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Almond Ornithology: A review of bird and nut tree interactions in Mediterranean climates worldwide to inform sustainability in California

Sacha K. Heath and Khara M. Strum, kstrum@audubon.org

Almond orchards around the world provide **bird habitat year-round.**

- The number of bird species using almond orchards was higher than in apple orchards or vineyards in SE Australia and similar to eucalypt wood lots (Luck et al. 2015).
- Winter birds were more abundant along transects with higher percentages of almond and other fruit trees in Cyprus (Ieronymidou 2012).
- Almond orchards provide habitat connectivity for parrots in Australia (Luck et al. 2014).
- The number of bird species detected was higher at the edges of almond orchards than at the interior and the age or area of an almond orchard did not affect abundance or the number of bird species (Schäckermann et al. 2015).

Features in the surrounding **landscape may influence bird use** of almond orchards.

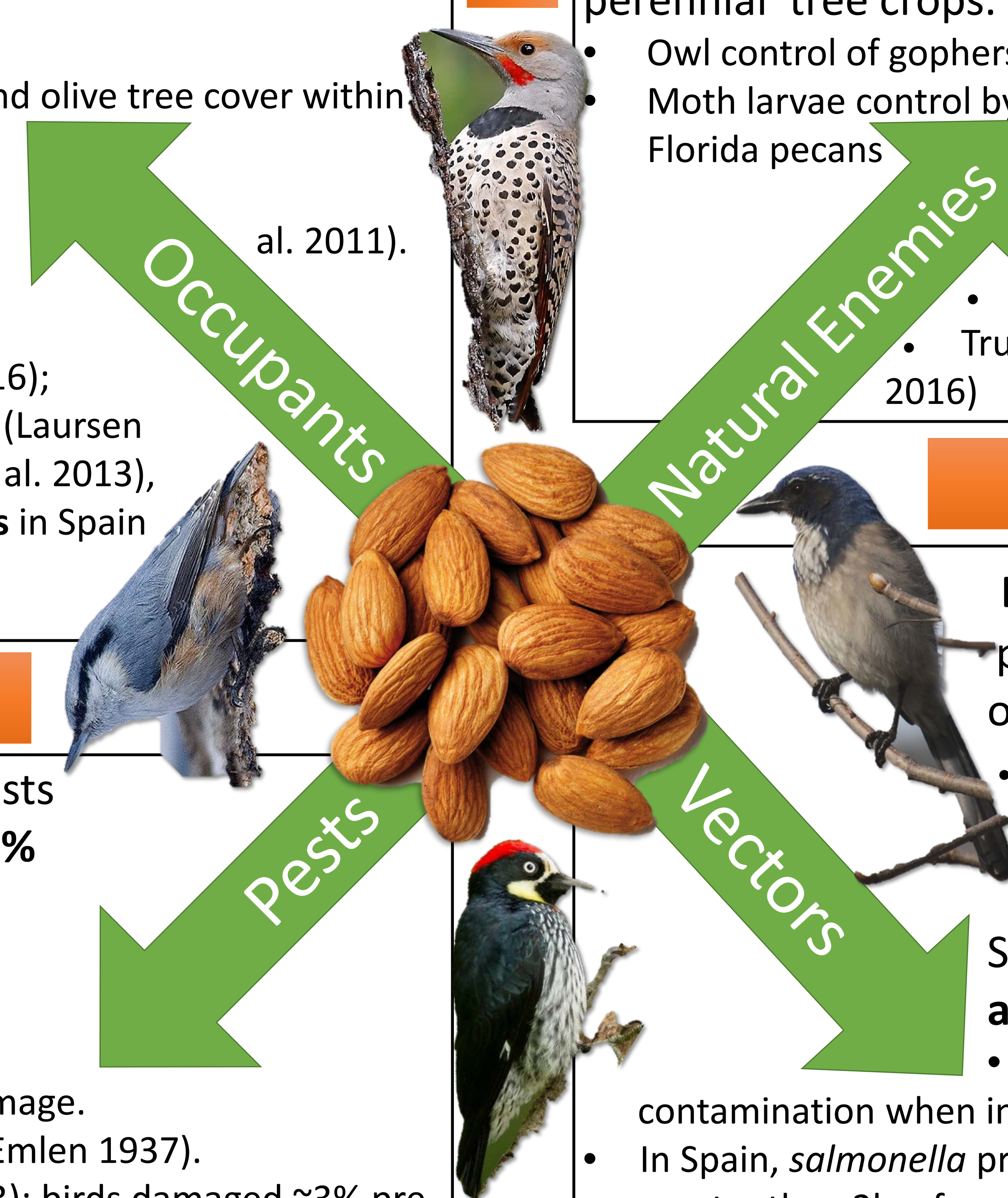
- The number of bird species using almond orchards increased with the amount of semi-natural habitat within 1km in Israel (Schäckermann et al. 2015).
- Regent parrots in Australia preferred almonds bordered by natural vegetation and other small parrots were more often detected in almond orchards close to riparian vegetation (Luck et al. 2013).

Almond orchards provide **nesting habitat.**

- The number of eggs laid by shrikes in northern Spain increased as almond and olive tree cover within 1km increased (Campos et al. 2006).
- Crows, magpies, woodpeckers and parrots have nested almond orchards around the world (Soler 1990, Martinez et al. 1996, Elmen 1937, Campos et al. 2011).

Almond orchards provide important contributions to **avian diets**.

- Migrating **shrikes** hunt from almond trees in Greece (Apageorgiou et al. 2016); almond pollen horns found attached to **long-distance migrants** in Denmark (Laursen et al. 1997); many birds consume almond nuts: **parrots** in Australia (Luck et al. 2013), **woodpeckers and crovids** in Israel (Moran & Keider 1993), **magpie nestlings** in Spain (Neve et al. 2007) and **woodpeckers and corvids** in California (Emlen 1937, Marsh & Salmon 1996, Miller & Bock 1972, Gignoux 1921).



Most bird damage estimates are grouped with other vertebrate pests (e.g. rodents) and it is expected that **birds contribute less than 2.6% damage** to almonds in California.

- Small parrots in Australia were responsible for <1% of damage and Regent parrots >2% of damage (Luck et al. 2013).
- In California, crows removed 40% of experimental nuts daily, woodpeckers removed ~5% of total yield, scrub jays and flickers accounted for <1% of damage. No damage documented by red-winged, tricolored or brewer's blackbirds (Emlen 1937).
- In Israel, woodpeckers and corvids consume almonds (Moran & Keider 1993); birds damaged ~3% pre-harvest almonds, damage was greater on orchard edges and damage was not influenced by semi-natural habitat within 1km (Schäckermann et al. 2015).

Perceptions of bird damage are 7.7% higher than using other means but are useful for development of **quantifiable data** (Gebhardt et al. 2011).

- Average cost of almond damage by birds was US$5.61 with and US$12.28 without bird control measures in place; average almond yield losses by birds were 2.2% with and 8.4% without bird control measures in place (Dobb 2014).
- California producers are willing to pay $24/ac to reduce bird damage by 50% (Hasey & Salmon 1993).

Preferred damage control efforts are **efficient, inexpensive**, **safe** to the applicator and the environment and **humane** to pests.

- Providing alternative and preferred natural food sources to pests (i..e. native plants to birds) may reduce overall damage (Schartel & Schauber 2016).

Natural enemy: predators, parasites, pathogens that kill or reduce the numbers of pests.

The only published empirical examples of avian pest reduction services in almonds are those which quantify the **bird consumption of mummy nuts**.

- In California, combined bird and rodent consumption of mummy nuts ranged from 2-96% and was 60% at orchard edges and 14% at orchard interiors and positively correlated with number of plant species in the orchard understory and natural vegetation within 1km (Eilers & Klein 2009).
- Mummy nut removal by birds in Australia was 55% at orchard edges and 27% at orchard interiors and 36% per tree over 3 a month winter (Luck 2013).

Services provided by birds **may exceed the damage** caused by birds.

- Luck (2013) estimated pre-harvest bird consumption damage of almonds at AUD $57/ha and mummy nut removal services at AU$82-332/ha for net gain of AU$25-275/ha.

There is a growing set of examples of **birds reducing similar pest groups** in other perennial tree crops.

- Owl control of gophers, voles and squirrels in annual crops in California (Kross et al. 2016).
- Moth larvae control by woodpeckers and nuthatches in California walnuts (Heath unpub.); titmice in Florida pecans (Tedders et al. 1983); various birds in Australian macadamia orchards (Crisol-Martinez et al. 2016); woodpeckers and tits in apples in Nova Scotia (Stairs 1985), England (Solomon et al. 1976) and the U.S. (MacLellan 1959).
- Beetle control by titmice in pecans (*in* Tedders et al. 1983)
- True bug control by birds in Australian macademia orchards (Crisol-Martinez et al. 2016)

Birds have not been directly implicated in outbreaks of pathogenic *Salmonella* and *Escherichia coli* involving almonds or other crops.

- Of 2,500 *salmonella* strains, 5 are responsible for *salmonella* illness in humans. Most *e. coli:* strains are not harmful to humans and 7 strains cause most human illness (Jay-Russell 2013).

Surrounding **landscape features may influence bird exposure to and prevalence** of *salmonella* and *e. coli* on almond orchards.

- A simulation study of apple orchards showed increased risk of *e. coli* contamination when in proximity of landfills or sewage (Duffy & Schaffner 2002).
- In Spain, *salmonella* prevalence was higher in birds tested near pig farms compared to birds tested greater than 2km from pig farms (Andrés et al. 2013).

Potential mechanisms for keeping **contamination risk low.**

- Collaborations between regional land use planning/zoning entities, wildlife professionals, producers, ranchers and feedlot operators to assess preventative risk reduction.
- Integration of bird damage control practices with those for vector control.
- Targeted reductions in large flocks of nuisance species on feedlots reduced *salmonella* presence in water and feed though it remained the same in cattle feces (Carlson et al. 2011).but long-term effectiveness is not well documented (Tracey et al. 2007).
- Habitat removal near crops conflicts with biodiversity goals and increased *e. coli* presence significantly in coastal California (Karp 2015).
- Avoid collecting produce direct from ground; use a tarp and protect produce from perching birds and ground dwelling vertebrate pests.
- Post-harvest pasteurization.

We thank the Almond Board of California for their support of this literature review. Presented November 2016 in Sacramento, CA.