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A Review of the Use of Pacific Madrone by Nesting, Pollinating and Frugivorous Birds

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Abstract: This paper reviews ecological interactions of birds with Pacific madrone (*Arbutus menziesii*). Results from a tree inventory in the Magnolia area during 1994–95 and a literature search are summarized. We surveyed 126 trees and found 2 Northern flicker (*Colaptes auratus*) cavity nests and 35 cup nests. American Crows (*Corvus brachyrhynchos*) occupied the cup nests. Madrone is a substrate for nesting and is a nutrient resource. Birds provide pollination service to the plant and disperse seeds. Madrone berries are consumed by numerous bird species. The role of frugivores as a mechanism for flower pollination and seed dispersal is discussed. Knowledge of the nutrient content of madrone berries may be useful for managing madrone-dependent frugivores. The presence of antifungal chemicals in madrone berries may be a factor in understanding the spread and control of madrone diseases. Successful management of the Pacific madrone entails protecting not only the trees, but also the wildlife that use it.

The Pacific madrone (*Arbutus menziesii*) provides habitat for nesting and nutrients for foraging birds. Madrone also serves as habitat for other wildlife, providing protection from predators and harsh weather, structures for nesting and sources of food (Benyus 1989). Pollination of flowers determines the size of fruit crop production that, in turn, influences foraging behavior of frugivore populations and dispersal of seeds (Meeuse 1961). Pollination and seed dispersal benefit the tree by increasing genetic variability through minimization of inbreeding and intraspecific competition (Dirzo and Dominguez 1986). Healthier trees may result because dispersed seeds germinate in areas distant from diseased stands. The purpose of this paper is threefold: we report on a study of bird nests found in Pacific madrones growing in the Magnolia area of Seattle, Washington; we review information relevant to ecological interactions of birds with Pacific madrones; and, we present research ideas relevant to madrone wildlife use and management.

METHODS

In the spring and summer of 1994–95 we inventoried 126 live madrone trees at 5 sites in the Magnolia neighborhood of Seattle. Exact locations and methods are in Adams, *et al*. (this volume). We conducted a literature review and interviewed people (in person and via the internet) in order to find what information exists on the use of madrone by nesting and foraging birds.

RESULTS

Field Results

We located 40 madrones [mean diameter at breast height (DBH) = 56.1 cm] with cavities (Table 4-1). Two of these trees contained active cavity nests with Northern flicker (*Colaptes auratus*) chicks. Both trees were alive with DBH measuring 74.4 cm and 81.8 cm, and the nests were located at least 7 meters above the ground. The presence of cavities in madrones with DBH greater than 30 cm is an indication of potential habitat for cavity-nesting birds in Magnolia. In addition, on 3 occasions we saw downy woodpeckers (*Picoides pubescens*) foraging on madrones, but we found no cavity nests of this species. Thirty-five cup nests (Table 4-1) were discovered in 30 madrones at Magnolia [most, if not all, were crows' (*Corvus brachyrhynchos*) nests].

Literature Survey and Interview Results

Pacific madrone as a nesting site. Raphael (this volume and 1987) reported the use of Pacific madrone by cavity-nesting birds. Tree cavities used for nesting can be excavated by birds themselves or formed as a result of disease. *Phellinus ignarius, Fomitopsis cajenderi* and *Poria subacida* are fungal infections that attack Pacific madrone and cause heart rot that results in hollow trunk cavities (Horst 1990).

The diameter of madrone trees determines their potential quality for cavity nests. Generally, trees with DBH >38 cm are suitable for cavity-nesting (Raphael and White 1984 and Benyus 1989). Raphael (1987) found 89% of the cavity nests in Pacific madrones in northwestern California were in trees with DBH >30 cm. Red-breasted sapsuckers (*Sphyrapicus ruber*), hairy woodpeckers (*Picoides villosus*) and acorn woodpeckers (*Melanerpes formicivorus*) were the most common primary cavity nesters (*i.e.*, those capable of excavating their own nest cavities). Primary cavity nesters provide habitat for secondary cavity nesters [passerine birds; raptors such as small

Table 4-1. Description of madrones containing cavity and cup nests in the Magnolia neighborhood of Seattle, Washington. Data for spring and summer of 1994–95.

SITE	No. of trees sampled	No. of trees with cavities	Total no. of cavities	Mean DBH of trees with cavities (cm)	Nest Type Cup	Nest Type Cavity
Discovery Park	13	1	1	9.7	0	0
Magnolia Annex	9	3	7	75.5	1	1
Magnolia Bluffs	48	19	37	53.3	18	0
Magnolia Park	17	7	9	86.0	4	0
Thorndyke	39	10	18	55.9	12	1
Mean				56.1		
Total	126	40	72	-	35	2

owls; and mammals such as raccoons, porcupines and northern flying squirrels (Benyus 1989)]. We noted reports of barred owls and great-horned owls eating crows and using their nests. Merlins (*Falco columbarius*) and raccoons also occupy crows' nests. Crows are less watchful over their nests in the period before egg laying, thus allowing other birds and animals to use them (Sullivan 1992).

Flowers, pollination and fruit production. Madrone flowers are small (~1 cm long), whitish, urn-shaped, and borne in racemes (~13–15 cm long). Flowers have a 5-parted calyx, a 5-lobed corolla, 10 stamens shorter than the corolla, a superior ovary. The style with its 5-lobed stigma extend out of the corolla (Hitchcock and Cronquist 1974, Roy 1974 and Wiggins 1980). Trees bloom in March at warmer sites and as late as May in colder places (Peattie 1953, Tarrant 1958, Roy 1974, McDonald and Tappeiner 1991 and Kelley, *et al*. 1993).

Honey bees (*Apis mellifera*) are attracted to the strong sweet odor of madrone flowers (Arno 1977). Bee pollinated flowers are generally blue or yellow with a nectary at the base of the corolla tube (Meeuse 1961). It is possible that madrone petals have an ultraviolet spectrum to attract bees, but it is not known whether the flowers have nectaries. Rufous and Anna's hummingbirds (*Selasphorus rufus* and *Calypte anna*, respectively) were observed feeding on madrone blossoms by P. Rose (personal communication); therefore, these hummingbirds may play a role in pollinating madrones. Pollination of madrone flowers is an important step towards the production of fruits and seeds.

Fruit utilization by frugivores. Fruits of the Pacific madrone are fleshy and indehiscent (Snow and Snow 1988). When ripe, these berries are ~8–12 mm in diameter with dry mealy flesh enclosed in a thin rough skin. Within each berry is a thin walled stone that contains about 20 dark brown seeds. Immature fruits are light green or yellow-green in color but turn red or bright orange-red when ripe. Fruits usually begin to ripen in September or October and continue until December. Most trees bear fruit at 3–5 years (Peattie 1953, Roy 1974 and McDonald and Tappeiner 1991).

Seeds of the fruits are dispersed by birds either by regurgitation or defecation. Birds that eat madrone berries include the band-tailed pigeon (*Columba fasciata*), varied thrush (*Ixoreus naevius*), American robin (*Turdus migratorius*), house finch (*Carpodacus mexicanus*), Northern flicker (*Colaptes auratus*), Steller's jay (*Cyanocitta stelleri*), cedar waxwing (*Bombycilla cedrorum*), Bewick's wren (*Thryomanes bewickii*), mourning dove (*Zenaida macroura*) and yellow-breasted chat (*Icteria virens*) (Arno 1977, Bauer 1984, Raphael 1987, McDonald and Tappeiner 1991, McDonald 1992 and P. Rose personal communication); all but the latter 2 birds are native to Seattle. In addition, Raphael (1987) and Hagar (1960) found that varied thrushes and American robins are more numerous in winters of heavy berry production and that these birds foraged heavily on madrone berries in those years. Martin, *et al*. (1951) reported Pacific madrone ranks among the top 30 food providers of all woody plants in the Pacific region.

Some frugivores are seed predators—that is they digest seeds of fruits they eat and do not aid in seed dispersal (Snow 1988). It is not known whether any of the frugivores that consume madrone berries are seed predators. There are conflicting reports on annual crop size. Some state that madrone trees produce good fruit crops almost every year (Roy 1974 and Arno 1977), whereas another study found that crop size decreased for a study period of 10 years (McDonald and Tappeiner 1991).

Birds require different nutrients and nutrient levels according to the species type, the age of the individual and the time of year (Poddar and Lederer 1982). Breeding females and growing nestlings need large amounts of protein, whereas migrating and wintering adults feed on high quantities of sugars in order to increase their fat reserves (Kear 1966 and Scott 1973). Fall fruits usually have low sugar content and variable water content (Cipollini and Stiles 1992). If this is true for madrones, they may be a less than optimal nutrient source for migratory birds (although several frugivorous birds listed above are migratory).

In general, the relationship between fruit bearing trees and frugivores is mutually beneficial. Fruits are a source of food for frugivores. The size of the fruit crop may determine the number of frugivores that are attracted to madrones (Hagar 1960 and Raphael 1987). In this case nutrient content and the effect of nutrients on palatability may determine the fruits' significance as a source of food for birds.Best (1981) developed an alternative approach to the ecology of fruit dispersal that may be useful for studying Pacific madrone. She proposed that fruit removal rate is a function of probability of encounter and accessibility as well as palatability. These 3 variables are considered interactive factors depending on characteristics of fruit, plant and individual frugivore. She also did nutritional analyses of madrone berries. Madrone fruits are high in carbohydrates (41.8% dry weight) but low in fat (1.48%) and nitrogen (0.28%). Fruit toxicity is low.

The seeds of Pacific madrone are too heavy for wind dispersal (430–700 seeds per gram) (Roy 1974 and Hughes, *et al*. 1994). Most fleshy fruits are adapted for dispersal by birds, and it seems frugivorous birds (and mammals) play a major role in madrone seed dispersal (Arno 1977 and McDonald and Tappeiner 1991). The advantages of seed dispersal are many. Dispersal reduces competition with other plants that require similar nutrient levels, and it also provides seeds an opportunity to colonize other potential sites (Dirzo and Dominguez 1986). In addition, it provides an escape from existing seed predation and disease (Stiles and White 1986).

DISCUSSION

Madrones in Magnolia provide potential habitat for nesting birds (Table 4-1). Our sample size is small, but nevertheless the proportion of trees with cavity nests found in our study is similar to that of Raphael's study (1987) that had a larger sample size. In Magnolia, crows' nests are often found in madrone. Although crows are considered a nuisance by some, their nests are important to other wildlife.

Little is known about madrone fruit crop production. Is the quantity of fruits produced dependent on the type of pollinator species, on the amount of living crown (McDonald and Tappeiner 1991) or on annual variations in weather? We cannot answer these questions because we found no information on the causes of variation in fruit production by madrone.

Pacific madrone berries ripen in the fall. Many people have observed numerous bird species using the Pacific madrone in the fall when other food sources are scarce. As madrone stands are removed for commercial purposes, madrone-dependent frugivore populations may also decline. Seed dispersal resulting from frugivore use of madrone is beneficial to the future success of tree establishment. This process may be more complex than the advantages usually associated with seed dispersal (*e.g.*, increase in genetic heterogeneity and escape from predators and disease). For instance, Chappell (this volume) notes there is a decrease in the band-tailed pigeon population in the Northwest. If band-tailed pigeons disperse madrone seeds, then their decline will have serious implications for tree regeneration. Such positive feedback would accelerate the decline of this pigeon.Interactive models of fruit ecology can be applied to madrones and the importance of intrinsic factors determined (*cf.*, Figure 5 of Best 1981).

Ericaceous species that produce berries late in the season often have more antifungal compounds than ericads that produce berries earlier in the season (Cipollini and Stiles 1992). There may be a connection between the lack of such compounds and fungal infections of older trees. Perhaps a good area for research would be to test madrone berries for the presence of antifungal compounds and determine whether these compounds protect young seedlings from disease.

Foresters managing madrones in urban environments should consider the habitat potential of a site when developing policy. For example, managers may want to limit removal of mature madrone from urban areas, including dead or sick trees. In this study, only living trees were considered, but Raphael (1987) found that 8 of 17 madrone trees with cavity nests were dead. These data indicate that dead trees, too, are potential habitat for cavity nests. The future success of the Pacific madrone depends on good management based on reliable information.

ACKNOWLEDGEMENTS

Thanks to B. Crooks, E. Hunn, N. Kroening, A. Kruckeberg, B. Meeuse, P. Rose and E. Stiles for interviews and comments.

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