Common Grackle Breeding on Bottomland Forest Restoration Sites

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Abstract - Two of 36 forest restoration sites in the Mississippi Alluvial Valley surveyed from 2000–2002 harbored *Quiscalus quiscula* (Common Grackle). Occupied sites were in less-forested landscapes and had sparser understory vegetation due to flooding. Probability of daily nest survival (0.9077) of 169 Common Grackle nests was influenced by nest-placement, temporal, and landscape effects. Age of nest markedly affected nest survival, which increased from <0.89 during egg laying (age < 6 days) to >0.92 when nestlings were present (age > 18 days). Extrapolating daily nest survival to a 31-day nest period resulted in 5% nest success, far less then previously estimated for this species in more northern latitudes and likely less than required to sustain populations on these sites.

Introduction

Within the past century, flood-control efforts in the Mississippi Alluvial Valley (MAV), including an extensive system of levees and stream channelization, have altered natural hydrologic and geomorphic processes (Fredrickson 2005, King et al. 2005). These changes have contributed to extensive forest loss and fragmentation and changed the character of bottomland forests within this ecoregion (Rudis 2001, Twedt and Loesch 1999). As a result, this ecosystem was converted from a forested wetland system to one that is dominated by agriculture, with forested wetlands embedded within an agricultural matrix. Concurrently, avian populations in the MAV have been impacted, with declines in abundance of silvicolous species and increased abundance of agrarian species (Smith et al. 1993).

In recent decades, however, extensive restoration of bottomland forest has been undertaken to reclaim some of the millions of hectares converted to agriculture (King et al. 2006, Schoenholtz et al. 2001). Hardwood trees have been planted on >200,000 ha of agricultural land with a restoration goal of circa 800,000 ha (Haynes 2004). The structure of vegetation on restoration sites, specifically tree height and density of vegetation, influences the composition and density of breeding birds on these sites (Twedt et al. 2002).

In a regional assessment of landscape and vegetation effects on birds breeding on reforested bottomlands which focused on 19 widely distributed species breeding on ≥6 of 36 study sites, Twedt et al. (2010) found that landscape context influenced abundance and nesting success of these relatively common species. One additional species, *Quiscalus quiscula* L. (Common Grackle), was a frequent nesting species on restoration sites. However, nesting Common Grackles were restricted to a relatively few restoration sites, likely because they nest semicolonially (Peer and Bollinger 1997).

With an estimated population of 97 million (Rich et al. 2004), Common Grackles are among the most abundant landbirds in North America (Peer and Bollinger

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1997). They are also among the most significant pest species within agricultural ecosystems (Mott 1984). Their propensity to consume agricultural crops (Homan et al. 1994) and their potential to harbor fungal diseases associated with communal roosts (Stickley and Weeks 1985) has prompted implementation of control measures, including lethal methods (Dolbeer 1988, Stickley et al. 1986). Indeed, Heisterberg et al. (1987) noted that Common Grackles accounted for 49% of all birds killed during lethal roost-control operations that used ground-based application of the surfactant PA-14.

Although abundant, Common Grackle populations have exhibited a significant long-term continental decline of -1.0% per year (P < 0.01) between 1966 and 2007. During this same time, their population within the MAV has declined even more markedly at -2.6% per year ($CI_{95\%}$ = -4.3 to -0.9%; Sauer et al. 2008). As a result, Common Grackles are among 14 common species with population declines of >60% during the last 40 years (Butcher and Niven 2007). Although lethal control efforts have been effective for local and short-term population reduction (Glahn et al. 1991), additional study is needed to evaluate any linkage between lethal control of blackbirds and regional population declines (Peer and Bollinger 1997). I postulate no such link, and other factors, such as landscape change, may account for observed population declines.

Homan et al. (1996) found landscape characteristics influenced nest-site selection of Common Grackles in an agriculture-dominated ecoregion. As Common Grackles nest semicolonially and they are among the first species to initiate nesting in the spring (Peer and Bollinger 1997), colony location may be an important factor influencing nest success. Indeed, unless mitigated by site conditions, early nesting may subject nests to increased mortality resulting from extreme weather conditions (Long and Long 1968). Similarly, the relative concentration of nests of Common Grackles, combined with the temporal paucity of active nests of other species, may increase their risk of nest predation.

Widely distributed and abundant, Common Grackles provide a great opportunity for study, and their purported population decline prompts inquiry into their population dynamics. Even so, information on nesting success of Common Grackle is predominantly from more northern portions of their breeding range (e.g., Illinois, Wisconsin, Ohio, North Dakota, and eastern Canadian provinces; Peer and Bollinger 1997). Moreover, most demographic evaluations were conducted before commencement of continental bird monitoring via the Breeding Bird Survey (i.e., before 1966), and these historical evaluations may not reflect factors currently impacting breeding populations. Within the southern range of Common Grackles in west-central Mississippi and northeast Louisiana, I sought to characterize habitat on bottomland forest restoration sites where Common Grackles were breeding and contrast these with habitat characteristics on sites where this species was absent. Additionally, I sought to assess the influence of landscape, vegetation, and temporal variables on survival of nests of Common Grackles breeding on bottomland restoration sites within this region.

Methods

I selected a stratified random sample of 36 bottomland forest restoration sites that was equally divided between younger (2–5 years post-restoration) and

older (6–15 years post-restoration) sites within Madison and Tensas parishes in Louisiana and Humphreys, Issaquena, Sharkey, Warren, and Yazoo counties in Mississippi. Restoration on most sites consisted of planting 1-year-old seedlings, primarily oaks (*Quercus nigra* L. [Water Oak]*, Q. phellos* L. [Willow Oak]*,* and *Q. nuttallii* Palmer [Nutall Oak]) and *Fraxinus pennsylvanica* Marsh. (Green Ash). Younger sites were dominated by grasses (*Andropogon virginicus* L. [Broomsedge Bluestem]*, Carex* spp*.* [sedges]), herbaceous vegetation (*Rubus* spp. [brambles], *Solidago* spp. [goldenrod], and *Verbena* spp. [verbena]), and low-growing vines (*Brunnichia ovata* Walt. Shinners [American Buckwheat Vine], *Campsis radicans* L. [Trumpet Vine], and *Toxicodendron radicans* L. Kuntze [Poison Ivy]). Natural recruitment of trees, such as *Celtis laevigata* Willd. (Sugarberry), *Liquidambar styraciflua* L. (Sweetgum), and *Ulmus* spp. (elms), was greater on older sites (Twedt 2004).

I estimated breeding bird densities within rectangular, 10–30-ha blocks within each restoration site based on multiple spot-mapping survey visits using Breeding Bird Census protocols for forested habitat (Svensson et al. 1970). For logistic efficiency, study sites were geographically clustered within study years, and each site was surveyed during a single year: 10 sites in 2000, 12 in 2001, and 14 in 2002.

I characterized surveyed plots based on their landscape context and vegetation structure. Landscape context included the proportion of forest cover and the proportion of agricultural land within a 5-km radius based on 2001 National Land Cover data (http://www.epa.gov/mrlc/nlcd-2001.html) after identifying and reclassifying areas of forest restoration (Twedt et al. 2006). Thus, restored areas were not included in the area of forest or agricultural land cover.

I collected data to assess vegetation structure within 8-m radius (200-m^2) sample plots that were systematically distributed along a 100- x 100-m grid throughout each study site. Habitat variables included tree height (m), species richness, stem density (stems/ha) of trees and shrubs, vegetation density, and ground cover density. I used the third quartile of tree heights (i.e., height at which 25% of trees were taller). Mean vegetation density (dm) was derived from four vegetation-density measurements within each sample plot determined from the visual obstruction of 0.5-dm intervals on a vertical pole when viewed from a distance of 4 m at a height of 1 m (Robel et al. 1970). Similarly, I estimated mean horizontal vegetation density at ground level (% ground-cover density) based on four obscurity readings of a 50-cm^2 checkerboard within each sample plot. I estimated species richness as the total number of species observed within sample plots on each study site after using program SPECRICH2 to adjust for unequal sampling effort among study sites (http://www.mbr-pwrc.usgs.gov/software/specrich2.html). I compared habitat and landscape characteristics between sites with breeding Common Grackles and sites devoid of this species using Wilcoxon rank-sum test for 2 samples.

Field personnel searched for active nests of all species approximately every 3 days on each monitored study site. Located nests were revisited at 2–3 day intervals to record their status and fate. Nests failed when adults abandoned the nest or the contents (eggs or chicks) disappeared before the projected date of fledging. If fate was ambiguous, the final observation interval was censored from analysis. Upon nest termination, I estimated nest concealment as the mean of visual observations from each of the four cardinal directions when viewed at a distance

of 5 m with visual obscurity ranked as: 0 (<5% visible), 1 (5–25%), 2 (26–75%), 3 (76–95%), or 4 (>95%).

I assessed the effect of landscape, temporal, nest-age, and nest-location variables on daily survival of Common Grackle nests using a logistic exposure model which used a binomial distribution (0 = fail, 1 = survive) and a logit link function $g(\theta) = \log_e(\theta^{1/t}/[1 - \theta^{1/t}])$, where θ was the interval survival rate and t was the interval length in days between nest observations (Shaffer 2004). I fit models using PROC GENMOD (SAS Institute, Cary, NC) following methods described by Shaffer and Thompson (2007; http://www.npwrc.usgs.gov/resource/birds/nestsurv/index.htm).

I evaluated the relative support for 15 a priori models that related nest survival to the effects of nest age, day of year, landscape (as defined by study site and distance [m] from nearest agricultural and forest edges), and nest location (as defined by nest concealment and nest height [cm]) using the information-theoretic approach (Burnham and Anderson 2002). The null model was an intercept-only, constant-survival model. I used Akaike information criteria adjusted for small sample sizes (AIC_c) as a measure of support among competing models, specifically assuming the most parsimonious models had strong support provided AIC_c was within two units of the lowest AIC_c value ($\Delta AIC_c < 2.0$). I calculated odds ratios for model effects within the most-supported models using model-averaged coefficients and 95% confidence intervals based on unconditional standard errors (Burnham and Anderson 2002).

Results

I detected breeding Common Grackles on only two of 36 surveyed study plots, with estimated densities at 0.65 and 5.71 birds/ha. Restoration sites on which I detected Common Grackles were in less-forested landscapes and had sparser understory vegetation than study sites that had no breeding grackles (Table 1).

I located 169 grackle nests and monitored their fate at 2.89 ± 0.03 ($\bar{x} \pm SE$) day intervals, resulting in 1417 nest observation intervals. Most nests were in *Salix nigra* Marsh. (Black Willow; $n = 126$) that averaged 6.67 ± 0.21 m in height or in *Cephalanthus occidentalis* L. (Buttonbush; $n = 38$) that were 4.02 ± 0.20 m in height. Nests were at an average height of 3.23 ± 0.07 m. Most nests failed as a result of depredation ($n = 137$), but I did not identify specific predators. Six nests

Table 1. Mean ($\bar{x} \pm SE$) vegetation density and ground cover within 8-m radius sample plots and forest area within a 5-km radius were lower ($P = 0.05$, Wilcoxon rank-sum test) on bottomland restoration sites in the Mississippi Alluvial Valley where breeding *Quiscalus quiscula* (Common Grackles) were present than on sites where this species was absent during 2000–2002.

Variable	Description	Present ($n = 2$)	Absent ($n = 34$)	P
Age	Year post planting	5.5 ± 2.5	6.7 ± 0.6	0.75
Tree height,	3rd quartile (m)	3.3 ± 0.8	2.4 ± 0.2	0.31
Vegetation density	Robel visual obstruction (dm)	4.6 ± 3.0	9.6 ± 0.3	0.05
Ground cover	%	61.7 ± 30.6	96.4 ± 0.8	0.05
Species richness	Number of species/study site	9.0 ± 2.0	9.5 ± 0.6	0.81
Stem density	Tree and shrub stems/ha	540 ± 186	1117 ± 227	0.81
Forest	% area within 5-km radius	12.2 ± 1.7	37.5 ± 3.3	0.05
Agriculture	% area within 5-km radius	52.0 ± 16.8	40.4 ± 3.4	0.39

were abandoned, two of which first suffered partial depredation. No nests were parasitized by *Molothrus ater* Boddaert (Brown-headed Cowbirds).

Nesting of Common Grackles was concentrated between mid-April and early May, generally earlier in the year and more temporally compressed than were monitored nests of other species breeding on these same restoration sites (Twedt et al. 2010; Fig. 1). Average clutch size was 3.69 ± 0.11 eggs (maximum = 6), but successful nests held 4.21 ± 0.16 eggs and fledged 3.58 ± 0.20 young.

The 24 Common Grackle nests that successfully fledged young resulted in apparent nest success of 14.2%, whereas the Mayfield (1961) estimate of nest success was 8.1% ($CI_{95\%}$ = 5.6–11.8%). Four logistic exposure models with strong support ($\Delta AIC_c < 1.65$) included age of nest. Three of these models included landscape factors, whereas day of year and nest location (height and cover) were each included in a single model (Table 2). Model-averaged daily nest survival was 0.9077 ($CI_{95\%}$ = 0.842−0.948), resulting in an interval nest survival of 5.0% ($CI_{95\%}$ = 0.5−19%) over a presumed 31-day nesting interval (4 egg laying, 14 incubation, and 13 nestling). Nest survival was positively related to distance from forest, day of year, nest
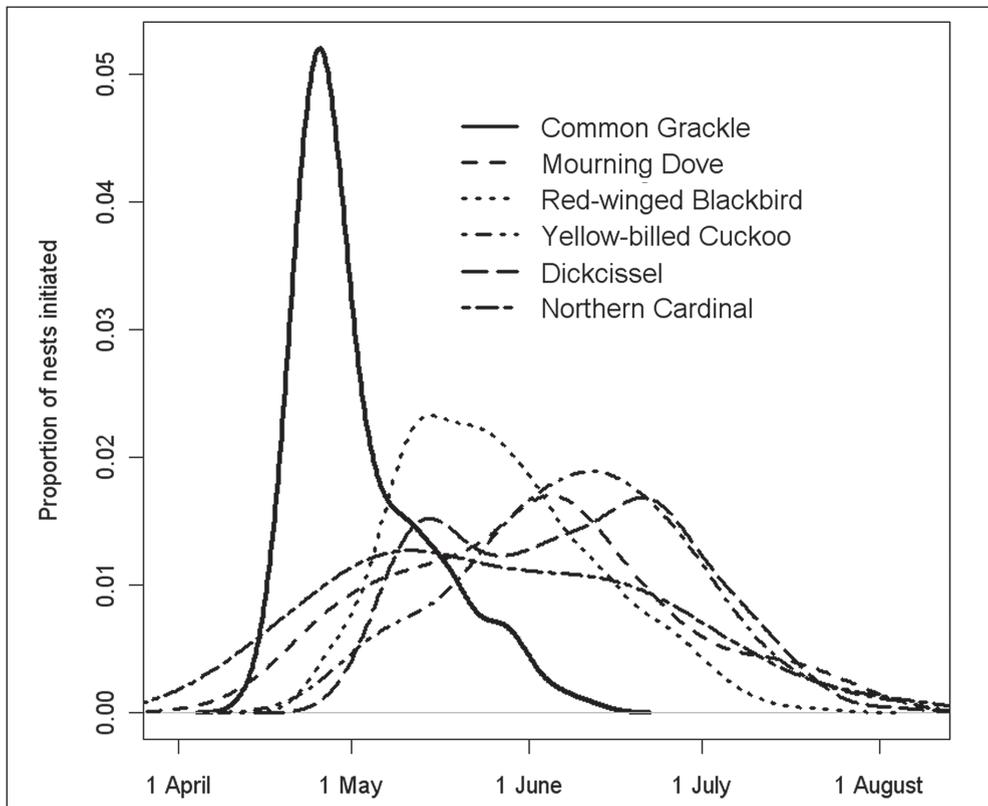

Figure 1. Probability density functions of nest-initiation date on bottomland forest restoration sites in the Mississippi Alluvial Valley during 2000–2002 indicated nests of *Quiscalus quiscula* (Common Grackle; *n* = 169) were initiated sooner and were more temporally compressed than were nests of *Zenaida macroura* L. (Mourning Dove; *n* = 131), *Agelaius phoeniceus* L. (Red-winged Blackbird; *n* = 1164), *Coccyzus americanus* L. (Yellow-billed Cuckoo; *n* = 47), *Spiza americana* Gmelin (Dickcissel; *n* = 385), or *Cardinalis cardinalis* L. (Northern Cardinal; *n* = 34).

concealment, and nest height (Table 3). However, confidence intervals on model parameters included zero, and confidence intervals on odds-ratios included 1 (equal odds) for all variables except age of nest (Table 3). These findings suggest that age of nest (i.e., nest stage) was the only variable that markedly influenced nest success of Common Grackles breeding on bottomland restoration sites. Daily nest survival increased from <0.89 during egg laying (days 1 through 6) to >0.92 after eggs hatched (day 18) through fledging on day 31 (Fig. 2).

Discussion

Reforested sites harboring breeding Common Grackles tended to have less understory vegetation and were in less forested landscapes. Although we did not quantify standing water, the persistence of winter floodwater into spring likely contributed to sparser vegetation on sites with nesting grackles compared to other study sites. Notably, however, study sites with similar flood conditions but lacking trees >3 m tall did not attract breeding Common Grackles. Nests of Common Grackles within these restoration sites were geographically concentrated in areas above or

Table 2. Akaike information criteria (ΔAIC_c) resulting from logistic exposure regression analyses indicated 4 of 15 a priori models hypothesized to influence nest survival of *Quiscalus quiscula* (Common Grackles) breeding on bottomland restoration sites in the Mississippi Alluvial Valley were well supported with Akaike weights (w_i) ≥0.113. The number of model parameters (K) included an intercept and up to 7 effect variables including: age of nest (AGE), day of year (DATE), nest height and concealment (LOCATION), as well as site identity, distance to forest edge, and distance to agriculture (LANDSCAPE). The effective sample size (Rotella et al. 2004) for analysis was 1417.

Model	K	AIC_c	ΔAIC_c	w_i
AGE and LANDSCAPE[A]	5	549.6	0	0.257
AGE, LANDSCAPE, and LOCATION[A]	7	550.7	1.079	0.150
AGE[A]	2	552.0	1.301	0.134
AGE, LANDSCAPE, and DATE[A]	6	553.6	1.641	0.113
AGE and DATE	3	555.7	2.113	0.089
Global	8	558.5	2.739	0.065

[A]Models with strong support ($\Delta AIC_c < 2.0$ and $w_i > 0.1$).

Table 3. Confidence intervals ($CI_{95\%}$) on the odds ratios of seven model parameters averaged over four well-supported ($\Delta AIC_c < 2.0$) models of nest survival of *Quiscalus quiscula* (Common Grackles) breeding on bottomland restoration sites in the Mississippi Alluvial Valley indicated that probability of nest survival increased with age of nest. Study site effects were categorical relative to baseline parameter estimate of 0.

Parameter	Estimate	SE	Odds ratio	$CI_{95\%}$
Intercept	-3.6192	7.4642		
Age of nest	0.0336	0.0138	1.034	1.020 – 1.050
Day of year	0.0010	0.0028	1.001	0.998 – 1.000
Nest height	0.0001	0.0003	1.000	0.999 – 1.000
Nest concealment	0.0042	0.0290	1.004	0.975 – 1.030
Distance to forest edge	0.0013	0.0018	1.001	0.999 – 1.000
Distance to agriculture	-0.0011	0.0028	0.998	0.996 – 1.000
Study site	4.4477	5.3260	1.000	1.000 – 1.000

adjacent to standing water and within trees > 3 m. The presence of water under nests has been thought to deter potential mammalian predators (Hoover 2006).

Standing water may also provide an important thermal buffer for nests of Common Grackles. Common Grackles are often among the first species to begin nesting in spring (Peer and Bollinger 1997), and nests on bottomland restoration sites were temporally concentrated early in the nesting season (Fig. 1). Thus, standing water near nests may mitigate temperature extremes to which nests are subjected during early spring.

The hydrologic condition of restoration sites supporting breeding Common Grackles also influenced woody vegetation on these sites. Black Willow and Buttonbush are both species very tolerant of flooding (Garber and Moorhead 1999). These two species represented only 11% of nest trees for all birds breeding on reforested bottomland sites (Twedt et al. 2010; D.J. Twedt, unpubl. data) yet these same species harbored 98% of grackle nests. Black Willow is a rapid-growing species that often achieves greater height than more-frequently planted oak and ash species on reforested bottomland sites (Twedt and Best 2004). This heterogeneity of tree heights resulted in mottes of taller trees within restoration sites that may have attracted breeding Common Grackles. Selection by Common Grackles of sites with isolated tree mottes, sites in less forested landscapes, and sites with sparse understory vegetation conforms to their reported affinity for open woodlands and forest edges in other geographic locations (Peer and Bollinger 1997).

Interval nesting success of 5% for Common Grackles on bottomland restoration sites within the southern portion of their range was markedly less that that previously
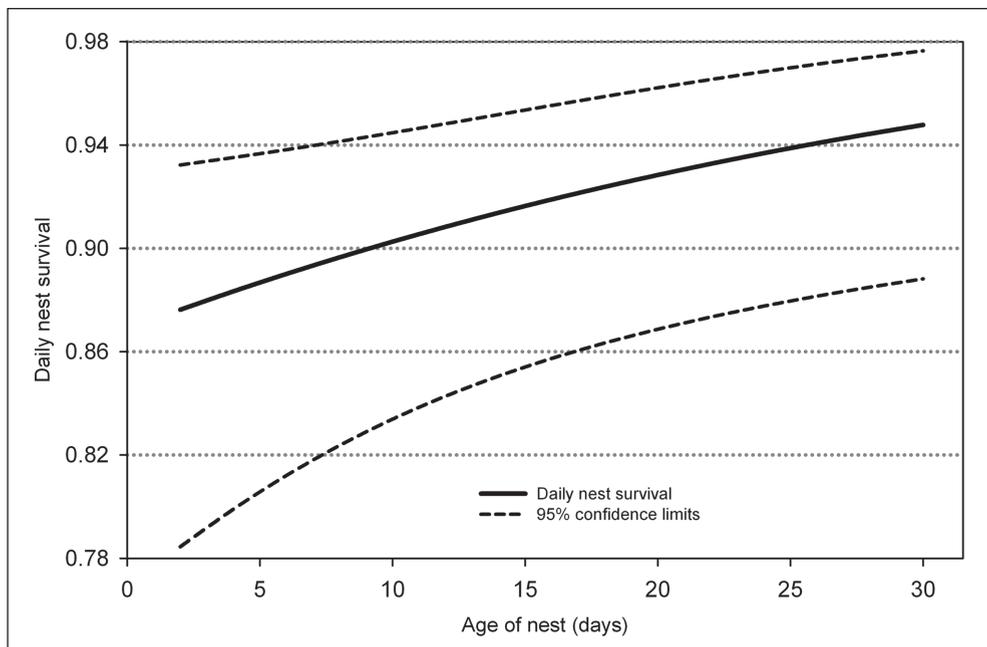

Figure 2. Probability of daily survival of nests of *Quiscalus quiscula* (Common Grackles) on bottomland restoration sites in the Mississippi Alluvial Valley increased with age of nest when other model factors were held at their mean values. Confidence interval (95%) is depicted with dashed lines.

reported for this species in more northern latitudes. Even when reverting to apparent nest success, the measure of success typically reported in nesting studies prior to Mayfield's insightful publication (Mayfield 1961), nest success of 14% on bottomland restoration sites was far less than that reported in Wisconsin (45% [Young 1948], 55% [Petersen and Young 1950], >53% [Wiens 1965]) or Ohio (53% [Maxwell and Putnam 1972]). Conspicuously, a nesting study at a slightly more southern location in Kentucky found a nest success of only 17% (Jones 1969). Clearly, more estimates of nest success of Common Grackles are needed from other locations to assess any geographically significant demographic trend.

In addition to reduced nesting success, the clutch size of 3.7 eggs and 3.6 fledgling per successful nest for Common Grackles nesting on bottomland restoration sites were below the 4.8 eggs and 4.0–4.3 fledglings reported for Common Grackles breeding elsewhere (Peer and Bollinger 1997). Low nest success and reduced number of fledglings produced from successful nests of Common Grackles on bottomland restoration sites likely provides insufficient recruitment to offset mortality within their population on these sites (Donovan and Thompson 2001). Recommended bottomland forest restoration strategies that promote rapid development of dense forest stands within forested landscapes (Wilson et al. 2007) may reduce colonization of these sites by Common Grackles, but should provide conditions for other thamnic and silvicolous birds where reproductive success is sufficient to sustain their populations (Twedt et al. 2010).

Acknowledgments

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