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Cover Photograph: A small Unmanned Aircraft System (UAS) is used to document entanglement hazards in an(*Pandion Haliaetus* (Osprey) nest in Fort Collins, CO, USA. Photograph © James F. Dwyer.

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Use of Small Unmanned Aircraft Systems (UAS) to Assess and Quantify Risk of Entanglement in Synthetic Baling Twine in *Pandion haliaetus* (Osprey) Nests

James F. Dwyer[1,*] and Michael C. Tincher[2]

Abstract - *Pandion haliaetus* (Osprey) incorporate anthropogenic litter into their nests. Collected material often includes baling twine, which can create entanglement hazards. Removing baling twine from nests could alleviate entanglement hazards, but assessment of the presence of twine within nest cups is often impossible from below. To evaluate a new, potentially useful technique to view nest contents, we used a small unmanned aircraft system to document the presence or absence of twine in 11 Osprey nests around Fort Collins, CO, USA. Prior to the nesting season, 4 nests included twine within the nest cup, and 8 included twine outside the nest cup. After the breeding season, 3 nests included twine within the nest cup, and 10 included twine outside the nest cup. People who use baling twine should collect and dispose of or recycle this material.

Introduction

Pandion haliaetus (L.) (Osprey) readily nest in or near human-dominated landscapes, including urban areas (Bierregaard et al. 2016). This behavior increases Osprey exposure to anthropogenic litter, which is regularly incorporated into the structure and lining of nests. Litter incorporated into nests includes beach toys, fishing line, nylon mesh, bait bags, paper, plastic bags, rope, and baling twine (Bierregaard et al. 2016, Blem et al. 2002, Houston and Scott 2006). Baling twine is particularly hazardous because it is typically constructed of synthetic polypropylene fibers woven together to create a durable, UV-resistant, high-strength, non-elastic cord designed to resist wear and weathering in natural conditions (Seacor et al. 2014). Once twine is wrapped around the talon, foot, or other appendage of a nestling Osprey, the strength of the material prevents breaking free, and the bird's movements can increasingly constrict the baling twine around the animal.

Incorporation of baling twine leads to regular entanglements and mortalities. For example, Blem et al. (2002) observed 12 baling-twine entanglements in 260 nests (5%) in Montana, USA. When possible, entangled birds were extricated, but at least 5 entanglements resulted in mortalities. Also in Montana, Seacor et al. (2014) found 4 of 120 nestlings (3%) entangled in baling twine. Two were extricated, and 2 died of injuries resulting from twine entanglement. In Saskatchewan, Canada, 9 of 77 (12%) nestlings were entangled in baling twine (Houston and Scott 2006). All were extricated, but 2 nestlings likely died later of their injuries, and an adult Osprey was

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found entangled and strangled by baling twine at another nest (Houston and Scott 2006). These observations were made in relatively rural areas, but baling twine is so ubiquitous that it is also present in urban habitats. For example, baling twine is used as symbolic fencing to warn the public away from seabird and shorebird nesting colonies on public beaches near urban areas. In 2016, M.C. Tincher (unpubl. data) removed 2 baling-twine–entangled nestling Osprey from nests around Fort Collins, CO, USA (Fig. 1A). The entanglement injuries were so severe (Fig. 1B) that one of the birds was euthanized, and the other required long-term captivity and extensive rehabilitative care prior to release back to the wild.

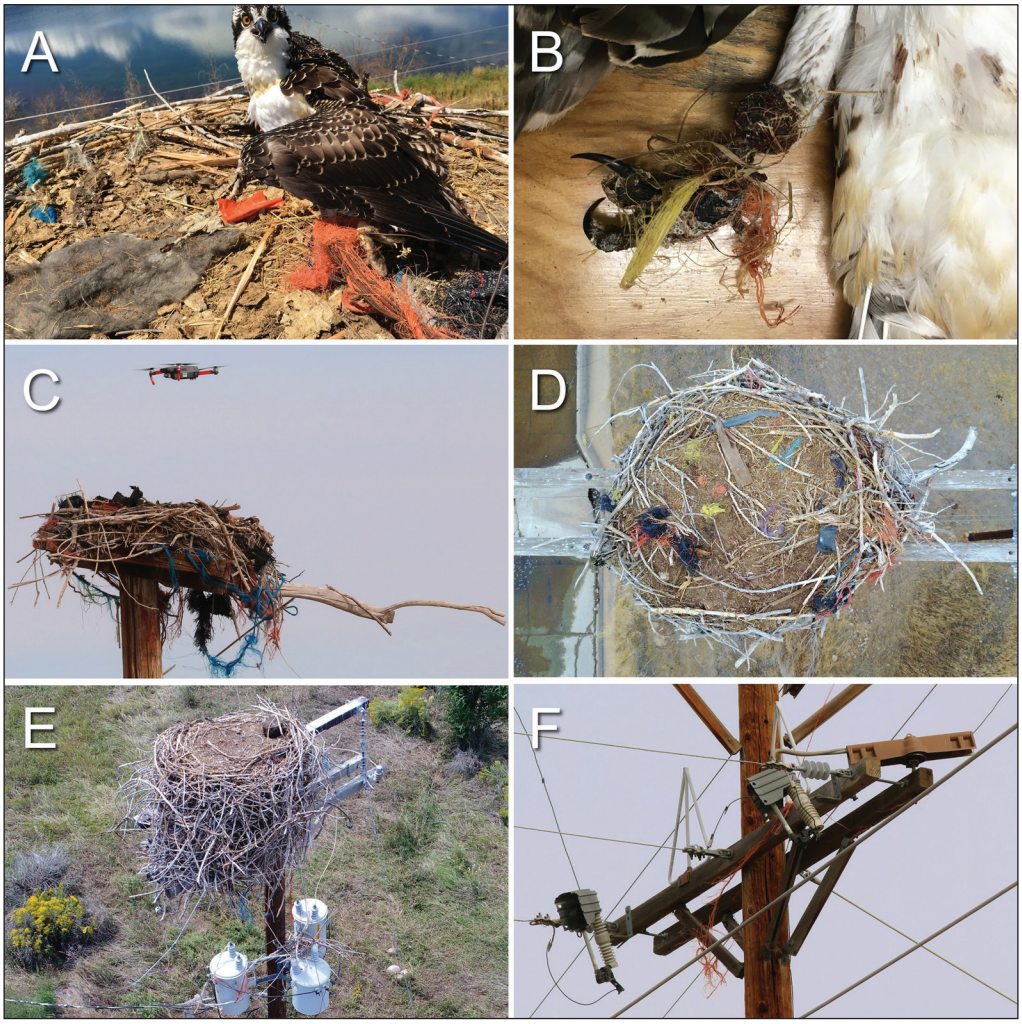

Figure 1. (A) A juvenile *Pandion haliaetus* (Osprey) entangled in baling twine incorporated into nesting material. (B) The necrotic foot of a juvenile Osprey euthanized following entanglement in baling twine. (C) A DJI Mavic small UAS collecting imagery to document baling twine within the cup of an Osprey nest. (D) Multiple pieces of baling twine within an Osprey nest cup. (E) Baling twine present on de-energized electrical equipment below an Osprey nest. (F) Baling twine contacting energized equipment on a power pole adjacent to an Osprey nest. All images from Fort Collins and Loveland, CO, USA.

Baling twine is readily observed around the outside of Osprey nests, but that baling twine may not be the most likely to result in entanglement of nestlings, and thus may not be the best indicator of entanglement hazards. Presumably, baling twine within the nest cup is more likely to entangle nestling Osprey, but the presence of baling twine within the nest cup has been difficult to assess without physically climbing into nests or viewing nest contents from a manned aircraft.

Recently, the decreasing costs and increasing reliability of small unmanned aircraft systems (UAS, also known as drones) have enabled a wide variety of wildlife conservation applications including counting colony-nesting birds (Hodgson et al. 2016), tracking radio-telemetered wildlife (Tremblay et al. 2017), installing markers to increase the visibility of power lines to flying birds (Lobermeier et al. 2015), and surveying for raptor nests (Junda et al. 2015). We believed that a small UAS might also enable observation of baling twine within Osprey nests. To assess that hypothesis, we used a small UAS to check for the presence of baling twine in Osprey nests in and around Fort Collins.

Field Site Description

We conducted this study in the vicinity of Fort Collins, CO, from Wellington, CO, in the north, to Loveland, CO, in the south. At the time of our study, Fort Collins was a city of 167,500 people in an area of 148 km^2 accessible by nearly 900 km of roads (City of Fort Collins 2017), making the area decidedly urban. We visited 11 Osprey nests. Ten nests were on supplemental platforms installed to redirect Osprey from nesting on nearby power poles. One nest was on a de-energized power pole. These nests were the only ones of which we were aware in and around Fort Collins, and included 2 nests with confirmed baling-twine entanglements of nesting Osprey in the previous (2016) nesting season, and 2 inactive Osprey-nest platforms.

Methods

We surveyed nests on 18 February 2017, prior to the spring arrival of Osprey in our study area, and again on 9 September 2017, after Osprey dispersed from nesting territories. This timing ensured that Osprey were not present at the nest sites during our surveys, and thus, that the operation of a small UAS near nest sites did not disrupt Osprey nesting or productivity in any way, though UAS can be used to monitor active raptor nests (Junda et al. 2015).

At each nest, we recorded the nest substrate and we used a DJI Mavic (Dà-Jiāng Innovations Science and Technology Co., Ltd., Shenzen, China) small UAS to hover 1–3 m directly above the nest cup (Fig. 1C). We used the Mavic's integrated 12-MP camera to record multiple nadir and oblique images from above each nest, and to record images of nearby power poles. We used these images to identify whether any baling twine was present on the surface of the nest cup (Fig. 1D), which we defined as the concave surface of the interior of the nest. We also used these images to identify whether baling twine was present anywhere in or on the convex exterior of each nest (Fig. 1E), and on the nearest power pole to each nest (Fig. 1F). We also looked for Osprey carcasses in, on, and below each nest.

This study was limited in scope, both in terms of numbers of nests viewed and in terms of surveys conducted at each nest. We report proportions of active nests in 3 categories (baling twine present in the nest cup, baling twine present anywhere on the nest, and baling twine present on the nearest power pole) before and after the 2017 breeding season, but we do not report any additional statistics. Our data quantify baling-twine hazards in Osprey nests in the Fort Collins vicinity, and provides foundational data for longer-term documentation and mitigation.

Results

We visited 11 Osprey nests before and after the 2017 breeding season. In February, prior to the 2017 breeding season, we found that 4 active nests included baling twine within the nest cup, 8 included baling twine outside the nest cup, and at 3 nests, baling twine was present on the nearest power pole. Some nests included twine in multiple locations, creating a percentage total >100%. In September, after the 2017 breeding season, 3 active nests included baling twine within the nest cup, 10 nests included baling twine outside the nest cup, and at 3 nests, baling twine was present on the nearest power pole. Some of these nests also included twine in multiple locations. The decrease from 4 to 3 nests with baling twine within the nest cup was due to the nesting-season placement by breeding Osprey of additional natural nest materials on top of the existing baling twine.

Discussion

Most Osprey nests in the Fort Collins area incorporated baling twine. Baling twine in Osprey nests poses entanglement hazards which can be lethal (Blem et al. 2002; Seacor et al. 2014; M.C. Tincher, unpubl. data). We suggest 3 methods to reduce entanglement hazards attributable to baling twine. Each of these methods may also be effective for limiting the negative impacts caused by fishing line in Osprey nests, and because baling twine, string, and fishing line also pose entanglement hazards to other species (Doucet and Dewitte 2015, Townsend and Barker 2014), may also be broadly applicable to the conservation of a range of other urban-nesting birds. Baling twine can also cause power outages and pole fires; thus, these methods may also increase the reliability of overhead electric systems where Osprey are present.

First, sources of baling twine, and other entanglement hazards like fishing line, should be removed from the environment as much as possible. Users of baling twine need to be educated to actively collect and appropriately recycle or dispose of waste materials, rather than leaving them as litter in the environment. Net wrapping, a tightly woven mesh of plastic threads, replaces baling twine in some areas (Seacor et al. 2014), and because Osprey are also prone to collecting netting (M.C. Tincher, unpubl. data), net wrapping also should be collected and disposed of properly. These materials (baling twine and net wrapping) should not be used to attach sticks to platforms when nest platforms are constructed.

Second, where feasible, resource managers and electric utilities should consider removing or cutting loops of baling twine in Osprey nests annually. Organizations

responsible for removing or cutting baling twine could be determined based on the ownership or origin of the nest substrate. For example, nests on natural substrates could be managed by natural resource agencies. Nests on anthropogenic substrates like nest platforms could be managed by the owners or erectors of those substrates. Cutting loops of baling twine may be more effective than removal because cutting is likely more time- and cost-efficient, and less likely to impact the overall structure of the nest within which baling twine is embedded.

Third, given the advances in small UAS techniques and technologies, it may be possible to equip a small UAS with a cutting tool to sever loops of baling twine (or other entanglement hazards). This practice could eliminate the need for humans to climb into the potentially dangerous elevated environments of Osprey nests to cut or remove loops of twine; thus, improving human safety and efficiency. Given that UAS-based nest surveys can be conducted when nests are occupied (Junda et al. 2015), this approach may have some potential applications even within breeding seasons.

Many Osprey nests, particularly those in urban areas, are constructed on platforms specifically installed to reduce Osprey use of nearby electric power poles (APLIC 2006). In these cases, Osprey and electric utilities may both benefit from active baling-twine management programs because outages, equipment damage, and fires can occur when nesting material, including baling twine, contacts energized equipment (APLIC 2006). Contact between Osprey and energized equipment can also lead to electrocution of the birds themselves (Dwyer 2016, Harness and Wilson 2001, Henny et al. 2008). Proactively addressing concerns associated with Osprey use of baling twine associated with nests and the supporting and nearby power poles would help mitigate these concerns.

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