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Proportions of bird damage in tree fruits are higher in low-fruit-abundance contexts

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ABSTRACT

Frugivorous birds impose significant costs on tree fruit growers through direct consumption of fruit and grower efforts to manage birds. We documented factors that influenced tree fruit bird damage from 2012 through 2014 with a coordinated field study in Michigan, New York, and Washington. For sweet cherries, percent bird damage was higher in 2012 compared to 2013 and 2014, in Michigan and New York compared to Washington, and in blocks with more edges adjacent to non-sweet cherry land-cover types. These patterns appeared to be associated with fruit abundance patterns; 2012 was a particularly low-yield year for tree fruits in Michigan and New York and percent bird damage was high. In addition, percent bird damage to sweet and tart cherries in Michigan was higher in landscapes with low to moderate forest cover compared to higher forest cover landscapes. 'Honeycrisp' apple blocks under utility wires were marginally more likely to have greater bird damage compared to blocks without wires. We recommend growers prepare bird management plans that consider the spatial distribution of fruit and non-fruit areas of the farm. Growers should generally expect to invest more in bird management in low-yield years, in blocks isolated from other blocks of the same crop, and in blocks where trees can provide entry to the crop for frugivorous birds.

1. Introduction

Increasing fruit and vegetable consumption is a goal of the World Health Organization (2010) because of the strong positive effects of fruits and vegetables on human health (Lock et al., 2005). U.S. per capita consumption of non-citrus fruits increased approximately 35% from 1976 through 2012 (USDA ERS, 2013). Fruit production is also a critical component of the global economy; the top five cherry-growing nations produced a collective yield valued at more than one and a half billion dollars in 2011 (FAOSTAT, 2011).

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Thus, increasing fruit production has both social and economic benefits.

Birds damage and consume numerous cultivated fruits (Tobin et al., 1991; Avery et al., 1992; Curtis et al., 1994; Tracey and Saunders, 2010; Lindell et al., 2012). Fruit growers from Michigan, New York, Oregon, California, and Washington estimated that bird damage to sweet cherries in 2011 was between 4.8 and 31.4%, to tart cherries between 3.0 and 26.7% and to 'Honeycrisp' apples between 0.4 and 7.4% (Anderson et al., 2013). Birds pose unique management challenges because of their high mobility (Bomford and O'Brien, 1990; Linz et al., 2011). This mobility means that spatial context is likely to influence levels of bird damage to fruit crops. Despite increasing awareness of the importance of spatial context to agricultural systems (Robertson et al., 2007), few studies have systematically investigated spatial effects on bird damage to fruit crops (Johnson et al., 1989).

Two spatial scales likely to be important are the farm scale, which we consider, roughly, as fractions of hectares, and the landscape scale, which we consider to be hectares. Different mechanisms may drive bird damage effects on these different scales. On the farm scale (Ries and Sisk, 2004), fruit blocks and adjacent areas that are not fruit may provide complementary resources, for example, food in one and nest sites in the other. Fruit blocks may be particularly susceptible to damage if they are adjacent to woody vegetation, which may provide cover from predators, and nesting and/or roosting sites. Johnson et al. (1989) suggested that higher bird damage in grapefruit groves close to sugarcane fields was a result of the sugarcane providing roost sites for great-tailed grackles (*Quiscalus mexicanus*), the species causing the majority of grapefruit damage. Similarly, sunflower fields near cattail marshes that provided roosting habitat for blackbirds suffered higher bird damage than those fields not adjacent to marshes (Otis and Kilburn, 1988). We refer to these farm-scale spatial effects as edge effects hereafter.

On the landscape scale, percent bird damage to fruit may be greater in areas with overall low fruit abundance. For example, grapefruit groves farther from other groves had higher bird damage than those close to other groves (Johnson et al., 1989). Additionally, fruit blocks in landscapes with alternative and supplemental food for frugivorous birds may be at higher risk for bird damage. For example, farms with grain or corn silage may provide food for species like European starlings (*Sturnus vulgaris*), which also eat fruit, thus contributing to higher starling population sizes and more fruit damage.

Apart from spatial context, areas that have resources important to birds may be at higher risk for bird damage. For example, fields with overhead utility wires that provide perches may experience greater damage than adjacent blocks without wires.

Our specific objective was to quantify the influence of environmental characteristics on bird damage in several tree fruit crops in three important fruit-growing states of the U.S. Identifying factors at the farm and landscape scales that influence levels of bird damage can provide a basis for making recommendations to fruit growers about the vulnerability to bird damage of areas with particular features. This information can aid in orchard site selection, farmland use, and selection of bird management strategies. Extension personnel and regional planning agencies also can use the information as a basis for land-use recommendations at a larger spatial scale than individual farms.

2. Methods

2.1. Study regions

The study was conducted from 2012 through 2014 in important production regions for sweet cherries (*Prunus avium*), tart cherries (*Prunus cerasus*), and 'Honeycrisp' apples (*Malus x domestica*). Sweet cherries were sampled in the northwestern Michigan counties of Leelanau, Antrim, and Grand Traverse, the New York counties of Niagara, Orleans, Monroe, Wayne, Oswego, and Tompkins, and the Washington counties of Franklin, Walla Walla, Yakima, Chelan, and Douglas. Tart cherry sampling took place only in Leelanau County in northwestern Michigan. 'Honeycrisp' sampling took place in the northwestern Michigan counties of Leelanau, Antrim, Grand Traverse, and Benzie, the New York counties of Niagara, Orleans, Wayne, Oswego, Tioga, and Tompkins, and the Washington counties of Whatcom, Skagit, Franklin, Walla Walla, Yakima, Okanogan and Douglas.

2.2. Block selection

We defined a block as a contiguous area of one crop, with boundaries delimited by other land-cover types at least 5 m wide. For example, orchard roads at least 5 m wide often comprised block boundaries. We approached fruit growers in each state to gain access to commercial orchards to conduct sampling of bird damage. We used one apple block at a university horticultural research station.

2.3. Sampling bird damage within blocks

To measure bird damage within blocks, and to quantify potential differences in damage between edges and interiors of blocks, we followed the method of Tracey and Saunders (2010) where blocks were divided into four edge strata and one interior stratum. Within a block, edge strata were two rows wide with the interior stratum comprising all other rows.

2.4. Plant selection

We sampled up to 12 plants per stratum. Within each stratum, we randomly selected a starting plant and then systematically chose 11 more plants to provide approximately even coverage of the stratum. For example, if we randomly selected the 4th plant from the southeast corner as the starting plant for a stratum and the stratum contained 103 plants in total, we sampled every 9th plant so that the 11 remaining sample trees were from all areas of the stratum.

2.5. Branch selection

For each plant, we randomly selected a branch by choosing random numbers to delineate the horizontal and vertical components of the branch location. For the horizontal component we randomly selected one of the eight half-winds of the compass rose (NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW). For the vertical component, we measured the height of the tree and randomly selected a number, based on the number of 0.5-m intervals between the base of the plant's foliage and the height of the tree. We sampled the branch closest to the randomly selected half-wind and height.

2.6. Sweet and tart cherry sampling

On the selected branch, we located the terminal tip of woody growth and followed the branch 1 m back toward the trunk. We counted all intact cherries, missing cherries, and damaged cherries on the 1-m-section of the branch. We identified missing cherries by fresh pedicels, grown in the year of sampling, without fruit. We disregarded desiccated pedicels from previous years. For selected