Modularity in plant-pollinator networks
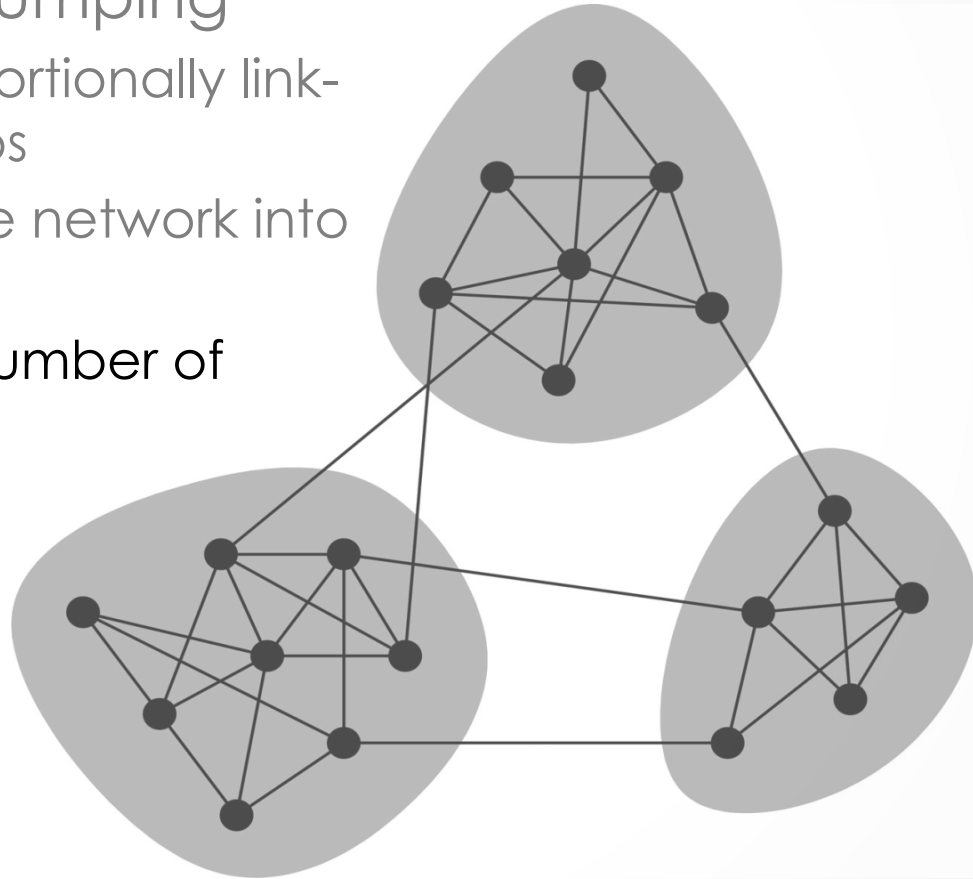
Lydia Miller

Introduction

- Modularity = "clumping"
  - Modules = proportionally link-dense subgroups
  - Breaks down the network into structural parts
  - **Modularity vs. number of modules**

Image source: Newman, 2006.

Binary approach

Weighted approach

Image source: Beckett, 2016.

Research questions

1. How modular are the networks?
2. How does observed network modularity differ from a null (random network) model?
3. How does modularity vary between years?
4. How does modularity relate to phylogenetic distance?

Methods:
Data used

- Four network groupings
  - 2016
  - 2015
  - 2011-14
  - All years
- All meadows, all watches

Methods:
Estimating modularity

- DIRTLPAwb+ (Beckett 2016)
  - Stochastic optimization algorithm - 20 trials
- null model distribution
  - 20 null networks, 10 trials each

Histogram of RANDbyfamALL$modularity
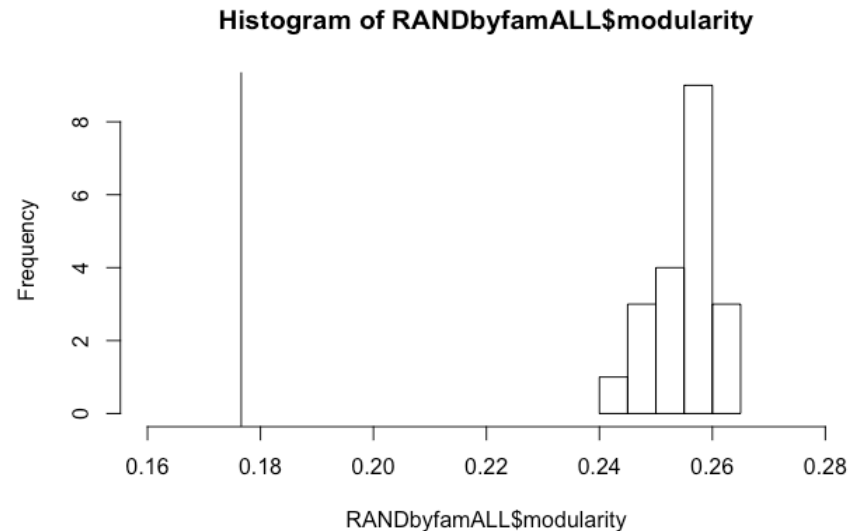
Each null model is randomly generated, and matches the observed network in the following ways:
Link density: number of links per species
Size: number of nodes
Connectance: proportion of realized links

Results:
Network modularity

DIRTLPawb+ modularity (best of 20 trials)

year (s)	weighted		binary	
	modularity	# of modules	modularity	# of modules
2016	0.224	5	0.311	5
2015	0.0939	5	. 0.315	5
2011-14	0.195	4	0.209	4
ALL	0.177	4	0.218	4
Other networks (averages)	0.473	7.3	.459	7.6

Our networks

DIRTLPawb+ modularity results for 23 observed ecological networks (Beckett 2016)

Weighted network modularity compared to a null distribution
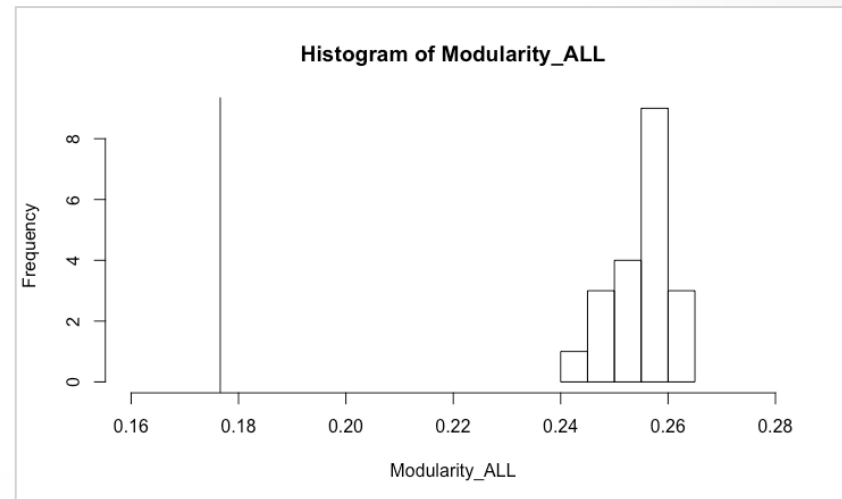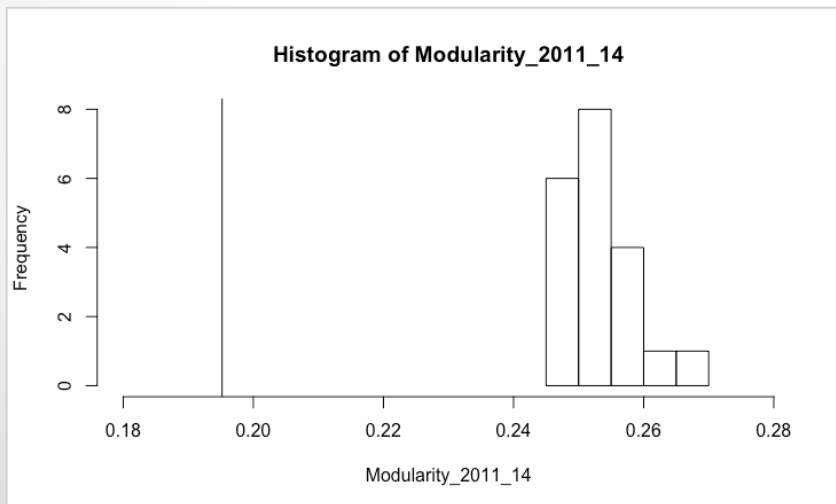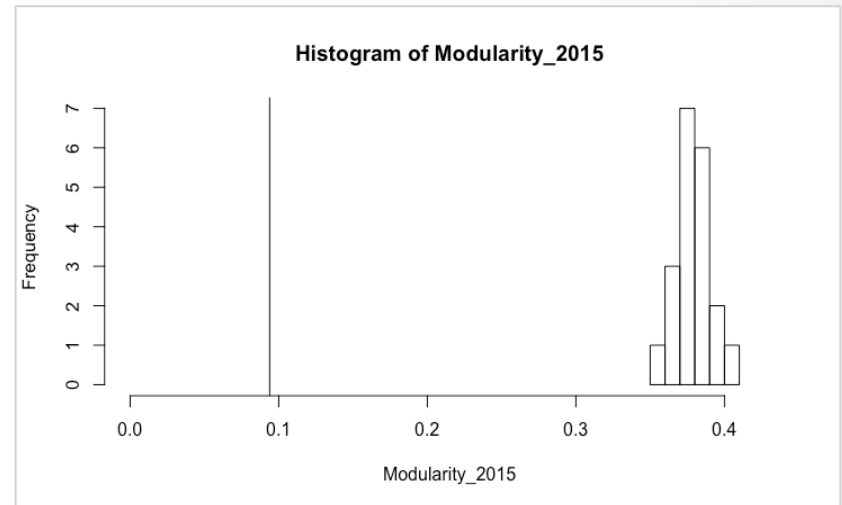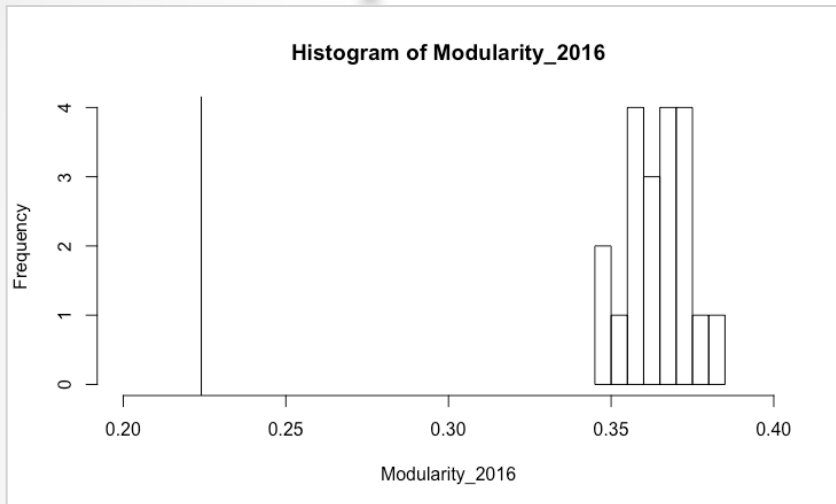
Binary network modularity compared to a null distribution
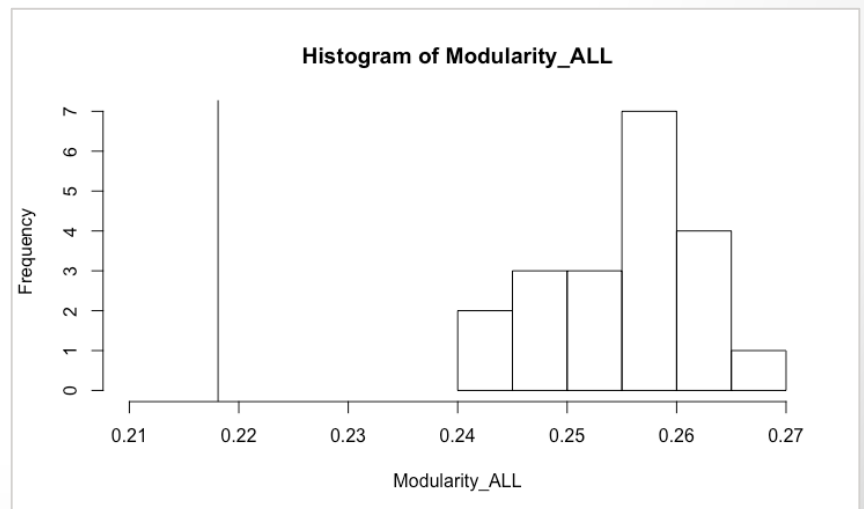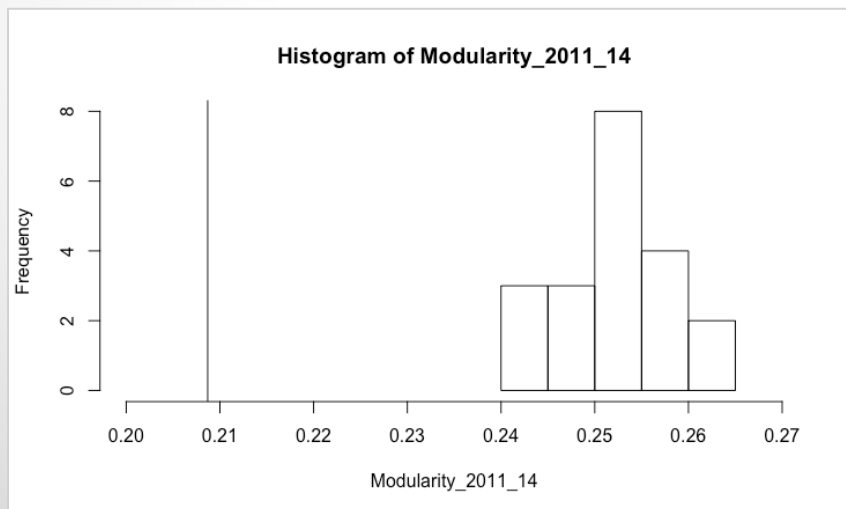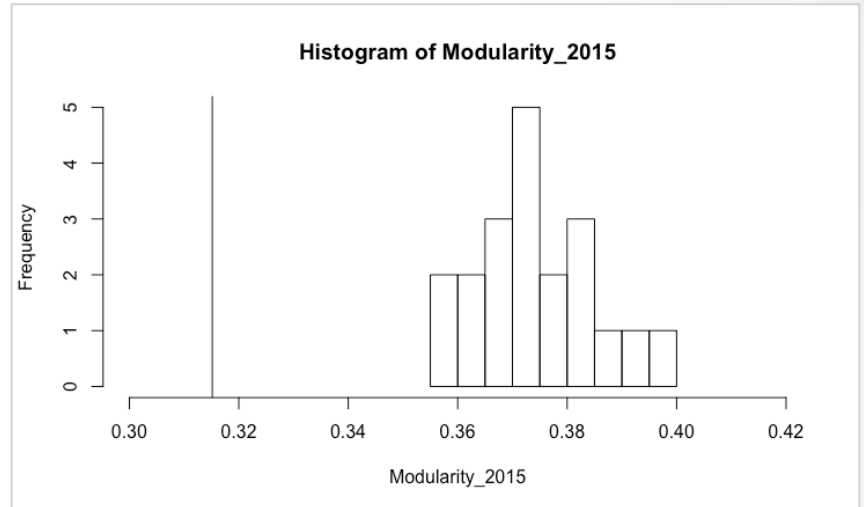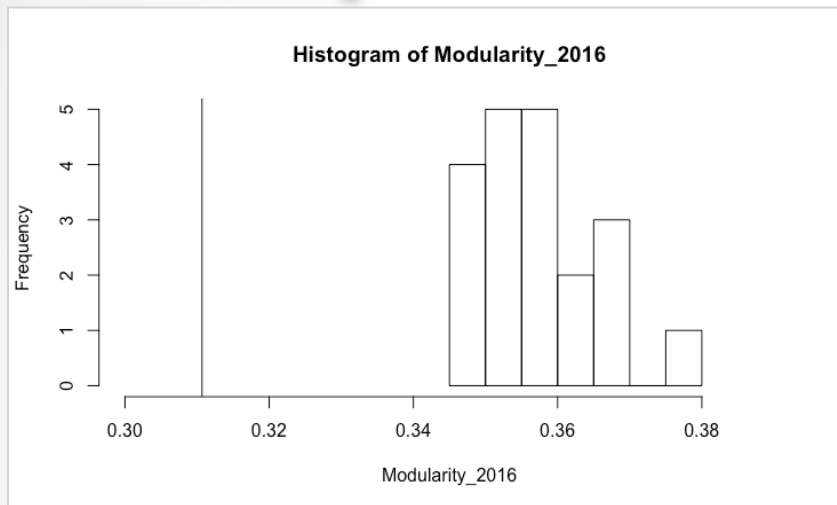
Results: Network modularity

Absolute modularity
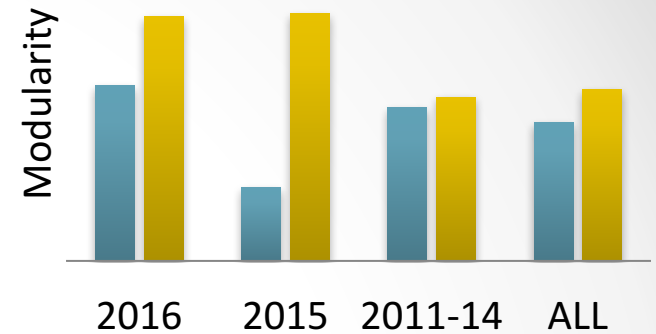
Z scores for modularity compared to null distribution

- weighted
- binary
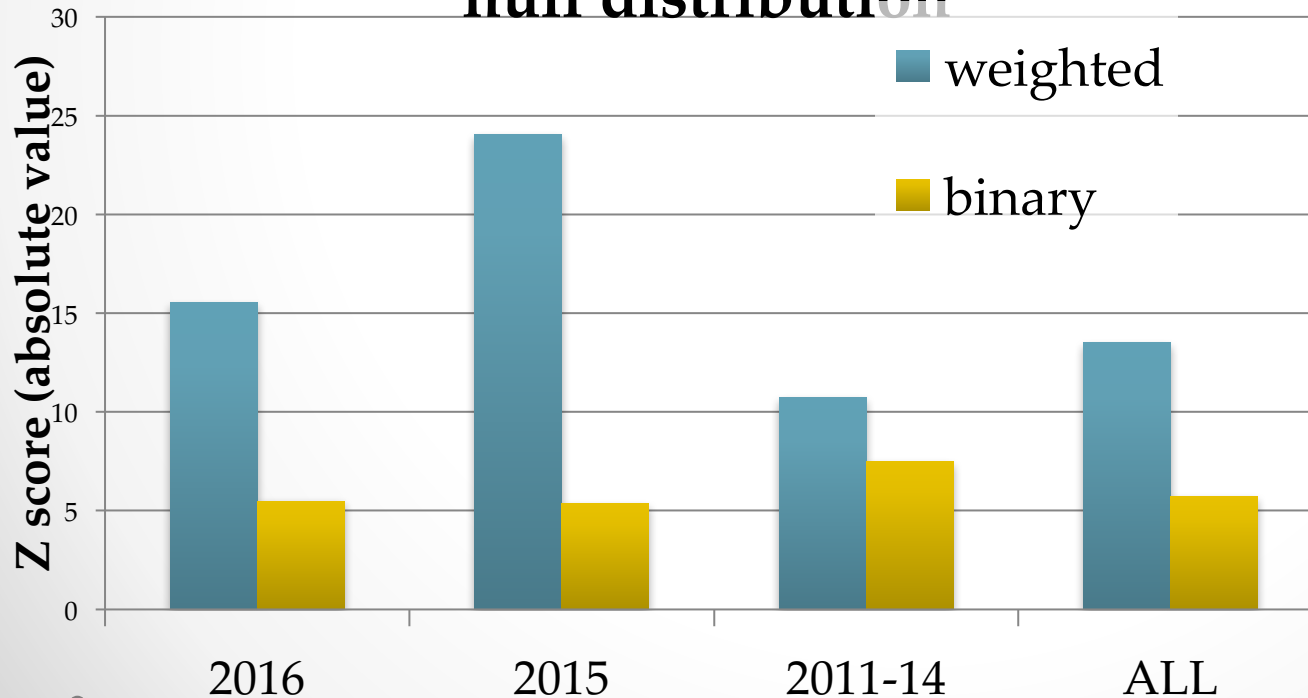
P-values for number of modules
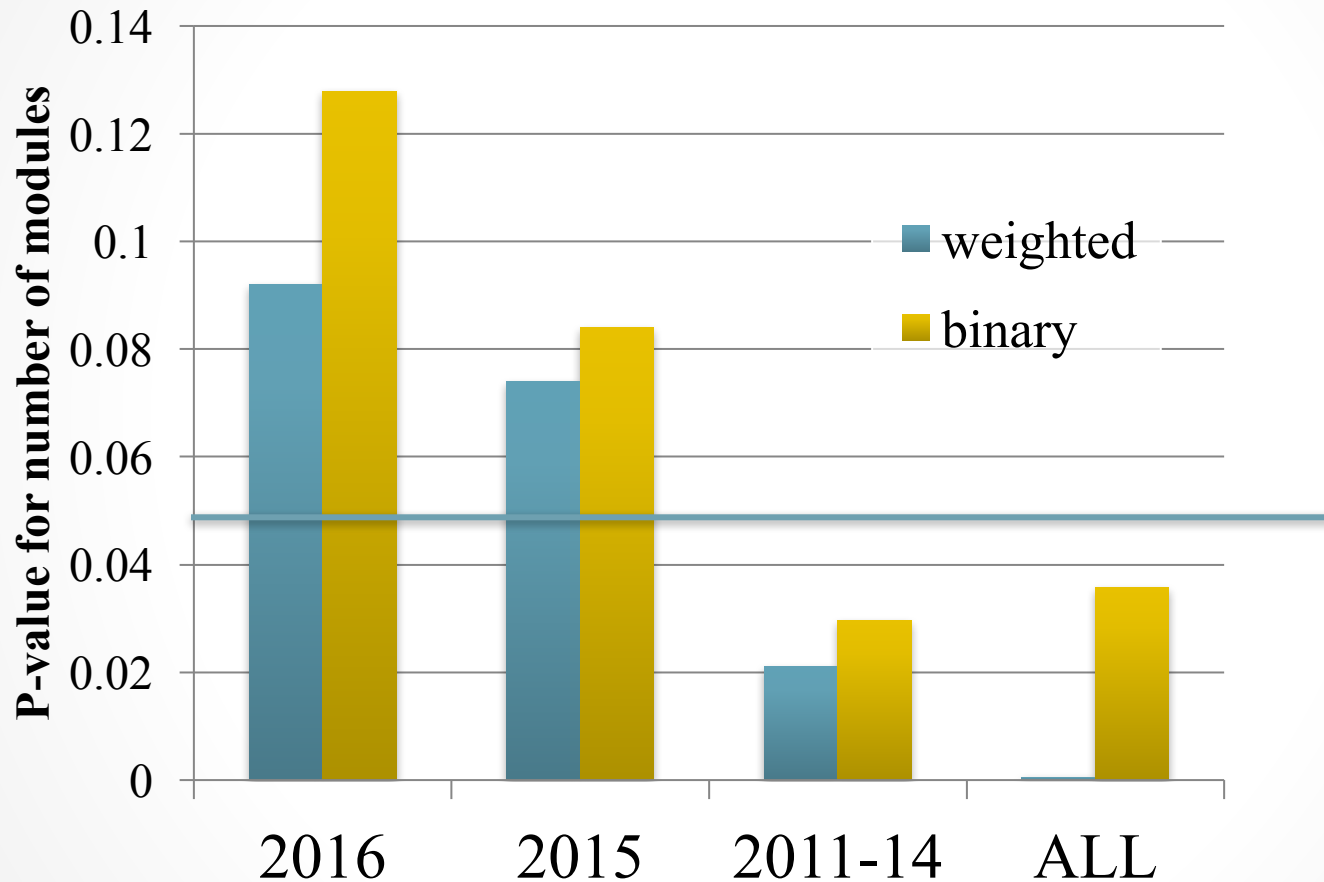
Observed number of modules lower than expected

Methods:
Phylogenetic distance

- Phylogenetic distance as defined by J. Huestis
  - average pairwise within-module phylogenetic distance
  - compared to a null grouping
    - A different partition of the same network – same number of modules, with nodes assigned randomly to a module

Within-module phylogenetic distance between plants

Within-module distance (weighted) observed null
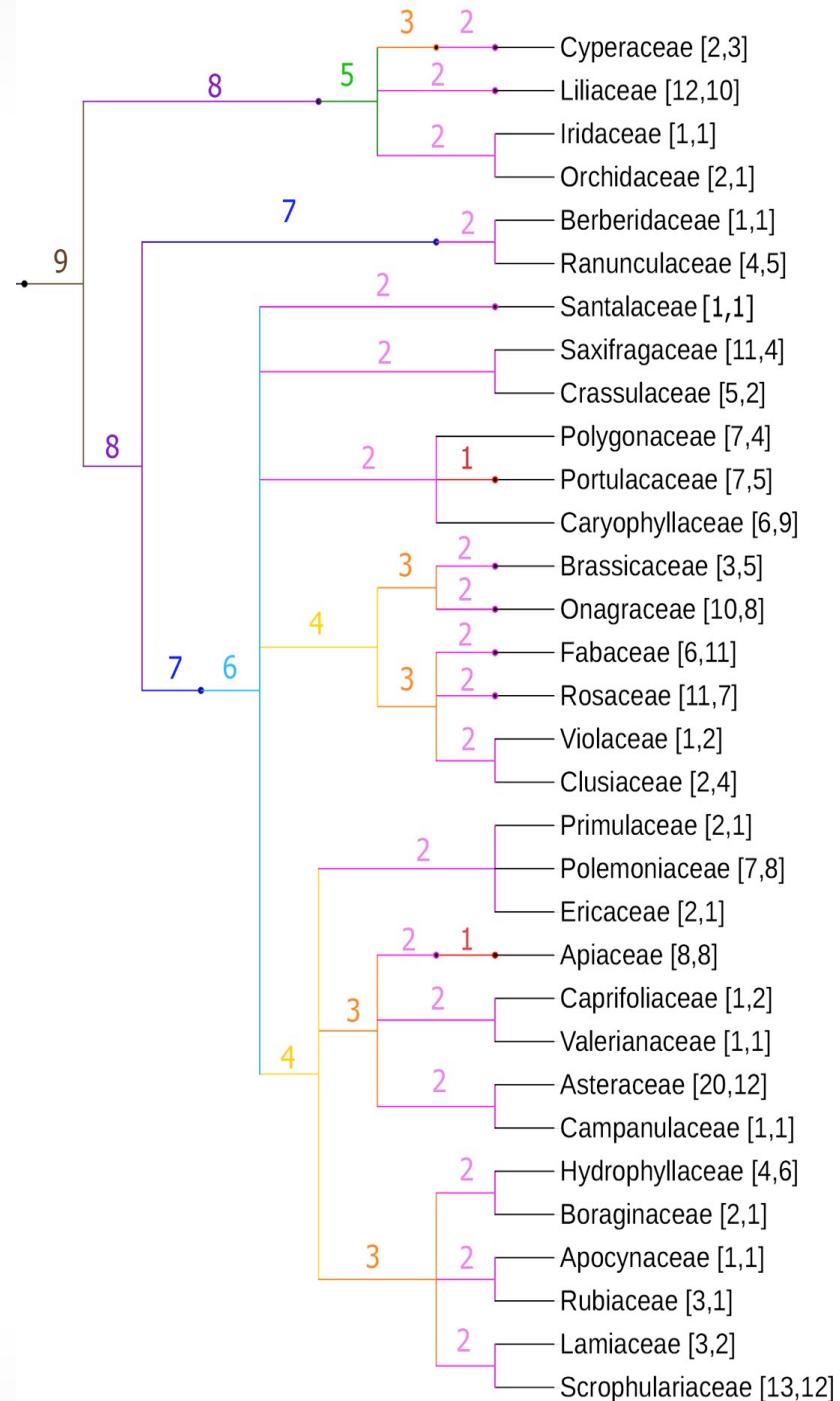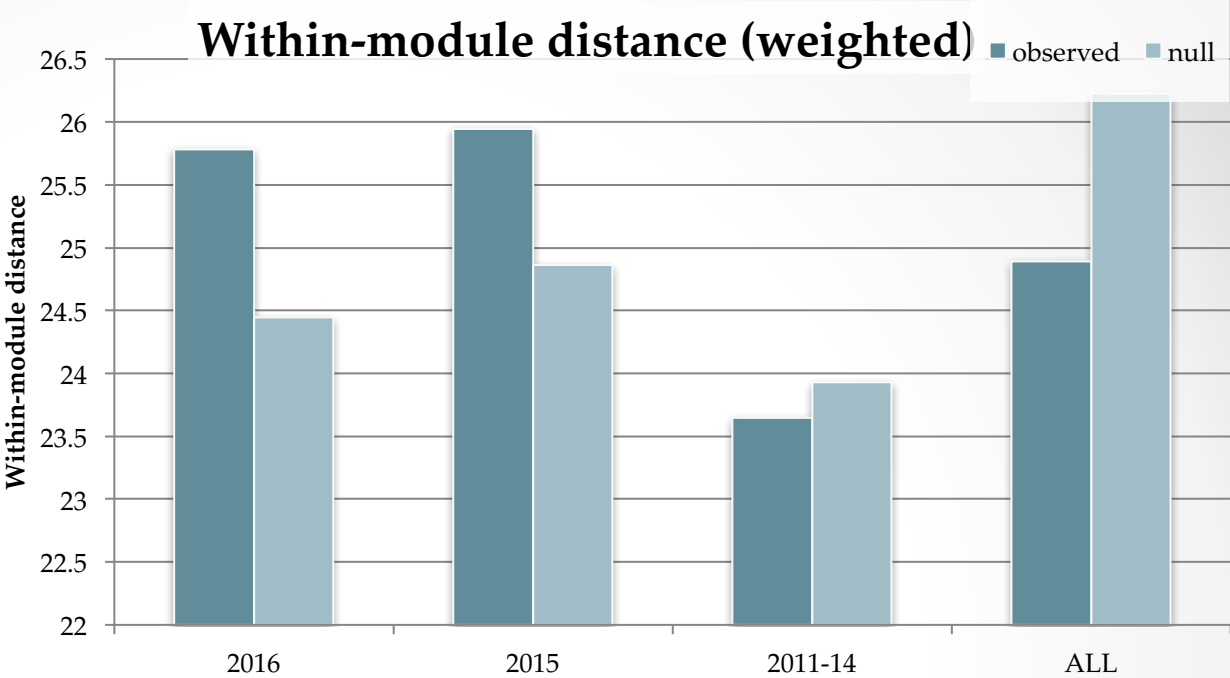
p values		
	weighted	binary
2016	0.221627	0.3008749
2015	0.4001985	0.02933728
2011-14	0.4113134	0.06483319
ALL	0.1367469	0.08427214

Within-module distance (binary) observed null
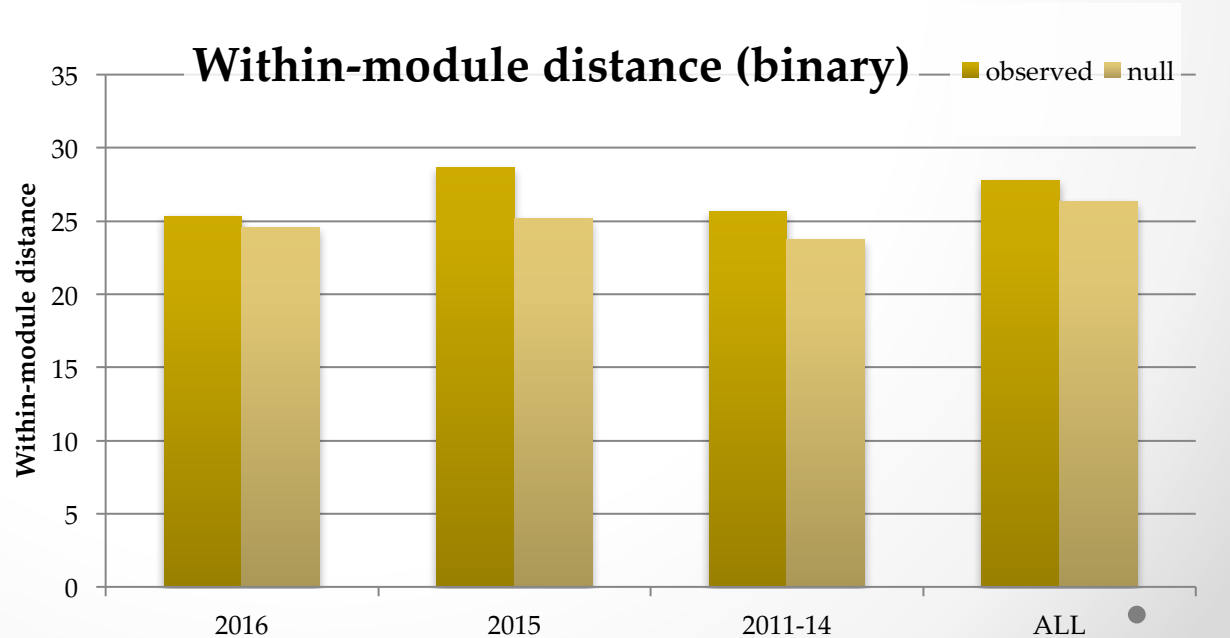
Results: Summary

1. *How modular are the networks? What results show this?*

The weighted networks are modular – results > 0, but much less modular than would be expected.

2. *How does observed modularity differ from a null (random network) model?*

Observed modularity was significantly lower than the null model distribution (p values close to zero) for both weighted and binary networks.

2. *Does modularity vary between years?*

Weighted modularity does vary considerably between years, but binary modularity is relatively consistent.

3. *How does modularity relate to phylogenetic relatedness?*

For the weighted networks, within-module phylogenetic relatedness scores fell within what could be predicted by the null model. The binary network, for one year, had a modularity score that was higher than what would be predicted, with p-value < .05

Discussion

- Why is modularity low?

Modularity may not be the defining network structure for these communities. Generalists dominate over specialists

- Why might modularity values vary between years?

Variation in populations of generalist vs. specialist species. Inconsistency in data collection

- Why are values from binary different than weighted?

Emphasis on super pollinators and super generalists (apis, bombus, eristalis)

- Why is modularity related (or not) to phylogenetic distance between plants?

Modularity could be driven by other factors. Traits, morphology, coevoultion.

Conclusions

- Modularity was extremely low in observed networks
- Binary and weighted approaches are different, and should be used with the appropriate intention
- Modularity is not strongly driven by phylogenetic relatedness of plants

- Further research
  - Phylogenetic relatedness of pollinators
  - Trait analysis
  - Comparison of module members in binary and weighted networks
  - Module member analysis
  - Properties of a meadow that might influence modularity – moisture, size, heterogeneity

Acknowledgements

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Questions?

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