

Habitat edges have weak effects on duck nest survival at local spatial scales

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Edge effects on nesting success have been documented in breeding birds in a variety of contexts, but there is still uncertainty in how edge type and spatial scale determine the magnitude and detectability of edge effects. Habitat edges are often viewed as predator corridors that surround or penetrate core habitat and increase the risk of predation for nearby nests. We studied the effects of three different types of potential predator corridors (main perimeter roads, field boundaries, and ATV trails within fields) on waterfowl nest survival in California. We measured the distance from duck nests to the nearest edge of each type, and used distance as a covariate in a logistic exposure analysis of nest survival. We found only weak evidence for edge effects due to predation. The best supported model of nest survival included all three distance categories, and while all coefficient estimates were positive (indicating that survival increased with distance from edge), 85% coefficient confidence intervals approached or bounded zero indicating an overall weak effect of habitat edges on nest success. We suggest that given the configuration of edges at our site, there may be few areas far enough from hard edges to be considered 'core' habitat, making edge effects on nest survival particularly difficult to detect.

Key words: edge effect, fragmentation, Gadwall, Mallard, nest success, predation, waterfowl

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Large expanses of habitat have been lost or fragmented as a result of anthropogenic destruction and degradation (Fischer & Lindenmayer 2007), and fragmentation tends to result in lower biodiversity, depressed population growth rates, lower dispersal rates and altered species interactions (Fahrig 2003). Fragmented landscapes also have a higher proportion of edge habitat, and deleterious edge effects are often observed in these environments (Paton 1994, Lahti 2001). Edges have a negative effect on breeding success by increasing the potential for nest predation and parasitism. Several studies have shown reduced nesting success near habitat edges (Andren & Angelstam 1988, Johnson & Temple 1990, Donovan *et al.* 1997), perhaps because

there is a greater abundance and diversity of predators that are attracted to edges, along which they can easily travel and forage on prey in both habitats (Gates & Gysel 1978, Cervinka *et al.* 2011). Despite decades of intensive research on this topic, many studies do not actually detect deleterious effects of habitat edges (Lahti 2001).

Evidence for an effect of edges on waterfowl nest survival is equivocal: some studies show strong edge effects, whereas others show only weak edge effects, or no effects at all. However, it seems that in waterfowl, edge effects are more likely to be detected at large spatial and temporal scales (Stephens *et al.* 2003), and at these scales, researchers have found that large tracts

of intact grassland are associated with greater breeding pair densities and nesting success (Johnson & Temple 1990, Clark & Nudds 1991, Herkert 1994, Ball *et al.* 1995, Sovada *et al.* 2000, Horn *et al.* 2005). Nevertheless, studies addressing edge effects at local scales have revealed considerable complexity in this pattern. Stronger edge effects are observed in environments with a high proportion of grassland (at the landscape level), distinct habitat edges, and patches of dense nesting cover (Phillips *et al.* 2003, Horn *et al.* 2005), perhaps because denser nesting cover creates harder edges by reducing the penetrability and foraging efficiency of mammalian predators in core habitat (Crabtree *et al.* 1989, Pasitschniak-Arts & Messier 1995). Meanwhile, edge effects are not observed when interior and edge habitats are similar, such as in agricultural habitat (Phillips *et al.* 2003). Pasitschniak-Arts *et al.* (1998) speculated that because the edges and interior of agricultural habitats are similar in structure and productivity, they might support similar densities of predators and prey, thereby resulting in similar predation rates in interior and edge habitat. Notably, few studies explicitly address the interaction of spatial scale and edge type, despite the fact that predator habitat selection and movements are hierarchical (Phillips *et al.* 2004).

We used three years of data on ground-nesting Mallards *Anas platyrhynchos* and Gadwalls *A. strepera* to study edge effects on waterfowl nest survival in the Suisun Marsh, California, USA. Unlike many studies conducted on the prairies, in this system, there are no hard edges between discrete habitat types (e.g. agriculture vs. grassland), and so edges are best viewed as potential predator corridors that surround and penetrate 'core' habitat. Our site is comprised of contiguous upland nesting cover containing several types of potential predator corridors that occur at different spatial scales: main roads surround the site and divide it in half, multiple nesting field boundaries are found within the site, and multiple ATV trails are created in each field while searching for duck nests. Our goal was to determine how proximity to these edge types influenced waterfowl nest survival, so that we may better understand which types of corridors may potentially be used by predators, and at what spatial scale edge effects become apparent.

METHODS

Study area

Our study was conducted at the Grizzly Island Wildlife Area, located in Suisun Marsh, California, USA (38°08'N, 121°59'W), and managed by the California Department of Fish and Wildlife. Of the 6190 ha in the wildlife area, our study took place in a 460-ha upland area that has been designated as waterfowl nesting habitat since the 1980s. This area is divided into fields (10–27 ha each) that are characterized by a heterogeneous mix of mid-height (<1 m) grasses (*Bromus* spp., *Lolium* spp., and *Hordeum* spp.), tall (>1 m) grasses (*Elytrigia* spp. and *Phalaris* spp.), herbs (*Atriplex patula*), vetch (*Vicia* spp.), Pickleweed *Salicornia virginica* and thistle (family Asteraceae). Fields are separated by various types of roads, ditches and ridges that are the main focus of our analysis (Figure 1). The predominant nest predators in our study area are Striped Skunk *Mephitis mephitis* and Raccoon *Procyon lotor*, with Coyote *Canis latrans*, Gopher Snake *Pituophis catenifer* and Common Raven *Corvus corax* occasionally present in lower numbers (KMR unpubl. data).

Data collection

Nest searches were conducted following the standardized protocols outlined in Klett *et al.* (1986) and modified by McLandress *et al.* (1996). Nest searches were conducted from 1 April through 7 July, beginning 2

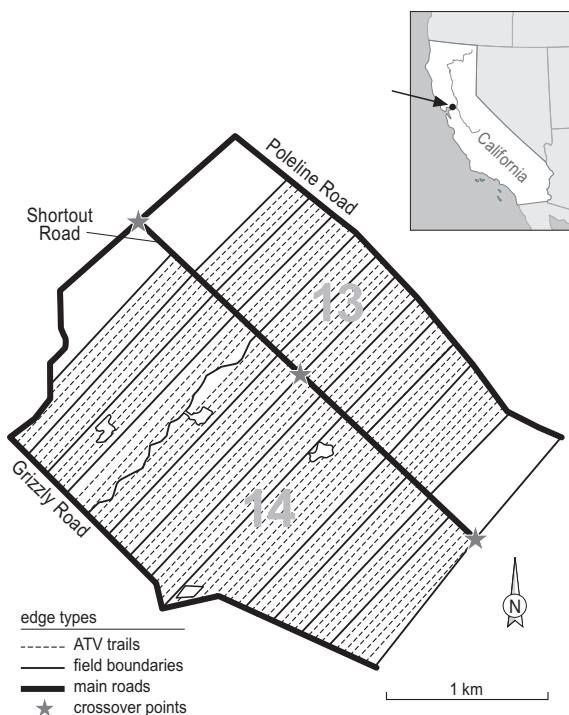


Figure 1. Map of the study area including habitat edge types at Grizzly Island Wildlife Area in the Suisun Marsh, CA, USA.

hours after sunrise and continuing until 14:00 PDT (a time period when hens are likely to be on the nest; Gloutney *et al.* 1993, McLandress *et al.* 1996). Each field was searched at 3-week intervals a total of 3–5 times to find as many nests as possible (Klett *et al.* 1986, McLandress *et al.* 1996). To locate nests, a 50-m rope with rock-filled tin cans attached every 2 m was tied between two all-terrain vehicles (ATVs). Observers watched the rope as it was dragged through the field, noted when a female flushed, and then went to that location and searched for a nest. At nests, short bamboo stakes were placed immediately south of the nest bowl at vegetation height, along with a 2-m bamboo stake placed 4 m north of nests to denote locations for later visits. At each nest, we recorded: (1) location using a GPSMAP 76 GPS receiver (Garmin International Inc., Olathe, KS), (2) number of eggs and incubation stage determined by candling (Weller 1956), (3) nest-initiation date determined by subtracting nest age when found (number of eggs when found plus the incubation stage) from the date the nest was found, and (4) vegetation density when the nest was found using Robel measurements (Robel *et al.* 1970), which is a measure of visual (and potentially olfactory) obstruction within 4 m of the nest. Nests were visited every 7 days to determine nest stage, number of eggs and nest fate (hatched nests were confirmed by the presence of intact egg membranes). Nest fates were classified as depredated if one or more eggs were missing or destroyed (Klett *et al.* 1986) because we were chiefly concerned with determining when a predator was likely in the area, as opposed to waterfowl productivity. Nests that were abandoned due to researcher disturbance (the hen did not return after the nest was found, as evidenced by cold eggs that did not advance in incubation) were excluded from analyses. We used three years of nesting data (2008, 2010 and 2011) when most fields were searched, forming a spatially contiguous dataset. For descriptive purposes, we report observed numbers of nests and Mayfield nest success (Mayfield 1975, Johnson 1979).

Edge classifications

We classified three different types of edges that could be used by predators as travel and foraging corridors: main roads, field boundaries and ATV trails. Main roads were defined as maintained roads (paved or gravel) with no vegetation; these roads might serve as linear features that predators use as travel lanes. After preliminary analyses, we determined there was little evidence to support an effect of distance to main roads. However, we surmised that calculating the distance

from any duck nest to the nearest main road may not be biologically meaningful, because there are natural barriers that would hinder predator movements from roads into some nesting areas (see Figure 1). Specifically, the main road running through the centre of the study area (Shortcut Road) divides the '13' fields from the '14' fields and was paralleled by a large, steep (5-m wide, 2-m deep) ditch running just south of the road, which would deter predator movements from the road into the southern block of '14' nesting fields. Therefore, for nests in those southern fields, we only used the southern perimeter road (Grizzly Road) in our revised analysis. The main road forming the north-eastern perimeter of the study site (Poleline Road) was separated from the northern '13' nesting fields by a similar ditch, and so in our revised analysis, we calculated the distance to Shortcut Road for nests in northern nesting fields. Additionally, there were four points where bridges cross the barrier ditches (Figure 1); clearly, these could serve as funnels for predator movement, so we also calculated the distance from each duck nest to the nearest crossover point ('crossover distance').

Field boundaries were either ditches or ridges that separated adjacent nesting fields. These boundaries varied in habitat characteristics, so we further classified them as wet or dry, and heavily vegetated or open. Wet boundaries were ditches that held water (>0.5 m deep) throughout the nesting season and dry boundaries were either gently sloping upland ridges (1 m high, 3–5 m wide) or dry ditches. Wet and dry field boundaries were categorized as either open or closed, depending on the density of vegetation along the boundary. Closed boundaries were characterized by dense strips of vegetation such as Coyotebrush *Baccharis pilularis* in dry areas and thick stands of Tule *Schoenoplectus acutus* in wet ditches. Open boundaries were large (>4 m wide) open ditches, or ridges with easily penetrable grassy vegetation. Thus, we had four field boundary classifications: (1) wet-open habitats, (2) wet-closed habitats, (3) dry-open habitats and (4) dry-closed habitats. Some boundaries between fields were qualitatively indistinguishable from the surrounding habitat and were not considered edges.

Finally, to study edge effects at a smaller spatial scale, we measured the distance from nests to the nearest ATV trail. While searching for duck nests, three ATV trails were created in the interior of each field that divided each field into four approximately equal sections (c. 50 m wide). These trails were characterized by flattened vegetation that may increase predator penetrability into a field, and could be used as foraging corridors within fields. Two other ATV trails were

created along field boundaries and therefore, considered to be part of the field boundary edge and were not considered in the ATV trails analysis.

Data analysis

We measured the distance from each nest to the closest edge of each type using the 'Near' tool in ArcGIS 10.0 (ESRI, Redlands, CA, USA). Following Horn *et al.* (2005), we combined Mallard and Gadwall nests to increase our statistical power, but retained variables such as nest initiation date and nest vegetation measurements to capture salient differences between species. We then used these distances as a covariate in a logistic exposure analysis of nest survival (Shaffer 2004) using the 'nestsurvival' package (Herzog 2009 unpubl.) in R v. 3.0.2 (R Development Core Team 2013). To determine whether particular types of field boundaries influenced the strength of predator edge effects (see above), we included a distance \times habitat interaction term. We also included year, vegetation density (Robel measurements) at the nest, nest age and nest-initiation date as covariates. Preliminary model exploration did not support the inclusion of squared terms for nest age and nest initiation date (sensu Pieron & Rohwer 2010). All combinations of these variables are biologically plausible, so we tested all possible models and ranked them by Akaike's information criterion corrected for small sample size (AIC_c ; Burnham & Anderson 2002). Models were assigned weights based on their AIC_c score; relative variable weights for parameters, model-averaged coefficients and 85% confidence intervals (Arnold 2010) were calculated based on the weights of the models in which each parameter appeared.

To assess how much the addition of each distance parameter improved the model, we first identified our top-ranking base model which did not include any

distance terms. We then compared this base model to models containing distance parameters, and used evidence ratios to assess evidence for edge effects. We present means \pm SE unless otherwise noted.

RESULTS

We monitored 2210 total duck nests during the three years of the study: 2008 (312 nests; Mayfield success = 17%), 2010 (910 nests; Mayfield success = 37%), and 2011 (988 nests; Mayfield success = 13%). In 2009, nesting vegetation was replanted in several unproductive fields, resulting in increases in nest numbers in 2010 and 2011. A summary of the average distance from waterfowl nests to each edge type is presented in Table 1.

Table 1. Summary of the mean distance in meters (\pm SE) from Mallard *Anas platyrhynchos* and Gadwall *A. strepera* nests found in the Suisun Marsh, CA, USA in 2008, 2010 and 2011 to the nearest edge of each type.

Edge type	2008	2010	2011
Main road	520.2 \pm 18.3	508.0 \pm 9.9	521.6 \pm 10.0
Crossover point	750.2 \pm 19.4	695.9 \pm 11.0	718.8 \pm 11.7
Field boundary	46.1 \pm 1.9	50.6 \pm 1.0	52.9 \pm 1.1
ATV trail	16.4 \pm 0.6	15.3 \pm 0.3	15.5 \pm 0.3

We considered Year + Date + Age + Vegetation to be our baseline model for nest survival, and assessed whether adding distance covariates improved model fit (Table 2). When we included our distance covariates, the model containing the main effect of main roads received moderate support and was 3.57 times more likely than the baseline model. The models containing

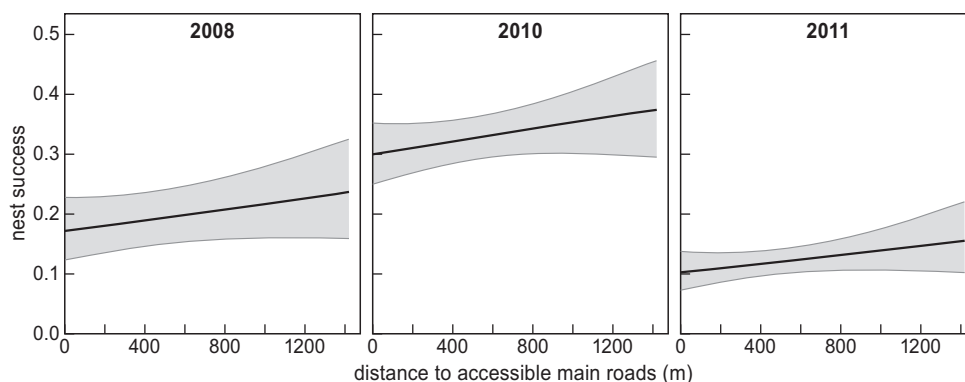


Figure 2. Probability of Mallard *Anas platyrhynchos* and Gadwall *A. strepera* nest success increased with distance to main roads by year in the Suisun Marsh, CA, USA. All other variables were held constant at their mean.

Table 2. Candidate models describing daily nest survival of Mallard *Anas platyrhynchos* and Gadwall *A. strepera* nests found in the Suisun Marsh, CA, USA in 2008, 2010 and 2011. This model set includes all possible combinations of edge distances added to the base model, and K refers to the number of model parameters. Models used to compute evidence ratios (see Results) are in bold.

Parameters	K	AICc	$\Delta AICc$	Weight	Cumulative Weight
+ Dist_{Road} + Dist_{Field} + Dist_{ATV}	10	5533.667	0.000	0.085	0.085
+ Dist _{Road} + Habitat _{Field} + Dist _{Field} + Dist _{ATV}	13	5533.994	0.327	0.072	0.157
+ Dist _{Road} + Dist _{ATV}	9	5534.169	0.502	0.066	0.223
+ Dist _{Road} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field} + Dist _{ATV}	16	5534.531	0.865	0.055	0.279
+ Dist_{Road}	8	5534.592	0.925	0.054	0.332
+ Dist _{Road} + Habitat _{Field} + Dist _{ATV}	12	5534.704	1.037	0.051	0.383
+ Dist _{Road} + Dist _{Cross} + Dist _{Field} + Dist _{ATV}	11	5535.032	1.366	0.043	0.426
+ Dist _{Road} + Habitat _{Field}	11	5535.368	1.701	0.036	0.462
+ Dist _{Road} + Dist _{Cross} + Dist _{ATV}	10	5535.455	1.788	0.035	0.497
+ Dist _{Cross} + Dist _{Field} + Dist _{ATV}	10	5535.669	2.002	0.031	0.528
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Dist _{ATV}	14	5535.684	2.018	0.031	0.559
+ Dist _{Cross} + Dist _{ATV}	9	5535.864	2.197	0.028	0.588
+ Dist _{Road} + Dist _{Cross}	9	5535.958	2.291	0.027	0.615
+ Dist _{Field} + Dist _{ATV}	9	5536.064	2.398	0.026	0.640
+ Dist _{Road} + Dist _{ATV}	9	5536.150	2.484	0.025	0.665
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field} + Dist _{ATV}	13	5536.298	2.632	0.023	0.688
+ Dist_{ATV}	8	5536.309	2.642	0.023	0.710
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field} + Dist _{ATV}	17	5536.368	2.701	0.022	0.732
+ Dist_{Cross}	8	5536.725	3.058	0.018	0.751
+ Dist _{Road} + Habitat _{Field} + Dist _{Field}	12	5536.902	3.235	0.017	0.768
+ Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Dist _{ATV}	13	5536.956	3.289	0.016	0.784
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field}	12	5537.009	3.342	0.016	0.800
+ Habitat _{Field} + Dist _{Field} + Dist _{ATV}	12	5537.121	3.454	0.015	0.815
BASE MODEL (Year + Date + Age + Veg)	7	5537.139	3.473	0.015	0.830
+ Dist _{Cross} + Habitat _{Field} + Dist _{ATV}	12	5537.191	3.524	0.015	0.845
+ Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field} + Dist _{ATV}	15	5537.336	3.669	0.014	0.859
+ Habitat _{Field} + Dist _{ATV}	11	5537.440	3.773	0.013	0.871
+ Dist _{Road} + Dist _{Cross} + Dist _{Field}	10	5537.557	3.890	0.012	0.884
+ Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field} + Dist _{ATV}	16	5537.653	3.986	0.012	0.895
+ Dist _{Road} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field}	15	5537.736	4.069	0.011	0.906
+ Dist _{Cross} + Habitat _{Field}	11	5538.231	4.564	0.009	0.915
+ Dist _{Cross} + Dist _{Field}	9	5538.467	4.801	0.008	0.923
+ Habitat _{Field}	10	5538.490	4.823	0.008	0.930
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field} + Dist _{Field}	13	5538.583	4.916	0.007	0.938
+ Dist _{Field}	8	5538.866	5.200	0.006	0.944
+ Dist _{Road} + Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field}	16	5539.545	5.879	0.005	0.948
+ Dist _{Cross} + Habitat _{Field} + Dist _{Field}	12	5539.989	6.322	0.004	0.952
+ Habitat _{Field} + Dist _{Field}	11	5540.227	6.561	0.003	0.955
+ Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field}	14	5540.716	7.050	0.003	0.961
+ Dist _{Cross} + Habitat _{Field} + Dist _{Field} + Habitat _{Field} × Dist _{Field}	15	5540.911	7.245	0.002	0.966

distance to the nearest ATV trail or to the crossover point were weakly supported, and were 1.51 and 1.23 times more likely than the baseline model, respectively. The top model contained three edge effects (main roads, ATV trails and field boundaries) and was 5.68

times more likely than the baseline model of Year + Date + Age + Vegetation (Table 2). Model-averaged coefficients indicated that nest survival increased with distance to main roads (Figure 2), ATV trails and field boundaries, but the 85% confidence intervals

approached or bounded zero indicating that the effect of distance was weak (Table 3). Post-hoc exploration of either of these global models did not support any interactive effects with any distance parameter (e.g. edge effects from main roads were not stronger for nests in sparser vegetation). Post-hoc exploration also did not reveal nonlinear effects of distance (e.g. edge effects that only persist for short distances, and are constant at farther distances).

Table 3. Relative variable weights and model-averaged coefficients with 85% confidence intervals for factors influencing Mallard *Anas platyrhynchos* and Gadwall *A. strepera* nest survival in the Suisun Marsh, CA, USA. Relative variable weights are the sum of the weights of all the models in which the parameter appears.

Parameter	Variable weight	Coefficient	85%-CI
Nest Age	1.000	0.03344	0.02863–0.03825
Year 2010	1.000	0.38719	0.26119–0.51319
Year 2011	1.000	–0.26187	–0.38853–(–0.13521)
Vegetation Density	0.994	0.05354	0.03110–0.07598
Date	0.966	–0.00412	–0.00424–(–0.00400)
Main Roads Distance	0.720	0.00014	0.00002–0.00026
ATV Distance	0.702	0.00399	0.00002–0.00748
Field Boundary Distance	0.547	0.00154	–0.00038–0.00346
Habitat Dry–Open	0.481	0.03591	–0.07462–(–0.14644)
Habitat Wet–Closed	0.481	0.14011	–0.02779–0.30801
Habitat Wet–Open	0.481	0.03671	–0.07967–0.15309
Crossover Distance	0.379	–0.00003	–0.00009–0.00003

DISCUSSION

Several prior studies of waterfowl nest survival have documented edge effects of varying strength, but it remains unclear what types of habitat edges are actually important, and at what spatial scale edge effects become apparent. Overall, we found that edge effects due to nest predation were weak in our system; several factors could account for the lack of stronger edge effects. Our study took place in upland habitat, where edge effects may be weaker than in areas that border marshes or forests (Batáry & Báldi 2004). Furthermore, our habitat was relatively homogenous and well-defined edges between distinct habitat types (e.g. agriculture and native prairie) are more likely show edge effects (Phillips *et al.* 2003, Horn *et al.* 2005, Crabtree *et al.* 1989, Pasitschniak-Arts & Messier 1995). Furthermore, given the configuration of edges at our site, there

may be few areas far enough from hard edges to be considered ‘core’ habitat (but see Paton 1994). Edges may be so prevalent that predators can easily penetrate habitats, weakening the overall effect of habitat edges. This is an important insight from our analysis: areas that may appear to be core habitat given edges at one scale (e.g. main roads), may be edge habitat at smaller scales (e.g. ATV trails). A better mechanistic understanding of predator movements along various types of edges is needed to understand which edges, at which spatial scale, are most relevant for studying edge effects.

We found weak evidence that nests farther from main roads, field boundaries and ATV trails tended to have higher nest survival. While effects of distance to ATV trails were weak, we found that the distance to main roads had a moderate effect on nest survival; nests farther from main roads were more likely to be successful. Yet, in our preliminary analysis, we found no effect when we failed to account for natural barriers to predator movement. This suggests that the ditches at our site may in fact serve as boundaries of predator movement. Further analyses that accounted for nest predator behaviour allowed for the effect of edge to be recognized. We also found that the distance to crossover points (locations that bridge the barrier ditches, affording access from the main road into an otherwise inaccessible nesting field) had no effect on nest survival. Thus, crossover points do not seem to funnel predators into nesting habitat. These results match anecdotal observations of predator movements at our site; although predators (especially raccoons) can cross these ditches, they tend not to. More generally, our results underscore the importance of accounting for predator accessibility and therefore, predator foraging behaviour when assessing edge effects. Interestingly, although skunks use densely-vegetated habitats as resting sites (Larivière & Messier 1998) and we expected to find an edge effect here, distance to field boundaries of particular habitat types, including the distance to dry-closed field boundaries, had little effect on nest survival.

Our analysis was conducted at the site-level scale, not at the larger spatial and temporal scales where harder-edge effects might be more easily detected (Stephens *et al.* 2003). Edge effects at small spatial scales may be influenced by how individual predators use edges as foraging corridors or as travel lanes, and are thus probably subject to individual variation in predator foraging behaviour. In contrast, edge effects at large spatial scales may be influenced more by the number and diversity of predators attracted to edge

habitats, and these numerical changes in the predator community may be more important than predator foraging behaviour in determining nest success. As Stephens *et al.* (2003) suggested, a full understanding of edge effects cannot be accomplished without explicitly accounting for differences in spatial scale and predator behaviour. Although the evidence for edge effects was weak in our system, this supports the idea that edge effects may vary in magnitude across spatial scales.

North American waterfowl are highly managed and their population trajectories are important in determining harvest regulations each year. Therefore, it is important to understand how changes on the landscape, particularly fragmentation, are affecting reproductive success and recruitment. We found that nest survival was only weakly influenced by distance to habitat edges of any type. On the one hand, this may indicate that local edge effects have little influence on nest success; on the other, it may be that extensive overall fragmentation may have resulted in few 'core' areas that might not be influenced by edges. We suggest that quantifying the degree of habitat fragmentation at various spatial scales (from large landscapes to individual sites) may prove a fruitful way forward. This requires understanding of how predators actually use fragmented landscapes, especially in terms of foraging corridors and barriers to movement.

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SAMENVATTING

Het is bekend dat habitatranden het broedsucces van broedvogels kunnen beïnvloeden. Het is echter minder duidelijk hoe verschillende typen habitatranden en hun ruimtelijke schaal de sterkte en detecteerbaarheid van randeffecten bepalen. Habitatranden worden vaak gezien als leidende corridors voor predatoren, die gebieden fragmenteren en de predatierisico's van nesten verhogen. In dit onderzoek zijn de effecten onderzocht van drie typen habitatranden (grote wegen, perceelgrenzen en autosporen van terreinwagens) op de nestoverleving van eenden in de Suisun Marsh in Californië. De overleving van nesten in relatie tot de afstand tot ieder randtype is geanalyseerd in een 'logistische exposure' analyse. De drie typen randen hadden slechts een zwakke invloed op de nestoverleving. In het onderzoekgebied hadden de meeste plekken een relatief korte afstand tot habitatranden, wat het aantonen van randeffecten op nestoverleving in dit gebied mogelijk lastig maakt. (AD)

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