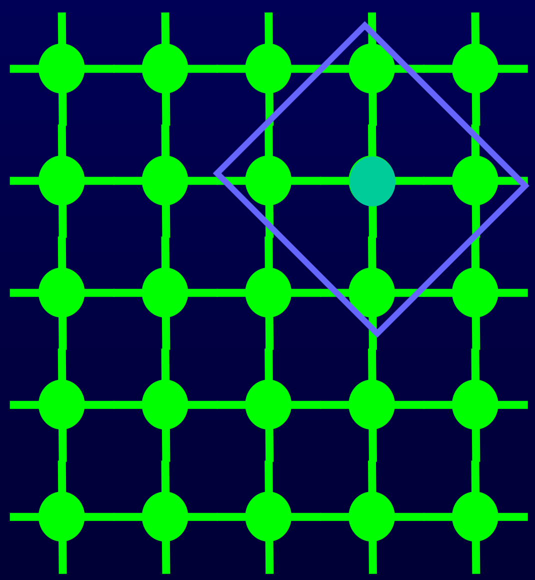
1 node

Regular	Offset
1 - 243	1 - 196
2 - 302	2 - 207
4 - 352	4 - 280

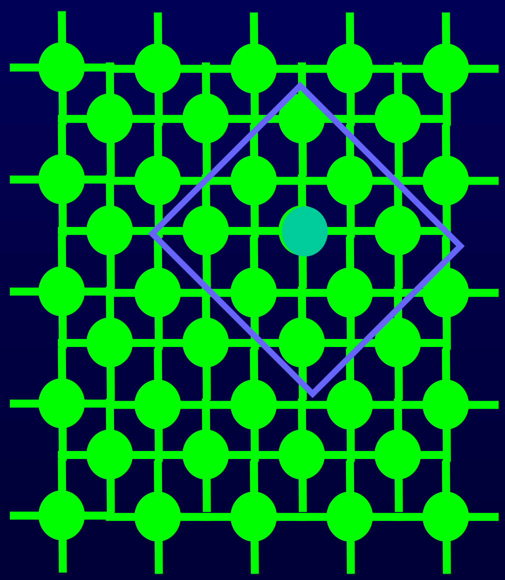
Changing connectivity but not distance

- Examine individual distances

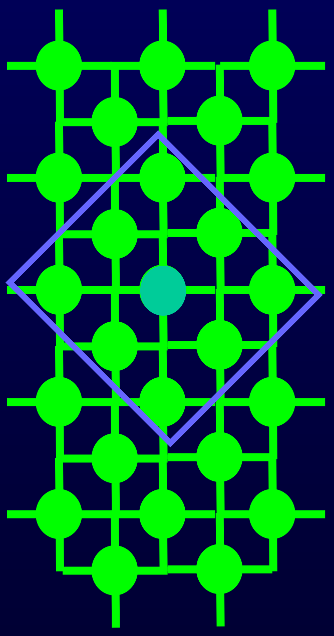
Regular grid



Composite grid



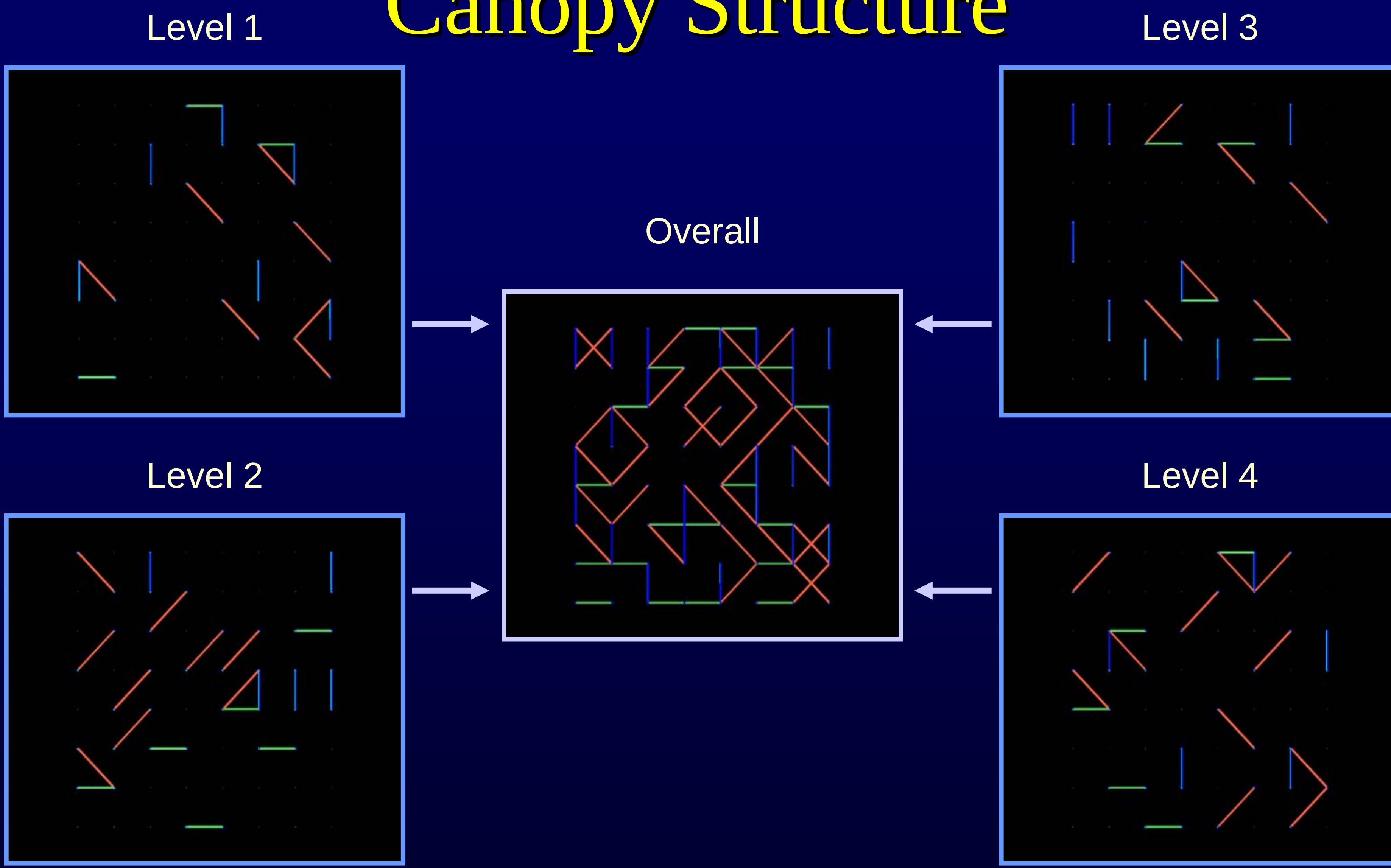
Offset grid



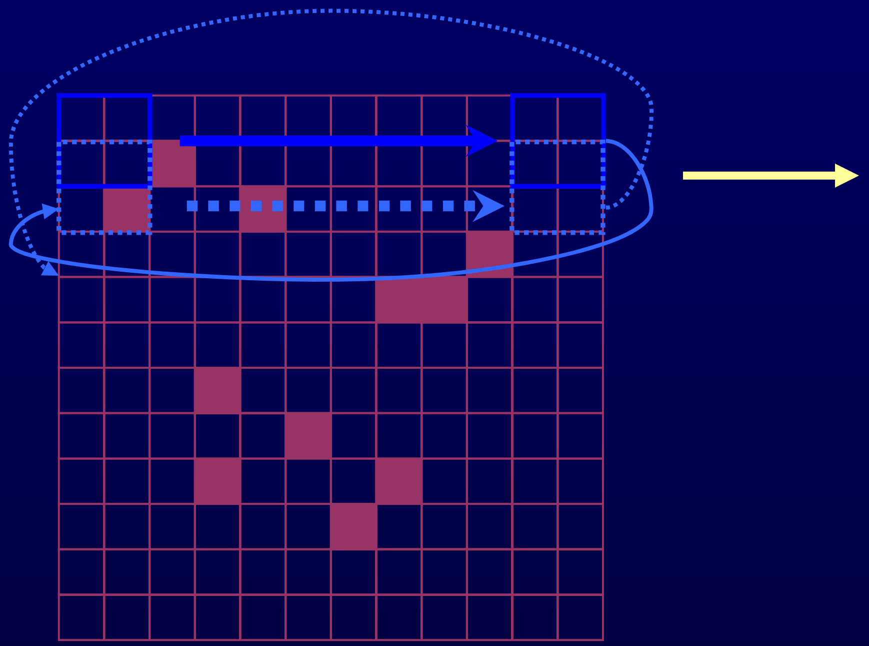
Comparing canopies

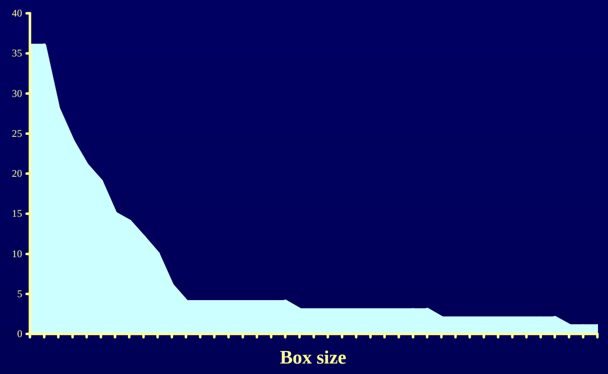
- Can we quantify real canopies?
  - Relationship between connections and prey location?
  - How do canopies differ in connectedness?
  - How do differences/similarities affect predators and biological control?

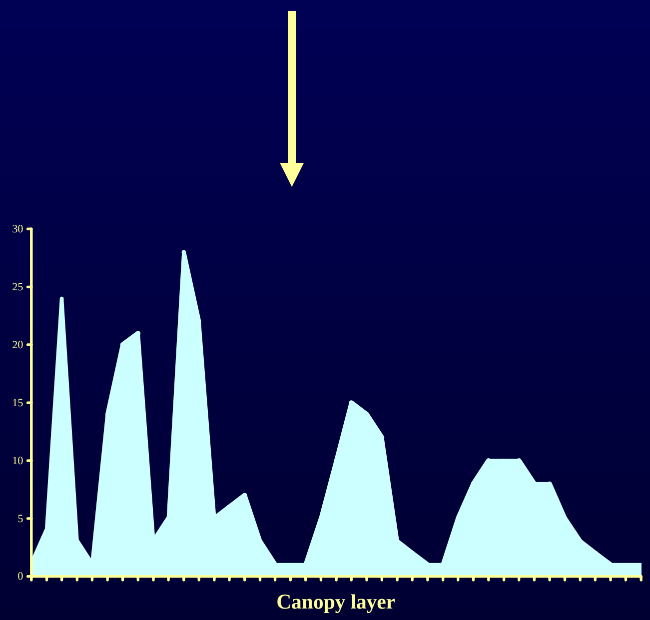
Canopy Structure



Gliding box algorithm



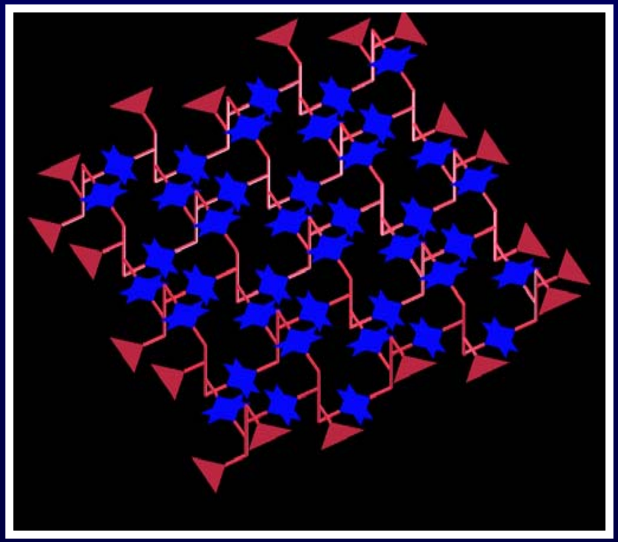


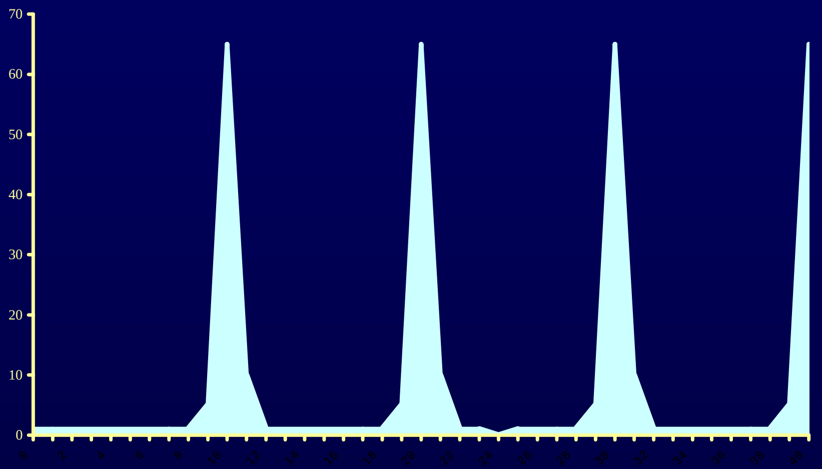


Lacunarity

- Create L-system model of canopy
- Voxelise canopy
- Analyse lacunarity

Progress to date





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Summary

- Plant structure crucial to predator-prey dynamics
- Effects on both predators & prey
- L-systems model plant architecture
- Networks useful for modelling predator searching
- Need methods to characterise plant canopies

Acknowledgements

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