Improving the pollinator pantry: restoration and management of open farmland ponds enhances the complexity of plant-pollinator networks

Highlights

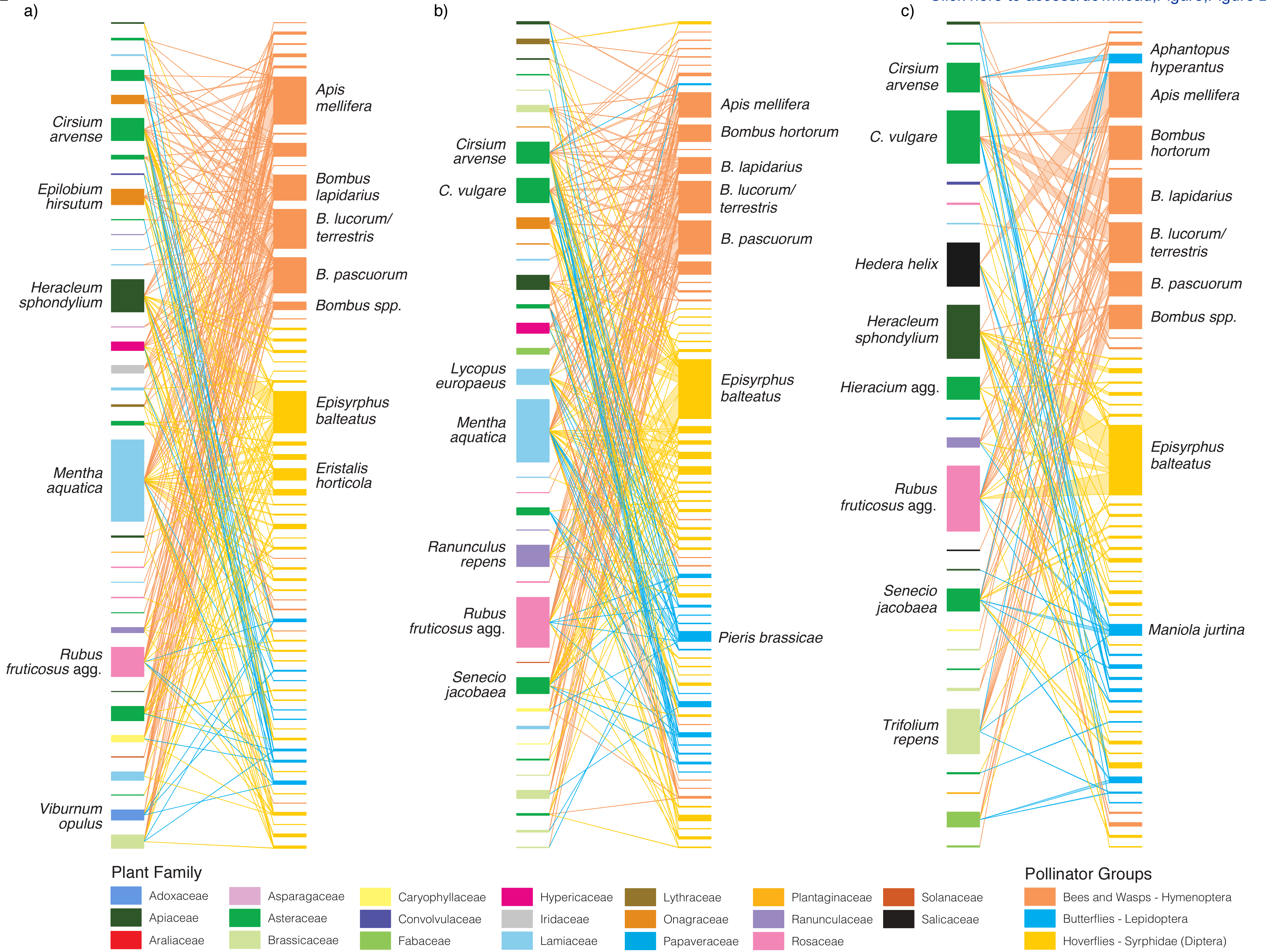
- Pond restoration improves plant-pollinator network complexity.
- Pond management and restoration increased interactions and inter-species links.
- Interactions at restored and managed ponds involved a greater number of plant species.
- Pond management effectively promotes plant-pollinator network diversity.

Figure 1

B

C

Figure 2


a)
Cirsium arvense
Epilobium hirsutum
Heracleum sphondylium
Mentha aquatica
Rubus fruticosus agg.
Viburnum opulus
Apis mellifera
Bombus lapidarius
B. lucorum/ terrestris
B. pascuorum
Bombus spp.
Episyrphus balteatus
Eristalis horticola
b)
Cirsium arvense
C. vulgare
Lycopus europaeus
Mentha aquatica
Ranunculus repens
Rubus fruticosus agg.
Senecio jacobaea
Apis mellifera
Bombus hortorum
B. lapidarius
B. lucorum/ terrestris
B. pascuorum
Episyrphus balteatus
Pieris brassicae
c)
Cirsium arvense
C. vulgare
Hedera helix
Heracleum sphondylium
Hieracium agg.
Rubus fruticosus agg.
Senecio jacobaea
Trifolium repens
Aphantopus hyperantus
Apis mellifera
Bombus hortorum
B. lapidarius
B. lucorum/ terrestris
B. pascuorum
Bombus spp.
Episyrphus balteatus
Maniola jurtina
Plant Family
Adoxaceae
Apiaceae
Araliaceae
Asparagaceae
Asteraceae
Brassicaceae
Caryophyllaceae
Convolvulaceae
Fabaceae
Hypericaceae
Iridaceae
Lamiaceae
Lythraceae
Onagraceae
Papaveraceae
Plantaginaceae
Ranunculaceae
Rosaceae
Solanaceae
Salicaceae
Pollinator Groups
Bees and Wasps - Hymenoptera
Butterflies - Lepidoptera
Hoverflies - Syrphidae (Diptera)

Improving the pollinator pantry: restoration and management o
ponds enhances the complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan C.

(a)

f open farmland

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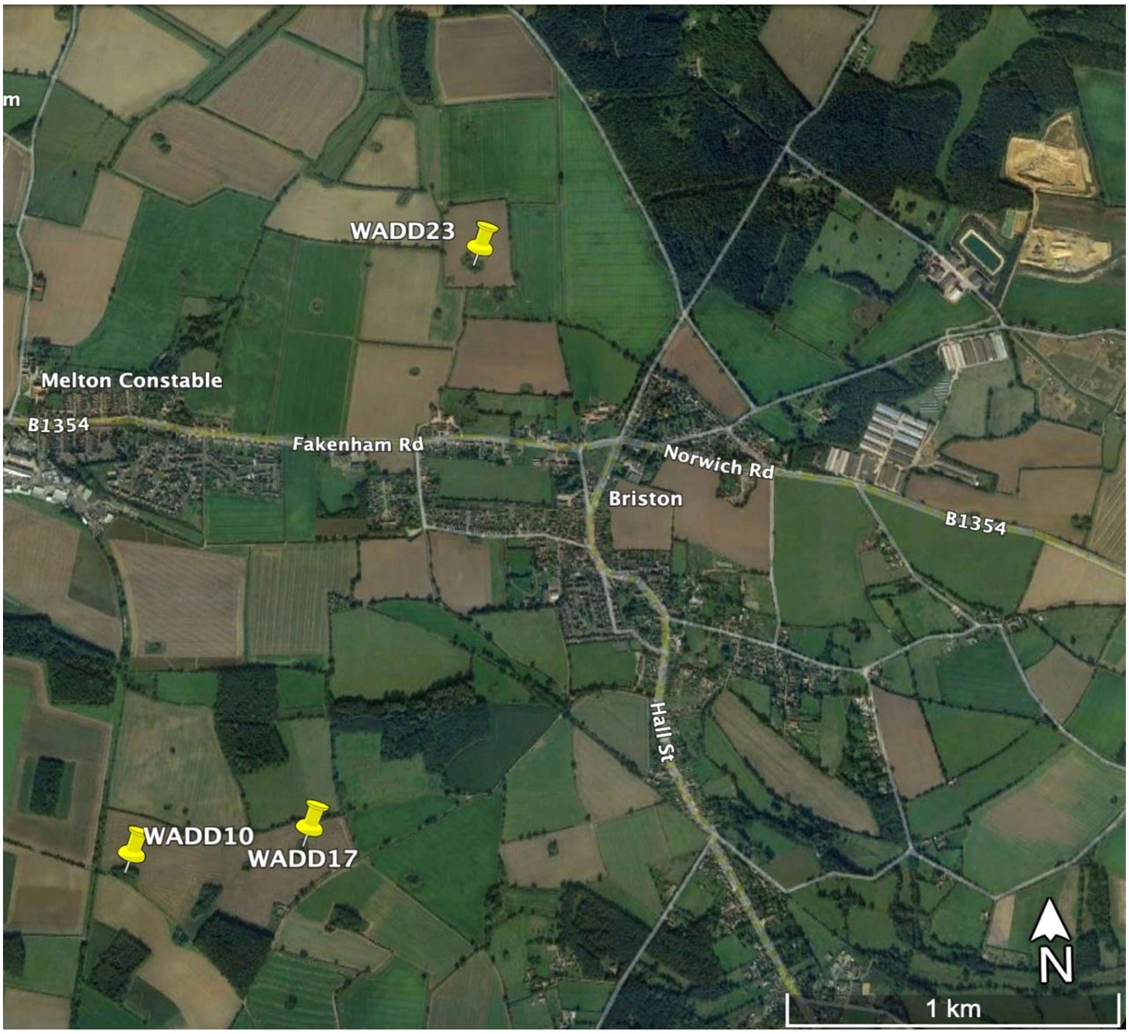
Figure S1. Satellite photo of ponds. (a) Overgrov recently restored ponds near the villages of Bodha Baconsthorpe. **(b)** Long-term managed ponds nea of Briston.

(b)

wn and
m and
r the village



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enhances the complexity of plant-pollinator networks

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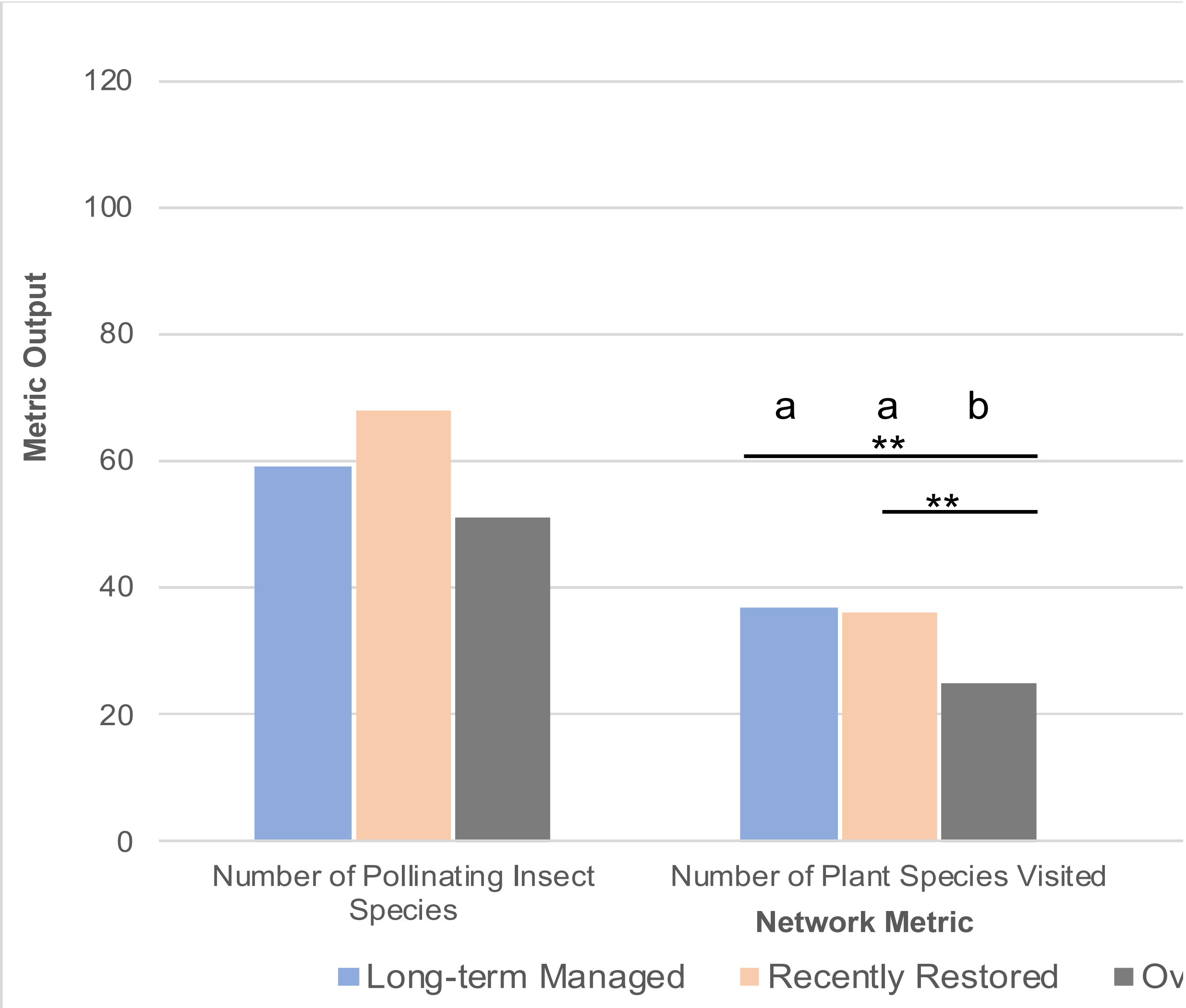
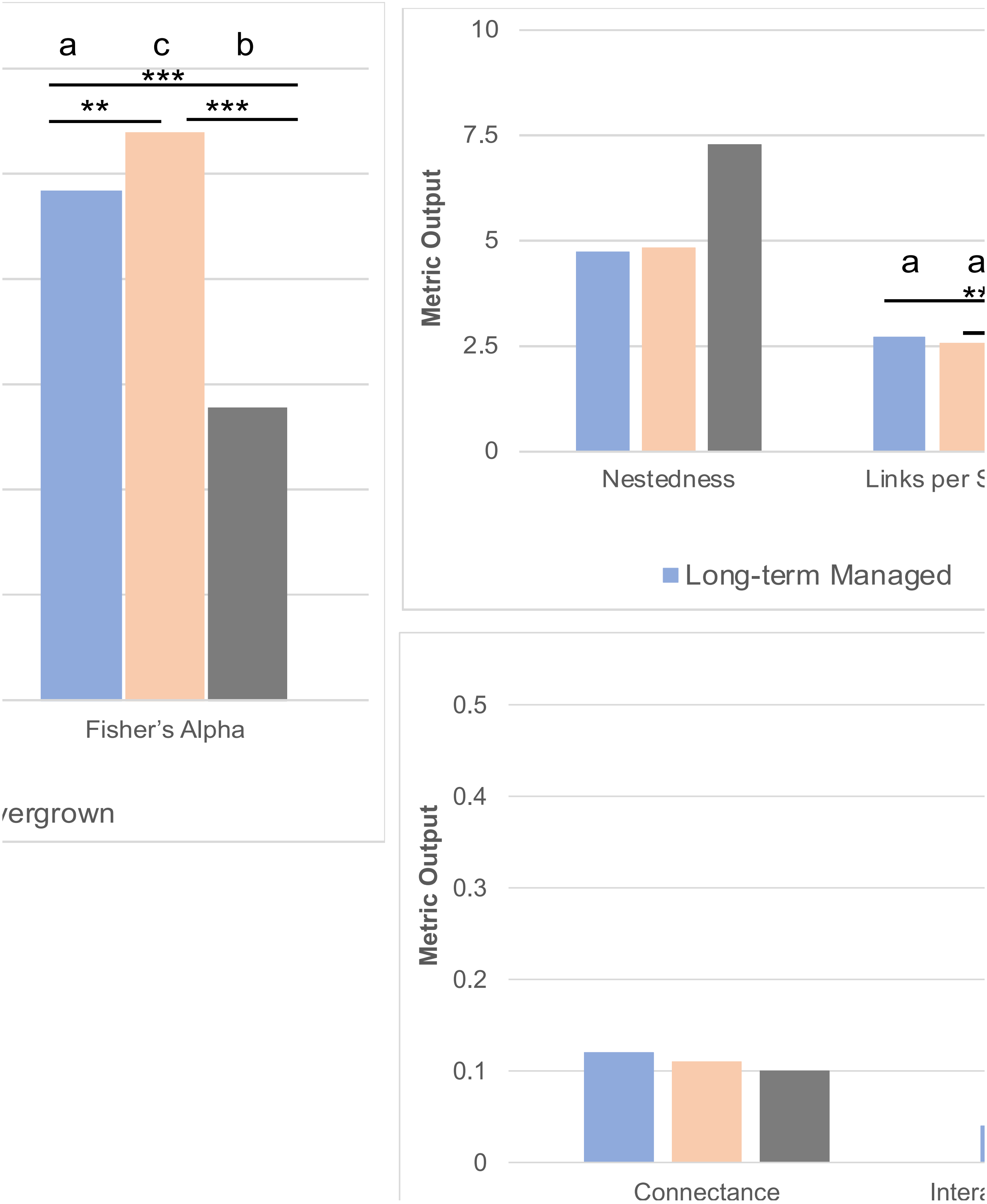
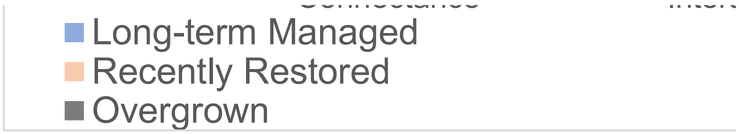


armland ponds

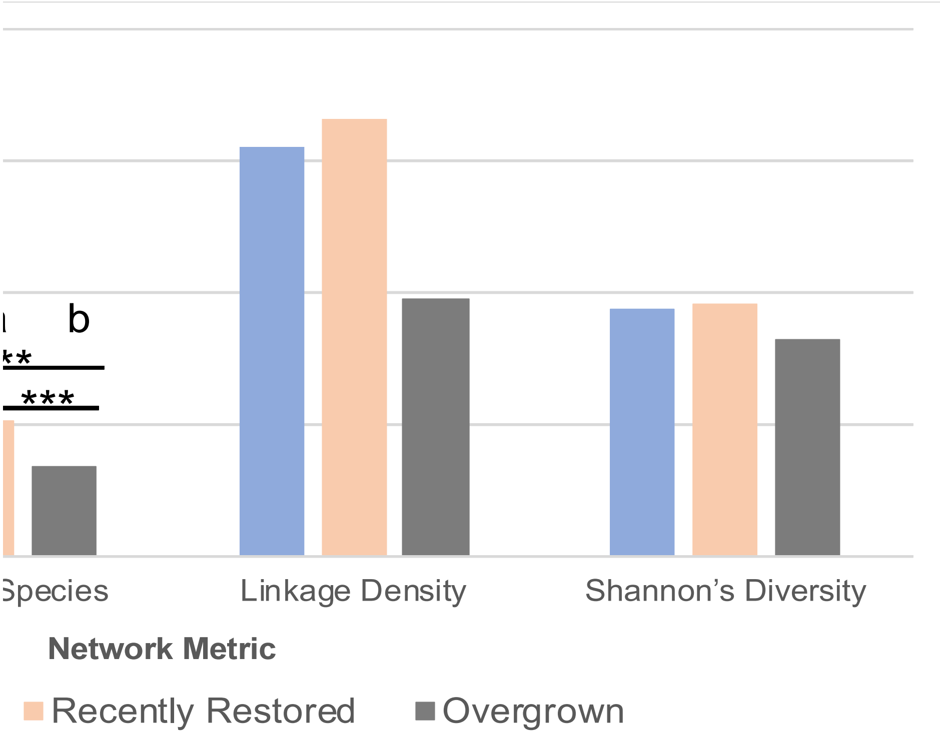
ıer

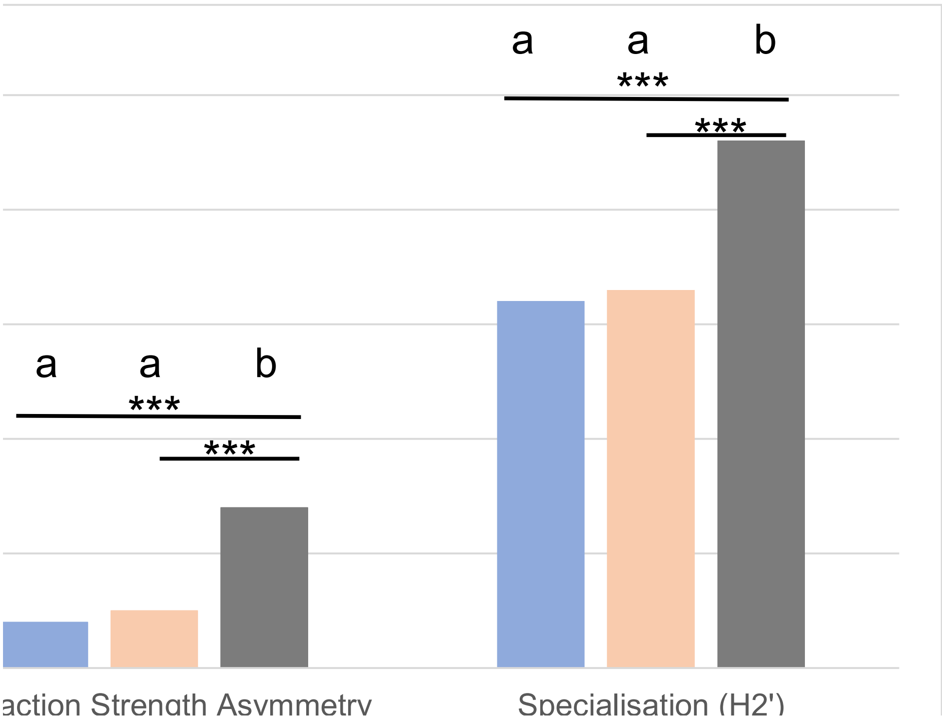
Supplementary Figure S2. Network level metrics produce
ponds over 2016-2017. Metrics are presented in three gr
Differences between management treatments are labelle
ponds, b – between recently restored and overgrown pon
restored ponds. The degree of significance is marked wit

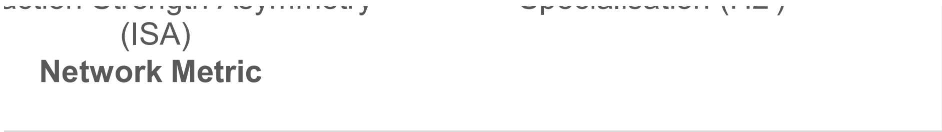



Long-term Managed
Recently Restored
Overgrown

ed by long-term managed, recently restored, and overgrown
aphs due to differences in metric measurements.
d as a – between long-term managed and overgrown
ids, and c – between long-term managed and recently
h asterisks: ‘**’ P < 0.01, ‘***’ P < 0.001.






(ISA)
Network Metric

Improving the pollinator pantry: restoration and management of open ponds enhances the complexity of plant-pollinator networks

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Table S1. Agricultural pond study sites used for plant-pollinator network analysis. Pond names, codes, and map coordinates are given for the nine study ponds.

Pond Name	Pond Code	Coordinates
Church Farm Pond 2	CHFA2	52°54'18" N 001°08'57" E
New Road Pond	NROAD	52°53'40" N 001°09'47" E
Baconsthorpe Wood Pond 2	BAWO2	52°54'02" N 001°09'48" E
Manor Farm Pond 10	WADD10	52°50'36" N 001°02'16" E
Manor Farm Pond 17	WADD17	52°50'39" N 001°02'44" E
Manor Farm Pond 23	WADD23	52°51'40" N 001°03'16" E
Shooting Close Pond	SHOOT	52°53'47" N 001°08'25" E
Beckett's Farm Pond	BECK	52°53'42" N 001°08'12" E
Sayer's Black Pit	SABA	52°54'42" N 001°09'40" E

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Improving the pollinator pantry: restoration and management of ponds enhances the complexity of plant-pollinator networks
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Pond	Category	Hedgerow Length Mean
BAWO2	Overgrown	218.56
CHFA2	Overgrown	292.70
NROAD	Overgrown	272.571
WADD23	Long-term Managed	333.05
WADD17	Long-term Managed	273.52
WADD10	Long-term Managed	456.52
SHOOT	Recently Restored	296.20
BECK	Recently Restored	344.28
SABA	Recently Restored	206.59

Pond	Category	Hedgerow Length Mean
BAWO2	Overgrown	335.52
CHFA2	Overgrown	315.01
NROAD	Overgrown	342.22
WADD23	Long-term Managed	313.74
WADD17	Long-term Managed	312.15
WADD10	Long-term Managed	344.10
SHOOT	Recently Restored	348.27
BECK	Recently Restored	338.35
SABA	Recently Restored	343.83

		Degrees of freedom
Hedgerow Length (500 m)	**Recently Restored**	2
	Overgrown	2
Grassland Area (500 m)	**Recently Restored**	2
	Overgrown	2
Woodland Area (500 m)	**Recently Restored**	2
	Overgrown	2
Other Freshwater Features Area (500 m)	**Recently Restored**	2
	Overgrown	2
Arable Field/Pasture Area (500 m)	**Recently Restored**	2
	Overgrown	2

Human Settlement Area (500 m)	**Recently Restored**	2
	Overgrown	2
Hedgerow Length (1000 m)	**Recently Restored**	2
	Overgrown	2
Grassland Area (1000 m)	**Recently Restored**	2
	Overgrown	2
Woodland Area (1000 m)	**Recently Restored**	2
	Overgrown	2
Other Freshwater Features Area (1000 m)	**Recently Restored**	2
	Overgrown	2
Arable Field/Pasture Area (1000 m)	**Recently Restored**	2
	Overgrown	2
Human Settlement Area (1000 m)	**Recently Restored**	2
	Overgrown	2

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Table S2. Comparison betwee **ponds.** Landscape elements fo radius from each study pond, an Bonferroni correction.

Table S2a (500 m radius)

Grassland Area Mean	Woodland Area Mean	Other Freshwater Features Mean
3125.79	48689.91	2296.33
3092.99	34578.20	1525.54
2750.55	8768.28	686.58
2644.16	2606.86	947.36
2058.10	27632.82	1441.57
1687.70	16872.35	1682.42
4985.40	3374.75	1358.66
3392.25	2211.8	1626.04
4524.72	2471.46	1987.62

Table S2b (1000 m radius)

Grassland Area Mean	Woodland Area Mean	Other Freshwater Features Mean
15041.31	51086.25	2386.37
9560.56	68974.87	2515.34
12627.06	58208.48	2403.10
5663.35	97392.37	1759.24
10757.96	25391.74	2057.40
8751.46	30457.13	2168.34
11693.22	15078.92	2128.25
7745.41	8155.51	2256.25
9745.86	3236.32	2378.33

Table S2c (Landscape comparison)

Long-term Managed		
t-value	*p-value*	*Degrees of freedom*
-0.764	0.78	NA
-1.562	0.48	2
4.910	0.01	NA
4.543	0.331	2
-1.714	0.87	NA
0.927	0.69	2
4.583	1	NA
0.215	1	2
-0.232	1	NA
-1.886	0.61	2

1.898	0.25	NA
3.588	0.37	2
1.921	0.35	NA
1.05	1	2
0.511	1	NA
1.316	0.27	2
-2.088	0.22	NA
0.301	1	2
4.718	0.225	NA
3.872	0.032	2
0.265	1	NA
-1.931	1	2
-0.407	1	NA
-0.829	1	2

n landcape elements present around Norfolk study
ınd in **(a)** 500 m radius from each study pond, **(b)** 1000 m
ıd **(c)** management comparisons using pairwise t-tests with

Arable Field/Pasture Area Mean	Human Settlement Area Mean
59492.19	12044.62
44016.56	37875.18
32266.14	32504.34
65618.50	0
59598.95	1509.28
77861.03	1509.28
72560.83	18131.20
85240.93	12537.71
29940.06	63992.22

Arable Field/Pasture Area Mean	Human Settlement Area Mean
44675.32	18554.58
51329.69	20740.74
39440.80	21173.00
58269.36	93529.23
51011.41	22016.04
53698.35	11198.77
70065.09	36750.43
66740.82	29175.63
34848.13	31675.18

Recently Restored	
t-value	*p-value*
NA	NA
-0.477	1
NA	NA
-2.588	0.087
NA	NA
2.440	0.14
NA	NA
-0.239	1
NA	NA
-1.359	0.94

NA	NA
-0.248	1
NA	NA
-2.003	0.9
NA	NA
5.911	0.69
NA	NA
6.757	0.13
NA	NA
2.318	0.553
NA	NA
-1.369	0.78
NA	NA
-4.168	1

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	Aegopodium podagraria	*Alisma plantago-aquatica*	*Anthriscus sylvestris*
Anasimyia spp.	0	4	0
Ancistrocerus parietum	0	0	0
Ancistrocerus trifasciatus	0	0	0
Andrena bicolor	0	0	0
Andrena dorsata	0	1	0
Andrena nigroaenea	0	0	0
Andrena/Lasioglossum spp.	0	1	0
Aphantopus hyperantus	0	0	0
Apis mellifera	6	0	0
Autographa gamma	0	0	0
Bombus hortorum	0	0	1
Bombus hypnorum	0	0	0
Bombus lapidarius	0	0	0
Bombus lucorum/terrestris	0	0	0
Bombus pascuorum	0	0	0
Bombus spp.	0	0	0
Bombus sylvestris	0	0	0
Bombus vestalis	0	0	0
Buathra laborator	0	0	0
Cheilosia illustrata	0	0	0
Cheilosia pagana	0	0	0
Cheilosia spp.	0	0	0
Chrysotoxum bicinctum	0	0	0
Elophila nympheata	0	0	0
Epistrophe diaphana	0	0	0
Epistrophe grossulariae	0	0	0
Episyrphus balteatus	1	12	1

Eristalis abusivus	0	0	0
Eristalis arbustorum	0	0	0
Eristalis horticola	0	0	0
Eristalis interruptus	0	1	0
Eristalis nemorum	0	0	0
Eristalis pertinax	0	0	0
Eristalis spp.	0	0	0
Eupeodes corollae	0	0	0
Gymnomerus laevipes	0	0	0
Helophilus hybridus	0	0	0
Helophilus pendulus	0	0	0
Helophilus trivittatus	0	0	0
Ichneumon sarcitorius	0	0	0
Ichneumon xanthorius	0	0	0
Maniola jurtina	0	0	0
Melangyna umbellatarum	0	0	0
Meliscaeva auricollis	0	0	0
Nymphalis urticae	0	0	0
Ochlodes sylvanus	0	0	0
Pararge aegeria	0	0	0
Pieris brassicae	1	0	0
Pieris rapae	0	0	0
Pipiza austriaca	0	0	0
Pipiza spp.	0	0	0
Platycheirus manicatus	0	0	0
Platycheirus scutatus	0	0	0
Polygonia c-album	0	0	0
Pyronia tithonus	0	0	0
Sphaerophoria scripta	0	0	0
Symmorphus gracilis	0	0	0
Thymelicus lineola	0	0	0
Thymelicus spp.	0	0	0
Thymelicus sylvestris	0	0	0
Vanessa atalanta	1	0	0
Vanessa cardui	0	0	0
Vespula germanica	0	0	0

Vespula spp.	0	0	0
Vespula vulgaris	0	0	0
Volucella bombylans	0	0	0
Volucella inanis	0	0	0
Volucella inflata	0	0	0
Volucella pellucens	0	0	1
Xylota segnis	0	0	0

Table S3. Interaction table of plants an restored ponds. Columns are plant spec species. Numbers indicate the number of given species was observed to directly vis species.

Arctium minus	*Brassica oleracea*	*Cardamine amara*	*Chamerion angustifolium*	*Cirsium arvense*
0	0	0	0	0
0	0	0	0	1
0	0	0	0	1
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	1
0	0	2	0	12
0	0	0	0	0
0	0	3	0	6
0	0	0	0	1
0	0	9	0	13
0	0	0	0	0
2	0	1	1	5
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	1	0	3

0	0	0	0	0
0	0	0	0	5
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	1
0	0	0	0	2
0	0	0	0	1
0	0	0	0	1
0	0	0	0	5
0	0	0	0	0
0	0	0	0	0
0	1	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	2
0	0	0	0	0
0	0	0	0	2
0	0	0	0	4
0	0	0	0	1
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	2	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0

d pollinators at recently
ies and rows are pollinator
times a pollinator from a
sit the flower face of a plant

Cirsium vulgare	*Epilobium hirsutum*	*Epilobium montanatum*	*Glechoma hederacea*	*Heracleum sphondylium*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	3	0	0	0
0	0	0	0	0
13	2	0	0	0
0	0	0	0	0
7	6	0	0	0
0	0	0	0	0
16	8	0	0	0
14	3	0	0	1
0	0	0	0	0
5	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	2
0	0	0	0	0
7	3	2	0	36

0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	4	0	0	4
0	0	0	0	0
1	1	0	0	0
1	1	0	0	0
0	1	0	0	0
0	0	0	0	1
0	0	0	0	1
1	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	1	0	0	0
0	0	0	0	1
1	0	0	0	0
2	0	0	0	0
1	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	1	0	0	1
0	0	0	0	0
0	0	0	0	5
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Hieracium agg.	*Hypericum perforatum*	*Lathyrus pratensis*	*Lycopus europaeus*	*Mentha aquatica*
0	0	0	5	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	1
0	0	0	0	0
2	0	0	2	2
0	0	0	0	0
0	0	0	9	24
0	0	0	0	1
0	1	0	0	9
0	0	0	0	0
0	3	1	0	5
0	0	0	0	0
1	7	22	5	37
0	2	0	0	3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	1	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	7	0
0	0	0	0	0
0	0	0	0	3
0	24	0	0	0

0	0	0	9	12
0	0	0	1	4
0	0	0	1	17
0	0	0	1	18
0	0	0	0	4
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	1	3
0	0	0	5	1
0	0	0	2	2
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0
0	0	0	0	0
0	1	0	7	1
0	0	0	2	0
0	0	0	0	0
0	0	0	0	2
2	1	0	0	28
0	0	0	1	1
0	0	0	0	0
0	0	0	0	3
0	0	0	0	0
0	0	0	0	10
0	0	0	0	0
0	0	0	1	1
2	0	0	0	0
0	0	0	0	0
1	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	1	0

0	0	0	1	0
1	0	0	1	1
0	0	0	0	0
0	0	0	0	17
0	0	0	0	0
0	0	0	0	6
0	0	0	1	0

Mentha spicata	*Prunus spinosa*	*Pulicaria dysenterica*	*Ranunculus aquatilis*	*Ranunculus repens*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	4
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	2
0	0	0	0	0
0	0	0	0	3
0	0	0	0	0
1	0	0	0	5
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	2
0	0	0	0	45

0	0	0	0	3
0	0	0	0	3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	2
0	0	2	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	1	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	18	0	0
0	0	0	0	0
0	0	0	0	0
0	0	5	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	1

Rosa canina	*Rubus fruticosus* agg.	*Salix cinerea* agg.	*Senecio jacobaea*	*Silene dioica*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	1	0	0	1
0	4	0	0	0
2	25	1	5	0
0	0	0	0	0
0	12	0	4	0
0	0	0	0	0
0	7	0	2	0
0	0	0	0	0
0	5	0	0	0
0	13	0	1	0
0	2	0	0	0
0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	1	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	85	0	1	4

0	0	0	1	0
0	0	0	1	0
0	0	0	6	0
0	0	0	9	0
0	0	0	0	0
0	0	0	2	0
0	0	0	1	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	2	0
0	0	0	1	0
0	0	0	0	0
0	0	0	0	0
0	5	0	3	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	2	0	5	0
0	0	0	0	0
0	0	0	0	0
0	0	0	1	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	1
0	1	0	1	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0

Stachys sylvatica	*Stellaria spp.*	*Taraxacum* agg.	*Trifolium dubium*	*Trifolium repens*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
1	0	2	0	0
0	0	0	0	0
0	0	0	0	11
0	0	0	0	0
3	0	0	0	3
0	0	0	0	0
4	0	0	0	3
0	0	0	0	11
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	1	0
0	1	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Tripleurospermum inodorum	*Vicia cracca*	*Vicia lutea*
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
1	4	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
2	0	0

0	0	0
0	0	0
0	0	0
1	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	1
0	0	0
0	0	0
0	0	0
0	1	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0

0	0	0
2	0	0
0	0	0
0	0	0
0	0	0
0	0	0
1	0	0

Improving the pollinator pantry: restoration and management of open farmland ponds enhances the complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan C. Axmacher

	Anthriscus sylvestris	*Arctium minus*	*Ballota nigra*
Andrena bicolor	0	0	0
Andrena dorsata	0	0	0
Andrena nigroaenea	0	0	0
Andrena/Lasioglossum spp.	0	0	0
Aphantopus hyperantus	0	0	0
Apis mellifera	0	2	0
Bombus campestris	0	0	0
Bombus hortorum	0	1	0
Bombus hypnorum	0	0	0
Bombus lapidarius	0	0	0
Bombus lucorum/terrestris	0	4	0
Bombus pascuorum	0	0	4
Bombus spp.	0	0	0
Bombus sylvestris	0	0	0
Cheilosia illustrata	0	0	0
Cheilosia spp.	0	0	0
Chrysotoxum bicinctum	2	0	0
Dolichovespula sylvestris	0	0	0
Elophila nympheata	0	0	0
Epistrophe diaphana	0	0	0
Epistrophe grossulariae	0	0	0
Episyrphus balteatus	0	0	0
Eristalis abusivus	0	0	0
Eristalis arbustorum	0	0	0
Eristalis horticola	0	0	0
Eristalis interruptus	0	0	0
Eristalis intricarius	0	0	0
Eristalis nemorum	0	0	0

Eristalis pertinax	0	0	0
Eristalis spp.	0	0	0
Eupeodes corollae	0	0	0
Gymnomerus laevipes	0	0	0
Helophilus hybridus	0	0	0
Helophilus pendulus	0	0	0
Helophilus trivittatus	0	0	0
Ichneumon sarcitorius	0	0	0
Ichneumon xanthorius	0	0	0
Maniola jurtina	0	0	0
Megachile centuncularis	0	0	0
Melangyna umbellatarum	2	0	0
Meliscaeva auricollis	0	0	0
Neoascia podagrica	0	0	0
Nymphalis urticae	0	0	0
Pieris rapae	0	0	0
Pipiza spp.	0	0	0
Platycheirus scutatus	0	0	0
Polygonia c-album	0	0	0
Pyronia tithonus	0	0	0
Scaeva pyrasti	0	0	0
Sphaerophoria scripta	0	0	0
Thymelicus lineola	0	1	0
Thymelicus sylvestris	0	0	0
Tropidia scita	0	0	0
Vanessa atalanta	0	0	0
Vanessa cardui	0	0	0
Vespula vulgaris	0	0	0
Volucella bombylans	0	0	0
Volucella inanis	0	0	0
Volucella pellucens	0	0	0
Xylota segnis	0	0	0

Table S4. Interaction table of plants and pol
managed ponds. Columns are plant species a
species. Numbers indicate the number of times
species was observed to directly visit the flowe

Centaurea nigra	*Chamerion angustifolium*	*Cirsium arvense*	*Cirsium vulgare*	*Convolvulus arvensis*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	3	0	0
0	0	0	0	0
1	6	15	0	0
1	0	0	0	0
3	2	5	2	0
0	0	0	0	0
29	8	19	3	0
7	12	16	5	0
2	4	5	2	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	4	0	0
0	0	1	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	4	1	0	1
0	0	0	0	0
0	0	2	0	0
0	0	1	0	0
0	0	2	0	0
0	0	1	0	0
0	0	0	0	0

0	0	3	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	1	5	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	1	0	0
0	0	0	0	0
0	0	1	0	1
0	0	5	0	0
1	0	2	3	1
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

llinators at long-term
ınd rows are pollinator
; a pollinator from a given
r face of a plant species.

Epilobium hirsutum	*Eupatorium cannabinum*	*Ficaria verna*	*Galeopsis tetrahit*	*Glechoma hederacea*
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
26	0	1	0	0
0	0	0	0	0
3	0	0	0	0
0	0	0	0	0
3	0	0	1	0
21	1	0	0	1
5	0	0	0	1
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
3	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Heracleum sphondylium	*Hyacinthoides non-scripta*	*Hypericum perforatum*	*Iris psuedacorus*	*Lycopus europaeus*
0	0	0	0	0
1	0	1	0	0
0	0	0	0	0
1	0	2	0	0
1	0	0	0	0
3	0	1	4	2
0	0	0	0	0
1	0	0	6	0
0	0	0	0	0
0	0	1	4	0
2	1	1	19	0
0	2	12	2	2
0	0	3	0	0
0	0	0	0	0
6	0	0	0	0
10	0	0	0	0
4	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	1	0	1
97	0	5	0	0
0	0	0	0	0
0	0	0	0	0
2	0	1	0	0
4	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
1	0	0	0	0
0	0	0	0	0
1	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	2	0	1
0	0	2	0	0
1	0	0	0	0
0	0	0	0	1
0	0	0	0	0
1	0	2	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	1	0	1
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0
1	0	0	0	0
0	0	0	0	0
1	0	3	0	1

Lythrum salicaria	*Matricaria chamomila*	*Mentha aquatica*	*Oenanthe aquatica*	*Plantago lanceolata*
0	0	0	0	0
0	0	4	0	0
0	0	0	0	1
0	0	8	0	1
0	0	0	3	0
1	0	98	0	0
0	0	2	0	0
2	0	14	0	0
0	0	1	0	0
0	0	5	0	0
0	0	45	0	0
2	0	53	0	0
0	0	11	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	12	1	0	0
0	2	12	0	0
0	2	14	0	0
0	0	11	1	0
0	0	20	0	0
0	0	2	0	0
0	0	4	0	0

0	0	6	0	0
0	0	0	0	0
1	0	4	0	0
0	0	1	0	0
0	0	3	0	0
0	0	6	0	0
0	0	3	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	12	0	0
0	0	1	0	0
0	0	1	0	0
2	0	2	0	0
0	0	0	0	0
0	0	13	0	0
0	0	2	2	0

Potentilla spp.	*Prunella vulgaris*	*Prunus spinosa*	*Pulicaria dysenterica*	*Ranunculus repens*
0	0	0	0	0
1	0	0	0	0
0	0	0	0	1
1	0	1	0	2
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	4
0	1	1	1	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
1	0	0	0	0
0	0	0	0	9
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Rubus fruticosus agg.	*Sambuca nigra*	*Senecio jacobaea*	*Silene dioica*	*Solanum dulcamara*
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
3	0	1	0	0
3	0	0	1	0
18	0	15	1	0
1	0	0	0	0
6	0	1	0	0
0	0	0	0	0
14	0	13	1	0
20	0	1	3	0
22	0	0	2	2
10	0	2	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	2	0
25	0	0	17	0
0	0	1	0	0
0	1	3	0	0
0	0	14	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	1	0	0
1	0	0	0	0
0	0	0	0	0
0	0	4	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	4	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	1	0	0
1	0	0	1	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	1	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Stachys palustris	*Stachys sylvatica*	*Tripleurosperm um inodorum*	*Viburnum opulus*	*Vicia cracca*
0	0	0	0	0
0	0	0	4	0
0	3	0	0	0
0	3	0	4	0
0	1	0	0	0
0	2	0	8	3
0	0	0	0	0
0	6	0	0	6
0	0	0	0	0
0	6	0	0	1
0	8	0	0	3
0	9	0	0	25
0	0	0	0	7
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	1	0	0	10
0	0	0	0	0
0	0	0	0	0
0	0	0	19	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	1	9	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	1	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	3	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0
0	0	0	1	0
0	0	0	0	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	2

Improving the pollinator pantry: restoration and management
farmland ponds enhances the complexity of plant-pollinator r
Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan (

	Anthriscus sylvestris	*Arctium minus*
Alomya debellator	1	0
Andrena dorsata	0	0
Andrena/Lasioglossum spp.	0	0
Aphantopus hyperantus	0	0
Apis mellifera	0	0
Bombus hortorum	0	0
Bombus hypnorum	0	0
Bombus lapidarius	0	0
Bombus lucorum/terrestris	0	0
Bombus pascuorum	0	0
Bombus spp.	0	0
Bombus vestalis	0	0
Buathra laborator	1	0
Cheilosia illustrata	0	0
Cheilosia spp.	0	0
Chrysotoxum bicinctum	0	0
Epistrophe diaphana	0	0
Epistrophe elegans	0	0
Epistrophe grossulariae	0	0
Episyrphus balteatus	0	0
Eristalis abusivus	0	0
Eristalis arbustorum	0	0
Eristalis horticola	0	0
Eristalis interruptus	0	0
Eristalis pertinax	0	0
Eupeodes corollae	0	0
Eupeodes luniger	0	0
Helophilus hybridus	0	0
Helophilus pendulus	0	0
Ichneumon xanthorius	0	0

Leucozona laternaria	0	0
Maniola jurtina	0	0
Meliscaeva auricollis	0	0
Nymphalis urticae	0	0
Ochlodes sylvanus	0	0
Pararge aegeria	0	0
Pieris brassicae	0	0
Pieris rapae	0	0
Platycheirus scutatus	0	0
Pyronia tithonus	0	0
Sericomyia silentis	0	0
Sphaerophoria scripta	0	0
Syritta pipiens	0	0
Syrphus vetripennis	0	0
Thymelicus lineola	1	0
Thymelicus sylvestris	0	0
Vanessa cardui	0	0
Vespula rufa	0	0
Vespula vulgaris	0	0
Volucella bombylans	0	0
Xylota segnis	0	0

of open
networks
C. Axmacher

Table S5. Interacti
plant species and r
pollinator from a gi

Centaurea nigra	*Cirsium arvense*	*Cirsium vulgare*	*Convolvulus arvensis*
0	0	0	0
0	0	0	0
0	1	0	1
0	7	0	0
0	1	0	0
0	0	8	0
0	0	0	0
0	7	26	0
0	2	23	0
1	6	7	0
0	0	0	0
0	1	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	2	2	1
0	0	0	0
0	1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	1	0	0
0	0	0	1
0	0	0	0

0	0	0	0
0	3	0	0
0	0	0	0
0	1	0	0
0	2	2	0
0	0	0	0
1	2	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	0
0	1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	1	0	0

ion table of plants and pollinators at overgrown ponds. Columns are
rows are pollinator species. Numbers indicate the number of times a
ven species was observed to directly visit the flower face of a plant species.

Crataegus monogyna	*Glechoma hederacea*	*Hedera helix*	*Heracleum sphondylium*
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	46	2
0	0	0	0
0	0	0	0
0	0	0	0
0	1	0	0
0	0	0	0
0	0	0	2
0	0	0	0
0	0	0	0
0	0	0	1
0	0	0	6
0	0	0	0
0	0	0	4
0	0	0	1
0	0	1	0
0	0	0	37
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	2	0
0	0	0	4
1	0	0	0
0	0	0	0
0	0	0	3
0	0	0	4

0	0	0	1
0	0	0	0
0	0	0	1
0	0	1	0
0	0	0	0
0	0	3	0
0	0	0	0
0	0	0	1
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
0	0	0	0
0	0	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	2
0	0	5	0
0	0	0	2
0	0	0	0

Hieracium agg.	*Papaver rhoeas*	*Ranunculus repens*	*Rubus fruticosus* agg.
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	3
1	0	2	6
0	0	0	18
0	0	0	1
3	0	0	1
0	1	1	7
0	0	0	11
0	0	1	4
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1	0	0	1
0	0	0	0
0	0	0	0
0	0	0	1
16	0	6	29
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	1	4
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	1
2	0	0	0
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
6	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	1
0	0	0	0

Salix cinerea agg.	*Sambuca nigra*	*Senecio jacobaea*	*Silene dioica*
0	0	0	0
0	0	1	0
0	0	2	0
0	0	1	0
0	0	2	1
0	0	0	0
0	0	0	0
0	0	0	0
1	0	4	0
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	2	0
0	0	0	0
0	0	2	0
0	0	3	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	1	5	0
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	3	0
0	0	1	0
0	0	0	0
0	0	2	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Sisymbrium officinale	*Taraxacum* agg.	*Trifolium dubium*	*Trifolium repens*
0	0	0	0
1	0	0	0
1	0	0	0
0	0	0	1
0	0	0	0
0	0	0	12
0	0	0	0
0	0	2	9
0	0	0	10
0	0	0	2
0	0	1	23
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Tripleurospermum inodorum	*Veronica persica*	*Vicia cracca*	*Vicia hirsuta*
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	5	2
0	0	0	0
0	0	0	0
0	0	4	0
0	1	5	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	1	0
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	4	0
0	0	1	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Improving the pollinator pantry: restoration and management of open farı complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan C. Axmacher

	species.degree	normalised.c	species.stre	interaction.p
Anasimyia spp.	2	0.05555556	0.30696799	-0.346516
Ancistrocerus parietum	1	0.02777778	0.01219512	-0.9878049
Ancistrocerus trifasciatus	2	0.05555556	0.03037694	-0.4848115
Andrena bicolor	2	0.05555556	0.0163445	-0.4918278
Andrena dorsata	2	0.05555556	0.05970493	-0.4701475
Andrena nigroaenea	1	0.02777778	0.1	-0.9
Andrena/Lasioglossum spp.	5	0.13888889	0.48015655	-0.1039687
Aphantopus hyperantus	2	0.05555556	0.03302846	-0.4834858
Apis mellifera	14	0.38888889	3.71677079	0.19405506
Bombus hortorum	11	0.30555556	1.28135763	0.02557797
Bombus hypnorum	1	0.02777778	0.01219512	-0.9878049
Bombus lapidarius	12	0.33333333	1.37864521	0.03155377
Bombus lucorum/terrestris	18	0.5	4.95903559	0.21994642
Bombus pascuorum	18	0.5	5.70471733	0.26137319
Bombus spp.	8	0.22222222	0.74095282	-0.0323809
Bombus sylvestris	1	0.02777778	0.01041667	-0.9895833
Bombus vestalis	2	0.05555556	0.09319149	-0.4534043
Buathra laborator	3	0.08333333	0.06263501	-0.312455
Cheilosia illustrata	1	0.02777778	0.01694915	-0.9830508
Cheilosia pagana	1	0.02777778	0.00414938	-0.9958506
Cheilosia spp.	1	0.02777778	0.01818182	-0.9818182
Chrysotoxum bicinctum	1	0.02777778	0.01612903	-0.983871
Epistrophe diaphana	1	0.02777778	0.03636364	-0.9636364
Epistrophe grossulariae	5	0.13888889	1.05394797	0.0107896
Episyrphus balteatus	16	0.44444444	6.29024353	0.33064022
Eristalis abusivus	4	0.11111111	0.25460852	-0.1863479
Eristalis arbustorum	5	0.13888889	0.14679588	-0.1706408
Eristalis horticola	4	0.11111111	0.19490106	-0.2012747
Eristalis interruptus	5	0.13888889	0.43521194	-0.1129576
Eristalis nemorum	1	0.02777778	0.01659751	-0.9834025
Eristalis pertinax	4	0.11111111	0.10050383	-0.224874
Eristalis spp.	3	0.08333333	0.10239823	-0.2992006
Eupeodes corollae	3	0.08333333	0.41796537	-0.1940115
Gymnomerus laevipes	1	0.02777778	0.07142857	-0.9285714
Helophilus hybridus	5	0.13888889	0.56384511	-0.087231
Helophilus pendulus	5	0.13888889	0.15560103	-0.1688798
Helophilus trivittatus	5	0.13888889	0.09433074	-0.1811339

Ichneumon sarcitorius	1	0.02777778	0.01818182	-0.9818182
Ichneumon xanthorius	3	0.08333333	0.04242513	-0.3191916
Maniola jurtina	6	0.16666667	0.75231445	-0.0412809
Melangyna umbellatarum	1	0.02777778	0.01219512	-0.9878049
Meliscaeva auricollis	6	0.16666667	0.2205837	-0.1299027
Nymphalis urticae	3	0.08333333	0.10008225	-0.2999726
Ochlodes sylvanus	1	0.02777778	0.14285714	-0.8571429
Pararge aegeria	1	0.02777778	0.00829876	-0.9917012
Pieris brassicae	10	0.27777778	1.56087064	0.05608706
Pieris rapae	3	0.08333333	0.03173683	-0.3227544
Pipiza austriaca	2	0.05555556	1.01204819	0.0060241
***Pipiza* spp.**	1	0.02777778	0.01244813	-0.9875519
Platycheirus manicatus	1	0.02777778	0.02380952	-0.9761905
Platycheirus scutatus	1	0.02777778	0.04149378	-0.9585062
Polygonia c-album	1	0.02777778	0.01219512	-0.9878049
Pyronia tithonus	4	0.11111111	0.72002326	-0.0699942
Sphaerophoria scripta	5	0.13888889	0.22175815	-0.1556484
Symmorphus gracilis	1	0.02777778	0.01818182	-0.9818182
Thymelicus lineola	7	0.19444444	0.3868535	-0.0875924
***Thymelicus* spp.**	1	0.02777778	0.0212766	-0.9787234
Thymelicus sylvestris	3	0.08333333	0.07206558	-0.3093115
Vanessa atalanta	5	0.13888889	0.19080831	-0.1618383
Vanessa cardui	1	0.02777778	0.01219512	-0.9878049
Vespula germanica	1	0.02777778	0.01694915	-0.9830508
***Vespula* spp.**	1	0.02777778	0.01694915	-0.9830508
Vespula vulgaris	7	0.19444444	0.52023273	-0.0685382
Volucella bombylans	3	0.08333333	0.10133737	-0.2995542
Volucella inanis	2	0.05555556	0.16144851	-0.4192757
Volucella inflata	1	0.02777778	0.01219512	-0.9878049
Volucella pellucens	4	0.11111111	0.37548613	-0.1561285
Xylota segnis	3	0.08333333	0.17185449	-0.2760485

	species.degree	normalised.c	species.stre	interaction.p
Aegopodium podagraria	4	0.05882353	0.21953154	-0.1951171
Alisima plantago-aquatica	4	0.05882353	1.03040936	0.00760234
Anthriscus sylvestris	3	0.04411765	0.13112208	-0.289626
Arctium minus	1	0.01470588	0.015625	-0.984375
Brassica oleracea	1	0.01470588	0.02631579	-0.9736842
Cardamine amara	9	0.13235294	1.09982829	0.01109203
Chamerion angustifolium	1	0.01470588	0.0078125	-0.9921875
Cirsium arvense	29	0.42647059	11.3169268	0.3557561
Cirsium vulgare	19	0.27941176	4.05372149	0.16072218

Epilobium hirsutum	15	0.22058824	2.51672175	0.10111478
Epilobium montanatum	1	0.01470588	0.00877193	-0.9912281
Glechoma hederacea	1	0.01470588	0.03278689	-0.9672131
Heracleum sphondylium	12	0.17647059	6.05877858	0.42156488
***Hieracium* agg.**	9	0.13235294	1.88923248	0.09880361
Hypericum perforatum	7	0.10294118	0.36337378	-0.0909466
Lathyrus pratensis	2	0.02941176	0.18800403	-0.405998
Lycopus europaeus	21	0.30882353	6.92937523	0.2823512
Mentha aquatica	31	0.45588235	13.3557836	0.39857366
Mentha spicata	2	0.02941176	0.15066964	-0.4246652
Prunus spinosa	1	0.01470588	0.00819672	-0.9918033
Pulicaria dysenterica	5	0.07352941	1.92757629	0.18551526
Ranunculus aquatilis	1	0.01470588	0.5	-0.5
Ranunculus repens	16	0.23529412	3.18556918	0.13659807
Rosa canina	2	0.02941176	0.02947332	-0.4852633
***Rubus fruticosus* agg.**	17	0.25	4.47439509	0.20437618
***Salix cinerea* agg.**	1	0.01470588	0.0106383	-0.9893617
Senecio jacobaea	21	0.30882353	4.51006948	0.16714617
Silene dioica	5	0.07352941	1.19344981	0.03868996
Stachys sylvatica	4	0.05882353	0.10666884	-0.2233328
***Stellaria* spp.**	1	0.01470588	0.00438597	-0.995614
***Taraxacum* agg.**	3	0.04411765	0.23238771	-0.2558708
Trifolium dubium	1	0.01470588	0.125	-0.875
Trifolium repens	6	0.08823529	0.53687875	-0.0771869
Tripleurospermum inodorum	5	0.07352941	0.6332511	-0.0733498
Vicia cracca	3	0.04411765	1.04764344	0.01588115
Vicia lutea	2	0.02941176	0.07962529	-0.4601874

mland ponds enhances the

Table S6. Species-Level Metric Res
Pollinator species (a) and plant specie
listed alongside species-level metrics

Pollinator Species (Table S6a)

nestedrank	PDI	species.spe	resource.ran	PSI	node.special	betweennes
0.53731343	0.9771429	0.9714286	0.7014724	0.14584641	1.671642	0.00049314
0.74626866	1	1	1	0.01219512	1.58209	0
0.58208955	0.9714286	0.9714286	0.6969321	0.01518847	1.462687	0.01849867
0.59701493	0.9714286	0.9714286	0.6969321	0.00817225	1.313433	0.01052996
0.6119403	0.9714286	0.9714286	0.6969321	0.02985247	1.522388	0.00108019
0.76119403	1	1	1	0.1	1.940299	0
0.20895522	0.9571429	0.8857143	0.4887301	0.08014903	1.432836	0.01400524
0.56716418	0.9928571	0.9714286	0.8190587	0.01910569	1.507463	0.00293465
0.04477612	0.9211429	0.6285714	0.3839737	0.18093362	1.104478	0.04531183
0.07462687	0.8879121	0.7142857	0.3443582	0.13041706	1.164179	0.03180009
0.7761194	1	1	1	0.01219512	1.58209	0
0.05970149	0.8923077	0.6857143	0.3030493	0.13993319	1.164179	0.03180009
0.01492537	0.8945055	0.5142857	0.3170462	0.18381229	1.059701	0.10047529
0	0.9297297	0.5142857	0.3469011	0.32279643	1.089552	0.07934991
0.10447761	0.9306122	0.8	0.4462142	0.15118845	1.223881	0.0512628
0.68656716	1	1	1	0.01041667	1.761194	0
0.55223881	0.9942857	0.9714286	0.8451543	0.05099291	1.701493	0.00026832
0.41791045	0.9714286	0.9428571	0.5976143	0.02372327	1.358209	0.02831236
0.79104478	1	1	1	0.01694915	1.701493	0
0.80597015	1	1	1	0.00414938	1.552239	0
0.82089552	1	1	1	0.01818182	1.850746	0
0.8358209	1	1	1	0.01612903	1.701493	0
0.70149254	1	1	1	0.03636364	1.850746	0
0.23880597	0.952381	0.8857143	0.4780914	0.13786758	1.238806	0.01901045
0.02985075	0.9519328	0.5714286	0.4429905	0.50385082	1.164179	0.07747641
0.31343284	0.9690476	0.9142857	0.5984743	0.08379818	1.313433	0.01419557
0.19402985	0.9485714	0.8857143	0.4942822	0.03662714	1.179104	0.02931687
0.32835821	0.9865546	0.9142857	0.7138467	0.07229611	1.298507	0.01578245
0.17910448	0.9809524	0.8857143	0.6615998	0.09554039	1.343284	0.01086759
0.65671642	1	1	1	0.01659751	1.552239	0
0.37313433	0.9428571	0.9142857	0.5070926	0.02614305	1.373134	0.00854091
0.43283582	0.9714286	0.9428571	0.5976143	0.04411808	1.447761	0.00444626
0.3880597	0.9642857	0.9428571	0.6248809	0.10242905	1.656716	0.00787462
0.85074627	1	1	1	0.07142857	1.880597	0
0.26865672	0.9619048	0.8857143	0.4942822	0.08410591	1.328358	0.01557888
0.2238806	0.9714286	0.8857143	0.5482439	0.05268421	1.268657	0.0208562
0.28358209	0.9285714	0.8857143	0.4498137	0.01950397	1.164179	0.03218183

0.86567164	1	1	1	0.01818182	1.850746	0
0.47761194	0.9428571	0.9428571	0.5606119	0.01414171	1.373134	0.02925323
0.14925373	0.9485714	0.8571429	0.4498137	0.08003591	1.328358	0.01634184
0.88059701	1	1	1	0.01219512	1.58209	0
0.1641791	0.9714286	0.8571429	0.5447871	0.07176695	1.179104	0.03144734
0.40298507	0.9828571	0.9428571	0.6734771	0.04723537	1.313433	0.01720292
0.89552239	1	1	1	0.14285714	2.029851	0
0.71641791	1	1	1	0.00829876	1.552239	0
0.08955224	0.9897959	0.7428571	0.7337745	0.12738572	1.208955	0.03767413
0.49253731	0.9428571	0.9428571	0.5606119	0.01057894	1.358209	0.01108597
0.62686567	0.9714286	0.9714286	0.6969321	0.5060241	1.776119	0
0.67164179	1	1	1	0.01244813	1.552239	0
0.91044776	1	1	1	0.02380952	1.791045	0
0.64179104	1	1	1	0.04149378	1.552239	0
0.92537313	1	1	1	0.01219512	1.58209	0
0.34328358	0.9952381	0.9142857	0.8568027	0.57396936	1.41791	0.00684927
0.29850746	0.9285714	0.8857143	0.4498137	0.05669619	1.328358	0.01802478
0.94029851	1	1	1	0.01818182	1.850746	0
0.11940299	0.9314286	0.8285714	0.4342026	0.08735187	1.208955	0.02711094
0.73134328	1	1	1	0.0212766	1.731343	0
0.44776119	0.9714286	0.9428571	0.5976143	0.02411396	1.462687	0.00492576
0.25373134	0.9714286	0.8857143	0.5411628	0.04214372	1.253731	0.01714973
0.95522388	1	1	1	0.01219512	1.58209	0
0.97014925	1	1	1	0.01694915	1.701493	0
0.98507463	1	1	1	0.01694915	1.701493	0
0.13432836	0.9142857	0.8285714	0.3635146	0.10074338	1.238806	0.07458497
0.46268657	0.9714286	0.9428571	0.5976143	0.04533434	1.567164	0.00228881
0.52238806	0.9915966	0.9714286	0.7992027	0.07516889	1.41791	0.02374581
1	1	1	1	0.01219512	1.58209	0
0.35820896	0.9857143	0.9142857	0.6831301	0.05555194	1.402985	0.00721803
0.50746269	0.9428571	0.9428571	0.5606119	0.05728483	1.58209	0.00284587

Plant Species (Table S6b)

nestedrank	PDI	species.spe	resource.ran	PSI	node.special	betweennes
0.51428571	0.9925373	0.6882895	0.9552239	1	1.314286	0.02813892
0.45714286	0.9925373	0.70181	0.9552239	1	1.514286	0.00147113
0.6	0.9701493	0.5686678	0.9701493	1	1.514286	0.00176724
0.77142857	1	1	1	1	1.514286	0
0.82857143	1	1	1	1	1.771429	0
0.25714286	0.973466	0.4373871	0.880597	1	1.114286	0.04921332
0.85714286	1	1	1	1	1.514286	0
0.02857143	0.9207807	0.2503161	0.5820896	1	1.028571	0.10559086
0.11428571	0.9410841	0.337225	0.7313433	1	1.057143	0.07387696

0.2	0.9365672	0.3072328	0.7910448	1	1.114286	0.04921332
0.8	1	1	1	1	1.571429	0
0.74285714	1	1	1	1	1.514286	0
0.22857143	0.9921227	0.6615746	0.8358209	1	1.428571	0.00680921
0.28571429	0.9104478	0.3306829	0.880597	1	1.2	0.03830471
0.31428571	0.9906716	0.6424935	0.9104478	1	1.228571	0.03700208
0.62857143	0.9993216	0.9568609	0.9850746	1	1.485714	0.00080972
0.08571429	0.9170813	0.2762849	0.7014925	1	1.171429	0.03834277
0	0.9177088	0.2569691	0.5522388	1	1.085714	0.08650489
0.68571429	0.9850746	0.70181	0.9850746	1	1.514286	0
0.88571429	1	1	1	1	1.514286	0
0.37142857	0.9925373	0.6923231	0.9402985	1	1.685714	0.00163068
0.91428571	1	1	1	1	2.028571	0
0.17142857	0.9873964	0.5500555	0.7761194	1	1.057143	0.21587999
0.65714286	0.9925373	0.7408927	0.9850746	1	1.428571	0.00586833
0.14285714	0.9812116	0.4816411	0.761194	1	1.028571	0.10559086
0.94285714	1	1	1	1	1.628571	0
0.05714286	0.9308005	0.2745403	0.7014925	1	1.171429	0.04175981
0.4	0.9776119	0.5188966	0.9402985	1	1.228571	0.03660822
0.48571429	0.9776119	0.5381006	0.9552239	1	1.257143	0.02140428
0.97142857	1	1	1	1	1.571429	0
0.57142857	0.9850746	0.6047079	0.9701493	1	1.571429	0.0012217
1	1	1	1	1	1.885714	0
0.34285714	0.972863	0.5147279	0.9253731	1	1.257143	0.0242102
0.42857143	0.9626866	0.4614272	0.9402985	1	1.285714	0.01926441
0.54285714	0.988806	0.648107	0.9701493	1	1.342857	0.00951639
0.71428571	0.9850746	0.70181	0.9850746	1	1.514286	0

ults of Bipartite Interactions at Recently Restored Ponds.
ɘs (b) involved in mutualistic interactions during 2016-2017 are
computed through the bipartite package in R.

weighted.be	closeness	weighted.clc	Fisher.alpha	partner.diver	effective.par	proportional
0	0.01283284	0.0092977	NA	0.6869616	1.987667	0.13458555
0	0.01369797	0.00170178	NA	0	1	0.06771031
0	0.01485149	0.00320647	NA	0.6931472	2	0.13542063
0	0.01629338	0.00321133	NA	0.6931472	2	0.13542063
0	0.01427473	0.00302493	NA	0.6931472	2	0.13542063
0	0.01023743	0.00168523	NA	0	1	0.06771031
0.00046342	0.01513986	0.01093297	NA	1.4708085	4.352753	0.29472626
0	0.01441892	0.00717045	NA	0.5004024	1.649385	0.11168037
0.06611514	0.01831203	0.03063997	NA	2.0689165	7.916242	0.5360112
0.00473722	0.01773527	0.02715063	NA	2.1013948	8.177568	0.55370569
0	0.01369797	0.00170178	NA	0	1	0.06771031
0.06302564	0.01773527	0.02809714	NA	2.2927877	9.902505	0.6705017
0.26384264	0.01874459	0.0324109	NA	2.3841898	10.850268	0.73467506
0.21214514	0.01845622	0.03146787	NA	2.3193235	10.168793	0.68853216
0	0.01715851	0.02483893	NA	1.6910768	5.42532	0.3673501
0	0.0119677	0.0032312	NA	0	1	0.06771031
0	0.01254446	0.00830181	NA	0.4505612	1.569193	0.10625052
0	0.01586081	0.00587594	NA	1.0397208	2.828427	0.19151369
0	0.01254446	0.00169206	NA	0	1	0.06771031
0	0.01398635	0.00168903	NA	0	1	0.06771031
0	0.01119869	0.00168283	NA	0	1	0.06771031
0	0.01254446	0.00168997	NA	0	1	0.06771031
0	0.01119869	0.0032234	NA	0	1	0.06771031
0	0.01701432	0.00912983	NA	1.4941751	4.45566	0.30169412
0.31348048	0.01773527	0.0352174	NA	1.8655086	6.45922	0.43735584
0.00370739	0.01629338	0.02024287	NA	1.1032863	3.014055	0.2040826
0	0.01759108	0.01429727	NA	1.4327571	4.190236	0.28372219
0	0.01643757	0.0201731	NA	0.8622685	2.368528	0.16037374
0.02656963	0.016005	0.02126416	NA	1.007807	2.739586	0.18549825
0	0.01398635	0.00602238	NA	0	1	0.06771031
0	0.01571662	0.00804969	NA	1.3296613	3.779763	0.25592895
0	0.01499567	0.00458473	NA	1.0397208	2.828427	0.19151369
0	0.01297703	0.01011263	NA	0.9649629	2.62469	0.17771861
0	0.01081419	0.00168812	NA	0	1	0.06771031
0	0.01614919	0.00886556	NA	1.4750763	4.371369	0.29598679
0	0.01672594	0.01156355	NA	1.3592367	3.89322	0.26361118
0	0.01773527	0.00899116	NA	1.549826	4.710651	0.31895963

0	0.01119869	0.00168283	NA	0	1	0.06771031
0	0.01571662	0.00459494	NA	1.0986123	3	0.20313094
0.00054924	0.01614919	0.01415647	NA	1.6307991	5.107955	0.34586123
0	0.01369797	0.00170178	NA	0	1	0.06771031
0	0.01759108	0.01436876	NA	1.4306853	4.181564	0.28313501
0	0.01629338	0.0100619	NA	0.9002561	2.460233	0.16658315
0	0.0097568	0.00167967	NA	0	1	0.06771031
0	0.01398635	0.00324623	NA	0	1	0.06771031
0.03038001	0.0173027	0.02392799	NA	1.1457961	3.144944	0.21294516
0	0.01586081	0.00459147	NA	1.0986123	3	0.20313094
0	0.01182351	0.00168614	NA	0.6931472	2	0.13542063
0	0.01398635	0.00468644	NA	0	1	0.06771031
0	0.01167932	0.00168873	NA	0	1	0.06771031
0	0.01398635	0.01236921	NA	0	1	0.06771031
0	0.01369797	0.00170178	NA	0	1	0.06771031
0.0018537	0.01528405	0.01431461	NA	0.5670609	1.763078	0.11937854
0.00053208	0.01614919	0.00904206	NA	1.549826	4.710651	0.31895963
0	0.01119869	0.00168283	NA	0	1	0.06771031
0.01259826	0.0173027	0.01296031	NA	1.7233917	5.603502	0.37941486
0	0.01225608	0.00324629	NA	0	1	0.06771031
0	0.01485149	0.00546702	NA	1.0397208	2.828427	0.19151369
0	0.01687013	0.00966953	NA	1.3862944	4	0.27084125
0	0.01369797	0.00170178	NA	0	1	0.06771031
0	0.01254446	0.00169206	NA	0	1	0.06771031
0	0.01254446	0.00169206	NA	0	1	0.06771031
0	0.01701432	0.00791868	NA	1.9061547	6.727171	0.45549888
0	0.01384216	0.00591798	NA	1.0397208	2.828427	0.19151369
0	0.01528405	0.01747316	NA	0.5359599	1.709088	0.11572288
0	0.01369797	0.00170178	NA	0	1	0.06771031
0	0.01542824	0.01015929	NA	1.0027183	2.725681	0.18455671
0	0.01369797	0.00452985	NA	1.0986123	3	0.20313094

weighted.be	closeness	weighted.clc	Fisher.alpha	partner.dive	effective.par	proportional
0	0.02908314	0.01044189	2.76E+00	1.0027183	2.725681	0.2319049
0	0.0256326	0.01339469	1.59E+00	0.9257019	2.523639	0.23209664
0	0.0256326	0.00470085	5.37E+08	1.0986123	3	0.25970664
0	0.0256326	0.00335008	7.96E-01	0	1	0.11044004
0	0.02152481	0.00174744	1.34E+08	0	1	0.03278689
0	0.03253368	0.01863875	5.04E+00	1.8632504	6.44465	0.38778257
0	0.0256326	0.00175215	1.34E+08	0	1	0.11044004
0	0.03401249	0.02587812	1.60E+01	2.9212826	18.565085	0.48232286
0.03514938	0.03351955	0.02789455	7.18E+00	2.3382615	10.363204	0.53404439

0	0.03253368	0.02160994	8.35E+00	2.4292023	11.349824	0.55544599
0	0.02464673	0.00331442	7.96E-01	0	1	0.19672131
0	0.0256326	0.00617073	4.28E-01	0	1	0.10526316
0	0.0271114	0.02263107	4.73E+00	1.3894179	4.012514	0.26063221
0	0.03105488	0.01169582	1.09E+01	2.1439522	8.533096	0.25865894
0	0.03056195	0.02210903	2.49E+00	1.2385156	3.450488	0.46543218
0	0.02612553	0.01993611	5.26E-01	0.1788449	1.195835	0.1539183
0.02899824	0.03154781	0.02326272	1.17E+01	2.6731619	14.485699	0.35499627
0.36643234	0.03302662	0.03192892	9.46E+00	2.820419	16.783882	0.56948149
0	0.0256326	0.00330244	2.68E+08	0.6931472	2	0.11647972
0	0.0256326	0.00175317	1.34E+08	0	1	0.10526316
0	0.02300361	0.01869626	1.81E+00	1.0195341	2.771903	0.07247627
0	0.01741702	0.0017636	1.34E+08	0	1	0.00172563
0.05975395	0.03351955	0.02623124	5.90E+00	1.8527567	6.377376	0.48264499
0	0.0271114	0.00476428	2.62E+00	0.6365142	1.889882	0.18636756
0.50966608	0.03401249	0.03165348	4.50E+00	1.9033053	6.70803	0.60025255
0	0.02366086	0.00174977	1.34E+08	0	1	0.0811044
0	0.03154781	0.02392139	1.12E+01	2.6953716	14.811022	0.45205823
0	0.03056195	0.01007828	3.98E+00	1.4184837	4.130852	0.34253667
0	0.03006901	0.01200045	2.47E+00	1.2798542	3.596115	0.35030198
0	0.02464673	0.00174235	1.34E+08	0	1	0.19672131
0	0.02464673	0.00471855	5.45E+00	1.0397208	2.828427	0.09749784
0	0.01922445	0.00175862	1.34E+08	0	1	0.0069025
0	0.03006901	0.02123541	2.22E+00	1.4749013	4.370604	0.32953881
0	0.02957608	0.00663212	7.82E+00	1.549826	4.710651	0.34253667
0	0.02859021	0.00840937	1.99E+00	0.9556999	2.60049	0.21656601
0	0.0256326	0.00330369	2.68E+08	0.6931472	2	0.11734254

proportional d	
0.06643658	0.545867
0.07075065	0.19655745
0.11820535	0.21673585
0.27868853	0.07919875
0.22346851	0.22035554
0.00862813	0.58018772
0.23805004	0.33545545
0.2364107	0.17500717
0.64621005	0.19478036
0.64066544	0.16989287
0.07075065	0.19655745
0.56901111	0.19395459
0.72174288	0.13880833
0.59910888	0.26876881
0.44756615	0.27709412
0.16566005	0.15020965
0.10267472	0.36652801
0.17169974	0.22443691
0.05090595	0.25657458
0.20793788	0
0.0474547	0.26937438
0.05349439	0.24753196
0.0474547	0.38296484
0.4761648	0.16861954
0.42392867	0.50633677
0.37045729	0.27968832
0.45470233	0.17303201
0.34143227	0.27215637
0.31633592	0.31559259
0.20793788	0.16800373
0.31334484	0.18468714
0.14754098	0.30273372
0.08714409	0.47364968
0.01207938	0.51884138
0.37791199	0.18946167
0.32174288	0.25554058
0.41932701	0.11482838

0.0474547	0.26937438
0.18981881	0.16045796
0.37513867	0.25249111
0.07075065	0.19655745
0.33458647	0.28155993
0.2466566	0.28564692
0.00603969	0.64521747
0.20793788	0.10789064
0.36583261	0.29223904
0.33994823	0.07719415
0.07247627	0.58865012
0.20793788	0.13915286
0.03623814	0.31854002
0.20793788	0.28155189
0.07075065	0.19655745
0.14528124	0.74983888
0.25366695	0.27489764
0.0474547	0.26937438
0.39491448	0.26740186
0.0811044	0.28317951
0.17515099	0.22523628
0.33811475	0.21914925
0.07075065	0.19655745
0.05090595	0.25657458
0.05090595	0.25657458
0.28634599	0.32019863
0.24072476	0.26736837
0.25539258	0.32182426
0.07075065	0.19655745
0.39325089	0.18525915
0.1285591	0.31685397

proportional d

0.12335037	0.29926515
0.11420698	0.38279864
0.13576464	0.21875087
0.04525488	0.19098706
0.04525488	0.33001389
0.29165188	0.26674059
0.04525488	0.1063324
0.8401607	0.30651857
0.46898558	0.2366185

0.51363496	0.17044411
0.04525488	0.07868392
0.04525488	0.3035243
0.18158582	0.45897919
0.38616423	0.40712338
0.15615142	0.19440153
0.05411738	0.48830918
0.65554857	0.44465236
0.75955257	0.38660622
0.09050976	0.33881024
0.04525488	0.11517495
0.12544214	0.83832454
0.04525488	0.8723332
0.28860738	0.25634849
0.08552637	0.17109796
0.30357109	0.26041123
0.04525488	0.16319662
0.67027104	0.30506602
0.18694121	0.23218746
0.16274178	0.16918855
0.04525488	0
0.12800013	0.37845553
0.04525488	0.6169996
0.19779118	0.36114741
0.21317994	0.32420716
0.11768487	0.30894121
0.09050976	0.27606203

Improving the pollinator pantry: restoration and management of open f
complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan C. Axmach

	species.degree	normalised.c	species.stre	interaction.p
Andrena bicolor	1	0.02702703	0.00769231	-0.9923077
Andrena dorsata	5	0.13513514	0.63335804	-0.0733284
Andrena nigroaenea	3	0.08108108	1.12653563	0.04217854
***Andrena/Lasioglossum* spp.**	7	0.18918919	0.47808466	-0.0745593
Aphantopus hyperantus	5	0.13513514	0.59162896	-0.0816742
Apis mellifera	19	0.51351351	3.48929717	0.13101564
Bombus campestris	3	0.08108108	0.03547009	-0.32151
Bombus hortorum	14	0.37837838	1.25005457	0.01786104
Bombus hypnorum	1	0.02702703	0.00277778	-0.9972222
Bombus lapidarius	15	0.40540541	3.13878812	0.14258588
Bombus lucorum/terrestris	21	0.56756757	6.66039413	0.26954258
Bombus pascuorum	18	0.48648649	5.45189907	0.24732773
***Bombus* spp.**	6	0.16216216	0.34954458	-0.1084092
Bombus sylvestris	1	0.02702703	0.01020408	-0.9897959
Cheilosia illustrata	2	0.05405405	0.0450313	-0.4774844
***Cheilosia* spp.**	1	0.02702703	0.07042254	-0.9295775
Chrysotoxum bicinctum	3	0.08108108	0.56898534	-0.1436716
Dolichovespula sylvestris	1	0.02702703	0.01020408	-0.9897959
Epistrophe diaphana	1	0.02702703	0.04545455	-0.9545455
Epistrophe grossulariae	7	0.18918919	0.73352917	-0.0380673
Episyrphus balteatus	12	0.32432432	3.35628238	0.19635687
Eristalis abusivus	3	0.08108108	0.16685341	-0.2777155
Eristalis arbustorum	5	0.13513514	1.22456316	0.04491263
Eristalis horticola	8	0.21621622	0.92168281	-0.0097896
Eristalis interruptus	3	0.08108108	0.10413273	-0.2986224
Eristalis intricarius	2	0.05405405	0.01575964	-0.4921202
Eristalis nemorum	1	0.02702703	0.01111111	-0.9888889
Eristalis pertinax	5	0.13513514	1.26198479	0.05239696
***Eristalis* spp.**	1	0.02702703	0.01587302	-0.984127
Eupeodes corollae	5	0.13513514	0.19946205	-0.1601076
Gymnomerus laevipes	1	0.02702703	0.00277778	-0.9972222
Helophilus hybridus	3	0.08108108	0.07886765	-0.3070441
Helophilus pendulus	3	0.08108108	0.14135598	-0.2862147
Helophilus trivittatus	2	0.05405405	0.02420635	-0.4878968
Ichneumon sarcitorius	1	0.02702703	0.00704225	-0.9929577
Ichneumon xanthorius	3	0.08108108	0.07606987	-0.3079767

Maniola jurtina	6	0.16216216	0.1617327	-0.1397112
Megachile centuncularis	1	0.02702703	0.00277778	-0.9972222
Melangyna umbellatarum	3	0.08108108	0.52239819	-0.1592006
Meliscaeva auricollis	4	0.10810811	0.54253057	-0.1143674
Neoascia podagrica	1	0.02702703	0.05263158	-0.9473684
Nymphalis urticae	3	0.08108108	0.083913	-0.3053623
Pieris rapae	1	0.02702703	0.11111111	-0.8888889
***Pipiza* spp.**	1	0.02702703	0.06349206	-0.9365079
Platycheirus scutatus	2	0.05405405	0.05967383	-0.4701631
Polygonia c-album	1	0.02702703	0.00277778	-0.9972222
Pyronia tithonus	2	0.05405405	0.0324263	-0.4837868
Scaeva pyrasti	1	0.02702703	0.00704225	-0.9929577
Sphaerophoria scripta	6	0.16216216	0.54095498	-0.0765075
Thymelicus lineola	4	0.10810811	0.20856009	-0.19786
Thymelicus sylvestris	7	0.18918919	0.62092516	-0.0541535
Tropidia scita	1	0.02702703	0.00277778	-0.9972222
Vanessa atalanta	5	0.13513514	0.57345195	-0.0853096
Vanessa cardui	1	0.02702703	0.00277778	-0.9972222
Vespula vulgaris	1	0.02702703	0.00277778	-0.9972222
Volucella bombylans	8	0.21621622	0.48540987	-0.0643238
Volucella inanis	1	0.02702703	0.00704225	-0.9929577
Volucella pellucens	1	0.02702703	0.03611111	-0.9638889
Xylota segnis	6	0.16216216	0.56932296	-0.0717795

	species.degree	normalised.	species.stre	interaction.p
Anthriscus sylvestris	2	0.03389831	0.7	-0.15
Arctium minus	4	0.06779661	0.17497815	-0.2062555
Ballota nigra	1	0.01694915	0.02564103	-0.974359
Centaurea nigra	8	0.13559322	1.21874334	0.02734292
Chamerion angustifolium	7	0.11864407	0.33495393	-0.0950066
Cirsium arvense	25	0.42372881	6.4239321	0.21695728
Cirsium vulgare	6	0.10169492	0.62521294	-0.0624645
Convolvulus arvensis	3	0.05084746	0.23046448	-0.2565118
Epilobium hirsutum	11	0.18644068	1.26724254	0.02429478
Eupatorium cannabinum	2	0.03389831	0.06828035	-0.4658598
Ficaria verna	1	0.01694915	0.00480769	-0.9951923
Galeopsis tetrahit	1	0.01694915	0.00892857	-0.9910714
Glechoma hederacea	2	0.03389831	0.0121906	-0.4939047
Heracleum sphondylium	21	0.3559322	7.57303772	0.3130018
Hyacinthoides non-scripta	2	0.03389831	0.01860086	-0.4906996
Hypericum perforatum	16	0.27118644	3.08883134	0.13055196
Iris psuedacorus	5	0.08474576	0.28104043	-0.1437919

Lycopus europaeus	7	0.11864407	1.56334499	0.08047786
Lythrum salicaria	5	0.08474576	0.33095712	-0.1338086
Matricaria chamomila	4	0.06779661	0.62314953	-0.0942126
Mentha aquatica	34	0.57627119	18.8904933	0.52619098
Oenanthe aquatica	3	0.05084746	0.53475936	-0.1550802
Plantago lanceolata	1	0.01694915	0.2	-0.8
Potentilla spp.	2	0.03389831	0.21590909	-0.3920455
Prunella vulgaris	1	0.01694915	0.00578035	-0.9942197
Prunus spinosa	3	0.05084746	0.28270342	-0.2390989
Pulicaria dysenterica	1	0.01694915	0.00578035	-0.9942197
Ranunculus repens	9	0.15254237	1.92239461	0.10248829
Rubus fruticosus agg.	18	0.30508475	3.64561822	0.14697879
Sambucus nigra	1	0.01694915	0.04545455	-0.9545455
Senecio jacobaea	15	0.25423729	3.82449525	0.18829968
Silene dioica	9	0.15254237	0.67482818	-0.0361302
Solanum dulcamara	1	0.01694915	0.01282051	-0.9871795
Stachys sylvatica	9	0.15254237	1.06406884	0.00711876
Tripleurospermum inodorum	1	0.01694915	0.05	-0.95
Viburnum opulus	7	0.11864407	1.97048026	0.13864004
Vicia cracca	11	0.18644068	1.08007605	0.00727964

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Table S7. Species-Level Metric Res
Ponds. Pollinator species (a) and plaı
2017 are listed alongside species-leve

Pollinator Species (Table S7a)

nestedrank	PDI	resource.ran	species.spe	PSI	node.special	betweenness
0.74137931	1	1	1	0.00769231	1.706897	0
0.31034483	0.9513889	0.8888889	0.5191467	0.08485073	1.189655	0.02668798
0.48275862	0.9814815	0.9444444	0.651494	0.25773956	1.793103	0.00097773
0.13793103	0.9375	0.8333333	0.4158276	0.04523285	1.086207	0.0564203
0.32758621	0.9444444	0.8888889	0.4885521	0.18197587	1.431034	0.01240427
0.01724138	0.9688209	0.5	0.4882945	0.24206902	1	0.09864381
0.51724138	0.9722222	0.9444444	0.5980292	0.01025641	1.327586	0.00857476
0.06896552	0.9126984	0.6388889	0.3063008	0.08623594	1.068966	0.05463178
0.75862069	1	1	1	0.00277778	1.431034	0
0.05172414	0.9204981	0.6111111	0.3395271	0.2880231	1.086207	0.0564203
0	0.9209877	0.4444444	0.3210825	0.24561975	1.034483	0.06513332
0.03448276	0.9460168	0.5277778	0.3899353	0.24570861	1.12069	0.04895781
0.18965517	0.9419192	0.8611111	0.4740477	0.06579555	1.224138	0.02564773
0.77586207	1	1	1	0.01020408	1.586207	0
0.56896552	0.9953704	0.9722222	0.865043	0.03661413	1.275862	0.0148817
0.67241379	1	1	1	0.07042254	1.655172	0
0.43103448	0.9583333	0.9444444	0.5849976	0.12759414	1.37931	0.01158256
0.79310345	1	1	1	0.01020408	1.586207	0
0.81034483	1	1	1	0.04545455	1.862069	0
0.17241379	0.9166667	0.8333333	0.3644345	0.10031184	1.241379	0.0288016
0.0862069	0.9753723	0.6944444	0.5480789	0.52631976	1.051724	0.0637543
0.4137931	0.9930556	0.9444444	0.8079848	0.04341114	1.344828	0.00858167
0.25862069	0.984127	0.8888889	0.6531867	0.089246	1.224138	0.01942532
0.10344828	0.9532164	0.8055556	0.4944478	0.23058085	1.068966	0.05241736
0.39655172	0.9916667	0.9444444	0.7815257	0.0486386	1.155172	0.02764994
0.60344828	0.9861111	0.9722222	0.7370277	0.00710506	1.258621	0.01118808
0.68965517	1	1	1	0.01111111	1.431034	0
0.27586207	0.9660494	0.8888889	0.5487359	0.15032713	1.241379	0.01343097
0.82758621	1	1	1	0.01587302	1.758621	0
0.34482759	0.9722222	0.8888889	0.5416667	0.02909942	1.155172	0.03689722
0.84482759	1	1	1	0.00277778	1.431034	0
0.46551724	0.9722222	0.9444444	0.6243052	0.03575131	1.206897	0.02740245
0.44827586	0.9861111	0.9444444	0.7017517	0.03803738	1.258621	0.01615336
0.5862069	0.9907407	0.9722222	0.7839537	0.01021825	1.362069	0.0074389
0.86206897	1	1	1	0.00704225	1.655172	0
0.55172414	0.9444444	0.9444444	0.5610836	0.02535662	1.37931	0.01068211

0.20689655	0.9611111	0.8611111	0.4787136	0.03421756	1.448276	0.00476633
0.87931034	1	1	1	0.00277778	1.431034	0
0.53448276	0.9722222	0.9444444	0.5980292	0.25559955	1.637931	0.00073227
0.37931034	0.9583333	0.9166667	0.509902	0.11903243	1.655172	0.00821142
0.72413793	1	1	1	0.05263158	1.741379	0
0.5	0.9814815	0.9444444	0.651494	0.04344927	1.396552	0.00957528
0.89655172	1	1	1	0.11111111	1.896552	0
0.70689655	1	1	1	0.06349206	1.758621	0
0.62068966	0.9861111	0.9722222	0.7370277	0.03743514	1.5	0.00698516
0.9137931	1	1	1	0.00277778	1.431034	0
0.63793103	0.9722222	0.9722222	0.6972167	0.01621315	1.568966	0.00046563
0.93103448	1	1	1	0.00704225	1.655172	0
0.24137931	0.9537037	0.8611111	0.4439016	0.07864878	1.344828	0.0265733
0.36206897	0.9833333	0.9166667	0.6495191	0.05158022	1.448276	0.00715936
0.15517241	0.9351852	0.8333333	0.3965126	0.09942745	1.37931	0.01112683
0.94827586	1	1	1	0.00277778	1.431034	0
0.29310345	0.9907407	0.8888889	0.7525997	0.05875741	1.206897	0.0179449
0.96551724	1	1	1	0.00277778	1.431034	0
0.98275862	1	1	1	0.00277778	1.431034	0
0.12068966	0.9074074	0.8055556	0.3525058	0.07905979	1.068966	0.05805367
1	1	1	1	0.00704225	1.655172	0
0.65517241	1	1	1	0.03611111	1.431034	0
0.22413793	0.9259259	0.8611111	0.4093714	0.09994908	1.155172	0.04361847

Plant Species (Table S7b)

nestedrank	PDI	species.spe	resource.ran	PSI	node.special	betweenness
0.63888889	0.9827586	0.7009845	0.9827586	1	1.916667	0
0.52777778	0.9827586	0.5765721	0.9482759	1	1.305556	0.00574702
0.77777778	1	1	1	1	1.527778	0
0.30555556	0.9904875	0.6621044	0.8793103	1	1.194444	0.01901597
0.36111111	0.9640805	0.4376721	0.8965517	1	1.166667	0.0256144
0.02777778	0.9283122	0.2977871	0.5862069	1	1.055556	0.13575396
0.41666667	0.9586207	0.419942	0.9137931	1	1.25	0.01357474
0.58333333	0.9655172	0.5673086	0.9655172	1	1.555556	0.00127227
0.16666667	0.9721485	0.4922893	0.8275862	1	1.111111	0.08483831
0.69444444	0.9827586	0.7009845	0.9827586	1	1.416667	0.0013945
0.83333333	1	1	1	1	1.5	0
0.86111111	1	1	1	1	1.611111	0
0.72222222	0.9827586	0.7009845	0.9827586	1	1.333333	0.00506291
0.05555556	0.9920014	0.6837892	0.6551724	1	1.166667	0.05791233
0.66666667	0.9913793	0.7401978	0.9827586	1	1.333333	0.00506291
0.11111111	0.9626437	0.3595643	0.7413793	1	1.111111	0.04580031
0.44444444	0.9854809	0.5850832	0.9310345	1	1.222222	0.01509711

0.38888889	0.9396552	0.3821251	0.8965517	1	1.25	0.02386543
0.47222222	0.9482759	0.4530785	0.9310345	1	1.361111	0.00493774
0.5	0.9928161	0.7220098	0.9482759	1	1.638889	0.00954199
0	0.9539057	0.3307503	0.4310345	1	1.055556	0.12022779
0.55555556	0.9827586	0.6151036	0.9655172	1	1.666667	0
0.88888889	1	1	1	1	2.055556	0
0.75	0.9827586	0.7009845	0.9827586	1	1.805556	0
0.91666667	1	1	1	1	1.444444	0
0.61111111	0.9655172	0.5673086	0.9655172	1	1.388889	0.00175068
0.94444444	1	1	1	1	1.444444	0
0.27777778	0.9750958	0.4670689	0.862069	1	1.333333	0.05826167
0.08333333	0.9275862	0.3384947	0.7068966	1	1.083333	0.07665272
0.97222222	1	1	1	1	1.916667	0
0.13888889	0.9448276	0.384132	0.7586207	1	1.166667	0.05518267
0.25	0.9878296	0.5991096	0.862069	1	1.111111	0.04580031
0.80555556	1	1	1	1	1.527778	0
0.22222222	0.9463602	0.3948294	0.862069	1	1.111111	0.11253513
1	1	1	1	1	1.916667	0
0.33333333	0.9764065	0.5005063	0.8965517	1	1.388889	0.02929686
0.19444444	0.9758621	0.467958	0.8275862	1	1.111111	0.04580031

ults of Bipartite Interactions at Long-term Managed

nt species (b) involved in mutualistic interactions during 2016-

el metrics computed through the bipartite package in R.

weighted.be	closeness	weighted.clc	Fisher.alpha	partner.dive	effective.par	proportional
0	0.01363636	0.00145968	NA	0	1	0.07140841
0	0.01909091	0.01153891	NA	1.3896812	4.01357	0.28660266
0	0.01272727	0.00542009	NA	0.9502705	2.586409	0.18469137
0	0.02018182	0.01329821	NA	1.7782333	5.919389	0.42269417
0	0.01654545	0.00768647	NA	1.4648164	4.326749	0.30896623
0.63529978	0.02109091	0.05001214	NA	1.9193297	6.816388	0.4867474
0	0.01763636	0.00536732	NA	1.0397208	2.828427	0.20197347
0	0.02036364	0.03194663	NA	2.3579124	10.568865	0.75470579
0	0.01654545	0.00146204	NA	0	1	0.07140841
0.07646682	0.02018182	0.04009838	NA	2.2452634	9.442903	0.67430263
0.03109971	0.02072727	0.044125	NA	2.3954806	10.97347	0.78359803
0.03991664	0.01981818	0.04457001	NA	2.1859503	8.899101	0.63547064
0	0.01872727	0.02603965	NA	1.5350017	4.641333	0.33143021
0	0.01490909	0.00146329	NA	0	1	0.07140841
0	0.01818182	0.00881028	NA	0.4101163	1.506993	0.10761197
0	0.01418182	0.01192655	NA	0	1	0.07140841
0	0.01709091	0.00982685	NA	1.0549202	2.871746	0.2050668
0	0.01490909	0.00146329	NA	0	1	0.07140841
0	0.012	0.00146296	NA	0	1	0.07140841
0	0.01854545	0.00868197	NA	1.9061547	6.727171	0.48037658
0.21721706	0.02054545	0.04682113	NA	1.6106031	5.005829	0.35745828
0	0.01745455	0.01482314	NA	0.6277053	1.873307	0.13376986
0	0.01872727	0.01860966	NA	1.1358048	3.113678	0.22234282
0	0.02036364	0.03035549	NA	1.5388731	4.659337	0.3327158
0	0.01945455	0.02279526	NA	0.687092	1.987926	0.14195465
0	0.01836364	0.00415941	NA	0.6365142	1.889882	0.13495343
0	0.01654545	0.00547477	NA	0	1	0.07140841
0	0.01854545	0.018189	NA	1.3046615	3.686441	0.26324289
0	0.01309091	0.00145929	NA	0	1	0.07140841
0	0.01945455	0.00967319	NA	1.3862944	4	0.28563363
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.01890909	0.00968522	NA	0.9743148	2.649351	0.18918594
0	0.01836364	0.01034381	NA	0.8486856	2.336574	0.16685099
0	0.01727273	0.00537611	NA	0.5623351	1.754765	0.125305
0	0.01418182	0.00145894	NA	0	1	0.07140841
0	0.01709091	0.00409734	NA	1.0986123	3	0.21422522

0	0.01636364	0.01323706	NA	1.5832585	4.870801	0.34781616
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.01436364	0.00283417	NA	1.0397208	2.828427	0.20197347
0	0.01418182	0.00537244	NA	1.332179	3.789291	0.27058726
0	0.01327273	0.00285827	NA	0	1	0.07140841
0	0.01690909	0.00651827	NA	0.9502705	2.586409	0.18469137
0	0.01163636	0.00146794	NA	0	1	0.07140841
0	0.01309091	0.00543635	NA	0	1	0.07140841
0	0.01581818	0.0041447	NA	0.6365142	1.889882	0.13495343
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.01509091	0.00283202	NA	0.6931472	2	0.14281681
0	0.01418182	0.00145894	NA	0	1	0.07140841
0	0.01745455	0.00867386	NA	1.6674619	5.298702	0.37837188
0	0.01636364	0.0097003	NA	1.0735428	2.925727	0.20892147
0	0.01709091	0.01045846	NA	1.834372	6.261201	0.44710236
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.01890909	0.01563824	NA	0.9089087	2.481613	0.17720803
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.01654545	0.00146204	NA	0	1	0.07140841
0	0.02036364	0.01401946	NA	1.9915094	7.326584	0.52317968
0	0.01418182	0.00145894	NA	0	1	0.07140841
0	0.01654545	0.01493263	NA	0	1	0.07140841
0	0.01945455	0.01062059	NA	1.7201935	5.585609	0.39885943

weighted.be	closeness	weighted.cl	Fisher.alpha	partner.dive	effective.par	proportional
0	0.01848975	0.00268879	1.59E+00	0.6931472	2	0.01071976
0	0.02843381	0.00832083	3.18E+00	1.2130076	3.363586	0.34226646
0	0.02470479	0.00507429	4.28E-01	0	1	0.1194487
0.02619761	0.03029832	0.02457853	2.83E+00	1.2298829	3.420829	0.34155181
0	0.03076445	0.02240834	2.56E+00	1.7276309	5.627307	0.64730351
0.06923653	0.03262896	0.02905655	1.08E+01	2.6522021	14.185242	0.62366784
0	0.02936607	0.01338367	3.31E+00	1.7274636	5.626365	0.3948293
0	0.02423866	0.00377519	5.37E+08	1.0986123	3	0.15390505
0	0.03169671	0.02762626	3.72E+00	1.7290258	5.635161	0.53069543
0	0.0265693	0.00268374	2.68E+08	0.6931472	2	0.14471669
0	0.02517091	0.00139367	1.34E+08	0	1	0.15926493
0	0.0233064	0.00139278	1.34E+08	0	1	0.08575804
0	0.02796768	0.00269157	2.68E+08	0.6931472	2	0.25191424
0.07859281	0.03076445	0.03283858	6.81E+00	1.4623873	4.316251	0.29170891
0	0.02796768	0.00390826	2.62E+00	0.6365142	1.889882	0.25191424
0.05239521	0.03169671	0.02031933	1.04E+01	2.3582013	10.571918	0.43668897
0	0.02983219	0.02224706	1.60E+00	1.2933039	3.644809	0.43406257

0	0.02936607	0.00739684	1.45E+01	1.8891592	6.613805	0.30398162
0	0.02750155	0.00888092	5.71E+00	1.5595812	4.756828	0.30493874
0	0.02284027	0.01443842	1.65E+00	0.9160681	2.499444	0.17075038
0.64446108	0.03262896	0.03820249	9.21E+00	2.6237096	13.786772	0.67264761
0	0.02237415	0.00690643	2.39E+00	1.0114043	2.749459	0.05436447
0	0.01709136	0.001365	1.34E+08	0	1	0.00382848
0	0.02035426	0.00270838	2.68E+08	0.6931472	2	0.01454824
0	0.02610317	0.0013958	1.34E+08	0	1	0.13246554
0	0.02703543	0.0035778	5.37E+08	1.0986123	3	0.14624809
0	0.02610317	0.0013958	1.34E+08	0	1	0.13246554
0	0.02796768	0.01606197	5.69E+00	1.7903136	5.991331	0.30579145
0.02582335	0.03216283	0.03207384	5.67E+00	2.2736283	9.714584	0.75491813
0	0.01848975	0.00139225	1.34E+08	0	1	0.01684533
0.0007485	0.03076445	0.02612836	6.23E+00	2.1322715	8.434003	0.40540606
0	0.03169671	0.0194851	4.47E+00	1.4971906	4.469116	0.41212969
0	0.02470479	0.00269859	7.96E-01	0	1	0.1194487
0.05164671	0.03169671	0.02182932	3.79E+00	1.9191936	6.81546	0.48383759
0	0.01848975	0.00139402	1.34E+08	0	1	0.01531394
0.0508982	0.02703543	0.02406181	2.32E+00	1.5578645	4.74867	0.24732006
0	0.03169671	0.02641976	3.95E+00	1.8302172	6.235241	0.47654416

proportional d

0.09954058	0.17304648
0.43164416	0.24311166
0.04594181	0.57135374
0.5467075	0.13076629
0.26339969	0.38584513
0.69291142	0.15662455
0.40964778	0.06082074
0.69129218	0.12352572
0.27565084	0
0.46957723	0.3326196
0.69081341	0.19249955
0.64102564	0.22313489
0.52788037	0.1949446
0.07503829	0.22105225
0.25158609	0.24991417
0.10872894	0.41084176
0.18683002	0.368059
0.07503829	0.22105225
0.01684533	0.47485766
0.33020674	0.28259447
0.37414957	0.57432459
0.33690659	0.22261236
0.41271057	0.23450979
0.42062277	0.37520472
0.45941807	0.19475996
0.35068913	0.04701524
0.27565084	0.11309478
0.43591118	0.33416311
0.0482389	0.29611595
0.47320061	0.12426449
0.27565084	0
0.43261868	0.1853782
0.39739663	0.18011551
0.32388974	0.08814353
0.10872894	0.1580463
0.19678407	0.21232152

0.33537519	0.2036566
0.27565084	0
0.15467075	0.48393057
0.05513017	0.50489485
0.02909648	0.45684234
0.21822358	0.28753843
0.00689127	0.62670986
0.0482389	0.45663121
0.13782542	0.30967066
0.27565084	0
0.10949464	0.22600228
0.10872894	0.1580463
0.2136294	0.32823126
0.17534456	0.32365807
0.27565084	0.3390586
0.27565084	0
0.43663859	0.18144864
0.27565084	0
0.27565084	0
0.48804335	0.21426531
0.10872894	0.1580463
0.27565084	0.23060407
0.35925101	0.30068129

proportional d

0.10959387	0.77806593
0.18431418	0.18484695
0.05479693	0.2937771
0.18745093	0.38154253
0.30835914	0.08639643
0.77730774	0.20303011
0.30830754	0.26336211
0.1643908	0.38908791
0.30878956	0.19406729
0.10959387	0.24851976
0.05479693	0
0.05479693	0.11597842
0.10959387	0.03260414
0.23651734	0.59741682
0.10355971	0.11678788
0.57930869	0.26534318
0.19972434	0.21635168

0.36241624	0.36538916
0.26065961	0.28877197
0.13696184	0.38012353
0.75547281	0.30748793
0.15066194	0.63977386
0.05479693	0.69846812
0.10959387	0.57548815
0.05479693	0.034519
0.1643908	0.40589228
0.05479693	0.034519
0.32830655	0.309304
0.53232941	0.11584263
0.05479693	0.42088611
0.46215749	0.34628884
0.24489384	0.2162788
0.05479693	0.17385061
0.37346633	0.17765137
0.05479693	0.43874269
0.26021254	0.56305053
0.34167207	0.21504902

Improving the pollinator pantry: restoration and management of open the complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jan C. Axmac

	species.degree	normalised.c	species.stre	interaction.p
Alomya debellator	1	0.04	0.33333333	-0.6666667
Andrena dorsata	2	0.08	1.03333333	0.01666667
Andrena/Lasioglossum spp.	4	0.16	0.46923077	-0.1326923
Aphantopus hyperantus	4	0.16	0.26357809	-0.1841055
Apis mellifera	8	0.32	2.15510779	0.14438847
Bombus hortorum	5	0.2	1.76722151	0.1534443
Bombus hypnorum	1	0.04	0.01136364	-0.9886364
Bombus lapidarius	6	0.24	1.47371467	0.07895244
Bombus lucorum/terrestris	10	0.4	4.03169424	0.30316942
Bombus pascuorum	7	0.28	2.16077104	0.16582443
Bombus spp.	6	0.24	0.9001554	-0.0166408
Bombus vestalis	1	0.04	0.02564103	-0.974359
Buathra laborator	2	0.08	0.34741784	-0.3262911
Cheilosia illustrata	2	0.08	0.04722222	-0.4763889
Cheilosia spp.	1	0.04	0.08333333	-0.9166667
Chrysotoxum bicinctum	2	0.08	0.04469697	-0.4776515
Epistrophe diaphana	1	0.04	0.05555556	-0.9444444
Epistrophe elegans	1	0.04	0.01388889	-0.9861111
Epistrophe grossulariae	3	0.12	0.07831279	-0.3072291
Episyrphus balteatus	8	0.32	2.2677572	0.15846965
Eristalis abusivus	1	0.04	0.06666667	-0.9333333
Eristalis arbustorum	3	0.12	0.54259018	-0.1524699
Eristalis horticola	1	0.04	0.06666667	-0.9333333
Eristalis interruptus	1	0.04	0.1	-0.9
Eristalis pertinax	2	0.08	1.03389831	0.01694915
Eupeodes corollae	2	0.08	0.13247863	-0.4337607
Eupeodes luniger	1	0.04	0.5	-0.5
Helophilus hybridus	1	0.04	0.02564103	-0.974359
Helophilus pendulus	2	0.08	0.375	-0.3125
Ichneumon xanthorius	1	0.04	0.05555556	-0.9444444
Leucozona laternaria	1	0.04	0.01388889	-0.9861111
Maniola jurtina	6	0.24	1.38263403	0.06377234
Meliscaeva auricollis	1	0.04	0.01388889	-0.9861111
Nymphalis urticae	2	0.08	0.04259018	-0.4787049
Ochlodes sylvanus	3	0.12	0.1127844	-0.2957385
Pararge aegeria	1	0.04	0.05084746	-0.9491525
Pieris brassicae	3	0.12	0.56536656	-0.1448778

Pieris rapae	2	0.08	0.02525253	-0.4873737
Platycheirus scutatus	1	0.04	0.06666667	-0.9333333
Pyronia tithonus	1	0.04	0.5	-0.5
Sericomyia silentis	1	0.04	0.5	-0.5
Sphaerophoria scripta	2	0.08	0.13333333	-0.4333333
Syritta pipiens	1	0.04	0.03333333	-0.9666667
Syrphus vetripennis	2	0.08	0.21388889	-0.3930556
Thymelicus lineola	4	0.16	0.61408451	-0.0964789
Thymelicus sylvestris	2	0.08	0.06666667	-0.4666667
Vanessa cardui	1	0.04	0.02564103	-0.974359
Vespula rufa	1	0.04	0.02777778	-0.9722222
Vespula vulgaris	1	0.04	0.08474576	-0.9152542
Volucella bombylans	2	0.08	0.03914141	-0.4804293
Xylota segnis	1	0.04	0.02564103	-0.974359

	species.degree	normalised.(	species.stre	interaction.p
Anthriscus sylvestris	3	0.05882353	1.625	0.20833333
Centaurea nigra	2	0.03921569	0.28030303	-0.3598485
Cirsium arvense	16	0.31372549	7.16902526	0.38556408
Cirsium vulgare	9	0.17647059	2.65376818	0.18375202
Convolvulus arvensis	3	0.05882353	0.5106383	-0.1631206
Crataegus monogyna	2	0.03921569	2	0.5
Glechoma hederacea	1	0.01960784	0.01851852	-0.9814815
Hedera helix	7	0.1372549	4.58743169	0.51249024
Heracleum sphondylium	16	0.31372549	10.8484277	0.61552673
Hieracium agg.	7	0.1372549	2.85624907	0.26517844
Papaver rhoeas	1	0.01960784	0.01851852	-0.9814815
Ranunculus repens	7	0.1372549	0.66305186	-0.0481355
Rubus fruticosus agg.	14	0.2745098	4.59900092	0.25707149
Salix cinerea agg.	1	0.01960784	0.01851852	-0.9814815
Sambucus nigra	1	0.01960784	0.06666667	-0.9333333
Senecio jacobaea	15	0.29411765	7.00477763	0.40031851
Silene dioica	1	0.01960784	0.01639344	-0.9836066
Sisymbrium officinale	1	0.01960784	0.5	-0.5
Taraxacum agg.	1	0.01960784	0.33333333	-0.6666667
Trifolium dubium	2	0.03921569	0.07291667	-0.4635417
Trifolium repens	9	0.17647059	2.07934621	0.11992736
Tripleurospermum inodorum	2	0.03921569	1.33333333	0.16666667
Veronica persica	1	0.01960784	0.03030303	-0.969697
Vicia cracca	6	0.11764706	1.67003367	0.11167228
Vicia hirsuta	1	0.01960784	0.04444444	-0.9555556

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Table S8. Species-Level Metric Res

Pollinator species (a) and plant specie
listed alongside species-level metrics

Pollinator Species (Table S8a)

nestedrank	PDI	resource.ran	species.spe	PSI	node.special	betweennes
0.76	1	1	1	0.33333333	2.5	0
0.42	0.9583333	0.9583333	0.6922187	0.51666667	1.729167	0
0.2	0.875	0.875	0.4677072	0.11730769	1.458333	0.0269559
0.16	0.9702381	0.875	0.6263873	0.11739025	1.354167	0.03708567
0.04	0.986413	0.7083333	0.7516443	0.62014841	1.083333	0.24090708
0.14	0.9375	0.8333333	0.496904	0.22740504	1.645833	0.00600488
0.78	1	1	1	0.01136364	1.770833	0
0.08	0.9647436	0.7916667	0.5736422	0.28692154	1.416667	0.03726255
0	0.9438406	0.625	0.4634874	0.2627224	1.3125	0.05099994
0.06	0.9166667	0.75	0.4301536	0.17590559	1.479167	0.01949724
0.1	0.9836957	0.7916667	0.7210109	0.29680094	1.3125	0.06998877
0.8	1	1	1	0.02564103	1.708333	0
0.44	0.9583333	0.9583333	0.6922187	0.17370892	1.895833	0.01234336
0.46	0.9583333	0.9583333	0.6922187	0.02361111	1.458333	0.03987558
0.56	1	1	1	0.08333333	1.729167	0
0.48	0.9583333	0.9583333	0.6922187	0.02234848	1.708333	0.00467713
0.6	1	1	1	0.05555556	1.729167	0
0.82	1	1	1	0.01388889	1.729167	0
0.26	0.9166667	0.9166667	0.5527708	0.02610426	1.583333	0.03096872
0.02	0.9358108	0.7083333	0.5044505	0.42959759	1.208333	0.13176855
0.68	1	1	1	0.06666667	1.729167	0
0.28	0.9166667	0.9166667	0.5527708	0.18086339	1.604167	0.07621107
0.7	1	1	1	0.06666667	1.729167	0
0.64	1	1	1	0.1	1.729167	0
0.38	0.9791667	0.9583333	0.7328281	0.3559322	1.916667	0
0.32	0.9895833	0.9583333	0.8164966	0.05982906	1.666667	0.00499171
0.84	1	1	1	0.5	1	0
0.86	1	1	1	0.02564103	1.708333	0
0.34	0.9861111	0.9583333	0.7806247	0.11458333	1.708333	0.00187466
0.62	1	1	1	0.05555556	1.729167	0
0.88	1	1	1	0.01388889	1.729167	0
0.12	0.9166667	0.7916667	0.4513355	0.15596737	1.333333	0.04230953
0.9	1	1	1	0.01388889	1.729167	0
0.5	0.9583333	0.9583333	0.6922187	0.02129509	1.625	0.01641464
0.22	0.9375	0.9166667	0.5773503	0.03844709	1.458333	0.02417162
0.66	1	1	1	0.05084746	1.916667	0
0.24	0.9583333	0.9166667	0.590727	0.15416215	1.625	0.0055874

0.52	0.9583333	0.9583333	0.6922187	0.01262626	1.541667	0.0190284
0.72	1	1	1	0.06666667	1.916667	0
0.92	1	1	1	0.5	2.583333	0
0.94	1	1	1	0.5	1	0
0.36	0.9861111	0.9583333	0.7806247	0.08333333	1.625	0.0114607
0.96	1	1	1	0.03333333	1.729167	0
0.3	0.9930556	0.9583333	0.8630747	0.1734127	1.645833	0.01115041
0.18	0.9583333	0.875	0.5625	0.1600939	1.541667	0.05943606
0.54	0.9583333	0.9583333	0.6922187	0.03333333	1.8125	0
0.98	1	1	1	0.02564103	1.708333	0
0.74	1	1	1	0.02777778	1.729167	0
0.58	1	1	1	0.08474576	1.916667	0
0.4	0.9791667	0.9583333	0.7328281	0.0223064	1.541667	0.0190284
1	1	1	1	0.02564103	1.708333	0

Plant Species (Table S8b)

nestedrank	PDI	species.spe	resource.ran	PSI	node.special	betweenness
0.41666667	0.96	0.5656854	0.96	1	1.956522	0
0.54166667	0.98	0.7	0.98	1	1.826087	0
0.04166667	0.9085714	0.303302	0.7	1	1.173913	0.17786376
0.16666667	0.9653846	0.4989097	0.84	1	1.304348	0.09404101
0.45833333	0.96	0.5656854	0.96	1	1.695652	0
0.58333333	0.98	0.7	0.98	1	NaN	0
0.70833333	1	1	1	1	1.652174	0
0.25	0.9943478	0.7823315	0.88	1	1.565217	0.15121693
0	0.9810811	0.5215273	0.7	1	1.521739	0.01127646
0.29166667	0.9825	0.5736433	0.88	1	1.521739	0.01127646
0.75	1	1	1	1	1.652174	0
0.33333333	0.9766667	0.5015951	0.88	1	1.304348	0.05193783
0.125	0.9593103	0.4083769	0.74	1	1.173913	0.12869709
0.79166667	1	1	1	1	1.652174	0
0.83333333	1	1	1	1	1.826087	0
0.08333333	0.9	0.2700617	0.72	1	1.217391	0.21712302
0.875	1	1	1	1	1.695652	0
0.91666667	1	1	1	1	2.173913	0
0.95833333	1	1	1	1	2.521739	0
0.5	0.99	0.7393691	0.98	1	1.695652	0
0.20833333	0.9678261	0.4735328	0.84	1	1.304348	0.07700397
0.625	0.98	0.7	0.98	1	2.043478	0
1	1	1	1	1	1.826087	0
0.375	0.94	0.4406813	0.9	1	1.391304	0.07956349
0.66666667	1	1	1	1	1.956522	0

ults of Bipartite Interactions at Overgrown Ponds.
es (b) involved in mutualistic interactions during 2016-2017 are
computed through the bipartite package in R.

weighted.be	closeness	weighted.clc	Fisher.alpha	partner.dive	effective.par	proportional
0	0.01292432	0.00300588	NA	0	1	0.09168909
0	0.01920482	0.00344555	NA	0.6931472	2	0.18337818
0	0.02304578	0.00862733	NA	1.3862944	4	0.36675636
0.01192843	0.02460293	0.0211389	NA	1.0751393	2.930401	0.26868582
0.18290258	0.02865151	0.02159387	NA	0.9792846	2.662551	0.24412686
0.00662691	0.02045053	0.03018337	NA	1.4085605	4.090064	0.37501422
0	0.01878958	0.00339731	NA	0	1	0.09168909
0.06527502	0.02366864	0.03119746	NA	1.3130961	3.717666	0.34086945
0.16269052	0.02522579	0.03075121	NA	1.7437945	5.719003	0.52437016
0.01689861	0.02273435	0.0273561	NA	1.6728027	5.327077	0.48843486
0.02584493	0.02543341	0.0285932	NA	0.9954909	2.706053	0.24811549
0	0.01951625	0.00344	NA	0	1	0.09168909
0.00049702	0.01733624	0.00498146	NA	0.6931472	2	0.18337818
0	0.0232534	0.00597434	NA	0.6931472	2	0.18337818
0	0.01941244	0.01401996	NA	0	1	0.09168909
0	0.01972387	0.00618121	NA	0.6931472	2	0.18337818
0	0.01941244	0.01066277	NA	0	1	0.09168909
0	0.01941244	0.00337951	NA	0	1	0.09168909
0	0.0211772	0.0060635	NA	1.0986123	3	0.27506727
0.38121272	0.02678293	0.03468217	NA	1.4673362	4.337665	0.39771656
0	0.01920482	0.0064315	NA	0	1	0.09168909
0.03114645	0.02107339	0.00562151	NA	1.0986123	3	0.27506727
0	0.01920482	0.0064315	NA	0	1	0.09168909
0	0.01920482	0.00904405	NA	0	1	0.09168909
0	0.01660957	0.00554873	NA	0.6365142	1.889882	0.17328152
0	0.02034672	0.01220292	NA	0.5004024	1.649385	0.1512306
0	0.00062286	NA	NA	0	1	0.09168909
0	0.01951625	0.00344	NA	0	1	0.09168909
0	0.01972387	0.01041041	NA	0.5623351	1.754765	0.16089284
0	0.01941244	0.01066277	NA	0	1	0.09168909
0	0.01941244	0.00337951	NA	0	1	0.09168909
0.06974818	0.02491436	0.02185271	NA	1.5821699	4.865502	0.44611347
0	0.01941244	0.00337951	NA	0	1	0.09168909
0	0.02076196	0.00553417	NA	0.6931472	2	0.18337818
0	0.02304578	0.01159859	NA	1.0549202	2.871746	0.26330777
0	0.01660957	0.00739063	NA	0	1	0.09168909
0	0.02055434	0.00965801	NA	1.0397208	2.828427	0.25933591

0	0.0222153	0.00614422	NA	0.6931472	2	0.18337818
0	0.01660957	0.00621223	NA	0	1	0.09168909
0	0.01230146	0.00226366	NA	0	1	0.09168909
0	0.00062286	NA	NA	0	1	0.09168909
0	0.02076196	0.00954958	NA	0.5623351	1.754765	0.16089284
0	0.01920482	0.00344555	NA	0	1	0.09168909
0	0.02065815	0.01508473	NA	0.4101163	1.506993	0.13817482
0.04522863	0.02200768	0.01431574	NA	1.2130076	3.363586	0.30840411
0	0.0179591	0.00601737	NA	0.6931472	2	0.18337818
0	0.01951625	0.00344	NA	0	1	0.09168909
0	0.01941244	0.00620515	NA	0	1	0.09168909
0	0.01660957	0.01006292	NA	0	1	0.09168909
0	0.0222153	0.00848609	NA	0.6365142	1.889882	0.17328152
0	0.01951625	0.00344	NA	0	1	0.09168909

weighted.be	closeness	weighted.clo	Fisher.alpha	partner.dive	effective.par	proportional
0	0.03292894	0.00577848	5.37E+08	1.0986123	3	0.02169625
0	0.03682842	0.00572796	2.68E+08	0.6931472	2	0.0729783
0.03165584	0.05459272	0.01839003	1.01E+01	2.4626818	11.736244	0.38461539
0.16883117	0.05155979	0.02090685	2.73E+00	1.5886465	4.897116	0.41897936
0	0.03986135	0.00563557	5.37E+08	1.0986123	3	0.20118343
0	0	NA	2.68E+08	0.6931472	2	0.00394477
0	0.04116118	0.00335019	1.34E+08	0	1	0.10650888
0.13717532	0.04289428	0.0226076	2.07E+00	0.8767438	2.403062	0.15779093
0.03896104	0.04419411	0.01990311	6.38E+00	1.9179013	6.806658	0.32380013
0	0.04419411	0.01755391	2.87E+00	1.4080605	4.088019	0.34299803
0	0.04116118	0.00335019	1.34E+08	0	1	0.10650888
0	0.05069324	0.01439714	6.18E+00	1.6313454	5.110746	0.49309665
0.41396104	0.05459272	0.02132426	4.69E+00	2.0362773	7.662033	0.61874664
0	0.04116118	0.00335019	1.34E+08	0	1	0.10650888
0	0.03596187	0.00334455	1.34E+08	0	1	0.0295858
0.10551948	0.05329289	0.01591988	1.19E+01	2.5435568	12.72485	0.32485207
0	0.0389948	0.00338053	1.34E+08	0	1	0.12031558
0	0.02902946	0.00324404	1.34E+08	0	1	0.00394477
0	0.02556326	0.00338691	1.34E+08	0	1	0.00591716
0	0.03986135	0.00761295	2.62E+00	0.6365142	1.889882	0.15779093
0.06818182	0.05155979	0.02021792	2.94E+00	1.658971	5.253902	0.44033531
0	0.03119584	0.0034549	2.68E+08	0.6931472	2	0.00788955
0	0.03682842	0.0033434	1.34E+08	0	1	0.06508876
0.03571429	0.04809359	0.01655657	2.91E+00	1.6364956	5.137135	0.28599606
0	0.03379549	0.0057947	7.96E-01	0	1	0.0887574

proportional d	
0.00591716	0.75462818
0.06114398	0.61146947
0.16765286	0.37301715
0.39299803	0.3183957
0.34070553	0.59552336
0.47534517	0.3218333
0.17357002	0
0.42122781	0.39091343
0.54810432	0.28349088
0.4965035	0.26755039
0.36865138	0.43852997
0.07692308	0.18175429
0.14595661	0.38756107
0.20118343	0.12293113
0.14201183	0.40007388
0.23274162	0.10000782
0.14201183	0.32432537
0.14201183	0.04481921
0.32938856	0.11263056
0.45950313	0.42044749
0.0591716	0.38130014
0.19723866	0.35204334
0.0591716	0.38130014
0.0591716	0.46931523
0.1183432	0.4799919
0.16765286	0.33329905
0.00394477	0.84518762
0.07692308	0.18175429
0.14792899	0.37860109
0.14201183	0.32432537
0.14201183	0.04481921
0.40394477	0.30690604
0.14201183	0.04481921
0.19329389	0.11570751
0.27613412	0.22217046
0.11637081	0.3134368
0.2209073	0.36317933

0.31558185	0
0.0591716	0.38130014
0.00394477	0.84518762
0.00394477	0.84518762
0.1183432	0.39752579
0.0591716	0.24035258
0.20118343	0.50684409
0.22953649	0.45615528
0.15779093	0.19007603
0.07692308	0.18175429
0.14201183	0.1812845
0.11637081	0.4175869
0.31558185	0.10542687
0.07692308	0.18175429

proportional d

0.16279753	0.78070432
0.10853168	0.43578614
0.63687715	0.38185164
0.26574613	0.4388886
0.16279753	0.42135607
0.10853168	1
0.05426584	0.12200633
0.13040419	0.85950906
0.36936905	0.60245828
0.22183978	0.43959949
0.05426584	0.12200633
0.27733894	0.16266073
0.41578664	0.20702149
0.05426584	0.12200633
0.05426584	0.40394574
0.6905247	0.52996042
0.05426584	0.09517783
0.05426584	0.84743513
0.05426584	0.7581904
0.10255601	0.22314918
0.28510741	0.40410838
0.10853168	0.87305398
0.05426584	0.23040266
0.27877097	0.40272947
0.05426584	0.28045883

Improving the pollinator pantry: restoration and managemer
complexity of plant-pollinator networks

Authors: Richard E. Walton, Carl D. Sayer, Helen Bennion & Jar

a)

	Patefield
Nestedness	0.395
Links per species	**<0.001**
Connectance	**<0.001**
Linkage Density	**<0.001**
Fisher's Alpha	**<0.001**
Shannon's Diversity	**<0.001**
H2'	**<0.001**

ıt of open farmland ponds enhances the

ı C. Axmacher

Long-term Managed		
Vazquez	Swap	Patefield
0.678	0.859	0.351
NaN	NaN	**<0.001**
NaN	NaN	**<0.001**
<0.001	**<0.001**	**<0.001**
NaN	NaN	**<0.001**
<0.001	**<0.001**	**<0.001**
<0.001	**<0.001**	**<0.001**

Table S9. Results from three null model tests ("Patefield", "Vasquez",
network-level metric indicating if a significant difference exists between the
metric from a randomly-generated network. NaN indicates "not a number"
were not calculable. Significant differences from random network structure

Recently Restored		
Vazquez	Swap	Patefield
0.677	0.937	0.968
NaN	NaN	**<0.001**
NaN	NaN	**<0.001**
<0.001	**<0.001**	**<0.001**
NaN	NaN	**<0.001**
<0.001	**<0.001**	**<0.001**
<0.001	**<0.001**	**<0.001**

and "Swap"). P-values are given for each
given networks metric and that of the same
and that some or all iterations of 500 model runs
are bolded.

Overgrown	
Vazquez	Swap
0.314	**0.023**
NaN	NaN
NaN	NaN
<0.001	**<0.001**
NaN	NaN
<0.001	**<0.001**
<0.001	**<0.001**

Declaration of Interest Statement

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Improving the pollinator pantry: restoration and management of open farmland ponds enhances the complexity of plant-pollinator networks

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Abstract

In line with general biodiversity losses across agricultural landscapes, insect pollinators have experienced recent sharp declines. A range of conservation measures have been developed to address these declines, with plant-pollinator interaction networks providing key insights into the effectiveness of these measures. For the first time, we studied interactions between three diurnal pollinator groups (bees, hoverflies, and butterflies) and insect-pollinated plants to understand how they are affected by pond management and restoration. Major network contributors were identified, and important network-level parameters compared at nine farmland ponds under different management strategies to assess management effects on plant-pollinator interactions: three 'overgrown' tree-covered ponds, three 'long-term managed ponds' kept in an open-canopy, early- to mid-successional state by periodic interventions involving tree and sediment removal, and three 'recently restored ponds', initially heavily overgrown with woody vegetation, and subsequently rapidly transformed into an early succession state through major tree and sediment removal. Interaction complexity, as measured by the metrics 'links per species', 'linkage density', Fisher's alpha and Shannon's Diversity, was higher for both long-term managed and recently restored ponds compared to overgrown ponds. Several network-level parameters indicated that highest complexity levels were found at recently restored ponds due to their substantially higher plant diversity. Bipartite interaction analysis suggests major benefits of pond management and restoration for agricultural pollinator assemblages. We strongly advocate the inclusion of ponds in conservation strategies and policies aimed at pollinators - ponds should be part of the pollinator pantry.

Keywords: Agricultural landscapes, agro-ecosystems, biodiversity conservation, ecosystem services, plant-pollinator relationships, pond management

1. **Introduction**

Numerous plant species rely strongly on insect visitors to successfully transfer pollen and thus produce viable seeds (Ollerton et al., 2011). However, dramatic declines in pollinating insect populations within agricultural landscapes raise serious concerns for the pollination services they provide (Potts et al., 2010; Ollerton et al., 2014; Potts et al., 2016). Insect pollinators can form complex networks with the flowering plants they visit in search of nectar and pollen (Memmott, 1999; Cole et al., 2017). Complexity in this context can be understood as the number of plant and pollinator species involved in network interactions and the number of specific plant-pollinator links (MacArthur, 1955; Pimm, 1980; Landi et al., 2018). Although complexity may in some instances decrease network stability (Allesina and Tang, 2012), recent studies have indicated that complexity can also increase resilience to disturbances linked to changing environmental conditions and/or local species extirpations (Vilà et al., 2009; Goldstein and Zych, 2016; Martínez-Núñez et al., 2019). Increased complexity is believed to allow plant-pollinator networks to adjust in ways that preserve a high number of links between network components resulting particularly from many different pollinator species visiting the same plant species.

Although bottom-up effects driven by flower richness and abundance exert a great influence on plant-pollinator network structure (Spiesman and Inouye, 2013; Cole et al., 2017), top-down effects linked, for example, to reductions in pollinating insect populations can trigger pollination gaps in plant species strongly reliant on flower visitors for reproduction (Blüthgen and Klein, 2011; Mathiasson and Rehan, 2020). Furthermore, losses of highly specialised pollinators may cause strong declines in ‘partner’ plant species in agricultural landscapes (Biesmeijer et al., 2006; Weiner et al., 2014). This can result in negative feedback loops, where plants with anemochorous and other non-zoochorous syndromes increasingly dominate in the landscape, while strictly insect pollinator-dependent plants decline (Biesmeijer et al., 2006). Reductions in plant visitors have also led to decreases in seed set of some insect-pollinated plant species (Pauw, 2007; Hermansen et al., 2017; Nabors et al., 2018), triggering declines in recruitment, population sizes and fitness. These findings accentuate the need not only for conservation of diverse forage resources, but for understanding the structure of plant-pollinator networks and their prominent players, specifically within the agricultural landscape where these networks are under considerable stress due to habitat modification and landscape homogenisation (Vanbergen, 2014; Moreira et al., 2015; Martínez-Núñez et al., 2019).

Plant-pollinator networks also represent important models for ecologists and conservationists to understand the interactions that drive a system towards enhanced complexity or simplification. Observing and analysing actual plant-pollinator interactions, therefore, can provide useful insights into plants and plant communities that are attracting the greatest number of pollinator specimens and species (Memmott, 1999; Dicks et al., 2002; Carvell et al., 2006; Walton et al., 2020). In turn, such knowledge enables conservation efforts to become more focused toward plant communities that best promote local pollinating insect abundance and diversity, thereby enhancing the provision of pollination services.

In agricultural landscapes, where plant-pollinator networks are increasingly trending toward high levels of generalism and homogenisation (Biesmeijer et al., 2006; Martínez-Núñez et al., 2019), it is important to understand how management strategies focused on remaining semi-natural habitat patches might help to promote increased complexity in plant-pollinator networks. A key semi-natural farmland habitat widely disregarded in this context is the pond. In many temperate agricultural landscapes, ponds are highly abundant (Biggs et al., 2005; Declerck et al., 2006; Ruggiero et al., 2008). Nonetheless, in many areas of Northern Europe, due to a general cessation of management practices involving periodic woody vegetation and sediment removal over recent decades, large numbers of ponds have become heavily overgrown by encroaching trees and shrubs (Sayer et al., 2012; Janssen et al., 2018). As a result, early-successional open-canopy ponds that support diverse communities of wetland plants have become relatively rare in the landscape (Sayer et al., 2013; Sayer and Greaves, 2020). Both pond restoration, that removes large parts of the encroaching woody vegetation and accumulated pond sediment, and pond management, that maintains ponds in an open-canopy state, have been shown to strongly promote communities of aquatic and semi-aquatic plants and invertebrates (Sayer et al., 2012; Sayer et al., 2013), whilst also enhancing avian abundance and diversity (Davies et al., 2016; Lewis-Phillips et al., 2019a, 2019b, 2020). Furthermore, pond management and restoration has been shown to significantly improve flower resources for pollinating insects (Walton et al., 2021) by creating an array of different micro-habitats both within and around ponds (Sayer et al., 2013; Walton et al. 2021). Ponds may therefore afford both edge and centre-of-field food resources for foraging adult pollinators, and there is evidence of linked benefits also for crop pollination (Stewart et al., 2017). However, while positive pollinator population responses to pond management and restoration have been observed (Walton et al. 2021), the overall impacts of these improvements on interaction networks between terrestrial pollinators and pond margin vegetation have been little explored.

In this study we analyse the effects of pond restoration and management on plant-pollinator networks. Focusing on links between the species-richness and abundance of flowering herbaceous species found in and around pond margins we test the hypothesis that pond restoration and regular pond management result in plant-pollinator networks that are more complex than at overgrown tree-covered ponds. We then discuss the implications of our results for both pond and pollinator conservation.

2. **Materials and methods**

2.1 Study sites

We selected nine farmland ponds located within reasonable proximity (≤ 14 km between ponds) to each other in North Norfolk, eastern England (Supplementary Information Table S1). Three ponds were subjected to light-to-moderate removal of woody vegetation about twice every decade over the last 50 years, a management strategy known to result in the long-term persistence of open-canopy, macrophyte-dominant early successional ponds hereby referred to as 'long-term managed ponds' (Fig. 1a – see Sayer et al., 2012). A further three ponds had been recently restored (1 in 2011 and 2 in 2014) by major removal of woody vegetation and sediment resulting in macrophyte-dominated, early successional conditions. These are hereby referred to as 'recently restored ponds' (Fig. 1b). The remaining three ponds represent the shrub- and tree-dominated "late successional" state resulting from at least 30-40 years of abandonment and are hereby referred to as 'overgrown ponds'. (Fig. 1c). The three different management treatments allowed us to determine the impacts of pond restoration and long-term pond management on plant-pollinator interactions.

The study region is characterised by chalk bedrock overlain by glacial deposits of sand, silt and gravel (Prince, 1964; Brenchley and Rawson, 2006). The agricultural landscape in this area, predominantly arable cropland (with wheat, barley, sugar beet, rapeseed, and broad beans as main crops) enclosed by hedgerows, some pastureland, and scattered semi-natural habitats including managed woodland and grassland (LUC, 2018), supports large numbers of farmland ponds dug as watering ponds for livestock or, especially during the 17th and 19th centuries, to extract marl deposits used to improve the soil (Prince, 1964). The long-term managed ponds were located at Manor Farm (mean distance between 3 ponds = 1.5 km) in the village of Briston which supports a mosaic of about 40 ponds representing differing stages of succession, with most of these ponds subject to regular rotational woody vegetation and sediment management (Sayer et al., 2012; Sayer et al., 2013). The three recently restored farmland ponds and the three unmanaged, overgrown ponds were located in a similar farmland matrix in the vicinity of the villages of Bodham and Baconsthorpe, about 14 km NE of Manor Farm. Recently restored and overgrown ponds were separated by a mean distance of 1.5 km. While we acknowledge the potential implications of separation between long-term managed and the other pond treatments owing to the rarity of managed and restored ponds, and of the overall low number of replicates per treatment, great efforts were made to select ponds with highly similar geological, agricultural, and environmental settings to ensure comparability of the results (see Supplementary Information Fig. S1). Additionally, no managed honey bee hives were located within 500 m of the ponds.

All ponds in this study were small (< 475 m^2, range: 121-455 m^2), shallow (≤ 1.3 m depth) and surrounded by uncropped margins (mean: 8.7 m, range: 5-17.2 m) consisting of rough grassland and woody vegetation. Typical of Norfolk farmland ponds in general, the ponds were found in arable fields in close proximity to hedgerows and small patches of deciduous woodland. The landscape matrix was analysed using Google Earth Pro (earth.google.com) with a focus on land-use and habitat elements within 500 m and 1000 m radii around each pond – distances that reflect the foraging ranges of most nesting pollinator species observed in this study (Gathmann and Tscharntke, 2002; Knight et al., 2005; Zurbuchen et al., 2010). Landscape elements were measured with Google Earth Pro tools and included mean hedgerow length as well as the mean area (m^2) of grassland, woodland, freshwater habitat features (primarily other ponds), arable fields, pasture, and human settlements.

2.2 Survey methods

Insect-pollinated plants and pollinating invertebrates were surveyed approximately one day per month at all ponds between March and October 2016-2017 – resulting in 12 surveys per pond. Flowering plants were surveyed on the same day as each pollinator survey by recording any insect-pollinated plant found in flower that either emerged above the pond water column or grew in the uncropped margin between the pond and surrounding cropland. The survey was terminated once no new species could be identified. All insect-pollinated plant species in flower were identified by morphological features to the lowest taxonomic level using Rose (2006).

Pollinating insects visiting flowers were surveyed using two different approaches, time-lapse photography and visual observation. Surveying pollinators using time-lapse photography has been shown to be an effective method when used concurrently with other survey methods (Edwards et al., 2015; Georgian et al., 2015), and was thus paired with direct flower-visiting observations made during the entire surveying event. Two Timelapse Cam 8.0 camera systems (© EBSCO Industries, Inc., Birmingham, AL) were set within randomly-chosen flower patches to reduce biases of highly visited plants. Flower patches were photographed at 30-second intervals between the hours of 07:30 and 18:00, the main activity period for diurnal pollinators (Campbell et al., 2014) to obtain a total of 12 surveys per pond. The cameras were set between 30-50 cm from flower patches including multiple plant species to ease insect identification and to have ~ 75 cm in viewing width, with cameras photographing the chosen flower patches throughout the duration of the survey day. All ensuing photographs were visually assessed for the presence of a flower visitor, and those with a clearly identifiable visitor (identified to genus or species level depending on photo resolution and angle) to the flower face were included in plant-pollinator network construction and analyses.

A standardised visual observation survey was used to obtain a more complete idea of plant-pollinator interactions at each pond margin. The entire pond margin of each pond was intensively observed during walks that followed irregular transects for a standardised time of 30 minutes by a single observer during each monthly survey. Interactions were counted when a flower visitor directly interacted with the flower face. Multiple species on the same plant were only counted if the interaction time with the flower allowed for confident identification. Due to the small size of the habitat patches formed by the pond margins, visual observation was undertaken by one observer circumnavigating the entire outer edge of the pond and its associated margin; matching the same area as the flowering plant survey.

Time-lapse and visual surveys were standardised by only conducting surveys when ambient air temperature was ≥ 8°C and wind speeds were < 25 km/h. Surveys were undertaken regardless of the presence of any precipitation during each respective day. These environmental conditions depart from those more commonly used (see Pollard and Yates, 1993), but allowed us to effectively sample all ponds throughout the entire study period (March-October), and to document any interactions occurring in the cooler months of spring and autumn (Corbet et al., 1993; Stubbs and Falk, 2002; Falk, 2015). For both surveying techniques, all specimens observed or recorded were identified to the lowest level possible using taxonomic keys (Stubbs and Falk, 2002; Owens and Richmond, 2012; Archer, 2014; Thomas and Lewington, 2014; Falk, 2015; Yeo and Corbet, 2015). Solitary bee specimens from the genus *Andrena* that could be safely identified as *Andrena bicolor* (Fabricius 1775), *Andrena dorsata* (Kirby 1802) and *Andrena nigroaenea* (Kirby 1802) were catergorised at the species level. However, due to difficulties of ascertaining correct identification in the field, smaller specimens in the genera *Andrena* and *Lasioglossum* were combined into one aggregate **"taxon", each**, in the analysis. We similarly combined specimens of the two bumblebee species *Bombus lucorum* and *B. terrestris*.

2.3 Statistical analysis

Data were preliminarily checked for potential spatial autocorrelation by calculating the Bray-Curtis similarity index (Magurran, 2004; Fortin and Dale, 2005) from the number of interactions made between pollinators and flowers at all sites. The distance between all sites was determined by calculating the haversine distance (Sinnott, 1984; Fortin and Dale, 2005). The resulting matrices were subjected to a Mantel test using 1000 permutations (Fortin and Dale, 2005), but no significant spatial autocorrelation signal was detected ($P = 0.83$). Overall measurements of landscape elements contained within the 500 m and 1000 m radii around each pond were compared according to pond management using a pairwise t-test with Bonferroni correction (Gotelli and Ellison, 2004).

Interaction networks for each pond were checked for sampling completeness to establish potential differences in sampling effort. Sampling completeness was calculated by dividing the pairwise interaction richness with the Chao estimator of interaction richness (Chacoff et al., 2012; Macgregor et al., 2017; Martínez-Núñez et al., 2019). Estimated completeness was 63 ± 11% (mean ± SD), a value that is similar to previous studies of plant-pollinator networks (Grass et al., 2018; Martínez-Núñez et al., 2019). To assess the effect of management on sampling completeness, we used Bonferroni-corrected pairwise t-tests (Gotelli and Ellison, 2004). These revealed that, despite a standardisation of sampling effort, long-term managed ponds showed a trend towards stronger undersampling when compared to overgrown ponds ($t_{2,4} = 17.32$, $P = 0.01$). No major difference for sampling completeness existed between recently restored and overgrown ponds.

We assessed the effect of management regime on the number of network-level interactions and on the number of pollinator and plant species involved in network interactions using MANOVA. The total data for each pond was checked for normality

(Huberty and Petoskey, 2000) prior to running the MANOVA. After calculating the MANOVA, pairwise t-tests using a Bonferroni correction (see Gotelli and Ellison, 2004) were conducted to specify which management categories differed significantly in their interaction indices (Wright, 1992; Cabin and Mitchell, 2000).

Bipartite networks of flowers visited by diurnal pollinator species were constructed by combining the data for each pond in each of the three pond management categories. Data were combined in this instance to help visualise trends between pond categories more clearly, as this approach simplified the number of networks and associated metrics produced. Several network-level metrics were computed for the three mutualistic networks. These included nestedness, which describes a network of interactions where specialist species (species only showing interactions with a single ‘partner’) can only interact with a subset of species that also have interactions with generalist species (Landi et al., 2018). Nestedness relates to network complexity, as high nestedness in a network indicates a high cohesion amongst species forming the core of interacting generalists, whereas a network with low nestedness has a low cohesion amongst interacting generalist species (Bascompte and Jordano, 2006; Burgos et al., 2007; Tylianakis et al., 2010). Connectance is a further common indicator of complexity that measures the fraction of the realised interactions in relation to all theoretically possible interactions (Dunne et al., 2002; Morris et al., 2014; Landi et al., 2018). Interaction strength asymmetry (ISA) can indicate if there is a loss in specialist-specialist and specialist-generalist interactions (Bascompte et al., 2006; Aizen et al., 2012; Soares et al., 2017), further leading ISA to act as a measure of stability in complex observed networks (Neutel and Thorne, 2018), since interacting pollinators become less dependent on a specific plant species, and plant species become less dependent on a specific pollinator species, as network complexity increases. The metric H_2', while not specifically related to network complexity, is important to understanding whether an observed network is dominated more strongly by specialist or generalist species, allowing for useful comparisons between networks with regards to proportions of generalist versus specialist interactions (Blüthgen et al., 2006; Morris et al., 2014; Soares et al., 2017). Finally, the metrics ‘links per species’, ‘linkage density’, ‘Fisher’s alpha’, and ‘Shannon’s Diversity’ of the networks characterise different aspects of complexity in interaction diversity, or richness of interactions, between plants and pollinators (Dormann et al., 2008; Ebeling et al., 2011; Fründ et al., 2013). To identify those flowering plant and pollinator species that provided major contributions to the constructed networks, the species-level metric ‘degree’ was assessed for each species to summarise the number of links with visits/visitors, with any species having $\geq$ 10 interactions included.

Null models were run to determine if trends observed in the networks could be explained by random occurrences such as those produced by sampling effects (Gotelli and Graves, 1996). For our analysis, three null models were tested against the observed networks. The “Patefield” null model was used as it is based on marginal totals of the observed network, thereby recreating an ecological equivalent of common and rare species involved in interactions (Patefield, 1981; Dormann et al., 2009). The “Vazquez” null model was used as it does not strictly constrain marginal totals of connectance for the observed network by recreating network interactions based on species’ relative abundances (i.e. more abundant species are likely to show more interactions with target species) (Vázquez et al., 2005, 2007).

Finally, the “Swap” null model was used as it constrains connectance to those values found in the observed network and thereby takes into account ecological or evolutionary processes that constrain interactions, such as morphological pollination barriers (Stang et al., 2006; Dormann et al., 2009). Null models were run using 500 simulations, and results were compared with generated network-level metrics.

Differences in network-level metrics between the three observed interaction networks were then tested for significance by comparing observed and null-modelled model outputs and by calculating the share of null model values exceeding observed values (see Dormann, 2020). This method avoids standardising values using z-scores, which can be disadvantageous when used with the calculated network metrics, as the standard deviation can be an unsuitable measure of spread (Dormann, 2020). Instead, this approach uses a method similar to bootstrapping, comparing the observed metric values with values obtained from a null model run several thousand times, and using the statistical outputs of observed and null-modelled networks by counting the proportion of null-modelled values that exceed observed values to obtain a p-value (Efron and Tibshirani, 1993; Dormann, 2020). Network-level metrics were used as response variables to calculate the mean difference between each management category, and Patefield null models, used here as this represents a conservative approach to compare against the observed networks (Dormann, 2020), were run 5000 times to check for significant differences between the categories for the metric of interest (Dormann, 2020). Flower-visitation networks and other analyses were calculated in R (Version 3.5.1 GUI El Capitan build, © 2016) using the bipartite (Dormann et al., 2008) and vegan packages (Oksanen et al., 2018).

3. **Results**

Comparison of land use between management categories indicated that the ponds were situated in very similar landscapes. There was a significantly higher area of grassland within 500 m of recently restored ponds compared to the long-term managed ponds ($t_{2,4}$ = 4.91, P = 0.01) and a significantly higher area of other freshwater features within 1000 m of long-term managed and overgrown ponds ($t_{2,4}$ = 3.87, P = 0.03). Nonetheless, no other significant differences in landscape components were observed between the management categories within the 500 and 1000 m radii (see Supplementary Information Table 2).

The flower-visiting network generated for recently restored ponds contained the highest number of diurnal pollinator species (n = 68) visiting flowering plant species (n = 36) (Fig. 2a, Table 1, Supplementary Information Fig. S2, Table S3). Long-term managed ponds had the second highest number of pollinator species (n = 59) interacting with a slightly higher number (n = 37) of flowering plant species (Fig. 2b, Table 1, Supplementary Information Fig. S2, Table S4). Overgrown ponds harboured the lowest number of diurnal pollinator species (n = 51) that furthermore visited the lowest number of flowering plant species (n = 25) (Fig. 2c, Table 1, Supplementary Information Fig. S2, Table S5).

Six insect species: the hoverfly *Episyrphus balteatus* (De Geer 1776), the bumblebees *Bombus pascuorum* (Scopoli 1763), *B. hortorum* (Linnaeus 1761), *B. lapidarius* (Linnaeus 1758), *B. lucorum/terrestris* (Linnaeus 1758), and the honey bee *Apis mellifera* (Linnaeus 1758), constituted a sizeable proportion of pollinator-flower interactions at both recently restored and long-term managed ponds (see

Supplementary Table S6 & S7 for number of interactions for each species). At recently restored ponds, the large white butterfly, *Pieris brassicae* (Linnaeus 1758), was also a major contributing pollinator in the network. Only *B. lucorum/terrestris* was found to be an important contributing pollinator species at overgrown ponds (Supplementary Table S8).

The insect-pollinated plant species that were major contributors towards network interactions in the overall recently restored plant-pollinator network were *Mentha aquatica* L., *Cirsium arvense* (L.) Scop., *Lycopus europaeus* L. (Lamiaceae), *Senecio jacobaea* L. (Asteraceae), *C. vulgare* (Savi) Ten., *Rubus fruticosus* agg. L. (Rosaceae), *Ranunculus repens* L. (Ranunculaceae), *Epilobium hirsutum* L. (Onagraceae) and *Heracleum sphondylium* L. (Apiaceae) (Supplementary Table S6). The most important plant species for the overall network at long-term managed ponds again included *M. aquatica*, *C. arvense*, *H. sphondylium*, *R. fruticosus* agg., *S. jacobaea*, and *E. hirsutum*, while *Hypericum perforatum* L. (Hypericaceae) and *Vicia cracca* L. (Fabaceae) were also important (Supplementary Table S7). Major contributing flowering plant species in the overgrown ponds network included *C. arvense*, *H. sphondylium*, *S. jacobaea*, and *R. fruticosus* agg. (Supplementary Table S8).

Results from the MANOVA revealed a strong association between the number of plant species involved in network interactions and pond management ($df = 2$, $F = 19.11$, $P = 0.002$) (Table 2). Further analysis with Bonferroni-corrected pairwise t-tests revealed that both recently restored and long-term managed ponds had significantly more plant species involved in network interactions than overgrown ponds ($t_{2,4}$ = -8.69, P = 0.009 & $t_{2,4}$ = -5.03, P = 0.004, respectively). The number of network interactions and pollinator species involved in network interactions was greater at both recently restored and long-term managed ponds, when compared with overgrown ponds, but MANOVA and pairwise analysis showed that these differences were not significant.

The plant-pollinator network recorded at the recently restored ponds showed the highest linkage density and the highest interaction diversity (Table 2, Supplementary Information Fig. S2). Long-term managed pond communities showed the highest degree of nestedness but displayed intermediate values in network metrics when compared to restored and overgrown ponds. Overgrown ponds had the highest specialisation but were otherwise characterised by the lowest network metric values.

Null model results showed each constructed network to be largely non-random. Nestedness formed an exception, as results were non-significant for the ‘Patefield, Vazquez, and Swap’ null models for all pond categories (Supplementary Information Table S9). All other network-level metrics were shown to be significantly different (P < 0.001 in all cases) from a random network structure for each management category (Supplementary Information, Table S9). Comparison of network-level metrics between categories using the null model approach revealed that both long-term managed and recently restored ponds differed significantly from overgrown ponds for several key metrics. Links per species, interaction diversity (Fisher’s alpha), and ISA were significantly higher at both long-term managed and recently restored ponds, while specialisation was significantly higher at overgrown ponds (Table 3), when compared with long-term managed and recently restored ponds.

Furthermore, the networks at recently restored ponds had a significantly higher interaction diversity (Fishers's alpha, Shannon Diversity) than at long-term managed ponds (Table 3).

4. **Discussion**

This study provides important and novel insights into the flower-visitation networks of diurnal pollinators at farmland ponds with different management histories. Our research reveals complex flower-visitation networks at these semi-natural habitats, strongly suggesting that ponds afford important food-supplying localities for pollinators in the agricultural landscape. In line with our initial hypothesis, this study shows that pond restoration and subsequent management, which lead to increases in the extent and diversity of pond and pond-marginal communities (Walton et al. 2021), has a highly significant positive impact on the forage networks of pollinators inhabiting agricultural landscapes with more plant species involved in the managed and restored networks. Pond restoration by tree and sediment removal and subsequent long-term management to maintain open-canopy conditions, therefore, has significant benefits that clearly extend into terrestrial plant-pollinator networks.

In general, overgrown ponds did not harbour plant species that were absent from neighbouring farmland habitats, suggesting that, in contrast to recently restored and managed ponds, they did not offer unique floral resources to pollinator communities. This interpretation is further strengthened by our observation that restored and managed pond networks had significantly more plant species involved in mutualistic networks than overgrown ponds. A phenomenon common to all pond management treatments was the presence of a few key high-quantity or high-quality nectar producing flowering plant species that were heavily foraged, especially thistles (*Cirsium* spp.) and bramble (*R. fruticosus* agg.). *Cirsium* spp. produce low quantities of nectar with a high sugar content (Hicks et al., 2016), while for *R. fruticosus* agg. nectar is provided in large quantities with a low sugar content (Fowler et al., 2016). Higher abundances of these plant species at managed and restored ponds likely served as an attracting force to pollinators known to congregate amongst the most abundant floral resources in the foraging landscape (Gathmann and Tscharntke, 2002; Fowler et al., 2016; Lucas et al., 2017). The greater abundance of *R. fruticosus* agg. and *Cirsium* spp. recorded at recently restored and long-term managed ponds (see Walton et al., 2021) in turn is likely a function of the plants' positive response to the openness and ground disturbance (Decocq et al., 2004; Gardiner and Vaughan, 2008) associated with woody vegetation and sediment removal at pond margins. However, the quality and especially the strength of these links will require further verification in future studies. The greater abundances of plant species found at all pond management treatments (Walton et al., 2021) furthermore coincided with the regular occurrence of plant species found exclusively at recently restored and long-term managed ponds, such as *M. aquatica* and *E. hirsutum*. In combination, these trends seemed to result in greater food resources being provided for farmland pollinators.

Although some plants, such as *R. fruticosus* agg., *Cirsium* spp., and *H. sphondylium*, were major species within each network, the important role of water mint, *M. aquatica*, is particularly noteworthy since this species only occurred at two ponds, one recently restored pond and one long-term managed pond. The strong presence of *M. aquatica*, and to some extent also *L. europaeus*, in the observed plant-pollinator networks strongly suggests that these plants are favoured by pollinators that visit ponds. *Mentha aquatica* flowers late in the summer, making this plant an important food source for pollinators that have few alternative flowering plant species to choose from at ponds during this part of the year, providing high-quality pollen and nectar (Ebeling et al., 2011; Kulloli et al., 2011) which is especially important for pollinators preparing to overwinter (Alford, 1969; Seeley and Visscher, 1985). Due to their semi-aquatic nature, *M. aquatica* and *L. europaeus* are closely associated with open-canopy ponds, and both are otherwise uncommon in the wider agricultural landscape. Results from the overgrown ponds suggests that pollinator species visiting this habitat rely on common plant species that are abundant in the wider agricultural landscape, such as *T. repens*, a species well known to provide pollen by foraging hymenopterans (Hanley et al., 2008; Kleijn and Raemakers, 2008).

The enhanced plant-pollinator network-level metric measures constructed for long-term managed and recently restored ponds, especially interaction diversity, supports previous work on network structure by Morris et al. (2014), who found increased taxonomic richness to improve key interaction metrics, while not automatically improving specialisation. The significantly higher specialisation found at overgrown ponds, described further by a higher ISA, is likely a function of fewer and less abundant plant species being available at these sites, resulting in some generalist pollinators regularly visiting less competitive plants (Blüthgen et al., 2007; Ebeling et al., 2011), as well as a greater abundance of early-spring flowering shrubs such as *P. spinosa* or *S. cinerea* agg. that are exclusively accessed by early flying pollinator species. Furthermore, the significantly lower ISA metrics at restored and managed ponds when compared to overgrown ponds indicates that the two former networks are more stable than the latter as there is an improved ratio between plant and pollinator species involved in the interactions (Neutel and Thorne, 2018). Other metrics that did not show significant differences between management categories, but were generally improved at canopy-managed ponds, may still highlight potential benefits of pond restoration and management for plant-pollinator networks. For example, nestedness, although considered to be a measure of cohesion amongst generalist species in a network (Soares et al., 2017), to a degree also measures robustness, as more nested communities are more resistant to extinction events (Burgos et al., 2007). Although we observed no significant differences between treatments, general improvements to nestedness in our results at managed and restored ponds indicate that a greater number of pollinator and plant contributors may lead to more robust flower-visitation networks at these sites, but further research is required to confirm this trend. Such management-linked improvements in network structure are increasingly important since flowering plant and pollinator communities are known to be faltering in many agricultural landscapes across the globe (Biesmeijer et al., 2006; Carey et al., 2008; Potts et al., 2010; Raven and Wagner, 2021), making open-canopy pond habitats potentially highly important pollinator conservation sites within farmed landscapes.

The networks produced in this study will have missed out on recording especially some of the rarer interactions due to time constraints of the surveys and also a potential slight observer bias towards large, easily identifiable species. Nonetheless, given the highly standardised recording approach used, these limitations will have affected samples similarly across the different treatments. The resulting network incompleteness was particularly apparent in long-term managed ponds in comparison to overgrown ponds. Despite these limitations, our results clearly show that interaction complexity increases with both pond management and restoration. This trend toward greater complexity was most evident with the significantly higher metrics links per species and interaction diversity (Fisher's alpha). These two specific metrics have been shown to increase in complexity with an increase in species diversity and abundance (Warren, 1990; Ebeling et al., 2011; Rzanny and Voigt, 2012). The significant improvements we observed in these metrics are likely related to an increased richness and abundance of the flowering plant species found at both, long-term managed and recently restored ponds (Walton et al., 2021). These increases in turn allow for a greater number of plant species being involved in the observed interactions at these ponds. The lack of significant differences for other complexity metrics such as connectance and linkage density could be resulting from dampening effects linked to neighbouring habitats and the overall landscape structure (Fründ et al., 2013; Martínez-Núñez et al., 2019; Marja et al., 2021). The complexity of the wider landscape, for example, can affect associations between network complexity and some of the network metrics (Martínez-Núñez et al., 2019), with these associations being dampened with increasing landscape homogeneity. Furthermore, connectance does not always improve significantly in line with increasing flowering plant diversity (Fründ et al., 2013).Overall, the metrics used in this study consistently indicate higher plant-pollinator network complexity is achieved by both pond management and restoration, with the matrix structure of the surrounding agricultural landscape apparently interacting with the degree of actual management- and restoration-linked changes observed in individual metrics.

5. Conclusions

Our analysis highlights the ability of interaction network analysis to reveal the wider ecological effects of habitat management beyond pure species richness and abundance. We show that diurnal plant-pollinator networks at farmland ponds are not only diverse and complex, but also exhibit strong variation according to pond successional stage and management history. Ponds subject to restoration and management by major woody vegetation and sediment removal, resulting in pond margins rich in flowering plants, had plant-pollinator networks that exhibited greater complexity than network interactions observed at highly overgrown, late-successional ponds. Variations in the plants and pollinators involved in interactions across the studied pond management categories also suggest that a landscape supporting a mosaic of ponds, at different stages of succession, may improve the overall complexity and diversity of plant-pollinator interactions at the landscape scale (see also Walton et al., 2021). Such improvements, which encourage greater stability in plant-pollinator networks at farmland ponds and the surrounding agricultural landscape, are only likely if the ratio of overgrown to managed or restored ponds is narrowed (Boothby and Hull, 1997; Sayer et al., 2012). Our study helps to highlight the multi-functional value of ponds, that extends beyond aquatic and semi-aquatic species into the terrestrial sphere with clear, positive implications for pollinator abundance and diversity. Due to their often-ubiquitous nature in agricultural landscapes, we strongly recommend that farmland ponds receive greater attention in agri-environmental and conservation strategies directed at pollinators.

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Data availability statement The data that support the findings of this study will be archived on www.figshare.com upon acceptance of this manuscript.

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Figures

Figure 1. Photographs of three ponds in North Norfolk, UK used to study plant-pollinator interactions which depict three management categories: (**a**) long-term managed pond (WADD17) near the village of Briston, (**b**) recently restored pond (SHOOT) near the village of Baconsthorpe, and (**c**) overgrown pond (BAWO2) between the villages of Baconsthorpe and Bodham.

Figure 2. Flower-visitation networks for (**a**) long-term managed ponds, (**b**) recently restored ponds, and (**c**) overgrown ponds during 2016-2017. Flower species are on the left-hand side of the networks and diurnal pollinator species are on the right-hand side. The width of corresponding boxes and connecting lines is directly proportional to the recorded number of visits for each species. Species with a high species-level 'degree' of interaction are named.

Table 1. Summary of network metrics for diurnal pollinators for the three pond management categories.

	Long-term Managed	Recently Restored	Overgrown
Number of Pollinating Insect Species	59	68	51
Number of Plant Species Visited	37	36	25
Nestedness	4.74	4.82	7.29
Connectance	0.12	0.11	0.10
Links per Species	2.70	2.56	1.70
Linkage Density	7.75	8.29	4.89
Interaction Strength Asymmetry (ISA)	0.04	0.05	0.14
Fisher's Alpha	96.91	108.05	55.83
Shannon's Diversity	4.67	4.80	4.09
Specialisation (H_2')	0.32	0.33	0.46

Table 2. MANOVA results on the effect of management on Number of Network Interactions, Number of Pollinator Species Involved in Interactions, and Number of Plant Species Involved in Interactions. Key: (Df) degrees of freedom, (Sum Sq) sum of squares, (Mean Sq) mean of squares (Sum Sq/Df), (F value) F-statistic, and (Pr(>F)) p-value.

a)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Response: Number of Network Interactions					
Management	**2**	**123587**	**61793**	**3.01**	**0.12**
Residuals	**6**	**123249**	**20541**		
Response: Number of Pollinator Species Involved in Interactions					
Management	**2**	**366.22**	**183.11**	**2.65**	**0.15**
Residuals	**6**	**415.33**	**69.22**		
Response: Number of Plant Species Involved in Interactions					
Management	**2**	**148.67**	**74.33**	**19.11**	**0.002****
Residuals	**6**	**23.33**	**3.89**		

Table 3. Comparison of network-level metrics between three pond management categories using p-values from Patefield null model analysis. Significant differences are tied to the first management category in the column header except for Specialisation which is in favour of Overgrown ponds. Significant differences where P < 0.05 are bolded.

	Long-term Managed versus Overgrown	Recently Restored versus Overgrown	Recently Restored versus Long-term Managed
Nestedness	0.55	0.61	0.52
Connectance	1	1	0.90
Links per Species	**<0.001**	**<0.001**	0.66
Linkage Density	1	0.83	0.11
Fisher's Alpha	**0.005**	**<0.001**	**0.001**
Shannon's Diversity	1	1	**0.02**
Interaction Strength Asymmetry (ISA)	**<0.001**	**<0.001**	0.89
Specialisation (H_2')	**<0.001**	**<0.001**	0.59