Management framework for protection of the heronry at Martin Griffin Preserve:

An assessment and response to the 2013 decline in Great Egret nesting in Picher Canyon

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Executive Summary

This is the final, comprehensive report regarding the 2013 nesting season at the Picher Canyon heronry at Martin Griffin Preserve, Stinson Beach, CA. As background information, the report contains relevant information about Great Egret nesting biology and a summary of the history of Great Egret nesting activity in Picher Canyon. This report also includes the complete evaluation of factors that may have contributed to the 2013 nesting failure, which is identical to a previous report (Millus et al. 2013, An assessment of the 2013 decline in Great Egret nesting in Picher Canyon, ACR Technical Report 67-1-2). Based on this information, we present a general management framework that incorporates the "precautionary principle[a]" to maximize the potential for colony recovery in the 2014 nesting season. The management framework includes the following key actions:

- Institute regular discussions involving science staff and Martin Griffin Preserve staff regarding changes in management at Picher Canyon
- Intensify monitoring of the heronry, including the installation of an infrared video camera
- Delay the public season until a minimum level of nesting success is observed
- Close the Henderson Overlook until a minimum level nesting success is observed
- Modify preserve maintenance activities in the canyon, January-August
- Eliminate or reduce traffic in the canyon January-August
- Close the canyon to major events January-August

These actions will minimize disturbance and promote conditions that returning herons or egrets may require to initiate new nests next season. In addition, the framework provides a structure for stewardship needed to appropriately manage ACR programs and activities in Picher Canyon.

[a] The **precautionary principle** or states if an action or policy has a suspected risk of causing harm in the absence of scientific evidence that it is harmful, the burden of proof that it is *not* harmful falls on those taking an act.

Background

A dramatic decline in Great Egret (*Ardea alba*) nesting activity occurred during the 2013 season in the Picher Canyon heronry at Martin Griffin Preserve, Stinson Beach, CA. This year saw a marked decline in both the number of nests initiated at the Picher Canyon heronry, as well as the failure of all nests. Total reproductive failure is unprecedented at this site and is cause for serious concern regarding the future viability of this colony. Similar catastrophic declines in nest abundance at other colony sites have occasionally resulted in complete abandonment in subsequent years. Although it is too soon to make this prediction for Picher Canyon, a thorough evaluation is important to understand the factors that may have affected breeding and to provide a basis for future management of the colony site.

All nests failed at Picher Canyon in 2013.

Great Egrets initiated nesting at Picher Canyon on 8 April this year. This was later than the historical average of 25 March ± 11 days (standard deviation), but is within the expected range of annual variation (Figure 1).

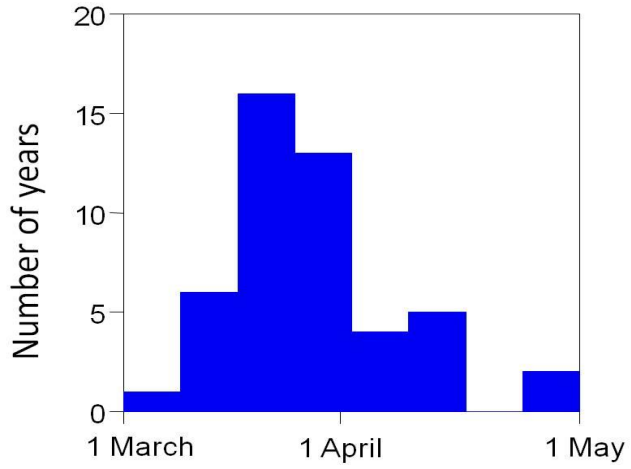


Figure 1. Distribution of first nest-initiation dates of Great Egrets at Picher Canyon, 1967-2013.

Nest initiations continued to occur at rates that were normal, relative to past years, reaching a peak of 32 nests on 2 May (Figure 2). The number of nests normally increases through mid-May so, at this point, it was apparent that the seasonal nesting activity would be dramatically low. Normally, new nest initiations in April and May have resulted in far stronger increases in the number of nests.

The majority of nests began incubating by mid-April and, given an average incubation time of 28 days (Pratt 1970), chicks should have started hatching around mid-May. Instead, most adults were still incubating.

Nest abundance did not begin a steady decline until the second half of May (Figure 2). Some of the occupied nests had failed earlier in the season and re-nest attempts (by the same or different pairs) were underway. Birds in the rest of the occupied nests had apparently been incubating the same clutch continuously beyond their due date, suggesting that (1) they were brooding hatchlings that could not be seen, (2) they failed but were still incubating infertile or inviable eggs, or (3) they had failed without being noticed and were already incubating a new clutch.

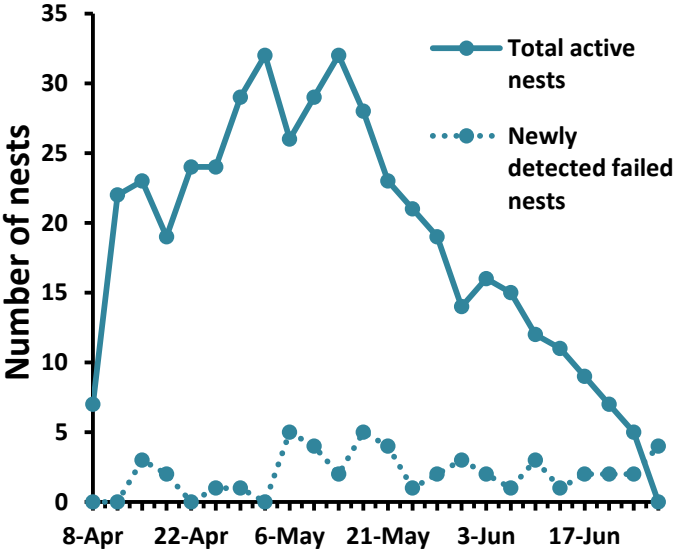


Figure 2. Number of Great Egret nests observed at Picher Canyon in 2013. Dashed line represents the number of newly failed Great Egret nests observed on each monitoring visit.

By mid- to late June, most of the nests had

failed and were unoccupied. Around this time, approximately 20% of the nests appeared to have chicks, based on the behavior of adults. No chicks were directly observed, but it is normally difficult to see chicks during the first week after they hatch, as they are small, weak, and spend most of their time low in the nest. The chicks that did hatch died shortly after hatching, for unknown reasons. The majority of the nests either incubated inviable eggs for a period much longer than is required, or they failed and re-nested, and the second attempt also failed. The last active Great Egret nest was observed on 29 June.

There was one nest attempt by a Great Blue Heron (*Ardea herodias*) this year. The nest was initiated on 2 May, which is much later than average for this region (Kelly et al. 2007). At least one chick hatched around 11 June. Although this nest was mostly obscured from all vantage points, a chick (possibly more than one) was directly observed and heard vocalizing and appeared to be healthy and developing normally.

Key aspects of Great Egret nesting performance in 2013

1. **Nesting activity in 2013 began at the normal time of the season, followed by a normal increase in the number of nests.**
2. **The peak number of nests was much lower than in previous years.**
3. **The steady decline in seasonal nest abundance was not apparent until mid- to late May.**
4. **No single event of major nest loss occurred; the rate of nest failure was relatively consistent throughout the season.**

Unusual Observations

19 April	**Sarah Millus (ACR Biologist) observed broken egg shell fragments above a previously occupied egret nest.**
7 June	**Yvonne Pierce (MGP Manager) found a large group of adult egret feathers in the MGP courtyard.**
11 June	**Sarah Millus observed adult egret flight feathers and aigrettes on an empty nest that had been occupied the previous monitoring visit.**
16 June	**Sam Hutchins (MGP Ranch Guide) observed an unidentified very large bird with a yellow beak in Picher Canyon.**
18 June	**Leslie Sproul (MGP Receptionist) observed an adult Bald Eagle flush the colony. Steven Pozsgai (ACR Controller) observed that most nests were unoccupied about an hour or two after the egrets were flushed.**
6 July	**Gwen Heistand (MGP Resident Biologist) found the remains of a Great Blue Heron chick near the Volunteer Center.**

On the morning of 6 July, Gwen Heistand found the depredated remains of a Great Blue Heron chick below a telephone pole at the end of the Osher Volunteer Center in Picher Canyon. Guano at the base of the pole near the remains appeared to be owl guano, based on its thick, slightly gritty, and even consistency. Owl guano is heavier and thicker than vulture, raven, or hawk guano (David Herlocker, personal communication). Osprey (*Pandion haliaetus*) quano closely resembles that of owls, but always smells like fish.

John Kelly and Sarah Millus investigated the area under the heronry on 29 June. We found two sets of egret feathers. One set was a clump of egret aigrettes that had apparently been pulled out at the same time. The other set of feathers were adult flight feathers that were cut off at the base, indicating owl predation. We also found two feathers belonging to Great Horned Owl (*Bubo virginianus*; K. Hansen, personal communication). We observed several egret egg shells, some that were depredated and some that had hatched normally. Depredated eggs are characterized by a shiny membrane adhering to the inside surface of the eggs with remains of yolk. In contrast, hatched eggs lack the shiny membrane or yolk (Sydeman et al. 1998).

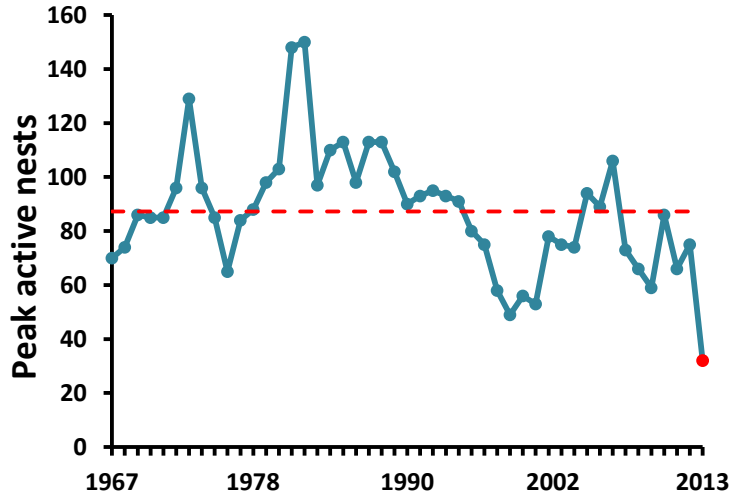


Figure 3. Peak number of active Great Egret nests at Picher Canyon 1967-2013. Dashed line represents the 47 year average of 87 ± 23.1 nests.

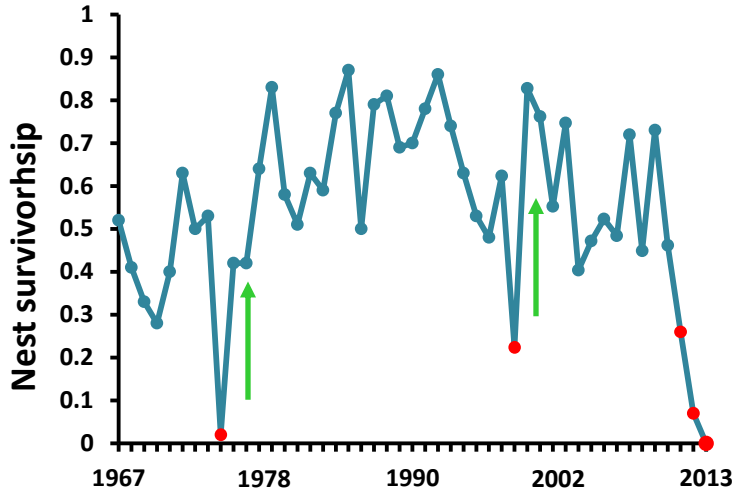


Figure 4. Proportional success of nest attempts at Picher Canyon 1967-2013. Green arrows indicate years with normal rates of nest survival immediately following very poor years.

Nest abundance has been decreasing, in general, since 1990.

Nest abundance at Picher Canyon has fluctuated since monitoring began in 1967 (Figure 3). Nest abundance increased in the early 1980s following a ban on DDT, an insecticide which reduced egg hatching in egrets and other birds (Faber et al. 1972). Peak nest abundance has been dynamic and gradually declining since 1990, and has been below average since 2007. The 2013 season was the lowest recorded nest abundance.

In the past, large drops in nest success have been followed by relatively good years.

Nest success has been far below average at Picher Canyon the last three years (Figure 4). The 2013 season was the first year since monitoring began that no chicks have fledged from the colony. The continuing decline in

nest success since 2010 suggests that the underlying cause(s) of colony failure may not have been limited to the 2013 season, but rather may have originated a few seasons ago.

This colony has experienced dramatic dips in reproductive success in the past (Figure 4). In 1975, raccoons attacked the colony and only three nests were successful that year, fledging only five chicks (Millus and Pratt 2013). In 1998, the egrets suffered severe nest predation by Common Ravens (Kelly 2002b). Most nests were lost or abandoned, and only 26 young were successfully fledged, compared with expected production of 100-150 young. Despite the low nest success in these high disturbance years (1975 and 1998), nest success rebounded after both of these events (Figure 4). In addition, each event was followed by increasing trends in annual nest abundance (Figure 3).

The nesting seasons of 2011, 2012 and 2013 provide the first recorded instance of very poor reproductive success for consecutive years at this colony. As mentioned previously, this pattern suggests that, in contrast to the previous patterns described above, underlying barriers to colony recovery may continue.

Great Egret abundance and reproductive success increased at the neighboring Bolinas colony.

The first year that Great Egrets nested at the Bolinas colony was 2011, when they joined the existing Great Blue Heron colony at the foot of the Francisco Mesa, near the town of Bolinas. In 2011, four egret nests were initiated at that site late in the season, at the beginning of June, and none of the four attempts were successful. In 2012, Great Egrets established three nests at this colony, and one was successful (33%), fledging two chicks.

In 2013, Great Egrets established 15 nests at the Bolinas colony. Of the 14 nests for which fates could be determined, five nests (36%) were successful. At least 13 chicks fledged from the colony, and an average of 2.4 ± 0.24 (standard error [SE]) chicks fledged from each successful nest. On 17 June, we observed a small increase in the number of egrets initiating nests, resulting in six new nests. This small jump in nest initiations coincided with four nest failures in Picher Canyon during the previous week and, in addition, the sighting of an adult Bald Eagle (*Haliaeetus leucocephalus*) in Picher Canyon. Although we have no direct evidence that the Bald Eagle caused nests to fail in Picher Canyon, the unusually late initiation of new nests (in June) at the Bolinas colony site suggests that those birds could have been fleeing from nest disturbance by the eagle in Picher Canyon. The relatively low nest success of 36% at the Bolinas site is consistent with expected lower success rates in nests that are initiated late in the season.

There were nine Great Blue Heron nests at the Bolinas mainland colony this year. The first nests were initiated on 8 March. Of the nine nests, six (67%) were successful, with an average of 2.57 ± 0.34 (SE) chicks fledged from successful nests. There was also one Great Blue Heron nest on Kent Island, but timing and survivorship data could not be collected for this nest.

Nest abundance and survivorship has been stable across the northern San Francisco Bay area.

The birds in a colony are members of a much larger breeding population and often move to different colony sites between years. Therefore, colony dynamics such as the current decline at Picher Canyon probably do not reflect the status of the overall population. Since the inception of the Heron and Egret Project in 1991, Great Egret peak nest abundance has fluctuated but remained stable throughout the San Francisco North Bay region (Figure 5). Nest survivorship has also been dynamic but does not exhibit a consistent trend (Kelly et al. 2007).

In evaluating possible scenarios for the low nest abundance and high rate of nest failure at Martin Griffin Preserve in 2013, we must consider that the decline of the heronry might be unrelated to local conditions or disturbance. Several other colonies in the region exhibited late nesting, low nest success, and/or low nest numbers in 2013. For example, Great Egrets nesting at the regionally important heronry on the Marin Islands exhibited a huge decline in nest abundance and an unusually high rate of nest failure (73% of nests failed). However, nesting abundance, timing, and success at many other colonies were approximately normal.

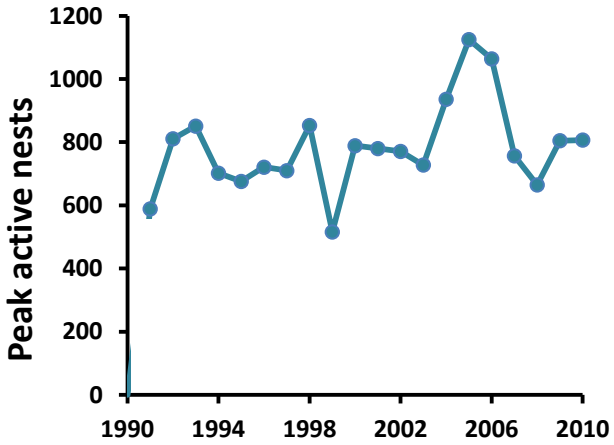


Figure 5. Total Great Egret peak nest abundance in northern San Francisco Bay area 1991-2010.

Local nesting failure has some effect on the regional reproductive rate. However, changes in the number of egrets nesting in Picher Canyon are not likely to significantly affect the status or health of the regional population.

The abundance and distribution of colony sites is dynamic across years.

Egrets choose nesting colony sites based on several factors, such as food availability in surrounding wetlands, level of disturbance, including humans and predators, and nesting substrate. Colony site choice is dynamic across breeding seasons, and egrets will readily move among nesting sites between or even within nesting seasons.

Only about half of the known colony sites monitored by ACR's Heron and Egret Project are active in any given year (Figure 6). Many colonies have become inactive over the course of the 20-year study period, and new colonies are continually being established. New colonies are often initiated with a few nests and grow, either gradually or abruptly, into larger colonies in subsequent years (Kelly et al. 2006).

Colonially nesting birds also tend to return to the most productive nesting colonies and avoid the least productive ones (Post 1990, Danchin et al. 1998, Kelly et al. 2007). In the San Francisco Bay area, rates of nest failure were significantly greater at colony sites that subsequently declined in size than at those that did not (Kelly et al. 2006). Individuals may also use the success of neighboring nests in a colony to aid in determining where to nest in future seasons (Boulinier 1996, Danchin et al. 1998, Sergio and Penteriani 2005).

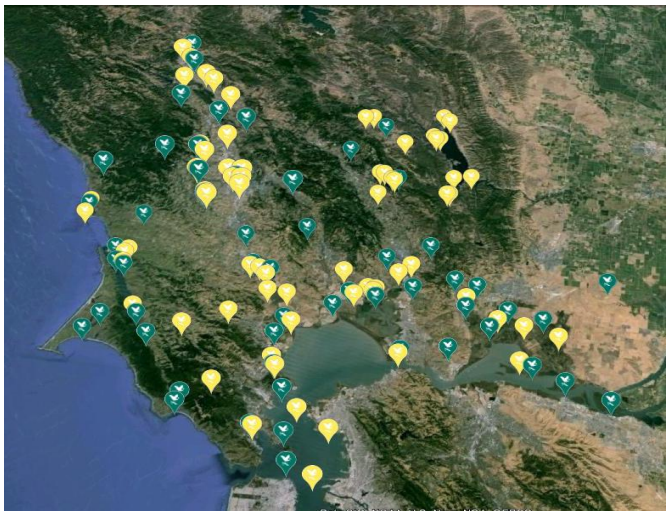


Figure 6. All known heronries in northern San Francisco Bay, which are monitored as part of ACR's Heron and Egret Project. Green markers are active sites; yellow markers are inactive sites. Data are for 2011.

Courting and nest building behavior in colonially nesting birds is often prompted by the sight of other breeding birds, which results in a physiological response that can stimulate courting and nesting behavior (Orians 1961). This social

facilitation of breeding is an important factor in colony choice for many colonial breeding birds (Burger 1988, Belzer and Lombardi 1989, Brown and Rannala 1995). Such facilitation may be particularly important for first-time breeders (Podolsky and Kress 1989) and, therefore, might lead to the subsequent growth of some nesting colonies. It seems reasonable that such social facilitation, even if stimulated by only a small number of returning birds, might enhance the resiliency of a colony after a major disturbance. Breeding facilitation can also occur between species in mixed-species colonies, where the presence of one wading bird species can stimulate breeding by a different species.

Historically at Picher Canyon, Great Blue Herons have initiated breeding first, before the Great Egrets arrive (Millus and Pratt 2013). This year (2013) was the third consecutive year at Picher Canyon that Great Egrets nested without the potentially stimulating presence of nesting Great Blue Herons.

Figure 7. Intensive, repeated displays by Great Egrets can reveal new nest initiations or re-nest attempts.

For the northern San Francisco Bay area, new Great Egret colonies tend to become inactive within five years unless nest abundance reaches a minimum threshold of about 20-30 nests (Kelly et al. 2007). Colonies with less than 10 nests tend to become inactive, on average, within approximately eight years. Probability of extinction is higher for small than for large colonies, and the probability that a colony site is occupied in a given year depends on whether that colony was occupied the previous year (Barbraud et al. 2003). Large, well established colonies tend to be more persistent.

We do not know how many adults egrets consider nesting in Picher Canyon while prospecting for colony sites and then ultimately choosing to breed elsewhere. Herons and egrets have been observed perched in and near the nesting trees at Picher Canyon before displaying and courting behavior has started, which indicates that birds do visit the colony before any individuals have committed to nest there (Millus and Pratt 2013). If the colony site is not found to be suitable for nesting, egrets may leave the area and nest at another colony site.

Egret nest success is affected by several factors, including food availability, disturbance, and predation risk.

Reproductive performance of egrets is influenced by several processes that affect nest survivorship and productivity. Nest survivorship (the proportion of nests that fledge at least one young) varies primarily with the risk of nest predation, severe weather, and colony site disturbance (Pratt and Winkler 1985, Kelly et al. 2005). In contrast, the number of young produced per nest depends on the amount of food available to produce eggs and provision nestlings (Frederick 2002, Kushlan and Hancock 2005).

Herons and egrets nest only once per year, but will attempt a second brood after a failure if it is not too late in the nesting season. After a failed attempt, many birds re-nest within the colony site; others wait to nest until the following year. However, it is not uncommon for some birds to initiate a second nest attempt at a new colony site. Every year, late nesters tend to abandon their eggs or chicks. This is normal and does not necessarily deter them from returning to nest in the following season.

Data are not available to predict if any young birds fledged at Picher Canyon are likely to return to breed there. Banded juvenile Great Egrets have been shown to disperse hundreds of kilometers within 1–2 months of fledging (McCrimmon et al. 2011). Fledging Great Blue Herons banded at a colony in the South San Francisco Bay were recovered in the surrounding area and also as far as the Sacramento River area (Gill and Mewaldt 1999). One of them was recovered at its natal colony when it was 29 months old, suggesting that it may have been returning to breed, but its breeding status was not determined. Melvin et al. (1999) found a mean dispersal distance for Great Egrets sampled across North America to be 909 ± 114 km, with a minimum distance of 17 km (n = 64). In one of the few studies of natal dispersal (distance from where an individual is fledged to where it first breeds), juvenile Little Egrets (*Egretta garzetta*) that dispersed from their natal colonies to breed in other locations showed only a slight tendency to nest nearby (Hafner et al. 1998). Because many or most of the young birds produced in Picher Canyon heronry may not return to nest there, annual productivity in the colony may have little if any influence on changes nest abundance. Instead, the recruitment of new breeders into the colony—and the recovery of the heronry—may depend on the extent to which young birds fledged in other heronries choose to nest in Picher Canyon.

Colony-site disturbance drives heronry distribution in northern San Francisco Bay.

Figure 8. Disturbances at heronries can result in dramatic displays and cause adults to leave nests unattended.

In our region, individual movements of nesting herons and egrets among colonies seem to be driven primarily by direct disturbance by predators or humans, or both. In addition, movements often result from damage to or degradation of suitable colony-site conditions. Some disturbance is normal and expected every year.

Disturbance affects egrets by reducing nesting success and can also lead to declines in colony size. In the San Francisco Bay area, colony sites subject to disturbance tend to decline in size and suffer significantly greater rates of nest failure than sites that are not disturbed (Kelly et al. 2007). Disturbances leading to nest failure are typically associated with avian and mammalian predators, weather (primarily wind), and human disturbance.

Disturbance can sometimes cause herons and egrets to abandon colonies altogether (Millus 2012) and move to an undisturbed, nearby location. Initiation of subcolonies or new colony sites near heronries can follow periods of heavy nest predation or disturbance (Custer et al. 1980; ACR, unpubl. data). In the year following the 1975 raccoon attacks at Picher Canyon, nesting Great Blue Herons moved to trees approximately 150 m closer to the mouth of the canyon, possibly in an effort to avoid predation in a second year. Herons and egrets may be particularly sensitive to disturbance early in the season—even before nesting—when adults are assessing different colonies and determining the best place to nest.

It is important to note that potential predators can cause significant disturbance without directly attacking or killing adults or chicks. For example, at a large heronry on West Marin Island, a juvenile Red-Tailed Hawk (*Buteo jamaicensis*) repeatedly disturbed the colony, flying low over the colony and flushing the birds. The disturbance mostly occurred at the very beginning of the breeding season, when birds were arriving and beginning to initiate nesting. No direct predation by the hawk was observed, but the disturbance delayed the initiation of breeding and nest numbers were lower than average that year.

Predation does not necessarily lead to colony abandonment or significantly affect a colony as a whole, as long as the frequency and intensity of disturbance remain low. However, most studies have documented heavy predation prior to site abandonment (Rodgers 1987).

Humans are a well-known source of disturbance at heronries (Kelly 2002a, 2002b). Colonies are most easily disturbed when at least some individuals are still in the pre-laying/courtship phase (March). Birds become more site-tenacious as they settle into the incubation phase (March-April). As nestlings grow large and begin to thermoregulate, adults may temporarily flee or alter their behavior without significantly neglecting their young (May). Toward the end of the nesting season, adults are rarely present at their nests; nestlings are large and alert to closely approaching observers but unwilling to flee the safety of the nest (June).

Impacts to nesting egrets by raccoons, eagles and ravens have occurred repeatedly in Picher Canyon.

Disturbance from predators has been observed numerous times at Picher Canyon, and predation pressure has varied from severe to minimal at this colony site over the last several decades (Millus and Pratt 2013). One of the most severe attacks on the colony occurred in 1975, when raccoons (*Procyon lotor*) raided the colony and destroyed most of the nests. Raccoons again attacked the colony in 1981, destroying one heron and ten egret nests, and again caused the failure of most egret nests in 1983. Bloody remains of egrets were observed in the colony trees before raccoons were discovered to be the source (S. Schwartz, personal communication). After the attacks in 1975 and 1983, ACR trapped and removed raccoons from the canyon and banded over 300 trees at the colony site to prevent raccoons from climbing into the nests.

The colony was subject to harassment and predation by a Golden Eagle (*Aquila chrysaetos*) in 1989 and 1990. An eagle first visited the colony when Great Blue Herons were incubating and Great Egrets were courting. The eagle flushed the colony on five separate occasions and took three heron chicks. Of the six nests that were attacked, four renested successfully. There were unhatched eggs in six nests that survived intermittent neglect when the birds were flushed, and all of these nests hatched young. In 1990, three egret nests failed just prior to the last eagle sighting; they could have been lost to nest predatory crows when the adult birds were flushed from their nests by the eagle. There were six sightings of eagles in March and April in 1990. This all occurred prior to the years when ravens have been present in the canyon.

Figure 9. Common Raven stealing a Great Egret egg after the adults were flushed off their nests by human disturbance at the Drakes Estero colony.

The second year of harassment by a Golden Eagle, 1990, was the year when the heronry at Bolinas was colonized, and six Great Blue Heron nests were established across the lagoon. A Golden Eagle was seen perched near the heron nesting trees in Picher Canyon in early February of that year. A week later, herons were observed in trees near the colony site in Bolinas. No egrets were present at the founding of the Bolinas colony, possibly because the eagle was

present in Picher Canyon before most egrets had arrived.

Predation from owls has also been a regular occurrence at Picher Canyon. In 1986, the carcasses of four adult egrets were found under the nesting trees with missing heads and neck, which is indicative of owl predation. Egret nest success was low that year, and a significant portion of the early egret failures were probably the result of predation. There has been evidence that Great Horned Owls have taken some young during several of the years that the colony has been monitored (Millus and Pratt 2013, unpublished data). Skip Schwartz, Executive Director of ACR at the time, and Tom Queer, assistant to Helen Pratt, found clumps of adult egret feathers during several of the years in the 1970s, 1980s, and 1990s, which were suggestive of owl predation (Millus and Pratt 2013).

Predation from Common Raven (*Corvus corax*) began in Picher Canyon in 1994. Since then, ravens have continued to prey on egret nests in the colony. Ravens have been observed directly attacking eggs and chicks at Picher Canyon, as well as scavenging nests following disturbance from eagles (G. Heistand, personal communication). Based on observations from West Marin Island, Kelly et al. (2005) found that the number of heron and egret chicks taken increases with the number of young the ravens fledge.

Evaluation of potential causes of nest failure

Available evidence does not support disease or parasites as a cause of nest failure.

Eustrongylidosis

Eustrongylidosis affects a variety of piscivorous birds and is caused by a nematode (*Eustrongylides ignotus*) which is ingested through infected fish. Chicks are particularly susceptible, most dying within the first four weeks after hatching (Wiese et al. 1977), and as early as two days after infection (Spalding et al. 1994). This parasite has been responsible for chick mortality, including Snowy Egret (*Egretta thula*) and Black-crowned Night-Heron (*Nycticorax nycticorax*) at West Marin Island (Franson and Custer 1994). Fish infected with *E. ignotus* larvae appear to be more prevalent in freshwater and estuarine environments near sources of nutrient pollution (Spalding et al. 1993), and infection rates are much lower in marine environments. Detection of eustrongylidosis requires either necropsy of dead chicks or direct palpitation of live nestlings (Spalding 1990).

Given that (1) the Bolinas colony was successful and had no appearance of being affected by this disease, (2) the birds at both colonies apparently feed in Bolinas Lagoon, and (3) eustrongylidosis is more prevalent in eutrophic freshwater wetlands rather than marine or estuarine environments, it seems unlikely that eustrongylidosis was responsible for the dramatic decline in Picher Canyon this year.

Salmonellosis

Avian salmonellosis is caused by *Salmonella* spp. bacteria, and is known to affect herons and egrets. Food sources contaminated by fecal discharges are the primary source for infection for wild birds. Salmonellosis can occur in dense nesting colonies where feces can be easily spread from one nest to another, but usually doesn't result in large outbreaks. Birds hatched from infected eggs can die within the first few weeks of life, and adult birds are less susceptible to infection, apparently because of intestinal microflora that protect them against infection. Outbreaks most often occur shortly after young are hatched (Friend 1999a).

Because the nests at Picher Canyon are somewhat separated with considerable distances between them, and many nests failed before hatching, it seems improbable that an outbreak of salmonellosis caused the colonywide nest mortality in 2013.

Avian Botulism

Avian botulism results when birds ingest toxin produced by the bacterium, *Clostridium botulinum.* Spores of botulism strains are widely distributed in wetland sediments; they can also be found in the tissues of most wetland inhabitants, including healthy birds (Rocke and Friend 1999). Birds, particularly waterfowl, contract this disease when they ingest infected maggots from vertebrate carcasses. Most botulism outbreaks take place July through September when ambient temperatures are high, with occasional outbreaks during early spring in California.

There is no evidence of an avian botulism outbreak at Picher Canyon.

Avian Cholera

Avian cholera results from ingestion of bacteria in contaminated food and water, including scavenging of diseased carcasses. Waterfowl and scavenger species, such as crows and gulls, are most often involved in major avian cholera mortalities of wild birds. Only a small number of infections have been reported for wading birds, generally only involving individual or a small numbers of birds (Friend 1999b).

It is therefore unlikely avian cholera affected the Picher Canyon colony.

Avian Influenza

Influenza naturally circulates in wild bird populations, especially waterbirds. The virus is spread directly in feces or other secretions and in contaminated food, water, equipment or feathers. Avian Influenza has not been detected within the United States.

Ticks

Colonial birds are hosts for many types of ectoparasites including ticks and lice. Symptoms of tick infestation include anemia (Campbell 1988), retarded growth, paralysis and death. Heavy tick infestation can result in high chick mortality, mainly within the first week after hatching and can result in some losses of entire broods (McKilligan 1996). Older chicks appear to be more resilient against tick infections (McKilligan 1996). There was no observed evidence of tick infestation at Picher Canyon, although undetected infestations could have occurred in nests with hatched young.

Available evidence does not support chemical toxicity as a cause of nest failure.

DDT, a type of chlorinated hydrocarbon insecticide, was first used on a large scale during the second half of WWII to control vectors for malaria and typhus, and afterward extensively as an agricultural insecticide. During the 1960s, the environmental impacts of this chemical came to light. Helen Pratt observed high rates of egg loss due to breakage at Picher Canyon beginning in 1967, with increasing egg loss in 1970 – 1973 (Millus and Pratt 2013). This was linked to egg thinning caused by DDT exposure (Faber et al. 1972). DDT was banned in the United States in 1972.

Egrets are susceptible to lead and mercury poisoning, given that they feed high on the food chain and these toxins bioaccumulate in the fish on which waders typically feed. Lead poisoning mostly affects waterfowl and other wetland species due to decades of residual lead shot in marsh sediments and continued deposition from use of lead shot during harvest of other species (Friend 1999c). Major bird die-offs from mercury poisoning are rarely reported and scattered mortalities are more common.

Symptoms of mercury and lead poisoning in birds are often obvious, and include inability to sustain flight for any distance, flying erratically and landing poorly, tremors, and drooping eyelids. In free-ranging birds, most cases of mercury poisoning result in emaciation and a variety of sublethal effects that may act together to cause eventual death.

No symptoms of mercury, lead, or organochloride poisoning were observed in adult egrets breeding in Picher Canyon.

Nest predation by mammals is an unlikely explanation for decline.

Mammalian predators seem to be an improbable explanation for the decline, as the sheet-metal bands on the nesting trees, installed previously to prevent mammalian predators from climbing the trees, were re-surveyed and repaired in March 2013.

Reduced food availability was probably not a primary cause of nest failure.

Spring rainfall was lower than average in 2013 (NCDC 2013). Great egrets often exploit drying pools for food (J. Kelly, personal observation), and below average rainfall might have reduced the extent of available food needed to create eggs and provision young. However, adult egrets nesting at MGP forage primarily in tidal habitat areas and are, therefore, probably not strongly affected by drought. It is unknown whether adults at Picher Canyon and Bolinas are using different food resources, but birds from both colonies are probably using Bolinas Lagoon as their primary food resource. Since brood sizes in Great Egret nests at the Bolinas colony were high, adult birds from this colony were apparently able to find sufficient food in the lagoon to provision healthy broods. It is therefore unlikely that food availability was low for egrets nesting at Picher Canyon.

Weather was not likely to have contributed to nest decline.

There were a lower-than-average number of major storms in the spring of 2013. It is possible that at least one nest was blown out of the tree by strong winds this season. During the 21 May monitoring visit, one nest that had an incubating bird was completely gone after a significant wind storm (S. Millus, personal observation). Other than this one nest, there is no evidence that severe weather affected the nesting egrets.

Vegetation changes were unlikely to have contributed to nest decline.

Major changes in vegetation structure of a colony can lead to abandonment (Kelly 2002). Loss of oaks to Sudden Oak Death has resulted in changes in the vegetation structure in Picher Canyon, including a more open canopy, but has not directly affected the nesting tress. The growth of the redwood forest, both at and near the colony site, appears normal. Although changes in vegetation have occurred in Picher Canyon over the last several decades, they are unlikely to be a major contributing factor to nest decline.

Unexplained infertility or inviability of eggs could not be excluded as a contributing cause of nest failure.

Infertile eggs are eggs which failed to be fertilized by sperm, and inviable eggs are fertilized eggs in which the embryo did not develop normally. Infertile or inviable eggs may be caused by high levels of pollutants in birds, such as mercury (Burger and Gochfeld 1997), and by inbreeding (Kempenaers et al. 1996). Inviable eggs or those with reduced hatchability have also been associated with low incubation temperatures caused by egg neglect (Vleck and Vleck 1996). Eggs exposed to suboptimal temperatures have a higher metabolic rate and these chicks have lower energy reserves upon hatching (Williams 1996), and therefore possibly higher rates of mortality. However, there is little evidence that intermittent exposure to suboptimal temperatures reduces egg hatchability for most temperate bird species (Williams 1996). Adult egrets showed no signs of being diseased, which makes it unlikely they were infected with a disease that could have been transmitted to their eggs, nor is there evidence of inbreeding. However, because it is difficult to remotely detect infertile or inviable eggs, we could not confidently exclude this as a possible contributor to nest failure.

Absence of nesting by Great Blue Heron could not be excluded as a contributing cause to nest failure.

2013 was the third year in a row that egrets nested at Picher Canyon in the absence of herons. This suggests that breeding facilitation is not required for egrets to initiate breeding at this colony. The ability of Great Egrets to initiate nests without the presence of nesting Great Blue Herons is further supported by nesting activity at other colony sites in the region. However, we could not exclude this as a possibility, and it is unknown to what extent, if any, the absence of Great Blue Herons in recent years might be affecting the nesting of egrets. Belzer and Lombardi (1989) found that Cattle Egrets (*Bubulcus ibis*) failed to nest at a traditional nesting colony after Little Blue Herons (*Egretta caerulea*) abandoned the site because of a significant decrease in their food availability. However, even if the absence of herons resulted in fewer egrets choosing to nest in Picher Canyon, this absence does not explain the complete failure of the nests that were established.

Human disturbance may be a contributing factor in deterring birds from choosing to nest in the canyon.

Human activities associated with the Overlook might be causing some disturbance to the birds. However, current evidence is lacking of behavioral responses by the nesting egrets. The original construction of the Overlook seems to have disturbed the nesting birds because, after the construction, the herons moved their nests to the south side of the canyon, away from the Overlook (S. Schwartz, personal communication). Herons and egrets may be particularly susceptible to disturbance from above, given that they typically nest in tall trees, and it is therefore unusual for humans to be above them, as is the case at the Overlook. Nest abundance was close to the expected number in 2012, the first nesting season after the reconstruction of the Overlook. This suggests that the recent construction work on the Overlook, which took place in the winter and early spring, did not deter egrets from nesting. However, we do not know if any birds were deterred from nesting (i.e., whether nest abundance would have been higher if the Overlook had not be remodeled). The new Overlook has a higher visual profile, is larger, and has a higher capacity, with more open seating than it had previously. There are also more metallic spotting scope stands at the new Overlook, although we do not know if the associated increase the amount of reflective surface visible from the nesting colony could have affected the birds. The open seating makes movement around the Overlook easier and also makes it easier for school children to jump between levels, potentially creating a significant amount of noise or movement (S. Millus, personal observation). This combination of factors might impose some disturbance on the nesting birds, although this possibility remains unknown because we did not monitor these effects or observe any behavioral responses by the birds.

Presence of the public and school children in Picher Canyon could be contributing to the element of human disturbance. The public season at MGP runs on weekday afternoons and weekends from mid-March through mid-July, and groups of school children are present during most weekdays. The number of visitors at MGP for the first four weeks of the 2013 public season was slightly higher (560 visitors) compared to 2012 (460 visitors). The total number of visitors over the entire public season was lower in 2013 (3,223 visitors) compared to 2012 (3,818 visitors). There was no dramatic increase in the number of visitors in 2013, so there is no evidence that an increase in numbers alone contributed to the colony decline. However, the presence of large groups of the public and classes of school children does create a large amount of noise in the canyon, and birds in other colonies are often disturbed by noise and human activity. Therefore, it is clearly possible that such activities and noise might disturb the nesting herons and egrets, but we have no direct observations to either confirm or disregard this possibility in Picher Canyon.

Major maintenance work, especially near the beginning of the nesting season, could be deterring birds from choosing to nest in Picher Canyon. Regular maintenance work, such as lawn mowing, is required in Picher Canyon on a regular basis. Major maintenance activities, such as tree trimming or construction, can result in a

large amount of noise and commotion that might deter or disturb nesting birds. ACR used to have a management policy of prohibiting all major work in the canyon for the entire nesting season, beginning in January; this policy has apparently not been consistently applied in recent years. Some major maintenance work took place during the 2013 season, including tree trimming in March (before egrets had established any active nests), which was associated with maintaining the metal bands on the colony site trees, and removal of a fallen tree that was blocking the base of the Kent Trail in late June.

Barking dogs in cars might be causing a minor disturbance to nesting birds. MGP currently has a no-dog policy, except for service dogs. When visitors come to the preserve with dogs, they are asked to leave them in their car. Barking dogs left in cars can create noise (A. Bratton, personal communication), which could be affecting nesting birds.

Avian Disturbance is the most compelling cause of the complete nest failure at Picher Canyon in 2013.

We have no conclusive evidence that allows us to determine with certainty the cause(s) of nest failure at Martin Griffin Preserve. Using our knowledge of egret nesting biology, observations of the colony this year, and information gained from interviews of people with particular knowledge of egrets and the Bolinas Lagoon area, we considered a number of possible explanations (above) for the decrease in nest numbers and poor reproductive performance of egrets. We conclude that the most reasonable cause of the complete nesting failure in 2013 is avian disturbance, either through harassment by predatory birds, or by direct predation on adults, chicks, and/or eggs (Table 1). We emphasize, however, that this conclusion is limited by considerable uncertainty and that, without further evidence, the basis for future management must rely on reasonable speculation about the actual cause(s).

The presence of Bald Eagles has been increasing in the West Marin area, with a known nest at Kent Lake and another nest discovered this year on Inverness Ridge. Bald Eagles have nested successfully at Kent Lake every year since they were first established in 2008, and have produced two chicks each year since, for a total of 12 chicks to date (J. Evens, personal communication). Nesting by Bald Eagle at Kent Lake has occurred with a simultaneous, significant decline in the number of Osprey breeding pairs at Kent Lake (J. Evens, personal communication). In addition, although correlated events may be unrelated, the four-year decline in Great Egret nest success at Picher Canyon coincides with the colonization of Marin County by Bald Eagles.

Disturbance and predation from Bald Eagles on colonially nesting birds, including Great Blue Herons, has increased in the Pacific Northwest following recent expansions of Bald Eagle populations (White et al. 2006, Vennesland and Butler 2004, Parrish et al. 2001). Bald Eagles increase vigilant behavior in herons at foraging sites (Forbes 1987), prey directly on both chicks and adults, and flush birds from colonies, facilitating predation on eggs by crows and gulls (Verbeek 1982).

Although no direct predation or scavenging of Great Egret nests was observed, potential nest predators were present in or near the heronry, along with the inferred predation of one egret nest. Some of the Great Egret nests might have failed due to direct predation from an avian predator. The direct harassment of the colony by nest-predatory eagles, hawks, or ravens, or just the perception by egrets of a heavy risk of nest failure, related to the presence of potential nest predator(s), could have caused other birds to abandon their nests or eggs. Even if the birds only temporarily abandoned their nests, this would leave their eggs or young chicks unattended and vulnerable to predation by other avian species, such as ravens.

In the late 1980s, the egrets recovered from disturbance by Golden Eagles after abandoning their nests for extended periods of time, but resident ravens were not present in the canyon so the potential for commensal predation of eggs or chicks was less likely at that time.

Predation pressure by Common Ravens has been predominant in the nesting colony for nearly 20 years and, in several years prior to 2013, nest predation by ravens has apparently been the leading cause of nest failure. Egrets are well aware of the threat of nest predation by ravens: when ravens spend more time in the canyon, the nesting egrets alter their nest attendance patterns and spend more time guarding their nests (Rothenbach and Kelly 2012). In addition, the predation of Great Egret nests by ravens tends to be high when the resident ravens successfully raise more young (Kelly et al. 2005). Heavy predation by ravens in 1998 resulted in the failure of all initial nest attempts by the egrets, although several re-nesting attempts were successful.

However, in 2013, raven activity in the canyon appeared to be minimal compared to other years. We did not directly observe any predation by ravens nor did we see any fledgling ravens (which are normally conspicuous) or evidence of successful nesting by the resident ravens. In fact, occasional observations of both members of the resident pair of ravens suggested that they were spending little, if any, time attending their own nest. Finally, as opportunistic feeders, ravens are expected to increase the effects of intense disturbance from other sources, by taking egret eggs or chicks whenever the adult egrets are forced away from their nests. Therefore, we cannot exclude nest predation by ravens as a contributing factor in the failure of the Great Egret nesting colony in 2013, but it seems unlikely that ravens were the primary cause.

The observations of a Bald Eagle in the heronry, egrets being flushed off their nests, at least one unidentified large raptor in the canyon, predation on at least one adult egret, and the failure of all nests, along with the fact that nest survival was normal in the Bolinas colony, suggests that avian disturbance related to direct predation and/or harassment is the most compelling scenario leading to colony failure.

Management Framework

Preservation of the natural resources on our lands is a central part of the mission of ACR. Therefore, preservation of the heronry should be a primary goal in the management of MGP. However, because the events and processes that determine the state of the preserve and the heronry are driven primarily by nature, we are limited in our ability to manage most of the potential causes of colony decline. Consequently, opportunities to address this issue, and most issues in wildlife management, are generally limited to the management of human activities. Given the substantial extent of uncertainties associated with the 2013 decline of the heronry, a precautionary approach to managing human activities is potentially critical. To minimize the potential impacts that we are able to control, the management of possible human activities in Picher Canyon is worthy of serious consideration. The actions presented below provide a framework for stewardship needed to guide the appropriate management of ACR programs and activities in Picher Canyon.

One central concern is to promote conditions that returning herons or egrets might require to initiate new nests next season, which could stimulate others to nest here. Of the potential causes of nest failure outlined above, disturbance appears to be the most important factor. Disturbance by eagles and owls is part of the natural processes at play in Picher Canyon, and is beyond our scope of appropriate management. However, we are able to manage human activities, which might have an additive negative effect, even if other types are deterring egrets from nesting. To most effectively encourage the return of egrets and the establishment of the heronry next season, ACR should prohibit any potential disturbance within our control by minimizing all human disturbances in and near the colony.

To ensure that human-induced disturbance to the Picher Canyon colony is minimized appropriately, ACR science staff should be consulted in every decision regarding the extent and types of human activity in Picher Canyon during the 2014 nesting season.

It is important to have an action plan in place prior to the start of the nesting and public season. The behavior of the birds should inform and drive our management decisions, so our approach to managing MGP during the 2014 nesting season should adaptive, allowing for changes in management of Picher Canyon, based on ongoing assessments by the ACR science staff.

To minimize disturbance and protect the colony, the following actions will be taken. Each management measure will be reevaluated annually. These management recommendations are limited to Picher Canyon. Therefore, activities in Volunteer and Garden Club Canyons do not need to be restricted. In addition, moving volunteer functions or other ACR activities to Volunteer Canyon could help minimize the extent of human activity in Picher Canyon.

- **Pre-season meeting.** ACR science staff and MGP management staff will meet in February 2014 to discuss changes in management for the upcoming nesting season.

- **Intensive monitoring.** Intensive monitoring of the colony site will begin early March, to assess how many egrets are visiting or arriving to nest. This will require the coordination of volunteer field observers to increase the monitoring effort.

- **Delay the beginning of the public season.** The public season in 2014 will be delayed (all public visitation prohibited) until April 15. After April 15, the public season may begin if all three of the following criteria are met. The ACR science staff will determine if and when these criteria have been satisfactorily met:

  1. the number of active nests has reached the seasonal peak for the colony;
  2. the peak number of active nests meets the minimum management threshold described below;
  3. egrets at all nests that were active at the seasonal peak are incubating.

  Because nesting egrets depend on nearby feeding areas such as Bolinas Lagoon, nesting abundances are more consistent and predictable at the subregional scale, reflecting the number of egrets supported by the surrounding wetland area. Therefore, the expected number of birds nesting in Picher Canyon in 2014 cannot be estimated without considering the number of nesting egrets in the Bolinas heronry, the only other known heronry on Bolinas Lagoon. We expect the carry-over effect of the disturbance at Picher Canyon in 2013 to result in a minimum of 32 Great Egret nests on Bolinas Lagoon in 2014. This Bolinas Lagoon-wide estimate is based on analyses of patterns of subregional recovery after colony-site disturbances measured throughout the northern San Francisco Bay area since 1991 (Millus et al., in preparation). Because this prediction is based on regional averages, it might under- or over-estimate the actual number of nests in 2014.

  We will adaptively set a management threshold for opening the 2014 public season using the minimum lagoonwide estimate described above, of 32 Great Egret nests. Each week, we will adjust the minimum expected number of nests at Picher Canyon by subtracting the number of nests in the rest of the lagoon — i.e., at the Bolinas colony site — from the minimum, lagoonwide prediction of 32 nests. To account for the expected recruitment of new breeders from other areas into the lagoon and the importance of colony site recovery before reconsidering our stewardship regime for the Canyon, we will set the threshold for opening the public season at double the calculated minimum number of nests in Picher Canyon.

For example, if 15 nests are initiated at the Bolinas colony site (same as in 2013), the minimum expected number in Picher Canyon will be (32-15) x 2 = 34 nests. In this example, the threshold number of nests in Picher Canyon would be very similar to the peak number of 32 nests in 2013. If the size of the heronry in Bolinas grows substantially, the expected number of nests in Picher Canyon—and the management threshold—will decline. This method of management is biologically realistic, based on patterns observed throughout the region, the behaviors of the birds, and the importance of Bolinas Lagoon.

It is important to emphasize that the threshold number of nests is just one of three criteria for management, as described above.

- **Weekly assessment and discussion.** Sarah Millus and the ACR science staff will provide MGP management staff with detailed, weekly, written accounts on the status of the colony, including management recommendations, beginning in February 2014. In addition, key science staff will hold weekly conference calls with MGP management staff, as needed, to discuss these updates.

- **Video monitoring.** A video camera will be installed by 1 January to aid in monitoring activity at the colony. Infrared or thermal images would be ideal, since this would also capture activity at night.

- **Closure of the Overlook.** The Overlook will be completely closed, to staff, school children, ranch guides, docents, and the public (but may be used by individuals who are monitoring the colony site) until the above criteria are met. During the time when the Overlook is closed, it will be covered with camouflage netting, to be installed no later than 1 Jan. All reflective surfaces, including spotting scopes posts will be painted with dark, non-reflective paint before the Overlook is reopened.

- **Minimize noise at the Overlook.** If the Overlook is opened to school groups and the public, it is potentially critical for ranch guides and docents to minimize noise, excessive movement and overcrowding whenever people are present at the Overlook.

- **Prohibit all dogs.** MGP currently has a no-dog policy, except for service dogs. Extending this policy to all dogs, including those left inside cars, will minimize potential disturbance to any nesting egrets and herons.

- **Raven-proof the Preserve.** All trash receptacles and other attractive features such as windows and reflective surfaces at MGP should be completely raven-proof.

- **Limit tree trimming.** Tree trimming should be prohibited from 1 Jan – 31 Aug., except when people or structures are endangered, in which case the science staff should be consulted prior to work.

- **Limit human disturbance in Picher Canyon courtyard.** Human disturbance that could deter nesting, especially near the parking lot trees, should be minimized as much as possible. Large gatherings should be moved to Volunteer Canyon whenever feasible. Buses, traffic and large groups of people, including school children, are a potential deterrent to nesting, especially early in the nesting season when birds are most sensitive to disturbance. This measure is especially important to encourage nesting by Great Blue Herons, given that they have preferred to nest in the parking lot trees in the past.

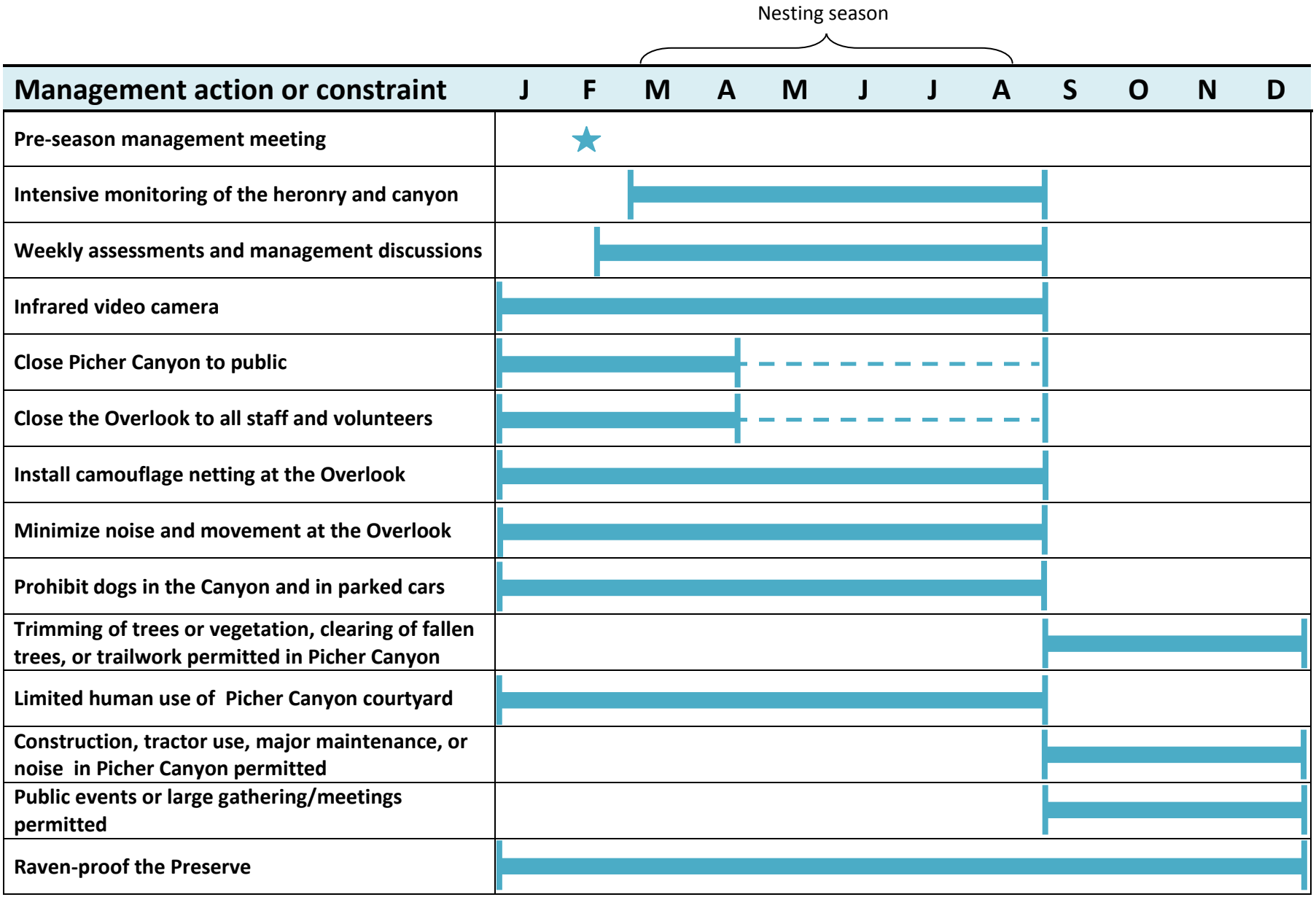
- **Limit noise from maintenance work**. Excessive noise, including lawn mowing, use of the tractor and the use of power tools, may be a deterrent to nesting birds, and should be prohibited or reduced in frequency and intensity as much as possible from 1 Jan – 31 Aug.

- **Limit major events.** No major events, other than docent and ranch guide training, should be permitted in Picher Canyon from 1 Jan. – 31 Aug. Whenever possible such events should be held in Volunteer Canyon.

Table 1. Likelihood of potential causes leading to nest failure and colony decline.

Cause	Unlikely	Possible contributing influence	Most likely
Disease and parasites	●		
Chemical toxicity	●		
Food availability	●		
Weather	●		
Vegetation changes	●		
Predation / Disturbance from mammals	●		
Eggs infertile or inviable for unknown reasons		●	
Absence of Great Blue Heron		●	
Disturbance from humans		●	
Predation / Disturbance from avian predators			●

Table 2. Timeline for management of MGP in 2014. See text for details regarding each management action or constraint.



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APPENDIX – Interviews

Interviews were conducted with both employees and volunteers who spent time in and near the Picher Canyon colony during the 2013 nesting season, as well as biologists and naturalists with particular knowledge about the Bolinas Lagoon area. A mass e-mail was sent out to all Ranch Guides volunteering at Martin Griffin Preserve during the 2013 public season requesting information about any unusual observations. However, no responses were received.

Bratton, Anna-Marie. Audubon Canyon Ranch Board Member and Martin Griffin Preserve Ranch Guide and Host. Personal interview. July 10, 2013.

Anna-Marie Bratton has been a Ranch Guide and Host at Martin Griffin Preserve (MGP) since 2003. She spent several days at MGP, including time at the Henderson Overlook, during the 2013 egret breeding season. Anna-Marie expressed concern over the difference in the egret colony this season. She observed normal egg-turning behavior at the time right around when chicks should have been hatching. After that, when there should have been chicks but weren't, it appeared that adults were more standing and fussing with the nest, rather than tending eggs. She observed that there wasn't as much displaying and courting behavior or nest relief behavior as in years past, and that in particular the first two nests of the season had a very short courting period and were incubating eggs in a short amount of time. She wonders if the increased amount of metal on the remodeled overlook might be reflecting more light and affecting the egrets. She observed a less than normal amount of activity in the canyon from Common Raven, particularly in the trees near the colony. She also mentioned that she has observed several cars coming in with barking dogs to visit the preserve this season.

Evens, Jules. Consulting Biologist, Avocet Research Associates. E-mail interview. July 8, 2013.

Jules Evans has acted as a Principal Investigator and/or Consulting Biologist on many long-term monitoring studies of avian populations. Mr. Evens is a certified wildlife biologist and the author of three books, including *California Birdlife*. Mr. Evens communicated that Bald Eagles have nested successfully at Kent Lake every year since they were first established in 2008, and have produced two chicks each year since, for a total of 12 chicks to date. This year he observed two large eagle chicks off of the Kent Lake nest in early June, and presumed they both fledged. Mr. Evens noted that the Osprey colony at Kent Lake was greatly reduced this year compared to previous years, with possibly much lower than average productivity. He felt the eagles may be responsible for the decline in Osprey nests, at least in part. He also mentioned the presence of another Bald Eagle nest on Inverness Ridge above 2nd Valley, which was discovered this year.

Flint, Leslie. Martin Griffin Preserve Ranch Guide. E-mail interview July 31, 2013.

Leslie Flint has been a Ranch Guide at Martin Griffin Preserve since 1986, when the program first started and was a docent at MGP from 1974-1976. She served on the ACR Board of Directors from 1994–2010, and was the Board President from 1998–1999. She has also done several educational research projects, including bedstraw as well as dragonflies and fungi of MGP. Leslie observed Common Ravens regularly in the canyon, but never observed any predation. She also observed the presumed male raven frequently around the buildings in Picher Canyon. Sometime in early June, Leslie observed a bird incubating on a nest fly out to Bolinas Lagoon and return an hour later. There was no nest relief, and the bird left the nest attended. This nest was empty on Leslie's next visit to MGP.

Hansen, Keith. Artist and Naturalist. Personal interview. July 3, 2013.

Keith Hanson is a renowned artist and naturalist who has been birding the Bolinas Lagoon area since 1986. He is a long-time resident of Bolinas and is considered a local expert on birds. He examined the feathers found under the heronry on June 29, 2013 and identified them as the breast and scapular feathers of Great Horned Owl. He described encountering Barred Owls on Bolinas-Fairfax Rd., on the top of the ridge near Picher Canyon. He also mentioned that Barred Owls have been heard at the Point Reyes Bird Observatory field house in Dogtown. He stated that he has seen Bald Eagle at Bolinas Lagoon, and that there is a Bald Eagle nest at Kent Lake and one on Inverness Ridge. He thought it unlikely that a Bald Eagle would attack an egret or heron chick. He thought a Golden Eagle would be more likely to take a chick, but that Golden Eagle is very rare in West Marin.

Heistand, Gwen. Martin Griffin Preserve Resident Biologist. Personal interview. July 11, 2013.

Gwen Heistand has been Resident Biologist at Martin Griffin Preserve since 2002. She was not present at the preserve this year as much as in past years. She noticed that the ravens stopped hanging around the Bourne House for most of June, and was not sure if the ravens nested this year, nor was aware of any raven nests in any of the canyons at MGP. She was aware of a coyote den at Volunteer Canyon and a fox den near the Crumb House. She did not notice an increase in the observation of mammalian predators, such as raccoons.

Keating, Julie. Martin Griffin Preserve Weekend Program Facilitator. E-mail interview July 18, 2013.

Julie Keating is present at MGP on the weekends during the public season. She works closely with the Ranch Guides to facilitate interpretation for the public at MGP. She has been the Weekend Program Facilitator since 2011. Julie passed on information that Ranch Guide Sam Hutchins observed "a very large bird that looked gray-ish and he thinks had a yellow beak" on 16 June.

Pierce, Yvonne. Martin Griffin Preserve Manager and Executive Administrator. E-mail interview July 23, 2013, follow-up personal interview August 14, 2013.

Yvonne Pierce is the Martin Griffin Preserve Manager and Executive Administrator. Yvonne observed feathers from an adult egret the MGP courtyard, including on top of the Bourne House, Osher Volunteer Center as well

as parts hanging from the telephone pole on 7 June. Yvonne also a clump of found several blue feathers, most likely belonging to a jay, in the Picher Canyon courtyard around 15 June. Yvonne also provided statistics on visitation to the Preserve in 2012 and 2013 as well significant maintenance that was done on the Preserve in 2012 and 2013.

Poszgai, Steven. Audubon Canyon Ranch Controller. Personal interview June 21, 2013. E-mail follow-up July 18, 2013.

Steven Poszgai 's office is located in Picher Canyon, and he frequently takes walks up to the Henderson Overlook. On 18 June, Steven hiked to the Henderson Overlook approximately an hour or two after the colony was flushed by a Bald Eagle. He observed that the colony was mostly empty, and most birds appeared to be off their nests at this time. Steven also observed what appeared to be an owl feather among the egret feathers found on 7 June.

Schwartz, Maurice 'Skip'. Audubon Canyon Ranch Emeritus Director. Personal interview August 1, 2013.

Skip Schwartz served as Executive Director of Audubon Canyon Ranch from 1975-2009, and continues to serve as a Senior Advisor. Skip described attacks on the colony by raccoons and ACR's multiple efforts to trap raccoons, as well as install the trees bands. He also described movement of the heronry following disturbance by predators and after building of the Henderson Overlook and associated tree trimming. He noticed that Great Egret were very sensitive to eagles, and the whole colony would flush to the lagoon when a eagle flew over the canyon. He described that each successive time the eagle flushed, the herons and egrets would stay away from the colony for longer amounts of time. He also noticed that the birds were much more sensitive to disturbance early in the nesting season, and thinks the birds are more sensitive to disturbance from above.

Sproul, Leslie. Martin Griffin Preserve Office Assistant. Personal interview. July 11, 2013.

Leslie Sproul is the Office Assistant at MGP. Leslie observed the ravens near the buildings in Picher Canyon consistently during the 2013 season. She noticed that the resident pair has learned the school visitation schedule, and is often on the ground looking for food after school children leave the Preserve. The presumed male has been more visible, and it appeared that the female comes and goes. She noticed on two different occasions piles of small feathers at the bird hide, one a collection of blue feathers, and presumed songbirds had been depredated there. She also noticed that bobcat were not around as much this season. She did not notice an increase in the observation of mammalian predators, such as raccoons.

Trivelpiece, Steve. Martin Griffin Preserve Land Steward. Personal interview. July 11, 2013.

Steve Trivelpiece has been the Land Steward at MGP since 2011 and lives in Pine County Gulch Canyon. Steve noticed fewer coyotes, bobcats, and foxes around his property and an increase in deer and raccoons this year, but no additional crow or raven activity over past years. He stated there was no difference in the maintenance schedule at MGP in 2013, except for maintenance of the trees bands around and near the colony trees, including replacing loose bands and cutting leaning branches in March 2013. He also noticed more boat activity in Bolinas Lagoon near the edge of the Preserve this year and mentioned the extensive construction, including mowing at Parsons Pond, that occurred during repaving of Hwy 1.