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A COMPARISON OF ADULT BUTTERFLY COMMUNITIES ON REMNANT AND PLANTED PRAIRIES IN NORTHEAST IOWA

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ABSTRACT. Adult butterfly abundance and diversity was compared in four remnant and four planted tallgrass prairies in Northeast Iowa. Butterfly surveys were conducted at approximately three week intervals over the summer of 2015. Researchers used a modified "Pollard Walk" technique following a meandering transect, and butterfly sightings recorded using the Unified Butterfly Recorder (UBR) Android app. If a butterfly was observed nectaring on a flower, the species of flower was recorded. Floral resource availability, plant species richness and percent cover were measured in each prairie. Although planted prairies contained significantly greater floral resources than remnant prairies, there was no significant difference in floral plant species richness between remnants and plantings. Remnant and planted prairies did not differ in butterfly abundance, but remnant prairies had significantly greater butterfly species richness than planted prairies. These results provide valuable information on the current status of butterflies in each prairie type in northeast Iowa, and can be used in directing future land management and conservation work.

Additional key words: tallgrass prairie, unified butterfly recorder

The tallgrass prairie is one of North America's most endangered landscapes. Over 80% of Iowa was covered by tallgrass prairie pre-European settlement, but now less than 0.01% of its original tallgrass prairie remains (Smith 1998). The few small fragments of remnant prairie are often miles from each other (Ries & Debinsky 2001) isolated among predominantly agricultural landscapes. Fragmentation of these prairies has reduced species abundance and diversity, particularly for populations of specialist plants and animals native to prairies (Collinge et al. 2003; Panzer 2002). Some prairie specialist organisms, such as smaller species of insects, are often unable to move freely among these isolated prairie fragments and are often extirpated while these remaining fragments become dominated by generalist and invasive species (Ries & Debinski 2001).

Prairie specialist insects provide many important ecosystem services vital to the overall health and productivity of prairie ecosystems, such as pollination, and serving as food for birds and small mammals that share their habitat (Powers & Larsen 2014). Without the services these insects provide, the prairie could lose flowering plant species from lack of pollination and lose more of its native fauna from lack of food, disrupting the ecosystem. Specialist butterfly populations have been negatively affected by habitat loss (Swengel et al. 2011), and many species have been extirpated from their historic range (Larsen and Bovee 2001). Some species, such as the regal fritillary, *Speyeria idalia* (Drury), have not been observed in Winneshiek County in Northeast Iowa since 1994 (Larsen, personal observation), although they have been observed in Howard County as recently as 2007 and Floyd County as recently as 2017 (www.insectsofiowa.org).

To slow species loss and conserve native habitats such as tallgrass prairies, conservation biologists have restored natural areas through habitat reconstruction (Shepherd & Debinski 2005). Habitat reconstruction repairs damaged plant communities as opposed to restoring faltering animal communities, but the effects of this plant-based approach are beneficial in that they often support the rehabilitation of animal communities (Debinski & Babbit 1997). Prairie plantings containing appropriate host plants are particularly important as potential habitat for imperiled butterfly populations, such as Species of Greatest Conservation Need (SGCN), as prairie remnants are usually too small or too far apart to support some butterfly species (Iowa DNR 2012, Smith & Cherry 2014).

It is often difficult to tell if planted prairies are functionally similar to remnant prairies in terms of their ability to provide suitable habitat for butterflies. One way to determine the quality of a planted prairie is to analyze the plant and butterfly community of the prairie relative to the community composition in remnant prairies. Butterfly surveys are of critical importance when documenting butterfly community profiles, and can suggest the quality of a prairie based on the proportion of specialist to generalist species present. The goal of this study was to compare butterfly abundance and species richness of eight tallgrass prairies in Northeast Iowa to determine if planted prairies are similar to remnant prairies in their butterfly community composition and abundance.

MATERIALS AND METHODS

Tallgrass Prairie Sites. Eight tallgrass prairies in Winneshiek County or Howard County, Iowa were surveyed in this study, including four remnant prairies

and four planted prairies (Table 1). Planted prairies ranged in age from 8 to 25 years old and varied in size, the plant species seeded, quality, management history, and level of human disruption. Remnant prairies also varied in size, management history, and level of human disruption.

Butterfly Surveys. Butterfly surveys were conducted at each prairie site approximately every three weeks throughout the summer of 2015 when conditions were appropriate for maximum butterfly activity: between 1000 and 1600h CDT, winds less than 20 km/h, temperatures of 20–30°C, and cloud cover less than 90%. A modified Pollard walk technique was used walking at a slow steady pace following a meandering transect established within each site (Pollard 1977). Butterfly survey transects ranged from 435 to 2500 m in length (Table 1) and crossed representative burned or unburned remnant or planted areas within each site. All butterflies observed within 10 m of the observers were recorded (Pollard 1977) using the Unified Butterfly Recorder (UBR) Android app (http://www.reimangardens.com/collections%20/insects/unified-butterfly-recorder-app/). Each butterfly observed was counted only once with reasonable confidence. Photographs of butterflies were taken regularly to aid in identification. Butterflies not identified in flight were netted for closer examination and released in the field if possible. Butterflies unable to be identified in the field were collected and identified in the lab. Identifications were made primarily using Schlicht et al. (2007). Voucher specimens from this survey are housed in the Research Insect Collection in the Hoslett Museum of Natural History, Department of Biology, Luther College, Decorah, Iowa. Butterfly abundance was standardized to butterflies per kilometer due to the different lengths of the survey transect in each prairie.

Plant Surveys. During butterfly surveys all flowering plant species in bloom observed along each butterfly survey transect were recorded at each site, and over the five survey dates the cumulative species list was used to conservatively estimate plant species richness for each prairie. We used floral percent cover to estimate floral resource (i.e. nectar) availability in each prairie. During each sampling period, the surface area of all floral blooms in ten random 1 × 0.5 meter quadrats along each survey transect was determined. Each 0.5 m^2 quadrat was delineated by a 1 × 0.5 m PVC frame with reference marks at 10 cm intervals, and a digital photograph taken of the quadrat from approximately 1 m above the canopy of each quadrat and flowers blooming in the quadrat recorded. Each photograph was then analyzed using *ImageJ* software (Rasband 2015) to estimate the surface area (cm^2) of flower heads for each species of flower in bloom in each quadrat. Floral surface area (cm^2/m^2) was converted to floral percent cover as a proxy of nectar resource availability of each species of flower, and floral percent cover averaged over the course of the summer for each prairie. Every species of blooming forb at the site was documented, regardless of whether or not it was represented in a quadrat image.

Using Iowa Coefficient of Conservatism (CoC) values (Drobney et al. 2001) for each species of flower observed blooming at each site, a Floristic Quality Assessment (FQA) was performed, generating a Floristic Quality Index (FQI) for that site (Swink & Wilhelm 1994). The FQI is a measure of the quality of habitat present at a site, with higher values corresponding to higher habitat quality.

Table 1. Prairie status, location, size, management agency, and butterfly survey transect length of each of the four remnant and four planted tallgrass prairies surveyed during the summer of 2015.

	Latitude	Longitude	Area (acres)	Land Manager/Owner	Transect Length (m)
Remnant Prairies					
Chipera	43° 7.89'N	92° 0.49'W	81	Winneshiek County Conservation Board	2500
Crossman	43° 24.48'N	92° 28.49'W	11	Iowa Nature Conservancy	925
Hayden	43° 26.51'N	92° 23.02'W	240	Iowa Department of Natural Resources	1440
Ludwig	43° 11.64'N	92° 58.74'W	2.6	Winneshiek County Conservation Board	435
Planted Prairies					
Anderson	43° 18.90'N	92° 47.95'W	27	Luther College	980
Decorah Community	43° 18.09'N	92° 48.15'W	39	Decorah Parks and Recreation	1445
Gateway	43° 19.07'N	92° 48.74'W	38.6	Luther College	1625
Plymouth Rock	43° 26.26'N	92° 0.35'W	33.8	private landowner	1200

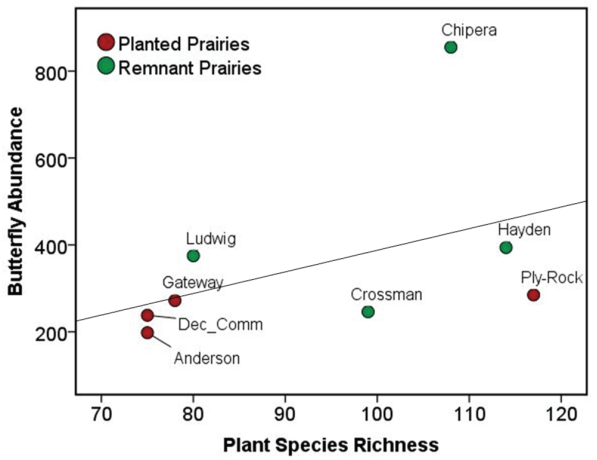

FIG. 1. Correlation of overall butterfly abundance and plant species richness in four remnant and four planted tallgrass prairies in Northeast Iowa in 2015.

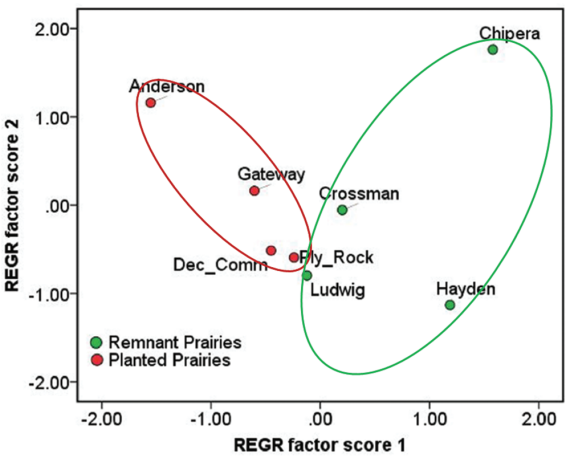

FIG. 2. Principal components analysis (PCA) comparing the similarity of butterfly assemblages among four remnant and four planted tallgrass prairies.

Statistical Analyses. The number of butterflies observed and butterfly species richness were determined for each prairie. Butterfly abundance for each prairie was calculated by combining the total number of butterflies observed in each prairie during the five surveys conducted. Species of Greatest Conservation Need were also identified, totaled, and listed for each prairie over the course of the summer. Butterfly community diversity was calculated for each prairie using the Shannon Diversity Index (*H'*) calculated with log base 2 (Eckblad, 1998). Floral plant species richness was compared between remnant and planted prairies using a two-sample t-test. A Spearman nonparametric correlation was used to correlate floral plant species richness at each site with butterfly abundance and butterfly species richness to evaluate possible relationships between plant and butterfly communities. Comparisons of butterfly abundance and species richness between remnant and planted prairies were analyzed using two-sample t-tests. Finally, a Principal Components Analysis (PCA) compared butterfly assemblages among the eight prairie sites. All data were analyzed using IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, N.Y., USA).

RESULTS

Butterfly Surveys. A total of 2,863 butterflies were observed in 2015, representing 42 species over the eight prairie sites (Table 2). Butterfly abundance and species richness for each prairie was determined by combining the five surveys conducted. When comparing prairie types there were significantly more (t = 2.746, df = 6, p = 0.033) butterfly species in remnant prairies (25.25 ± 1.031 species, mean ± standard error) than in planted prairies (21.75 ± 0.75 species). On average, almost twice as many butterflies were observed in remnant prairies (467.5 ± 133.28 butterflies) than planted prairies (248.3 ± 19.46), although this was not significant (t = 1.628, df = 6, p = 0.15). On average there were more butterflies sighted per kilometer in remnant prairies (87.78 ± 28.49 butterflies/km) than in planted prairies (38.58 ± 3.42 butterflies/km), although this was not significantly different (t = 1.715, df = 6, p = 0.137).

Overall, 18 butterflies representing three SGCN species (*Erynnis baptisiae* (Forbes), *Satyrium acadica* (Edwards), *Speyeria aphrodite* (Fabricius)) were sighted in remnant prairies, while only four butterflies representing two SGCN species (*E. baptisiae*, *S. aphrodite*) were observed in planted prairies. Butterfly diversity as measured by Shannon's diversity index (*H'*) was significantly greater (t = 5.415, df = 6, p < 0.01) in remnant prairies (2.591 ± 0.095) than in planted prairies (2.133 ± 0.075).

When comparing the relationship of butterfly abundance with plant species richness in each prairie, there was a significant correlation between flowering plant species richness and butterfly abundance (Figure 1, r = 0.73; p = 0.041).

A Principal Components Analysis (PCA) of the butterfly communities in each prairie compared the similarities and differences of butterfly assemblages of the eight prairie sites. The groupings of sites indicate differences exist in butterfly communities between remnant and planted prairies (Figure 2). Remnant prairies have more similarities in butterfly assemblages among them than with butterfly assemblages of planted prairies. Planted prairies also tended to group in the same way, with planted prairie butterfly assemblages more similar to each other than they are to remnant

Table 2: A comprehensive list of all butterfly species observed in four remnant and four planted tallgrass prairies in northeast Iowa in 2015, combining counts over five surveys throughout the summer. ** indicates species considered species of greatest conservation need (SGCN) in Iowa.

			Remnant Prairie Sites					Planted Prairie Sites					
	Scientific Name	**Common Name**	**Crossman**	**Hayden**	**Chipera**	**Ludwig**	**Remnant Total**	**Ply Rock**	**Dec Comm**	**Anderson**	**Gateway**	**Planted Total**	**Overall Total**
HESPERIIDAE (skippers)													
5	*Epargyreus clarus* (Cramer)	Silver-spotted Skipper	0	0	0	1	1	1	0	0	0	1	2
87	*Erynnis juvenalis* (Fabricius)	Juvenal's Duskywing	0	0	0	0	0	0	0	1	0	1	1
98	*Erynnis baptisiae* (Forbes)**	Wild Indigo Duskywing	1	0	0	0	1	0	0	2	1	3	4
146	*Ancyloxypha numitor* (Fabricius)	Least Skipper	13	0	36	2	51	0	2	0	17	19	70
154	*Thymelicus lineola* (Ochsenheimer)	European Skipper	1	2	2	0	5	1	0	0	0	1	6
180	*Polites peckius* (Kirby)	Peck's Skipper	3	0	1	1	5	2	3	2	13	20	25
184	*Polites themistocles* (Latrielle)	Tawny-edged Skipper	0	0	1	2	3	1	1	6	3	11	14
187	*Polites mystic* (Edwards)	Long Dash	1	3	4	1	9	0	0	0	0	0	9
191	*Wallengrenia egeremet* (Scudder)	Northern Broken-Dash	0	0	0	0	0	0	0	1	0	1	1
194	*Anatrytone logan* (Edwards)	Delaware Skipper	7	2	95	22	126	0	0	1	0	1	127
PAPILIONIDAE (swallowtails)													
294	*Papilio polyxenes* Fabricius	Black Swallowtail	1	10	1	1	13	0	0	0	0	0	13
297	*Papilio glaucus* Linnaeus	Eastern Tiger Swallowtail	0	1	3	7	11	5	3	8	3	19	30
308	*Papilio cresphontes* Cramer	Giant Swallowtail	0	0	0	0	0	0	0	1	0	1	1
PIERIDAE (whites and sulphurs)													
326	*Pieris rapae* (Linnaeus)	Cabbage White	8	2	15	8	33	12	7	4	43	66	99
348	*Colias philodice* Godart	Clouded Sulphur	7	2	14	4	27	9	8	5	2	24	51
349	*Colias eurytheme* Boisduval	Orange Sulphur	22	12	10	1	45	2	3	3	15	23	68
385	*Eurema lisa* (Boisduval & LeConte)	Little Yellow	1	0	0	0	1	1	2	0	1	4	5
LYCAENIDAE (coppers, hairstreaks, blues)													
392	*Lycaena phlaeas* (Linnaeus)	American Copper	0	1	0	0	1	0	0	0	0	0	1
395	*Lycaena dione* (Scudder)	Gray Copper	0	0	0	0	0	0	1	0	0	1	1
398	*Lycaena hyllus* (Cramer)	Bronze Copper	1	1	1	0	3	0	0	0	1	1	4
445	*Satyrium titus* (Fabricius)	Coral Hairstreak	3	1	0	0	4	0	0	1	0	1	5

Table 2: Continued.

			Remnant Prairie Sites					Planted Prairie Sites					
	Scientific Name	**Common Name**	**Crossman**	**Hayden**	**Chipera**	**Ludwig**	**Remnant Total**	**Ply Rock**	**Dec Comm**	**Anderson**	**Gateway**	**Planted Total**	**Overall Total**
LYCAENIDAE (coppers, hairstreaks, blues)													
446	*Satyrium acadica* (Edwards)**	Acadian Hairstreak	0	5	7	1	13	0	0	0	0	0	13
451	*Satyrium calanus* (Hübner)	Banded Hairstreak	0	0	0	0	0	0	0	2	0	2	2
499	*Cupido comyntas* (Godart)	Eastern Tailed-Blue	16	8	7	4	35	9	10	10	4	33	68
503	*Celastrina neglecta* (Edwards)	Summer Azure	7	7	127	13	154	6	6	0	0	12	166
NYMPHALIDAE (brush-footed butterflies)													
573	*Danaus plexippus* (Linnaeus)	Monarch	40	76	33	25	174	74	122	87	87	370	544
588	*Speyeria cybele* (Fabricius)	Great Spangled Fritillary	20	20	9	114	163	59	29	16	19	123	286
589	*Speyeria aphrodite* (Fabricius)**	Aphrodite Fritillary	0	1	0	4	5	1	0	0	0	1	6
605	*Boloria selene* (Denis & Schiffermüller)	Silver-bordered Fritillary	0	0	2	0	2	0	0	0	0	0	2
606	*Boloria bellona* (Fabricius)	Meadow Fritillary	9	7	133	54	203	10	5	1	12	28	231
632	*Chlosyne nycteis* (Doubleday)	Silvery Checkerspot	0	0	0	0	0	0	8	0	7	15	15
648	*Phyciodes tharos* (Drury)	Pearl Crescent	49	43	276	7	375	7	5	3	3	18	393
664	*Junonia coenia* Hübner	Buckeye	0	0	0	0	0	0	0	1	1	2	2
673	*Polygonia comma* (Harris)	Eastern Comma	1	0	1	0	2	2	0	2	5	9	11
682	*Nymphalis antiopa* (Linnaeus)	Mourning Cloak	0	3	1	0	4	0	0	0	0	0	4
684	*Vanessa atalanta* (Linnaeus)	Red Admiral	22	54	26	21	123	54	14	16	29	113	236
685	*Vanessa cardui* (Linnaeus)	Painted Lady	1	2	1	1	5	0	0	0	1	1	6
687	*Vanessa virginiensis* (Drury)	American Lady	1	2	3	0	6	1	2	0	0	3	9
692	*Limenitis arthemis astyanax* (Fabricius)	Red-spotted Purple	0	0	1	0	1	2	0	0	1	3	4
693	*Limenitis archippus* (Cramer)	Viceroy	10	26	12	1	49	0	3	0	3	6	55
726	*Asterocampa celtis* (Boisduval & LeConte)	Hackberry Emperor	0	0	0	0	0	0	0	1	0	1	1
750	*Cercyonis pegala* (Fabricius)	Common Wood-Nymph	1	103	33	80	217	26	4	24	1	55	272
		Total	246	394	855	375	1870	285	238	198	272	993	2863
		Species Richness	25	25	28	23	34	21	20	23	23	36	42

prairies (Figure 2). Component 1 separated remnant from planted prairies and explained 31.6% of the variation and was most highly correlated with the abundance of *Polites mystic* (Edwards)(0.917), *Thymelicus lineola* (Ochsenheimer)(0.886) and *S. acadica* (0.869). Component 2 explained an additional 16.2% of the variation and was most highly correlated with the abundance of *Boloria selene* (Denis & Schiffermüller)(0.712) and *Ancyloxypha numitor* (Fabricius)(0.701).

Plant Surveys. A total of 194 species of flowering plants were observed throughout the summer of 2015. Although more flowering plant species were found in remnant (90.25 ± 6.10 species, mean ± SE) prairies than planted prairies (74 ± 9.74 species), this difference in plant species richness was not significant (t = 1.414, df = 6, p = 0.207). Although all four remnant prairies had more flowering plant species than three of the planted sites, the fourth planted site, Plymouth Rock, was a particularly high-diverse planting with over 250 plant species planted, and more species of flowering plants were observed blooming there (n = 104) than at any of the four remnant prairie sites.

As expected, the FQI for remnant prairies (44.26 + 1.88) was significantly greater (t = 3.176; df = 6; p = 0.019) than the FQI for planted prairies (32.96 + 3.02). In contrast to flowering plant species richness and the FQI, floral percent cover was almost four times greater in planted prairies (2.10 ± 0.46%) than in remnant prairies (0.58 ± 0.15%), revealing planted prairies had significantly greater floral resources available than remnant prairies (t = 3.116, df = 6, p = 0.021).

Discussion

When comparing butterfly abundance and species richness between remnant and planted prairies in Northeast Iowa, we found greater butterfly species richness in remnant prairies than in planted prairies. The ability of remnant prairies to support more butterfly species compared to planted prairies is likely due to a greater grass to forb ratio present in remnants. There were more grasses observed in remnant prairies, and lower percent floral cover in remnants compared to planted prairies. Butterflies such as the grass skippers (Subfamily: Hesperiinae) often require little bluestem (*Schizachyrium scoparium* (Michx.)Nash) and prairie dropseed (*Sporobolus heterolepis* (A.Gray)) for larval development to complete their lifecycle, and are not likely to be found in habitats without an abundance of these vital host plants (Nelson 2007). Although planted prairies provide an abundance of nectar resources that support populations of adult butterflies, remnant prairies are more likely to support populations of prairie specialist species of butterflies due to their greater plant species richness (Stoner & Joern 2004, Summerville et al. 2005).

Herein lies the great challenge of creating a planted prairie with the goal of developing a haven for plant and animal species similar to remnant prairies. Remnant prairies have had thousands of years to develop into the complex, intricate ecosystems they are today. This means there are thousands of years of soil and nutrient buildup, varied fire and grazing regimes, herbivory exposure, and plant diversification that have occurred to produce spatially distinct regions of prairie with unique matrixes of biotic and abiotic factors (Foster et al. 2003, Panzer 2002). The settlement of the American Midwest in the mid-1800s and more recent agricultural intensification and urbanization has fragmented the tallgrass prairie ecosystem and upset the delicate balance of organisms within, from which they cannot easily recover (Samson & Knopf 1994, Orlofske et al. 2011). Planting cropland back into native prairie is often a weak attempt to restore what existed previously (Collinge et al. 2003, Foster et al. 2003). The biotic and abiotic factors required to support prairie habitat may have been so disrupted by habitat conversion that the site may no longer be conducive to prairie development. Butterfly populations that were extirpated due to loss of habitat during fragmentation are slow to return, especially when their habitat needs include specific plant species common in remnant prairies but not represented well enough in planted prairies (Severns & Warren 2008, Schultz et al. 2011).

This is not to say that planting prairie is a complete failure. Planted prairies of a reasonable size and with a good mix of forbs and abundance of grasses such as Decorah Community Prairie and Plymouth Rock were fairly comparable to smaller remnant prairies such as Ludwig and Crossman Prairie in terms of their butterfly communities, suggesting that these planted prairies are of a sufficient quality to potentially host rarer butterflies. Given enough time and resources dedicated to ensuring the land can again support a prairie, planted prairies may become functionally similar and alike in plant community structure to remnants to begin hosting prairie butterflies in the same way (Smith & Cherry 2014), provided prairie specialist remnant-dependent species of butterflies can be reintroduced to these sites. For those that engage in the conservation of prairie habitat through reconstruction, the reintroduction of diverse management regimes such as controlled burns, grazing, mowing, and removal of invasive species must be used

to return planted prairies to a more remnant-like state (Panzer 2002).

For planted prairies to be appropriate as butterfly habitat, the age, floral abundance, species richness, and even size of the prairie must be considered. There is no hard measure for whether a prairie is going to be suitable habitat for native butterflies other than to perform surveys and collect data on the plant and butterfly abundance and diversity present to assess its function. The results of this study provide evidence that planted prairies can eventually begin to function like remnant prairies in terms of their plant communities and the butterfly community they support. Future studies of planted prairies should evaluate whether or not the overabundance of forb species over grasses in many seed mixes is resulting in decreased butterfly species richness in planted prairies, or if other factors may confound this finding such as the size of the prairie or its proximity to remnants. Continued study and management efforts are required in order to protect and conserve these magnificent prairie ecosystems and the diversity of life found living within them.

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