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1 Appendix S1. Methods and analysis of establishing and maintaining wildflower plantings

3 Field margins were prepared for the establishment of wildflower plantings with an application of 4 1% glyphosate herbicide at 200 L/ha (Roundup®, Monsanto, Creve Coeur, MO) in the fall of 5 2008 and again in early spring 2009 (Year 1). The sites were not tilled, to reduce the germination 6 of dormant weed seeds. A perennial wildflower seed mix (Michigan Wildflower Farm, Portland, 7 MI) was selected that consisted of 15 species of Michigan native wildflowers with bloom periods 8 that together span May through October and have been shown to be attractive to bees (Tuell et 9 al. 2008). To reduce competition with invasive plants, provide fuel for potential controlled 10 burnings for future management, and provide nesting habitat for ground nesting bees (Goulson, 11 Lye & Darvill 2008), three native grass species were also included in the seed mix (Table S1a). 12 The seeds were combined with sawdust at 1:10 ratio, and hand-broadcasted into the prepared 13 sites in early May of Year 1 at 2.25 kg/ha, and the sites were then lightly raked, rolled, or 14 "cultipacked" in order to maximize soil-seed contact. Establishment rates in the first year were 15 low with few wildflowers blooming per site, so in the spring of 2010, we used a hand-operated seed spreader (Earthway Products, Inc., Bristol, IN) to add another 2.25 kg of seed per hectare 16 17 combined with vermiculite at 1:10 ratio at four of the five sites, for a total of 4.5 kg of native 18 seed per hectare (Table S1a). The fifth field site was predominately covered with weeds with 19 little germination of native wildflowers in Year 1, so this site was treated again with glyphosate 20 in the fall of Year 1 and early spring of Year 2. This site was reseeded with a total of 4.5 kg/ha of 21 native seed mix (Table S1a) using a hand-operated seed spreader.

According to standard prairie plant establishment procedures in Michigan, the plantings were mowed (8-12 cm height) two to three times during the first year of establishment to prevent seed set by annual weeds (Stewart 2009). During the second year, half of each planting was 25 mowed two to three times while alternating which half was mowed to allow for weed control as 26 well as for some of the native wildflowers to bloom and set seed. The plantings were not mowed 27 in the third or fourth years.

28 Establishment of wildflowers within the plantings was assessed once each fall in Years 1-4 29 by randomly sampling the five wildflower plantings and their corresponding control perimeters using a 1 m^2 polyvinyl chloride (PVC) quadrat. The quadrat was randomly tossed within the 30 31 plantings and control perimeters 20 times and all the grasses and forbs within the 1 m² area were 32 counted, identified, and recorded. We determined the density of plant species seeded by us and 33 those not seeded by us (volunteer) per square meter and visually estimated their relative coverage 34 area within the quadrat. Seeded plant density was compared between the flower and control 35 treatments for each individual year using a generalized linear mixed model (GLMM) with 36 treatment (wildflowers or control) as the fixed coefficient, farm site as a random factor, Poisson 37 distribution, and a log link function (Bolker et al. 2009) (SPSS, Version 20, IBM Corp., Armonk, 38 NY). The percent coverage of seeded and volunteer plant species were transformed (ln + 1) and 39 compared separately for each treatment for each of the four years using a GLMM with treatment 40 as the fixed coefficient, farm site as a random factor, normal distribution, and an identity link 41 function.

The density of wildflower blooms within the plantings and control perimeters was also determined by sampling the wildflower plantings and their corresponding control perimeters using a 1 m² PVC quadrat. Similar to the previous methods, all the flowers that were in bloom within the 1 m² area were recorded as described above, and composites and umbels were considered individual flowers. This was done once every two weeks from May through September in 2010 and 2011 (Years 2 and 3, respectively). Bloom density per square meter was averaged for and compared between the flower and control treatments for each individual year

using a GLMM with treatment as the fixed coefficient, farm site as a random factor, a Poissondistribution and a log link function.

51 In all four years of this study the density of seeded plants per square meter within the 52 wildflower plantings was greater than the density of seeded plants in the control mown grass 53 field margins (Table S1b). The percent coverage of the seeded plants was also significantly 54 greater during each of the four years within the wildflower plantings (Table S1b). The density of 55 the seeded plants was significantly greater in Year 4 than in Year 1 within the wildflower 56 plantings (Flower: $F_{1,7} = 8.8$, P = 0.021), but did not significantly change across the years for the control field margins ($F_{1,7} = 14.9$, P = 0.41). Similarly, the percent coverage for seeded plants 57 58 was significantly greater in Year 4 in the wildflower plantings compared to Year 1 ($F_{1,7} = 19.2, P$ 59 = 0.003). The percent coverage of seeded plants did not change significantly from Year 1 to Year 60 4 in the control treatments ($F_{1,7} = 0.78$, P = 0.41). Also, there was no difference in percent 61 coverage of volunteer plants between the two treatments during 2010, whereas in 2011 the 62 control field margins had significantly greater coverage of volunteer plants than the wildflower 63 plantings (Table S1b). The percent coverage of volunteer plants did not change significantly from year to year for either treatment (Flower: $F_{1,7} = 0.54$, P = 0.49; Control: $F_{1,7} = 1.7$, P =64 65 0.23). 66 67 68 69 70 71

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96 Table S1a. List of native Mid-Western perennial wildflowers, grasses, bloom periods, and

97 respective seeding rates for seed mix sown in the wildflower plantings.

98			Blo	om	Per	iod	Seeding Rate			
99	Common Name	Scientific Name	Λ	J	J	А	S	0	(kg/ha)	Seeds ⁻¹ m ²
100	Flowers									
101	Golden Alexanders	Zizia aurea X	(х					0.07	10.88
102	Foxglove beard-tongue	Penstemon digitalis		х	х				0.14	64.24
103	Sand coreopsis	Coreopsis lanceolata		х	Х				0.28	19.76
104	Black-eyed Susan	Rudbeckia hirta		х	х	Х	Х		0.14	90.94
105	Swamp milkweed	Asclepias incarnata			Х	Х			0.28	4.74
106	Butterfly milkweed	Asclepias tuberosa			х	Х			0.14	3.78
107	Wild bergamot	Monarda fistulosa			х	Х			0.07	69.18
108	Joe pye-Weed	Eupatorium maculatum			Х	Х	Х		0.03	48.94
109	Boneset	Eupatorium perfoliatum			х	Х	Х		0.28	39.54
110	Blue lobelia	Lobelia siphilitica			Х	Х	Х		0.14	61.78
111	Yellow coneflower	Ratibida pinnata			х	Х	Х		0.14	14.82
112	Cup plant	Silphium perfoliatum			Х	Х	Х		0.28	1.38
113	Stiff goldenrod	Solidago rigida				Х	Х	Х	0.28	20.26
114	New England aster	Symphyotrichum novae-an	ngl	liae		Х	Х	Х	0.14	32.62
115	Smooth aster	Symphyotrichum laeve					Х	Х	0.28	13.58
116	Grasses									
117	Canada wild-rye	Elymus canadensis		х	Х	Х			0.28	22.61
118	Indiangrass	Sorghastrum nutans			Х	Х	Х		0.28	11.86
119	Big bluestem	Andropogon gerardii			х	Х	х	Х	1.23	9.88

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Table S1b. Comparison of the average (\pm SE) number of seeded plants per m², a comparison of the average percent coverage (\pm SE) of seeded and volunteer plants, and the number of flower blooms per m² within the flower and control treatments over four years.

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Year

126		Plant type	Treatment	1	2	3	4
127	Plant density	Seeded	Flower	8.7 ± 1.7	10.1 ± 1.9	11.2 ± 1.8	10.2 ± 1.6
128	(per m ²)	Seeded	Control	0.01 ± 0.003	0	0.01 ± 0.003	0
129			F _{1,8}	161.6	47.8	49.3	47.9
130			Ρ	0.0009	< 0.0001	< 0.0001	< 0.0001
131	% coverage	Seeded	Flower	5.1 ± 1.1	13.6 ± 3.5	24.6 ± 5.1	26.3 ± 5.3
132			Control	0.3 ± 0.3	0	0.05 ± 0.05	0
133			F _{1,8}	19.7	14.9	23.1	24.1
134			Р	0.002	0.005	0.001	0.003
135		Volunteer	Flower	42.6 + 10.1	60.6 ± 6.4	49.7 ± 4.2	42.3 ± 5.8
136			Control	86.1 ± 2.0	87.8 ± 2.9	89.3 ± 3.6	88.8 ± 1.2
137			F _{1,8}	27.3	14.9	57.4	91.1
138			Р	0.001	0.005	0.0009	0.0007
139	Bloom density	Seeded	Flower	-	4.7 ± 0.9	11.5 ± 2.3	-
140	(per m ²)		Control	-	0.1 ± 0.08	0.03 ± 0.03	-
141			F _{1,8}	-	62.7	76.7	-
142			Р	-	< 0.0001	< 0.0001	-
143		Volunteer	Flower	-	43.8 ± 10.9	90.7 ± 27.9	-
144			Control	-	12.9 ± 3.5	22.9 ± 9.9	-
145			F _{1,8}	-	2.9	11.1	-
146			Р	-	0.09	0.001	-
1.47							

Appendix S2. Wildflower planting establishment costs and the estimated profits from these plantings

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The expenses that growers face when preparing, establishing, and maintaining wildflower plantings to support pollinators are extensive and may impede widespread adoption of this approach. To better understand the costs and benefits of adding these resources to farms, our grower cooperators recorded all the expenses involved in establishment, including site preparation, wildflower seeds, site maintenance, and labor during the four-year period of this study. We were then able to use the estimated yield calculations to determine the increase in profit from the establishment of wildflowers over time.

158 In Michigan, USA, the Conservation Reserve Program (CRP) supported through the 159 Natural Resources and Conservation Service and administered by the Farm Services Agency 160 provides subsidies to establish pollinator habitat within farm landscapes. The State Acres for 161 Wildlife Enhancement (SAFE) provides an incentive payment up to \$124 per 0.4 ha of land 162 planted and an initial 90% cost-share (up to \$600) for the costs of establishing the wildflowers. 163 Additionally, the program requires growers to dedicate at least 0.8 ha of their farmland to 164 wildflower plantings and growers receive \$62 annually in land rental payment per 0.4 ha of 165 wildflower habitat (NRCS 2010).

From grower questionnaires we learned that each hectare of wildflower planting requires on average \$222 to prepare it for wildflower establishment and the seed mix cost \$2,224. At the labor rate of $10 h^{-1}$ site preparation cost \$49 in labor, and on average \$198, \$148, \$99, and \$49 were spent on maintenance in Years 1 through 4, respectively. It is expected that the maintenance costs will be \$49 for the subsequent years with an added \$247 to conduct midcontract maintenance for each hectare in Year 5. Using these data, we calculated the relative cost

of wildflower planting establishment with and without the subsidy (Cost = (size of planting x site preparation cost ha⁻¹) + (size of planting x seed cost ha⁻¹) + (size of planting x salary x establishment costs for that year)).

Fruit yield (kg ha⁻¹) for field sites was estimated by multiplying percent fruit set, berry 175 weight, bushes ha⁻¹, and average number of flowers bush⁻¹. Comparing fruit yield from crop 176 177 fields adjacent to wildflower plantings to those adjacent to control field perimeters we were able 178 to determine the percent yield change each year due to the addition of wildflower habitat 179 (Percent yield change = (avg. yield flower treatment – avg. yield control treatment) / avg. yield 180 flower treatment). We used the average, maximum, and minimum price of US blueberries, \$4.72 kg⁻¹ (Joshua 2011), along with the estimated yield to calculate the expected profit increase due to 181 the wildflower plantings for each of our farm sites (profit = $[(yield x price kg^{-1}) x (size of crop)]$ 182 183 field x proportion of crop field enhanced) x $(1 + \text{percent yield increase})] - [(yield x price kg^{-1}) x]$ 184 (size of crop field x proportion of crop field enhanced)] – [costs of establishment and 185 maintenance]).

186 To determine the general effect of wildflower plantings on profit from blueberry fields, 187 we assumed a single standard 0.8 ha wildflower planting (80 x 100 m), a minimum for the CRP-188 SAFE program (NRCS 2010), established on marginal land adjacent to the shorter edge of a 189 typically-sized 4 ha highbush blueberry field (100 x 400 m). In this study we measured 190 pollination in roughly 4.5% of the 4 ha blueberry field area, so we used this value as a very 191 conservative estimate of the area of crop field enhanced by the adjacent planting. Using these values, along with the US average blueberry price of \$4.72 kg⁻¹ (Joshua 2011), average yield of 192 6.657 kg ha⁻¹ (Joshua 2011), our measured changes in yield in response to the planting, and the 193 194 costs associated with establishment (with and without subsidy), we calculated the cumulative 195 profit for a 4 ha blueberry field in response to establishing a 0.8 ha wildflower planting based on

our data. We then assumed that by Year 10 the expected yield would increase to 8,597 kg ha⁻¹, or 196 197 roughly 30% higher than the average, which is on the upper scale of US blueberry production 198 (Joshua 2011). In order to extrapolate a 30% increase in yield by Year 10, we assumed that the 199 change in percent yield between the wildflower and control treatments would increase by 4% 200 from Year 4 to Year 5 and then decrease by half sequentially each year thereafter (Table S2). 201 These calculations were then repeated using the national US minimum blueberry price of \$3.75 kg^{-1} (Joshua 2011) without subsidy and the maximum price of \$7.12 kg⁻¹ (Joshua 2011) with 202 203 subsidy to highlight the range of possible profits.

204 We found that after Year 1 there was a 1% decrease in blueberry yield within the area of 205 the crop fields sampled adjacent to the wildflower plantings when compared to the samples taken 206 from the control sites (Table S2). The small decrease in yield along with the initial expenses of 207 the wildflower planting establishment resulted in negative profit for both unsubsidized and 208 subsidized plantings. The small decrease in yield during the first year may be due to the 209 disturbance of former populations of pollinators and the removal of potential resources during 210 preparation of the sites for wildflower establishment. After Year 2, when vegetative and floral 211 resources began to grow back, we found that the percent yield change between flower and 212 control treatments positively favored the enhanced sites, with greater yields being measured for 213 the following two years and extrapolated out to Year 10 for our theoretical 4 ha farm (Table S2). 214 The positive changes in yield in response to wildflower plantings result in an overall increase in 215 yield and therefore positive additional profit for the grower (Fig. 4).

The calculated expenses associated with the establishment of a 0.8 ha wildflower planting at a 4 ha highbush blueberry farm is substantially higher at the unsubsidized farm than for the farm receiving assistance. Therefore, while the cumulative profits based on US average price for highbush blueberries for the unsubsidized and subsidized farms are both expected to make a

220	positive profit during the fourth year, the subsidized farm is expected to have considerably
221	higher profit (Table S2). Either way, within the first four to five years the increase in profit due
222	to the benefits of wildflower plantings on adjacent crop yield offsets the growers' costs
223	associated with preparation, establishment, and maintenance of wildflower plantings.
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Table S2. Estimated costs and profits from the establishment of wildflower plantings to support pollination in adjacent highbush
blueberry fields, over a 10 year period. Costs and profits were based on grower expenses and US average price (\$4.72 kg⁻¹) and yield
(6,657 kg ha⁻¹) for highbush blueberry (Joshua 2011). Change in percent yield between the wildflower and control treatments for the first
four years was calculated from our data, thereafter assuming that the change in percent yield decreased by half each year. Calculations
are made for a 4 ha highbush blueberry field with a 0.8 ha wildflower planting under unsubsidized and unsubsidized scenarios.

248					Unsubs	sidized		Subsidized				
249		Year	% yield	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	
250			change	cost (USD)	cost (USD)	profit (USD)	profit (USD)	cost (USD)	cost (USD)	profit (USD)	Profit (USD)	
251	From data	0	-	2020	2020	-2020	-2020	1270	1270	-1270	-1270	
252		1	-0.6	160	2180	-195	-2215	110	1380	-145	-1415	
253		2	3.1	120	2300	56	-2159	70	1450	106	-1309	
254		3	18.2	80	2380	960	-1200	30	1480	1010	-299	
255		4	22.2	40	2419	1230	31	-10	1469	1280	981	
256	Extrapolated	15	26.2	240	2659	1260	1291	190	1659	1310	2291	
257		6	28.2	40	2699	1575	2866	-10	1649	1625	3916	
258		7	29.2	40	2738	1633	4498	-10	1638	1683	5598	
259		8	29.7	40	2778	1661	6160	-10	1628	1711	7310	
260		9	29.9	40	2818	1676	7835	-10	1618	1726	9036	
261		10	30.1	40	2857	1683	9518	-10	1607	1733	10769	