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Effects of Cover Object Size and Material, Rainfall, and Month on Reptile Detection in Nebraska

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Abstract - A commonly employed method for detecting reptiles and amphibians involves placement of artificial cover objects across landscapes. Cover objects can be of different sizes and different materials. We examined whether use of large wooden, small wooden, or metal cover objects influenced detections of herpetofauna in grasslands of Nebraska, in an area with few natural cover objects (e.g., rocks). We also examined whether rainfall events or month influenced detections. We monitored arrays during warmer months for 4 years. We observed 8 species of reptiles, with >3 times as many detections associated with large wooden cover objects compared to small wooden cover objects. A few reptile detections (2.8%) were recorded under metal cover objects. We did not detect any amphibians using cover objects. Beneficial microclimates of large wooden cover objects likely increased use by reptiles. Exposed metal cover objects in grasslands likely limited use because of high temperatures, low humidity, or both. Survey dates with recent rainfall had similar numbers of detections compared to survey dates without rainfall. Monthly detection rates varied by year, but no single month consistently yielded the greatest number of observations. Large wooden cover objects appear to increase detections of reptiles in upland grasslands of the Great Plains.

Introduction

Reptiles and amphibians are important contributors to ecological communities and indicators of environmental change (Burton and Likens 1975, Corn and Bury 1989, Davic and Welsh 2004, Hyde and Simons 2001, Moreno-Rueda et al. 2012, Valencia-Aguilar et al. 2013). Unfortunately, many species are experiencing declines and extinctions throughout the world (Gibbons et al. 2000, Stuart et al. 2004). Examination of herpetofaunal populations and community dynamics requires robust and diverse methods to capture, document, and study species (Fitch 1992, Ford and Hampton 2005, Kjoss and Litvaitis 2001, McKnight et al. 2015, Ryan et al. 2002, Willson and Gibbons 2010). Such data also are important for guiding management decisions, especially for rare or threatened taxa. However, many species of reptiles and amphibians are difficult to study in the field because of their small sizes, fossorial behaviors, unpredictable seasonality, and nocturnal habits (Fitch 1987, Gibbons 1988, Scheffers et al. 2009). Several sampling techniques, such as funnel and pitfall traps associated with drift fences (Gibbons and Semlitsch 1982, Willson and Gibbons 2010), have been employed successfully to detect and capture herpetofauna. However, a number of these methods are labor-intensive, cause stress or injury to animals, and/or take considerable time to manage and maintain, as individuals need to be released shortly after capture (DeGraaf and Yamasaki 1992, Fitch 1992, Gibbons and Semlitsch 1982, Grant et al. 1992, Kjoss and Litvaitis 2001, Willson and Gibbons 2010). Use of alternative sampling techniques that are non-destructive and non-intrusive to individuals and their habitats is beneficial and especially important for rare species and species in need of conservation (Davis 1997, DeGraaf and Yamasaki 1992, Gibbons 1988).

Artificial cover objects used to detect and study herpetofauna have advantages compared to some traditional survey methods (Fitch 1992, Grant et al. 1992, Kjoss and Litvaitis 2001,

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Scheffers et al. 2009, Tietje and Vreeland 1997, Willson and Gibbons 2010). Artificial cover objects require little to no maintenance, can be checked at irregular schedules, and pose lower risks to herpetofauna. Additionally, use of artificial cover objects has little to no negative effect on the environment. With this technique, it is unnecessary to displace natural cover objects to sample individuals, which potentially reduces suitability of microhabitats under natural objects (Davis 1997, Grant et al. 1992). Once artificial cover objects are placed in habitats, individuals use them for various functions, including protection, thermoregulation, and moisture (Grant et al. 1992, Joppa et al. 2010, Willson and Gibbons 2010). Limited research has examined how different types of artificial cover objects influence detections of herpetofauna in the Great Plains (Cox et al. 2009, Fitch 1992, Parmelee and Fitch 1995). Studies have examined cover objects in other parts of the United States with varied results regarding which cover object materials best promote detections (Engelstoft and Ovaska 2000, Grant et al. 1992, Hampton 2007, Scheffers et al. 2009). Further research is needed to understand regional differences in sampling methodologies for herpetofauna (Scheffers et al. 2009).

Use of artificial cover objects can promote observations and detections of herpetofauna where natural cover is scarce (Parmelee and Fitch 1995). In Nebraska, few natural cover objects, such as rocks and logs, exist in grasslands throughout the state. Our overarching objective was to determine the best material, size, and timing for checking artificial cover objects for reptiles and amphibians in grasslands. We also examined whether recent precipitation or checking cover objects during specific months increased detections. For this project, we used arrays consisting of a large wooden cover object, small wooden cover objects, and a large metal cover object, all with a similar total surface area for the different materials. In southern Nebraska, a number of species reach their distributional limits. Thus, our research also provided a benchmark of species that occur in the region and their relative abundance in the area.

Materials and Methods

We began this artificial cover object experiment in 2016 at 3 sites in Harlan County, Nebraska. Specifically, sites included the Alma Municipal Airport (40.11628°N, 99.34536°W), the Cedar Run ATV Trail area south of the dam at Harlan County Reservoir (40.05268°N, 99.20760°W), and an area north of the Cedar Run ATV Trail overlooking the reservoir (40.05489°N, 99.20641°W). In March 2019, we moved arrays from 1 site (the Alma Municipal Airport) to another of our sites (the Cedar Run ATV Trail south of the dam) because few detections were recorded at the original site. All sites consisted of grasslands. The 2 sites near the Harlan Reservoir dam consisted of relatively flat, semi-open mixed grasslands with scattered *Juniperus virginiana* L. (Eastern Redcedar), *Populus deltoides* W. Bartram ex Marshall (Eastern Cottonwood), *Rhus glabra* L. (Smooth Sumac), *Verbascum thapsus* L. (Common Mullein), and *Yucca glauca* Nutt. (Soapweed Yucca). Grasses at those sites were dominated by *Bromus inermis* Leyss. (Smooth Brome), *Schizachyrium scoparium* (Michx.) Nash (Little Bluestem), and *Sorghastrum nutans* (L.) Nash (Indiangrass). Dominant plants in grasslands at the Alma site consisted of *Bromus tectorum* L. (Cheatgrass), Smooth Brome, *Andropogon gerardii* Vitman (Big Bluestem), and Little Bluestem.

We placed 4 arrays of cover objects at each site. Each array had 6 total cover objects, including one 1.2 m × 1.2 m (4 ft × 4 ft) and four 0.6 m × 0.6 m (2 ft × 2 ft) pieces of 0.95 cm (3/8 in) plywood and 1 sheet of corrugated galvanized roofing metal ~1.2 m × 1.2 m (4 ft × 4 ft). Each type of material had about the same amount of total area covering the ground in each array. We deployed arrays at the 3 original sites in early March 2016, a few weeks prior to first checking underneath objects for individuals. We used similar timing, i.e., deployment of arrays in early March and initial checking a few weeks later, in 2019 when we moved the 4 arrays from the Alma Municipal Airport to the Cedar Run ATV Trail area south of the dam.

We examined artificial cover objects for herpetofauna starting in late March 2016 and checked them approximately every other week until mid-October 2016. We first examined the upper surfaces of cover objects for individuals residing on top, and then we lifted 1 side of each cover object to observe individuals underneath. Most checks were conducted in the afternoon because of a variety of time constraints. We repeated this process in 2017, 2019, and 2020. On each day cover objects were examined, we documented the precipitation for that day and 1 day prior from a nearby weather station (Harlan County Lake; 40.0892°N, 99.2133°W, climod.unl.edu). For comparison, days having a total of ≥ 0.254 cm (0.1 in) of rain the day of and day before checking cover objects were considered wet days, whereas days having precipitation <0.254 cm (0.1 in) for the day of and day before were considered dry days. For each individual observed under cover objects, we recorded species and cover object size and material. We also recorded animals that were on top of cover objects. These observations were included in our results and treated the same as those individuals underneath cover objects for statistical analysis and graphical representation. No animals were marked; thus, individuals could have represented recaptures throughout the study. We used a chi-square analysis to determine whether there were differences in the numbers of detections between cover object types.

Results

We recorded 214 total observations of reptiles of 8 species across sites during the 4-year study period, with a total of 158 observations at large wooden cover objects, 50 observations at small wooden cover objects, and 6 observations at metal cover objects (Table 1, Fig. 1). We did not detect any amphibians using cover objects during this study. We detected a significant difference between the 3 cover object types ($\chi^2 = 171.5$, df = 2, $P < 0.001$), with large wooden cover objects yielding the most observations compared to small wooden and metal cover objects. Upon inspection, larger wooden cover objects appeared to retain more moisture under boards than did smaller wooden cover objects, although we did not quantify this observation. We observed 7 *Aspidoscelis sexlineata* (L.) (Six-lined Racerunner) and 1 *Coluber constrictor* L. (North American Racer) on top of cover objects, whereas all other individuals were observed underneath cover objects. For all species except *Diadophis punctatus* (L.) (Ring-necked Snake), all individuals observed associated with cover objects were singletons. For Ring-necked Snakes, the mean number observed under a single cover object was 2.9 individuals, with a median of 2 and a mode of 1 (SD = 4.5, minimum = 1, maximum = 30).

Wet days yielded 59 observations on 18 sampling days (3.28 observations/day), whereas dry days yielded 154 observations on 40 sampling days (3.85 observations/day). Monthly observations varied from year to year (Fig. 2), without a pattern of a single month consistently having the greatest number of observations per sampling effort (number of site visits).

Discussion

Many studies with artificial cover objects demonstrate their utility in sampling and detecting herpetofauna. In fact, some studies report similar or higher detections and species richness when employing artificial cover objects compared to other techniques (Fitch 1987, Kjoss and Litvaitis 2001, Monti et al. 2000, Tietje and Vreeland 1997). However, other studies report lower detections or diversity with artificial cover objects (Ford and Hampton 2005, Grant et al. 1992, Harpole and Haas 1999, Kjoss and Litvaitis 2001, McKnight et al. 2015, Sung et al. 2011). Artificial cover objects also have been shown to have similar detection rates compared to natural cover objects (Houze and Chandler 2002, Marsh and Goicochea 2003). Our study documented that 3 types of artificial cover objects in grassland habitats lacking natural cover objects varied in herpetofauna detections on the basis of material and size. However, we did not find predictable patterns of detections with rainfall or seasonality.

Herpetofauna commonly reside underneath artificial cover objects of different materials, including wood, metal, plastic, and carpet (Cox et al. 2009, Engelstoft and Ovaska 2000, Grant et al. 1992, Hampton 2007, Kjoss and Litvaitis 2001, Miller Hesed 2012, Monti et al. 2000, Parmelee and Fitch 1995). Variation in use of these materials appears dependent, in part, on individual species requirements, geographic location, and habitat. Our study in Nebraska demonstrated that wooden cover objects were used by more reptiles than were metal cover objects in open grasslands, and there were no observations of amphibians using any of our cover object types. In South Carolina, reptiles preferred metal cover objects, but amphibians preferred plywood cover objects in mainly wooded habitats (Grant et al. 1992). In Texas, more herpetofauna were detected under metal and more in open-canopy woodland sites in mesic floodplain habitats (Hampton 2007). In Iowa, Cox et al. (2009) reported herpetofauna favored metal cover objects in an open floodplain in wetland habitats.

Overall, differences in use of cover objects are linked mainly to microclimates related to temperature, humidity, and heat retention underneath objects (Goldsbrough et al. 2006, Grant et al. 1992, Harpole and Haas 1999, Joppa et al. 2010, Kjoss and Litvaitis 2001, Webb

Table 1. Species and numbers of herpetofauna observed using artificial cover objects (large wooden, small wooden, and metal objects) in grassland habitats of Harlan County, Nebraska, during 2016, 2017, 2019, and 2020.

	Known from county	2016	2017	2019	2020	Total
Diadophis punctatus (L.) (Ring-necked Snake)	Yes	14	58	29	36	137
Coluber constrictor L. (North American Racer)	Yes	4	7	12	8	31
Aspidoscelis sexlineata (L.) (Six-lined Racerunner)	Yes	2	7	1	-	10
Lampropeltis gentilis (Baird and Girard) (Western Milksnake)	Yes	-	1	5	3	9
Pituophis catenifer (Blainville) (Gophersnake)	Yes	-	4	3	2	9
Thamnophis radix (Baird and Girard) (Plains Gartersnake)	Yes	-	6	1	2	9
Thamnophis sirtalis (L.) (Common Gartersnake)	Yes	-	3	4	1	8
Crotalus viridis (Rafinesque) (Prairie Rattlesnake)	No	-	1	-	-	1
Totals		20	87	55	52	214

and Shine 1998). Some studies report that few individuals use artificial cover objects when materials reach high temperatures or become too dry underneath (Fitch 1987, Harpole and Haas 1999, Kjoss and Litvaitis 2001, McKnight et al. 2015), as may occur with metal objects. However, in cooler climates in British Columbia, Canada, such materials can promote use by snakes in certain seasons (Engelstoft and Ovaska 2000). Metal cover objects in our study likely were avoided because of excessive heat when in direct sunlight, as also shown in grasslands of eastern Kansas (Parmelee and Fitch 1995). Direct comparisons between wooden and metal cover objects show wooden cover objects are cooler underneath than metal, among other differences (Engelstoft and Ovaska 2000, Grant et al. 1992). Such data suggest that metal cover objects are less beneficial for detecting herpetofauna in open, dry grasslands than are other artificial cover objects, such as wooden ones. We checked cover objects consistently in the heat of the afternoon; thus, checks earlier in the day or in the evening might have increased detections under metal cover objects (Parmelee and Fitch 1995). The lack of amphibians in our study likely relates to increased heat and low humidity under cover objects in open habitats, as amphibians rely more on moisture than do reptiles (Grant et al. 1992). However, the lack of amphibians could also relate to the distance to the nearest wetlands, which were located downhill ~0.4 km away.

Cover object size, both area and thickness, can affect use by herpetofauna (Goldsbrough et al. 2006, Huey et al. 1989, Webb and Shine 1998). Our study demonstrated that placing larger wooden boards was more effective than cutting up the same sized large board into smaller cover objects in an upland grassland system. For wooden cover objects in our study, we had 3 times as many observations under larger boards compared to smaller boards (Fig. 1), although total surface area was roughly equal between treatments. Larger cover objects, natural and artificial, generally are used more frequently than smaller cover objects by various herpetofauna (Goldsbrough et al. 2006; Gregory 1983, 2009; Mathis 1990; Moore 2005), although some research has shown that some species have no preference or prefer small cover objects (Cox et al. 2009). The larger surface area of our larger wooden cover

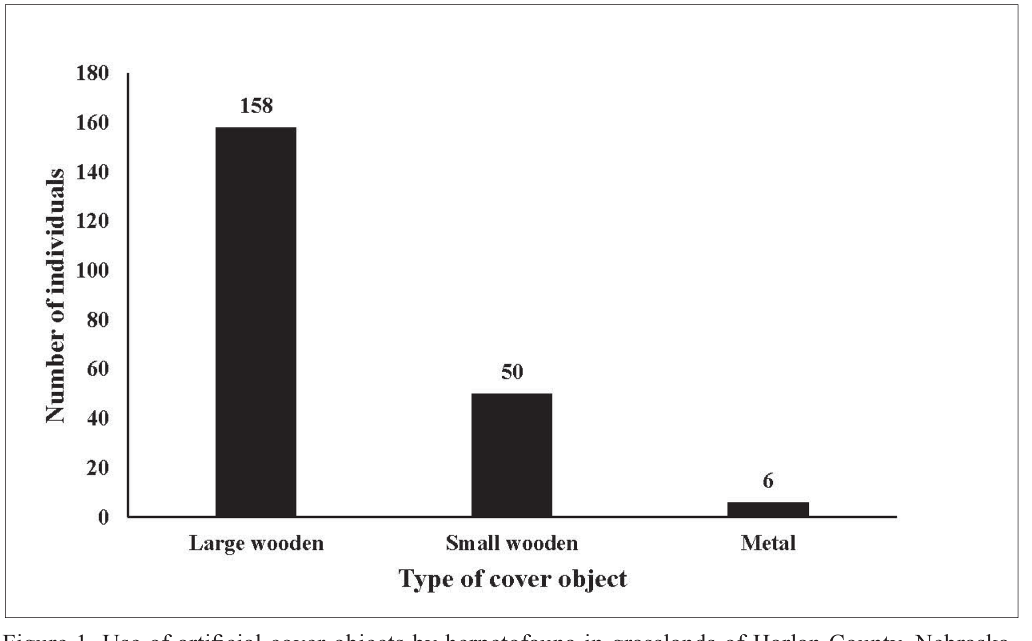

Figure 1. Use of artificial cover objects by herpetofauna in grasslands of Harlan County, Nebraska, during 2016, 2017, 2019, and 2020.

objects likely had more stable temperatures and greater humidity compared to smaller cover objects (Grant et al. 1992). Wooden cover objects also were thicker and likely yielded more stable thermal properties than thin metal cover objects.

Moderate temperatures and high humidity under cover objects also likely attract prey items, such as invertebrates and small mammals, that might further attract herpetofauna (Kjoss and Litvaitis 2001). Several snake species (North American Racer, *Lampropeltis gentilis* [Baird and Girard] [Western Milksnake], and *Pituophis catenifer* [Blainville] [Gophersnake]) detected in our study commonly prey upon small mammals (Ernst and Ernst 2003), and we often encountered small mammals (*Peromyscus* and *Microtus*) and their nests under cover objects.

Overall, multiple factors under cover objects potentially drive occupancy (Goldsbrough et al. 2006), and most species likely use various cues of multiple sensory systems in the process of habitat selection. However, for many ectotherms, thermally suitable cover objects might be particularly important because many behavioral and physiological processes are temperature dependent (Lillywhite 1987, Stevenson et al. 1985).

Rainfall can influence herpetofaunal activity (Fellers and Drost 1994, Harpole and Haas 1999, Reynolds 1982, Schlesinger et al. 2010). For amphibians, such as salamanders, precipitation increases activity (Fellers and Drost 1994, Harpole and Haas 1999). However, some studies do not show a relationship between herpetofaunal activity and rainfall (Eskew and Todd 2017). We failed to find an immediate association of rainfall with herpetofauna detections in south-central Nebraska. Some studies with observed correlations between rainfall and reptile activity revealed more seasonal patterns rather than effects of increased activity immediately after rainfall (Reynolds 1982, Schlesinger et al. 2010). Furthermore, other factors, such as prey availability (Reynolds 1982, Schlesinger et al. 2010), might drive such relationships. Additionally, recent precipitation might have reduced the need for artificial cover objects because vegetation and substrates in the surrounding grasslands were suitably moist. Although we failed to see differences in detections associated with precipitation, more complex patterns of cover object use associated with precipitation, ambient temperature, and seasonality may exist.

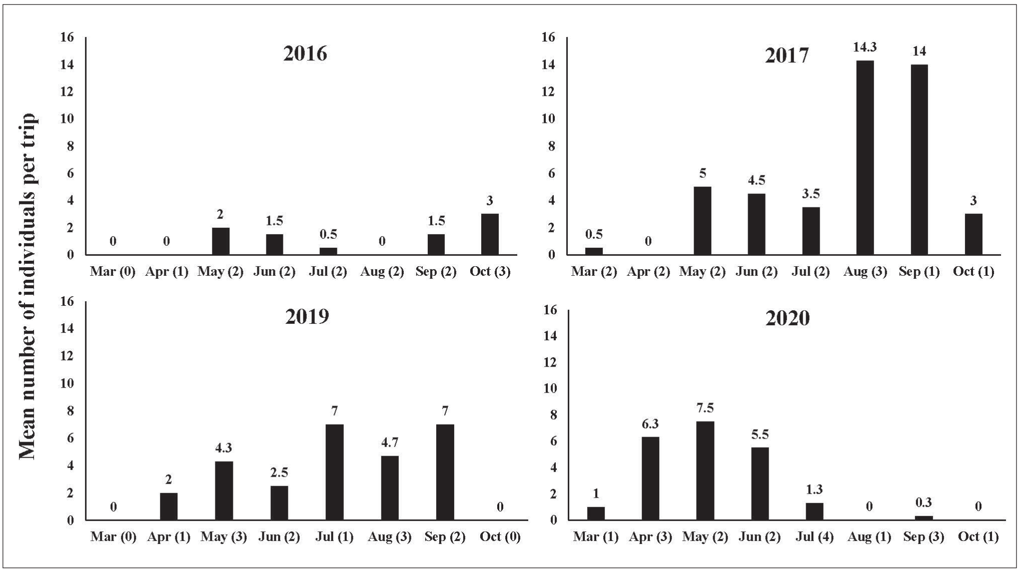

Figure 2. Mean number of herpetofauna detected per sampling trip each month for 4 years associated with artificial cover objects in Harlan County, Nebraska. Number of visits to sites each month is given in parentheses after each month.

Studies have demonstrated that seasonality can affect activity and detections of herpetofauna (Engelstoft and Ovaska 2000, Fitch 1987, Reynolds 1982). We suspect monthly detections of herpetofauna differed between years at our study site in response to variation in temperature and precipitation (Fig. 2). In Nebraska, Geluso (2012) has documented a number of county records in mid- and late-October during warm days or periods, as these periods are when many young snakes are above ground moving toward hibernacula (Fogell 2010). During October 2020, however, 1 of the authors did not have success in finding snakes while driving roads throughout Nebraska (K. Geluso, unpublished data), which coincided with the general lack of detections under cover objects in this study during autumn 2020. In August and September 2017, we had our greatest rates of observation under cover objects (Fig. 2). Those 2 months also had our 2 largest groups of Ring-necked Snakes under single cover objects, with 30 individuals under 1 board in August and 12 individuals under 1 board in September, which increased rates of detection. It is unclear why larger groups of individuals of this single species were observed those 2 months, but females are known to release pheromones to attract males and aggregate them for mating (Ernst and Ernst 2003). We recognize that a note of caution has been raised regarding seasonal patterns in cover object studies. Specifically, seasonal activity patterns of snakes determined from cover object detections may reflect thermal properties of the cover objects and not actually represent surface activity patterns for snakes (Engelstoft and Ovaska 2000). More data with complex analyses likely are needed to elucidate seasonal patterns of cover object detections at our site.

Nebraska counties that border Kansas, such as Harlan County, have some of the highest herpetofaunal diversity in the state (Ballinger et al. 2010, Fogell 2010). In our study, use of artificial cover objects to document species resulted in mixed success in detecting species previously known from the county, reflecting taxonomic group and species differences. In Harlan County, 8 snake, 6 anuran, 3 turtle, 1 lizard, and 1 salamander species are known to occur (Bridger et al. 2014, Fogell 2010, Fogell and Taggart 2010, Geluso 2012). We observed 7 snake species, including 6 of the 8 previously documented species as well as a new species for the county, *Crotalus viridis* (Rafinesque) (Prairie Rattlesnake). The 2 snake species not detected by our study, *Heterodon nasicus* Baird and Girard (Plains Hog-nosed Snake) and *Nerodia sipedon* (L.) (Common Watersnake), likely reflect placement of cover objects away from desired habitats. Common Watersnakes prefer mesic habitats, whereas Plains Hog-nosed Snakes prefer open sandy areas (Ballinger et al. 2010, Fogell 2010). Neither of those habitats occurred at or near our study sites. Although we achieved a 75% success rate in detecting snakes and 100% in detecting the single lizard species, cover objects failed to detect any chelonian, anuran, or salamander species. We did detect *Ambystoma mavortium* Baird (Western Tiger Salamander) at the study sites, but individuals were not associated with cover objects. Anurans occurring in the county generally are not associated with dry upland grasslands distant from water (Ballinger et al. 2010, Fogell 2010). Other studies also have reported the limitations of using only cover objects to detect the diversity of herpetofaunal communities in areas, especially for turtles (Grant et al. 1992, McKnight et al. 2015). Although our results can be used as a baseline for future studies in upland sites in the region, more diverse methodologies and habitats would need to be incorporated in future studies to more accurately document the other known species in the county.

When studying herpetofauna in the Great Plains, especially in dry, open upland habitats, metal cover objects appear inferior to wooden cover objects, although checking them at other times of the day, such as early morning, evening, or night, might yield different results. Our research suggests that use of large wooden cover objects can improve detections of species and promote greater sample sizes. However, our study did not elucidate any consistent associations between detections and precipitation or month, but more research examining multiple factors simultaneously might uncover such patterns. Ultimately, studying the effectiveness of cover objects in different regions will facilitate studying herpetofauna and lead to a better understanding of their occurrences, seasonality, and biology.

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