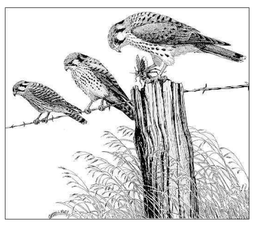
Competition for nesting cavities between the American Kestrel *(Falco sparverius)* and European Starlings *(Sturnus vulgaris)* results from a long-term nest box study at the Ridgefield National Wildlife Refuge.



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ABSTRACT

Declines in raptor populations have been well documented based on several measures. These collectively indicate long-term declines of American Kestrel (*Falco sparverius*) populations in numerous regions of North America. We report data from 16 years of nest box monitoring at the Ridgefield National Wildlife Refuge (Clark County) in southwest Washington, USA. Over this period, American Kestrels have occupied the nest boxes 41 times, while European Starlings have attempted to use the nest boxes 90 times. Of the 41 nesting attempts by American Kestrels, 31 were successful (70.9±17.0 %) over the sixteen-year period. Kestrels laid 4.6 ±0.87 eggs per box. American Kestrel populations at the Ridgefield National Wildlife Refuge began to decline steadily in 2005 until 2013 when populations began to incrementally increase, as measured by nest box occupation and productivity. Our data suggests that one reason American Kestrels are declining on the refuge is due to the increase in competition for nesting cavities by European Starlings (*Sturnus vulgaris*). Management implications indicate eviction of starlings can increase American kestrel nest box use.

INTRODUCTION

Declines in raptor populations have been well documented based on several measures (McClure et al. 2017, Goodrich et al. 2012, Bystrak et al. 2012). Data from the US Geological Survey's Breeding Bird Survey, National Audubon Society's Christmas Bird Count, nest box monitoring programs (Smallwood et al. 2009), and Raptor Population Index (migration counts) (Hoffman and Smith 2003), collectively indicate long-term declines of American Kestrel populations in numerous regions of North America (Figure 1). These declines have been noted in western North America including the Pacific Northwest region.

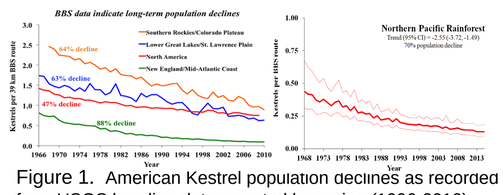

Figure 1. American Kestrel population declines as recorded from USGS banding data reported by region (1996-2010) and from the Northern Pacific Rainforest (1968-2013). (http://kestrel.peregrinefund.org/docs/pdf/American-Kestrel-Partnership)

The American kestrel (*Falco sparverius*) is the smallest of the North American falcons; they are one of the most commonly recorded raptors. They range from northern Canada all the way to Tierra del Fuego in South America. They are secondary cavity nesters, nesting within hollowed out cavities created by other birds or mammals. American Kestrels will also readily use nest boxes due to lack of available cavities. Nest box programs have been used as a management tool for the study of kestrels and also in an effort to increase population sizes (Anderson *et al.* 2016, Strasser and Heath 2013, Katzer *et al*. 2005).

The literature suggests several possible reasons for raptor population declines and American kestrel declines in particular: (1) habitat loss and fragmentation, (2) herbicide and pesticide use, (3)human disturbance (Stupik *et al* 2015, Strasser and Heath 2013), (4) disease, (5) climate change (McClure *et al.* 2017), and in the case of kestrels, (6) changes in their biology (Smith *et al.* 2017), (7) predation (Stupik *et al.* 2015, Smallwood *et al.* 2009) and (8) competition for nest cavities. One of the main competitors for these cavities is the European Starling (*Sturnus vulgaris)* (Koenig 2003*)*. Each of these factors may independently contribute to effect on overall population declines.

Here we report data from 16 years of nest box monitoring at the Ridgefield National Wildlife Refuge (Clark County) in southwest Washington, USA.

STUDY SITE

Our study was conducted at the Ridgefield National Wildlife Refuge located in Ridgefield, Washington. The Ridgefield NWR is an area of marshes, wetlands, grasslands and riparian corridors as well as forests of Douglas fir and Oregon white oak that total 2,084 hectacres, with the elevation ranging between 3 and 30m (Figure 2)(CCP 2010). Ridgefield NWR is made up of five units: the River “S”, the Carty, Bachelor Island, Roth, and Ridgeport Dairy. The purpose of the refuge is to provide habitat for wintering waterfowl, except for the Carty and Roth units as they are managed as a natural floodplain. For this study nest boxes where set up in four of the five units of Ridgefield; River “S”, Bachelor Island, Roth, and Ridgeport Dairy.

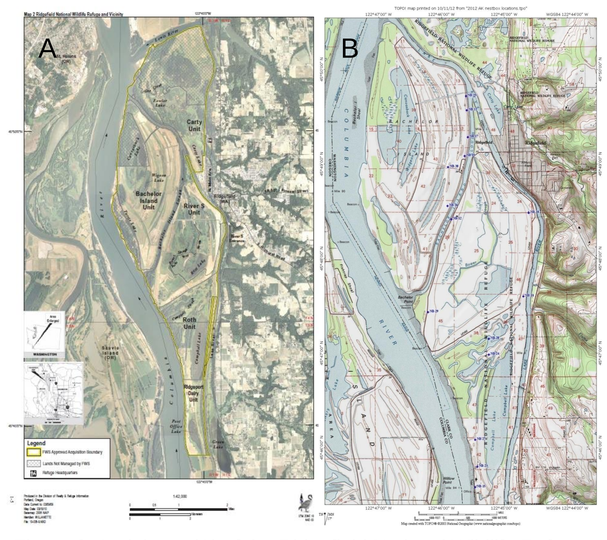

Figure 2. Aerial map(A) of the Ridgefield National Wildlife Refuge (WA) with units identified and 2012 American Kestrel nestbox locations (B) identified.

RESULTS

American Kestrels are found year-round on the refuge and in the surrounding area and portions of this population may also be migratory. During the sixteen years of study, nest boxes were available for use 186 times. American Kestrels occupied boxes 41 times while European Starlings attempted to use boxes 90 times (Table 1). American Kestrel production was highest in 2019 when 5 pairs fledged 20 chicks, followed closely by 2005 when 4 pairs fledged 19 chicks (Figure 3). Production was lowest in 2004, 2011 and 2013 when no chicks were fledged. Two other native species used the nest boxes successfully: Purple Martins (*Progne subis*) and Tree Swallows (*Tachycineta bicolor*). American Kestrels had a total mean percent occupation of 23.9±16.2 while European Starlings had a 45.6± 25.8 total mean percent occupation over the sixteen years of the study; however, year to year occupation varied greatly.

Table 1. Occupation data and American Kestrel (*Falco sparverius*) productivity at the Ridgefield National Wildlife Refuge (WA) from 2004-2019.

Year	Number of Boxes	Number Occupied by Kestrels	Number Occupied by Starlings	Number Occupied by Others	American Kestrel Eggs	American Kestrel Chicks	American Kestrel Fledged	Pairs Successful Fledging	Post Removal Occupation
2004	7	2	2	0	9	5	0	0	0
2005	7	4	1	0	19	19	19	4	0
2006	9	4	1	0	17	6	6	3	0
2007	11	5	1	1	25	23	18	4	0
2008	11	3	1	0	15	15	13	3	0
2009	11	2	6	4	6	5	2	1	0
2010	11	3	3	1	15	8	8	2	0
2011	14	1	7	1	5	0	0	0	1
2012	15	1	7	2	5	4	3	1	0
2013	12	0	10	6	0	0	0	0	0
2014	12	1	9	2	5	5	5	1	0
2015	12	3	8	7	13	9	4	2	1
2016	13	2	10	5	8	4	4	1	1
2017	13	1	9	5	5	2	2	1	0
2018	14	4	8	7	19	13	11	3	0
2019	14	5	7	4	23	21	20	5	2
Total	186	41	90	45	189	139	115	31	5

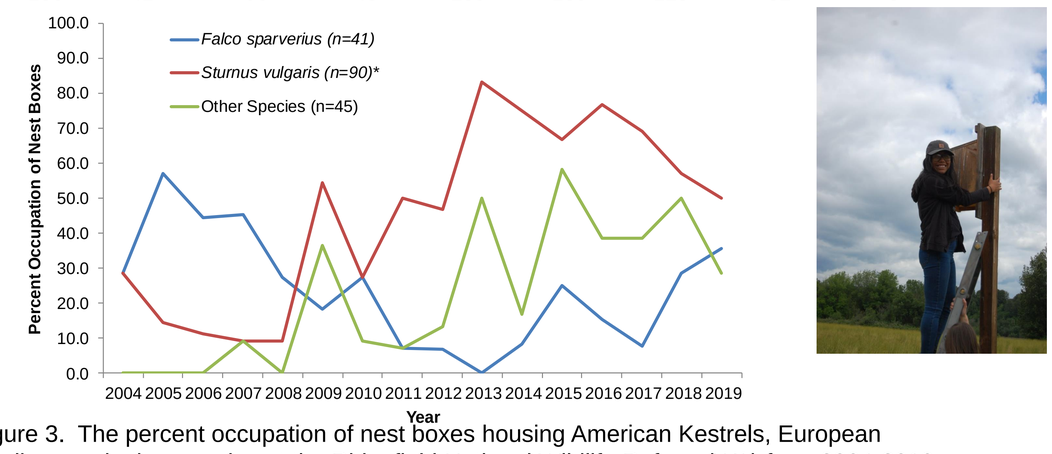

Figure 3. The percent occupation of nest boxes housing American Kestrels, European Starlings and other species at the Ridgefield National Wildlife Refuge (WA) from 2004-2019.

Of the 41 nesting attempts by American Kestrels 31 were successful (70.9±17.0 %) over the sixteen-year period. Kestrels laid 4.6 ±0.87 eggs per box (Figure 4). The mean percentage of eggs to fledge young was (51.1±16.4%); the conversion rate of chicks to fledglings was (68.7±20.1 %). While there were individual adults that were recorded year to year, one male used the same box in three successive seasons with different females. Three females nested on the refuge in three successive years. No pair of adult birds attempted nesting in subsequent years. One female chick from 2004 successfully nested as an adult in 2005. One band recovery occurred from a male chick hatched in 2005 that was found dead in Yamhill County Oregon, 78km southwest of the refuge. American Kestrels attempted nesting in boxes 5 times after the removal of starling nests with eggs or nesting material only, starlings laid first eggs 14.2±14.7 day earlier than kestrels (Table 2).

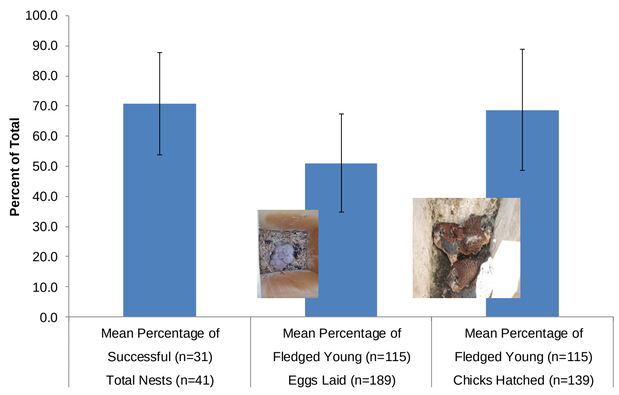

Figure 4. Mean American Kestrel productivity measures of nesting success rate, fledged young to eggs laid, and fledged young to chicks hatched with standard deviation at the Ridgefield National Wildlife Refuge (WA) from 2004-2019.

METHODS

Nest boxes suitable for American Kestrels were placed at the Ridgefield National Wildlife Refuge (WA) in 2004; during subsequent years’ additional nest boxes were added and others repaired and occasionally relocated (Fig 2 current locations). The number of boxes ranged from 7 to 15 with a mean of 10.6. Nest boxes were cleaned and 5-7 cm of new wood shavings added each March. All nest boxes were monitored weekly for occupation in the spring of each year. Kestrel pairs were observed during the breeding season; records of nesting chronology and occupation of other species were recorded. European Starling nesting material and eggs, if present, were removed while native species were not otherwise disturbed. During 2004-2008, blood samples from this population (0.05 ml) were collected from the brachial vein as part of a paternity study. In 2016, we attached RFID chips to the leg bands of nesting adults. Adult birds were trapped via a *bal-chatri* trap or within the nest box; nestlings were sampled prior to fledging. All subjects were banded with USGS aluminum bands to allow for the identification of individual birds and standard morphometric data was collected for all individuals including: age, sex, tarsus length, beak length and weight. All samples were collected in accordance with *Guidelines to the use of wild birds in research* (Fair 2010). We report productivity measures and reproductive output following Smallwood, 2009 and Katzner *et al.* 2005.

Table 2. Difference between the first egg of American Kestrel and European Starling by Julian laying dates with standard deviation at the Ridgefield National Wildlife Refuge (WA) from 2004-2019.

Year	First Egg American Kestrel	First Egg European Starling	Days Difference
2004*	114	97	17
2005	121	121	0
2006	108	no	
2007	107	no	
2008*	114	127	-13
2009	121	109	12
2010	118	105	13
2011	144	107	37
2012*	119	112	7
2013		95	
2014	120	97	23
2015	99	99	0
2016*	133	97	36
2017	123	101	22
2018	104	100	4
2019	125	99	26
*Leap year		Mean	14.2
		Standard Deviation	14.7

DISCUSSION/CONCLUSION

American Kestrel populations at the Ridgefield National Wildlife Refuge have declined steadily since 2005 as measured by nest box occupation and productivity. This decline mirrors data reported in the literature (Anderson *et al.* 2016, Strasser and Heath 2013, Goodrich *et al.* 2012, Bystrak *et al*. 2012, Smallwood 2009 and Katzner *et al.* 2005). Our measures of productivity are also similar to those reported by other studies. Smallwood 2009 postulates several reasons for declines. American Kestrels are found year-round both on the refuge and in the surrounding areas; it is unlikely that the predominant portion of the population is migratory as in other parts of their range. Migration mortality is probably not a cause of decline in our study area. However, first year mortality is probably similar as reported by Stupik *et al.* (2015).

Predation by Cooper’s Hawks could lead to population declines. Within in our study site Cooper’s Hawks occur; however, we found no evidence of predation by Cooper’ Hawks but Great Horned Owls (*Bubo virginianus*) were commonly observed and they are known to hunt kestrels. One nest in 2015 had predation of 4 of the 5 chicks but a specific predator was not identified.

Habitat loss and fragmentation are often cited as possible causes. The area surrounding the refuge has been transformed from mainly rural to semi-suburban with several large housing subdivisions and smaller housing developments during the course of the study. This may have affected the quality of wintering areas adjacent to the refuge. Additionally, the increased traffic may result in more automobile mortality of first year birds. Smallwood (2016) indicates that researcher disturbance is low and not likely a cause for population declines of kestrels. The refuge size and habitat management have remained consistent; haying and grazing have even been increased. This should have provided more suitable habitat for kestrels, however, the increase in short grass areas and the presence of cattle may have increased the prevalence of European Starlings.

Our data suggests that one reason American Kestrels are declining on the refuge is due to the increase in competition for nesting cavities by European Starlings. We disagree with Koenig (2003) in that starlings are a major competitor for nest cavities. Starlings can be aggressive and we witnessed kestrels being mobbed by starlings on several occasions often in near proximity to nest boxes. We actively tried to evict starlings from nest boxes by removing nesting material and eggs. Five kestrel pairs breed in boxes from which starlings had been repeatedly evicted. We have observed startling’s at boxes occupied by kestrels. Starlings may have a direct effect via nest box competition by earlier nesting but an indirect effect via repeated stress (Mobbing, landing at the nest box entrance, perhaps competition for food resources) however we did not directly measure these effects). Management implications indicate that eviction of starlings can increase American kestrel nesting attempts. However removal frequency may be a prohibitive factor. More research needs to be conducted to determine if European Starlings competition for nest boxes is a major contributing factor to American Kestrel population declines at other locations.

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