Accelerating Decline of the Sacramento Purple Martin Breeding Population in 2014: What Are the Possible Causes?

Daniel A. Airola, Northwest Hydraulic Consultants, 3950 Industrial Blvd #100c, West Sacramento, CA 95691. d.airola@nhcweb.com.

Bruce Cousens, Georgia Basin Ecological Assessment and Restoration Society, P.O. Box 41012, RPO Woodgrove Nanaimo, BC, CANADA V9T 6M7. pmartins@island.net

Dan Kopp, California Department of Parks and Recreation, One Capital Mall, Suite 410, Sacramento, CA 95814. dan.kopp@parks.ca.gov

We report on the status of the western Purple Martin (*Progne subis arboricola*) nesting population in the Sacramento area in 2014. This population has been the last sizable nesting population in California's Central Valley, where it was once widespread (Airola and Williams 2008). The Purple Martin is recognized as a species of special concern by the California Department of Fish and Wildlife due to substantial reductions in the species' geographic range and numbers (Airola and Williams 2008).

We previously reported a consistent decline in the Sacramento Purple Martin nesting population from 2003 through 2013, and that a new predation threat from American Kestrels (*Falco sparverius*) may accelerate the decline in the future (Airola and Kopp 2013). We report here on the nesting status in 2014, the effects of kestrel predation, possible new causes for the decline, and prospects for the future of the population.

STUDY AREA AND METHODS

As annually since 2002, we surveyed for nesting Purple Martins at bridges in the Sacramento region (Sacramento, Yolo, and western Placer counties) that were occupied or suitable for use by the species. Colony locations and other suitable sites, and the criteria used to define them, were described by Airola and Grantham (2003), Leeman et al. (2003), and Kopp and Airola (2007).

To count nesting pairs, we mapped holes in which martins nested and recorded diagnostic breeding behaviors (i.e., carrying food to nests, removing fecal sacs, begging by nestlings, and nestlings perched at hole entrances; Airola and Grantham 2003). These methods provide a consistent and repeatable basis for estimating the nesting population. We confirmed diagnostic breeding behaviors for all of the pairs counted in 2014.

RESULTS AND DISCUSSION

Nesting Population Status and Colony Occupancy

Purple Martins nested at six sites in Sacramento during 2014 (Table 1), one less than in 2013 and the smallest number since systematic monitoring of the population began in 2002 (Figure 1). The number of colonies has decreased steadily such that only half the number present in 2005 were occupied in 2014. The El Camino colony was abandoned in 2014; a few birds explored the site early in the nesting season but did not nest. This colony was first discovered in 2003, when it supported 15 nesting pairs, so likely had been active for some years earlier. In 2004, it supported its largest nesting population of 23 pairs.

A total of 30 pairs nested at Sacramento colonies in 2014, representing a 35% population decline from the 46 pairs in 2013. This decline is the highest rate of annual loss in the Purple Martin population since intensive monitoring began in 2002 (Figure 1). Overall, the martin nesting population in Sacramento has declined by 83% from its high of 173 pairs in 2004.

Declines in nesting pairs between 2013 and 2014 occurred at five colonies, including the abandonment of the El Camino site. Small increases (of 1 and 2 pairs) occurred at two colonies (Table 1). One colony, Redding Avenue, supports 33% of the remaining population, and three colonies support 80% of the total.

The average size of colonies has decreased from a high of 16 in 2004 to 5 in 2014 (Figure 1). In 2014, two colonies (35th St and Sutterville) supported only single nesting pairs. In the past, colonies of 1-2 pairs have had higher rates of later abandonment (Table 1), so these sites may be particularly at risk.

Kestrel Predation in 2014

As previously noted by Airola and Kopp (2013), American Kestrels began entering nest holes and preying on Purple Martins at two of the larger remaining nesting colonies in 2013. We predicted declines in martin populations at these sites. In 2014, kestrels again returned to the Sutterville and Redding Road colonies and initiated nesting. We report on interactions and outcomes at each of these colonies during 2014.

<u>Redding Avenue</u>. Martins were first observed at the colony on 23 March, and numbers increased during April and May. Nest building was first seen on 4 May, and we first observed adults bringing food to young on 14 June. Ten pairs fed young during June through early July. Young appeared to have fledged successfully from all nests during 5-12 July.

We observed kestrels during several visits to Redding Ave. in January and then regularly after the first martin surveys began on 23 March. During

Table 1. Number of breeding pairs of Purple Martins in the Sacramento region, California, 2002–2014

Colony	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
I Street	37	29	35	32	17	11	6	5	4	5	7	5	7
20th Street	14	21	23	23	16	15	6	5	1	3	2	0	0
Sutterville	4	6	8	5	6	6	5	6	8	10	10	10	1
Broadway	8	7	7	7	5	1	1	0	0	0	0	0	0
S Street	14	14	16	14	18	9	7	6	7	7	7	3	4
35th Street	29	19	15	14	6	3	3	1	2	3	1	2	1
Redding Ave.	0	3	12	10	14	14	15	17	16	20	20	13	10
Arden	ns[a]	0	3	6	13	9	11	12	9	3	0	0	0
El Camino	ns	15	23	21	21	20	11	5	10	7	7	3	0
Marconi	ns	1	4	3	0	0	0	0	0	0	0	0	0
Roseville Rd.	29	39	27	24	24	17	17	13	11	12	9	10	7
Airbase	ns	0	0	1	1	0	0	0	0	0	0	0	0
Hwy. 65/ Taylor	ns	ns	ns	ns	ns	1	1	0	0	0	1	0	0
Pole Line	ns	2	0	0	0	0	0	0	0	0	0	0	0
Total	135	156	173	160	141	106	83	70	68	70	64	46	30

[a]ns = not surveyed.

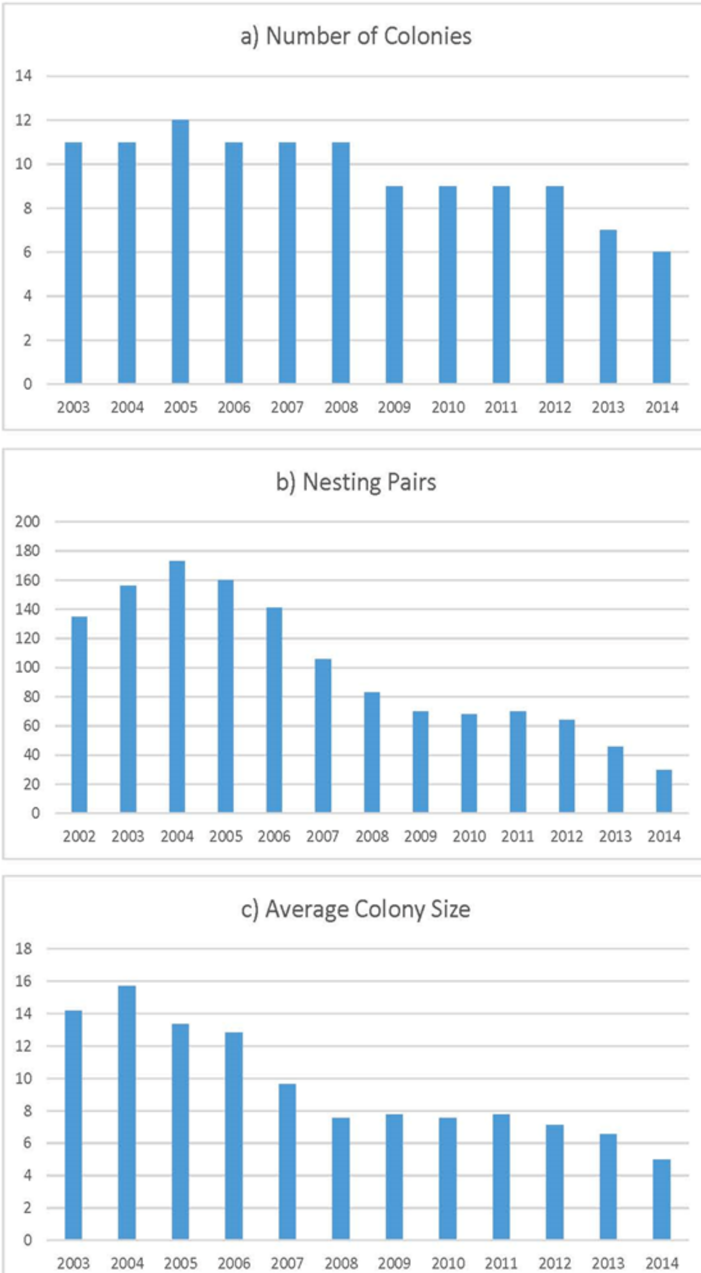

Figure 1. Changes in a) number of Purple Martin nesting colonies, b) nesting population size, and c) average number of nesting pairs per colony in Sacramento, 2003-2014.

January and in mid-late March, we observed kestrels feeding on White-throated Swifts, which also nest in this elevated freeway segment. On 12 April, kestrels were seen copulating, and we identified a probable kestrel nest site in a nearby building within a fenced complex. Overall, kestrels were seen on 10 of 14 visits to the colony between 23 March and 28 June, but not on any of 11 surveys from 2-18 July. Martins regularly mobbed kestrels during the period they were present but we observed no direct evidence of predation on martins at the colony. Although the kestrels remained in the area for several months, no fledglings were detected. The nesting attempt appeared to have failed, perhaps due to predation or interference by the building's owner.

Sutterville Road. Martins were first observed at the site on 17 March. Five to 11 martins (ave=8.3/visit) and a maximum of 6 after-second year (ASY) males who presumably nested there in 2013, were present at Sutterville during three visits during 2-17 May. Pairs explored nine holes and conducted nest building in five holes during 2-17 May. (The number of holes explored, however, does not directly indicate the number of nesting pairs because some pairs and unpaired individuals may explore multiple holes.) During 11 visits between 21 May and 6 July we saw an average of only 2.6 martins per visit. During three monitoring visits over 21 May-11 June, only three Purple Martin nest sites appeared to be active, and numbers of martins in the area decreased. Only one nesting site was observed to be active during 8 visits between 18 June and 6 July. Adults carried food to the one nest hole and removed fecal sacs as late as 6 July, indicating that the young could have reached fledging age.

We first observed kestrels at Sutterville on 7 April, when they entered a potential nest site in the cross-arm of a high voltage electrical transmission pole. They were also seen entering the cross-arm again on 18 April. Overall, we observed kestrels in the immediate vicinity of the colony on 11 of 15 visits between 11 April and 3 July. A female kestrel was seen flying from a perch pole near the colony and entered a martin nest hole shortly after an ASY male martin left it on 11 June, and kestrels were seen flying underneath the colony on several other occasions. Two fledged kestrel young were first observed on 18 June, and were seen during every visit in the immediate vicinity of the Sutterville colony through 3 July.

The single martin pair that appeared to rear young was highly wary of the kestrels. They returned from foraging bouts to the nest site and perched on wires, rather than flying straight to the nest hole. This behavior is atypical and has only been observed in Sacramento when disturbance occurs near the colony (Airola et al. 2009). Martins remained on the wire as long as kestrels were present at the colony. When kestrels left, the martins quickly flew to the nest hole with food, and upon leaving, flew away from the colony.

Conclusions. Although the population at Redding Ave. declined from 20 to 10 between 2012 and 2014, it is not clear that kestrel predation had a substantial role. The 50% decline here is similar to the 35% decline at other colonies that did not have kestrels. The disappearance of the kestrel pair from the Redding Ave. colony appears to have occurred early enough that a substantial number of pairs were able to nest successfully.

Observations at the Sutterville colony indicate that kestrel predation, or the threat of predation, likely caused the abandonment of the colony by at least 5-6 nesting pairs that initiated nesting or were intending to nest at the site. From 2012, before kestrel predation was first observed, to 2014, the number of successful nesting pairs at Sutterville declined from 10 to 1 (Table 1). Colony abandonment is a typical response to nest predation in Purple Martins (Cousens and Lee 2012).

Causes for Martin Population Decline

The evidence presented here shows that American Kestrels likely had a strong detrimental effect on the Purple Martin nesting population at the Sutterville colony site in 2013 and 2014, but not on the Redding Ave. colony, nor at other colonies. The decline in the Sacramento Purple Martin population, however, extends back for a decade. Thus, as previously noted (Airola and Kopp 2013), kestrels are contributing to, but not the primary cause for the Sacramento Purple Martin population decline.

We have evaluated and tried to manage many factors that we thought might be responsible for the decade-long decline in the Sacramento Purple Martin population. Potential causes for local or widespread decline have been systematically studied and addressed. Competition with European Starlings (*Sturnus vulgarus*) and mortality due to West Nile virus have been shown to not be major threats (Airola and Grantham 2003, Leeman et al. 2003). The following localized factors that either were shown or suspected to affect breeding populations were addressed through planning and conservation actions: predation by feral cats, removal of perch sites, growth of vegetation that obstructs access, loss of nest material collection sites, and exclusion from nest sites during construction projects (Airola et al. 2008, 2009, Airola and Kopp 2005, 2007, 2009, 2013). The issue of nestling fallout from the vertical weep holes has been shown to have a minor effect on reproduction (Airola and Kopp 2005, 2008); the effect was reduced at three sites by installing "nest guard" railings in nest holes (Airola and Kopp, unpublished data).

Banding studies during 2003-2010 suggested that adult mortality rates of Purple Martins in Sacramento were higher than at other studied populations (Airola et al. 2008, Airola, unpublished data). Assessment of reproduction has been hampered by difficulties of accessing nest sites in bridges, but average productivity during 2007 was 3.4 young per occupied nest (Airola et al. 2008).

Long-term monitoring in British Columbia has shown that a minimum average annual production of 2.6 young per pair is needed to offset normal annual mortality to maintain that population with its average annual survival of 46% (Cousens and Lee 2012).

Through a process of elimination of potential factors causing the martin population decline, we have previously suggested that vehicle collisions from light rail and freight trains and increased general motor vehicle traffic may be resulting in levels of collision mortality that has reduced the population (Airola and Kopp 2008). We have seen dramatic increases in vehicle traffic, however, only at certain colony sites in response to nearby changes in land use (i.e., at 35th St after construction of several large hospitals). While we have directly observed numerous vehicle collisions and found birds on rail tracks that almost surely were killed by collisions (Airola 2008), we have not been able to fully document the rate of this source of mortality. Therefore, while vehicle collisions clearly has some effect, we cannot quantify its magnitude.

The other explanation we have long considered is the additive effects of the many previously described factors that together could be increasing mortality or reducing reproduction and recruitment (Airola and Kopp 2009, 2013).

Given the apparently accelerating rate of decline, possibly as a result of increasing mortality of older age classes (senescence) without sufficient recruitment for replacement, it is likely that the Sacramento Purple Martin population could disappear in as little as five years if the decline is not reversed. If so, they would not be the first such loss in recent times–a population known to have nested in lava tubes at Lava Beds National Monument as early as 1899 (Williams 1998), and that supported an estimated 15-23 pairs during 2001-2009 (Airola 2009), also has declined in recent years and disappeared after 2012 (Nordensten unpub. data.).

Potential Effects of Neonicotinoid Pesticides on Sacramento Purple Martin Populations

A newly recognized possible contributing factor for the decade-long Purple Martin decline in Sacramento, which we have not analyzed but are interested in exploring, is the dramatic increase in use of neonicotinoid insecticides and its potential effects on martin prey populations, as described by Meneau and Palmer (2013). Although neonicotinoids are generally considered to have comparatively low direct toxicity to vertebrates, despite possible sub-lethal effects (Gibbons et al. 2014), the US Environmental Protection Agency (EPA) has characterized them as highly toxic to aquatic invertebrate communities (Starner and Goh 2012). Neonicotinoid use in the Netherlands has been associated with declines in flying insect populations, consistent with results from many other studies (Van Dijk et al. 2013), and also has more recently been associated with declines in insectivorous birds (Hallman et al. 2014).

Neonicotinoid use had rapidly increased in California over the same time period during which martin populations have declined (Kanawi et al, no date; Figure 2). Use is widespread in California, and amounts used have doubled since 2005 (Starner and Goh 2012). The neonicotinoid pesticide Imidacloprid was recently detected in 89% of samples taken from aquatic systems in three California agricultural regions outside the Central Valley, with levels exceeding EPA safety standards for aquatic life (19% of samples) and more stringent European standards (71% of samples; Starner and Goh 2012).

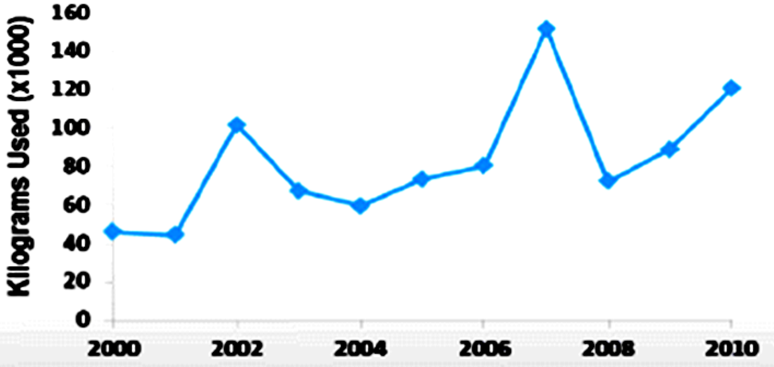

Figure 2. Use of the neonicotinoid insecticide Imidocloprid (Kg) in California, 2000-2010 (from Kanawi et al. no date).

Imidacloprid was also widely detected in aquatic systems in urban Sacramento, but at lower frequencies (29% of samples) and concentrations than in sampled agricultural lands (Kanawi et al., no date). Unfortunately, there appear to be no other data on occurrence of these insecticides in aquatic systems within the Central Valley (M. Ensminger, pers. comm.). Relatively low levels of neonicotinoids were detected in the Sacramento-San Joaquin Delta and Grizzly Bay areas, confirming their presence (Orlando et al. 2013, 2014), and because these compounds are degraded fairly rapidly by sunlight, it is likely that they occur in higher concentrations upstream, closer to sources in irrigated croplands near Sacramento (Hladik unpub, data). Direct lethal or sub-lethal impacts to aquatic insect larvae and indirect secondary impacts via food webs to insectivore populations might occur at levels above 20 ng/L in aquatic systems (Hladik pers. comm.).

The potential magnitude of effects of neonicotinoids on pest and non-target insect populations have not been studied in California. There appears to be little or no systematic baseline information (i.e., no "Christmas Insect Counts" or equivalent annual summer abundance surveys) with which to compare current and former flying insect populations. Our studies have not included any sampling, or even anecdotal observations, on the abundance of odonates (dragonflies and damselflies), which appear to be an important and possibly essential food source for Sacramento Purple Martin nestlings. Larval stages of these insects are aquatic, and thus subject to dissolved pesticide effects via surface runoff and groundwater seepage.

Anecdotal information on the Tricolored Blackbird (*Agelaius tricolor*), a lowland species whose largest breeding colonies have for decades been associated with agriculture in the Central Valley and that is rapidly declining due to chronic low reproductive success (Meese 2014), may also be relevant. Tricolored Blackbirds also feed only insects to nestlings and depend on insect populations to reproduce successfully (Meese 2013). Recent observations suggest that Tricolor numbers have plummeted in many areas in the Sacramento Valley where they were until recently common to abundant. Now, larger colonies are often situated adjacent to organic rice and other croplands grown without pesticides (Meese pers. comm.).

At present, any connection between increased neonictonoid pesticide use and Purple Martin declines during the same period, while concerning, is only circumstantial. Nonetheless, available information suggests a high priority for additional evaluation of neonicotinoid pesticide levels in the environment and their effects on insects, other invertebrates, and the associated vertebrate food web (Gibbons et al 2014; Hladik et al 2014; Main et al. 2014). Are Purple Martins the "canary in the coal mine" for neonict-onoids in the Central Valley?

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