# Wisconsin's Red Crossbill Irruption of 2017–18: Distribution, Abundance, and Breeding Behavior of Multiple Call Types

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## ABSTRACT

Red Crossbills staged a major flight into Wisconsin from late summer 2017 to early summer 2018 as part of a significant irruption to eastern North America. At least six "call types" were documented with audio recordings, most stemming from the West and including first state records of Types 1, 4, and 5. Type 2 was most common, followed by Type 4 and then Type 3, while Types 1, 5, and 10 were rare, the latter surprisingly so given its previously known occurrence as a breeding type here most years. Crossbills were most common across the north woods and predominately associated with pine tree species statewide. Most arrived in late summer and fall, nested from mid-winter through spring, and departed by mid-summer. Breeding activity peaked from early February through May 2018 and was documented in Types 2, 3, 4, and 10, the confirmations of Types 3 and 4 marking firsts for the state. Thirteen nests were also found, which more than doubled the five previously reported here. Our findings provide an important benchmark for comparison of future irruptions into Wisconsin and significantly advance the knowledge of Red Crossbills and their call types in the Great Lakes region.

#### INTRODUCTION

Red Crossbill (Loxia curvirostra) is an enigmatic finch species that in North America inhabits boreal and boreal hardwood transition forests from Alaska to Newfoundland, as well as montane coniferous forests of the Appalachians, Pacific Northwest, and interior western United States as far south as Central America (Benkman and Young 2019). Its reliance on conifer seeds for food coupled with the variable nature of cone production throughout its range lead to a nomadic lifestyle in search of adequate cone crops for survival and reproduction (Benkman and Young 2019). In some years, the extent of crop failure is great enough to result in irruptive movements of large numbers of crossbills outside their core ranges (Benkman and Young 2019).

Beyond their atypical movement patterns, Red Crossbills have become increasingly known for their biological and ecological diversity. In particular,

as many as ten "call types" are now recognized in North America, with each type of crossbill giving a unique, identifiable call when in flight (Groth 1993, 1998; Benkman and Young 2019). The crossbill types have also been shown to correspond with slight differences in morphology, genetics, and ecological associations (Benkman 1993, Groth 1993, Parchman et al. 2006). These differences, combined with some evidence of reproductive isolation (Benkman et al. 2009, Benkman and Young 2019) suggest some types may even represent different species (Parchman et al. 2006). Indeed, "Type 9" of Idaho's South Hills was recently elevated to species level as Cassia Crossbill (Loxia sinesciurus; Benkman et al. 2009).

In Wisconsin, Red Crossbills occur annually and year-round in varying numbers, typically where conifers are present. In most years they are uncommon both as residents and breeders, their primary haunts lying within or adjacent to the state's sandy, pine-dominated outwash plains like those found in the Northwest Sands, Northeast Sands, and Northern Highland ecological landscapes (Bartelt et al. 2015). However, periodic irruptions may bring high numbers at various times of year, especially to conifer-rich forests of northern and central Wisconsin (Robbins 1991). In turn, sufficient cone crops may allow opportunistic breeding during several months of the year, with the majority of nesting taking place in two periods: January-April and again July-September (Benkman and Young 2019).

Prior to 2017, only three call types of Red Crossbill had been documented in Wisconsin, including Type 2 (Ponderosa Pine Crossbill), Type 3 (Western Hemlock Crossbill), and Type 10 (Sitka Spruce Crossbill; eBird 2019). Types 2 and 10 have occurred most regularly, perhaps in most years, and been documented as breeding. Type 3 was not known to nest here but has irrupted into Wisconsin periodically from the far west, most notably during a significant flight in 2012–2013 (Domagalski 2013a, eBird 2019, Benkman and Young 2019).

A major irruption of Red Crossbills into most of Wisconsin and other parts of eastern North America began in July 2017 and continued until August 2018. Owing to increased awareness and knowledge of call types, improved recording technology of cell phones and digital cameras, and growing popularity of the eBird platform, this flight became the most thoroughly documented in both state and continental history. Here we characterize the irruption from a Wisconsin perspective, including the occurrence, distribution, relative abundance, breeding behavior, and habitat associations of multiple call types, including several not previously recorded in the state.

#### METHODS

Identification of Red Crossbill call types requires assessment of flight calls and cannot be achieved via songs, secondary calls, or visual cues (e.g. photographs; Young and Spahr 2017, Benkman and Young 2019). While some experts can differentiate types in the field by ear alone, the primary and preferred identification method is an audiospectrographic analysis of sound recordings taken at the time of field observation. The resulting spectrograms provide visual signatures unique to each call type (Figure 1).

During the 2017-18 irruption in Wis-

consin and elsewhere, observers made field recordings with cell phones, digital cameras, and other handheld recording devices. Audio recordings were sent to crossbill experts coauthor Young and Tim Spahr at the Cornell Lab of Ornithology for type assessment. Following identification, observers uploaded recordings as sound files to the eBird database, which allows for reporting of observations as a specific call type and thus made it possible to assess patterns in distribution, phenology, and relative abundance of the various types. Type-level observations without recordings were generally not validated by eBird data quality reviewers unless they involved a very experienced observer, non-rare type, and area of known or expected occurrence.

Throughout the irruption we developed and distributed several online communication pieces, such as eBird articles, social media posts, and direct one-on-one appeals, to raise awareness, garner interest, and educate birders about the opportunity to obtain field recordings and learn more about Red Crossbill call types in Wisconsin. Given the ease of making recordings with phones and cameras, these efforts were effective at improving data collection across the state.

Furthermore, this crossbill irruption also occurred during the data collection period of Wisconsin Breeding Bird Atlas II (WBBA II). The data collected for that effort, recorded in a dedicated eBird portal, included observations of courtship and nesting activities in addition to typical eBird observations of presence and numbers.

References to locations in this article refer to Wisconsin counties unless otherwise specified.

#### RESULTS

### Irruption Phenology

July 2017 provided the first signs of increased numbers of Red Crossbills in Wisconsin as 18 eBird observations more than doubled the 8 and 7 of May and June, respectively. August brought an uptick to the state and region, especially in the latter half of the month (Figure 2). When coauthor Brady detected three different call types in a single flock on August 20, including two state firsts of western origin, it was clear that a significant irruption event was underway.

September saw only a modest influx before the flood gates opened in mid-October and remained so through November into mid-December (Figure 2). Christmas Bird Count season yielded 671 birds in 26 count circles compared to an average of 78 birds in 7 count circles over the previous three years (National Audubon Society 2019). By January 2018, any influx of new birds was less apparent, although crossbills had settled into Wisconsin's coniferous habitats and were now unusually common and widespread.

Breeding activities commenced in earnest by mid-January with courtship, followed by nest-building as early as mid-February, and fledged young by early April. (See below for details on breeding activity.) Spring and early summer featured family groups and lingering adults through June. July saw a marked decline in observations statewide before birds became notably scarce by mid-August 2018 and thereafter (Figure 2).

## Call Types

From July 2017 to August 2018, 1,716 observations of Red Crossbills repre-



senting 11,130 birds (not necessarily unique individuals) were reported to eBird from 59 Wisconsin counties. This compares to 124 observations of 514 birds in 32 counties; 164 observations of 1266 birds in 33 counties; and 157 observations of 722 birds in 19 counties during each of the three previous, nonirruption years (July-August 2016-2017, 2015-2016, and 2014-2015, respectively [eBird 2019]). Among the 2017–18 irruption observations, 688 (40%) were identified to a specific call type. These included 17 Type 1 (Appalachian Crossbill), 348 Type 2 (Ponderosa Pine Crossbill), 82 Type 3 (Western Hemlock Crossbill), 197 Type 4 (Douglas-fir Crossbill), 11 Type 5 (Lodgepole Pine Crossbill), and 33 Type 10 (Sitka Spruce Crossbill) (Table

1). The observations of Types 1, 4, and 5 represent first state records for Wisconsin. More details are provided in the following accounts.

# Type 1 (Appalachian Crossbill; Groth 1988, Young et al. 2011)

As its name suggests, this type is primarily found throughout the Appalachian Mountains, and occasionally elsewhere in the eastern U.S. and Canada. It also occurs regularly but rarely as far west as the Pacific Coast. The Type 1 flight call is sharp, descending, and reminiscent of American Goldfinch (*Spinus tristis*; Figure 1; call note descriptions from Young and Spahr 2017, Pieplow 2017, or our own impressions). Prior to the 2017–18 ir-

Type 1 (ML89722731, Douglas Co., 3/13/2018): Short, descending, and sharp *chit* resembling flight call of American Goldfinch. Spectrogram is nearly straight or slightly curved, sometimes preceded by a short rising (upward) hook on the left side, and always falls off faster than Type 2 (<0.04 sec).

Type 2 unkinked (ML90188351, Bayfield Co., 3/17/2018): A simple, hearty *choop*. Spectrogram descends as in Type 1 but less quickly (i.e. taking more horizontal distance, >0.04 sec) and often shows a slight S-curve (vertical, then angled right, then vertical). Separating this type from Type 1 is difficult and typically requires assessment of flight call details at finer scales than displayed by ML spectrograms.

Type 2 kinked (ML89076471, Bayfield Co., 3/9/2018): A hearty, low-pitched *choop*. Spectrographically, the midpoint curve rises in frequency, sometimes enough to yield the shape of a lowercase "n", but does not exceed 4–4.25 kHz.

Type 3 (ML87817191, Bayfield Co., 2/27/2018): Similar to Type 2 but scratchier and higher pitched. Spectrogram peaks around 4.5–6 kHz, producing a hump that often looks like a compressed lowercase "n" with two long legs.

Type 4 (ML81236401, Bayfield Co., 1/6/2018): A distinctive bouncing *pwit*. Spectrogram is forked with obvious Y-shape, the highest frequency often reaching 6 kHz.

Type 5 (ML82687781, Bayfield Co., 1/20/2018): Flight call a jangly *cheet* consisting of two distinct polyphonic elements given in rapid succession. Very distinctive on the spectrogram, with 2-parted notes that generally do not connect and range from 2.5–5.5 kHz.

Type 10 eastern (ML89997101, Bayfield Co., 3/15/2018): A hard *jit*, husky and not obviously rising. Spectrogram initially rises as in "western" Type 10 but then shows a downward, nearly vertical tail. Peak is at or over 4 kHz. May actually be Type 7 (see text).

Type 10 western (ML81230581, Bayfield Co., 1/6/2018): A quick rising *whit* like the call note of Least Flycatcher (*Empidonax minimus*) but harder and more musical. Spectrogram like a reversed image of unkinked Type 2 except higher with the curve of the shape at or over 4 kHz and the top reaching about 5.5 kHz.

Figure 1 (left). Examples of Red Crossbill flight calls by type. All recordings were made by the authors in Wisconsin during the 2017–18 irruption. Spectrograms are courtesy of the Macaulay Library (ML) at the Cornell Lab of Ornithology. For each spectrogram, the vertical scale is 0–10 kHz and the horizontal scale spans just over one second. Descriptions follow Pieplow (2017), Young and Spahr (2017), and/or the authors' experience.



Figure 2. Phenological occurrence of Red Crossbill call types during the 2017–18 irruption. Each gray dot represents a crossbill observation reported to eBird (n = 1,716), and dots are jittered vertically to better show overlapping observations. On boxplots for each type, the thick black line indicates the median date, while the left and right sides of the box indicate 25th and 75th percentile dates, respectively. Open circles indicate potential outliers based on the distribution of observation dates.

Call type	# observations	# counties	First date observed	Last date observed	# probable or confirmed breeding records	# nests found	Previously- recorded status in WI	
1	17	4	12-Feb-18	19-Jun-18	0	0	Unrecorded	
2	348	29	9-Jul-17	14-Aug-18	93	8	Common	
3	82	11	21-Aug-17	26-Aug-18	3	1	Uncommon	
4	197	20	20-Aug-17	24-Jul-18	26	0	Unrecorded	
5	11	4	20-Aug-17	20-Jun-18	0	0	Unrecorded	
East 10	12	6	20-Aug-17	9-Aug-18	1	0	Common	
West 10	14	3	12-Nov-17	7-Aug-18	0	0	Uncommon	
Unknown 10	) 7	2	31-Jan-18	7-May-18	0	0	Common	
Not typed	1028	56	11-Aug-17	7-Aug-18	168	4		

Table 1. Summary of Red Crossbill observations and breeding activity by call type in Wisconsin during the 2017–18 irruption.

ruption, this type was unknown from Wisconsin.

Wisconsin's first Type 1 Red Crossbill was recorded by Brian McCaffery in Bayfield County on 12 February 2018. February and March produced an impressive 8 additional records, all from Bayfield and Douglas in the northwest corner of the state. Six more records were established from April to June, including from Eau Claire and Burnett, until the last in Bayfield on 19 June 2018 (Table 1; Figure 3).

Type 1 occurred primarily across the Northwest Sands and North Central Forest ecological landscapes (ELs) with one record in the Western Coulees and Ridges EL. The small sample size and flyover nature of detection make it difficult to assess tree types preferred for foraging, and sites with sightings were characterized by a wide diversity of conifer species ranging from lowland tamarack (Larix laricina) and spruce (Picea glauca and P. mariana) to upland red (Pinus resinosa) and jack pine (P. banksiana). Fourteen of 17 eBird checklists with Type 1 also included Type 2, while eight included Type 4, two included Type 5, and six included Type 3,

although the extent of association among types cannot be extrapolated from these data.

No probable (pairs, courtship displays, etc.) or confirmed (nest building, fledged young, etc.) breeding behaviors were observed for this type. In fact, only 3 of 17 checklists presumed more than one individual.

## Type 2 (Ponderosa Pine Crossbill; Groth 1988, Groth 1993)

Although most common in the ponderosa pine (P. ponderosa) forests from the Rockies westward, Type 2 is the most widespread call type in North America (Groth 1993), occurring in the East annually and Wisconsin most years including somewhat regular breeding activity here. Its flight call is generally a hearty, husky choop (Figure 1). However, Type 2 Red Crossbills from the West tend to produce a "kinked" spectrogram more similar to Type 3, while the sound tends to be "unkinked" and more like Type 1 in birds from the East (Figure 1; Benkman and Young 2019).

This irruption's first Type 2 Red Crossbills were recorded on 9 July 2017.



Figure 3. Distribution of Type 1 (Appalachian) and Type 5 (Lodgepole Pine) Red Crossbills recorded in Wisconsin during the 2017–18 irruption (n = 17 and 11, respectively).

Small numbers were found through early September (Figure 2), mostly in northwestern Wisconsin. Late October and November saw larger and more frequent flocks east to Lake Michigan and as far south as Kenosha. Flock sizes in the dozens were common in some prime locations by December, and high numbers of 50+ per site remained through winter, spring, and even the early summer post-breeding period. However, with exception of southeast Wisconsin's Kettle Moraine State Forest, nearly all records from March 2018 onward came from the northern third of the state. The last Type 2 record came from Price County on 14 August 2018.

This ultimately proved to be the most abundant call type in this irruption, with 348 observations from 29 counties (Table 1; Figure 4). Anecdotally (because we did not attempt to quantify here), the majority of these appeared to be "kinked" Type 2 of probable western origin.

Type 2 also showed the widest variation in habitat use, occurring in 10 ELs, but they were especially common in landscapes dominated by red and jack pine on sandy soils. Red pine was the most commonly noted conifer used for foraging. This call type was frequently recorded (n = 122) on the same eBird checklists as Type 4 and occasionally with all other types. Mixed flocks of



Figure 4. Distribution of Type 2 (Ponderosa Pine) Red Crossbill recorded in Wisconsin during the 2017-18 irruption (n = 348).

multiple call types were less common during breeding season than fall, winter, or summer. Breeding activity was common and widespread in this call type (see details below).

# Type 3 (Western Hemlock Crossbill; Groth 1993)

The core area of occurrence for Type 3 is northern coastal regions of western North America, although it is highly irruptive every 2–5 years east to the Great Lakes and Atlantic Coast. Its flight call is squeakier, scratchier, and higherpitched than the similar Type 2 (Figure 1). Wisconsin previously had dozens of records of this type stemming from a large irruption in 2012–13 and smaller flight in 2015–16.

With 82 observations from 11 counties, Type 3 was the third most common call type recorded here during the



Figure 5. Distribution of Type 3 (Western Hemlock) Red Crossbill recorded in Wisconsin during the 2017-18 irruption (n = 82).

2017–18 irruption (Table 1; Figure 5). Following the first in Wood County on 21 August 2017, 19 observations were tallied by 1 January, all occurring in far northwest Wisconsin and none including more than 14 birds. Small, scattered flocks continued through winter, with a slight rise in detections during March and April (Figure 2), including the only two additional records outside of the north woods (Waupaca and Fond du Lac). After a handful of observations up to a dozen birds in May and June, none were found in July and the only August observation was the irruption's last on 26 August 2018 in Bayfield.

Type 3 was found mostly in the North Central Forest, Northwest Sands, and Superior Coastal Plain ELs. Four or fewer records occurred in the Northeast Sands, Southeast Glacial Plain, Northern Highland, and Forest Transition ELs. Consistent with its preference for soft-coned conifers suitable for its



Figure 6. Distribution of Type 4 (Douglas-fir) Red Crossbill recorded in Wisconsin during the 2017-18 irruption (n = 197).

smaller bill, this type was less frequently found in areas of red and jack pine and more often occurred where white pine (*P. strobus*) and spruce were prominent. Foraging observations were limited. Notably, none were reported as feeding in Eastern hemlock (*Tsuga canadensis*), which is generally scarce in the northwestern counties where this species was most frequently recorded. We are also unaware of any hemlock-associated observations of Type 3 crossbills where hemlock grows more commonly in northeastern Wisconsin.

Type 3 regularly occurred on the same eBird checklists as Types 2 and 4, and occasionally with the rarer types. The only confirmed breeding activity was an active nest found by coauthor Brady on 25 March 2018, the state's first and only documented breeding record for this type.

# Type 4 (Douglas-fir Crossbill; Groth 1993)

Type 4 is another western call type whose core range lies in the Pacific Northwest.

Records in the eastern U.S. have been rare but its true status may be somewhat confounded by confusion with Type 10, which was not described until 2010 (Irwin 2010). Wisconsin had no confirmed records of Type 4 before 2017. The flight call is a bouncy *pwit* that rapidly falls then rises in pitch, the latter half resembling that of Type 10 (Figure 1).

Surprisingly, Type 4 was the second most common call type found in Wisconsin during the 2017-18 irruption, with 197 observations across 20 counties (Table 1; Figure 6). The first state record was established by coauthor Brady in Bayfield on 20 August 2017, followed by observations there and in Waukesha, Wood, and Rusk through September, the latter including an impressive flock of 27 birds on 2 September. While most eBird checklists involved less than 15 birds, some involved 20-25 birds and three checklists from 16 November to 19 December reported 35–60 birds. This call type was regularly detected through June 2018 (Figure 2), although only a few observations after mid-March came outside of northwest Wisconsin, where the last was recorded on 24 July 2018 in Ashland.

Type 4 was found in 10 ELs similar to Type 2 and was noted among various conifer types, such as alongside Type 2 in red and jack pines or with Type 3 amid areas featuring more spruce and balsam fir (*Abies balsamea*). Landscapes with a significant component of white pine were most likely to host this type. Type 4 was seen foraging in red, jack, and white pines, frequently in the company of Type 2, although not necessarily in closely associating flocks. Seven breeding confirmations were not only the first ever documented in the state (see details below) but also anywhere from the Great Plains eastward (Benkman and Young 2019).

## Type 5 (Lodgepole Pine Crossbill; Groth 1993)

Type 5 is typically found across western North America, especially the central Rockies and other portions of the Intermountain West. It rarely irrupts eastward into the Great Plains but had been recorded only once east of the Mississippi River in New York state (Young 2010) prior to the 2017–18 irruption. Its flight call is a twangy *cheet* consisting of two distinct elements given in rapid succession (Figure 1).

Coauthor Brady recorded Wisconsin's first Type 5 Red Crossbill in Bayfield on 20 August 2017, a single individual within a flock of Type 4 and Type 10 moving west to east overhead. No additional records were established until 20 January 2018 (Figure 2), when he recorded two individuals again in Bayfield. February through early April produced seven more records, all consisting of one or two birds in Bayfield and Douglas. Two individuals recorded in Eau Claire on 25 April 2018 were exceptional, as was a flock of five birds in Ashland on 20 June, the eleventh and final record of the irruption (Table 1; Figure 3).

Type 5 was rare and occurred primarily in the Northwest Sands and North Central Forest ELs, in addition to one record in each of the Western Coulees and Ridges and Superior Coastal Plain ELs. Red pine was a common denomi-



Figure 7. Distribution of Type 10 (Sitka Spruce) Red Crossbill recorded in Wisconsin during the 2017–18 irruption (n = 33). Fourteen observations fit the "western" form, 12 the "eastern" form, and seven could not be distinguished (see text for details).

nator across nearly all observations, although no eBird checklists noted foraging activity (e.g., coauthor Brady's six records all represented flyovers). This type was documented in the same recordings as Types 1, 2, 4, and 10 and on some checklists also containing Type 3.

No Type 5 breeding activity was confirmed. However, two observations lend intrigue to the possibility. First, Peder Svingen's recording of a Type 5 (and no other types) from Douglas on 3 March 2018 included "chittoo" calls of begging juvenile crossbills. No juveniles or suspicious adult breeding behaviors were observed in the field, however, and the birds could not be relocated. Second, coauthor Brady's observation in Ashland on 20 June 2018 involved a flock of five birds and no other types, suggesting but not confirming a potential family group with fledged young.

# Type 10 (Sitka Spruce Crossbill; Irwin 2010)

Type 10, as currently understood, has two distinct forms. The classic "western" form has a quick, rising *whit* flight call and core zone of occurrence in the Pacific Northwest (Irwin 2010). The "eastern" form, principally found from the Great Lakes to the Atlantic coast, sounds huskier and shows a downward tail in the spectrogram (Figure 1), in both regards strongly resembling the poorly known Type 7 (Young and Spahr 2017). In fact, "eastern" Type 10 may be Type 7 (Benkman and Young 2019) but much work remains to definitively reach that conclusion-one that contradicts Groth's (1993) assertion that

Type 7 is a western type—and is beyond the scope of this paper. Nonetheless, Wisconsin had records of both forms prior to this irruption, including "eastern" Type 10 in most years.

Overall, Type 10 was surprisingly scarce during this irruption as only 33 observations were made, all but a lone Langlade County recording occurring in far northwestern counties from Burnett to Bayfield to Iron (Table 1; Figure 7). The first Type 10 was detected on 20 August 2017, but this was followed by only two additional records in 2017, both in Bayfield from 12 November to 1 December. January through April 2018 produced 13 records, again all from Bayfield. After two May records, June through August furnished 13 records ending 9 August 2018. No eBird checklist indicated more than 10 birds of this call type.

The total of 33 observations were comprised of 14 spectrograms fitting the "western" form and 12 the "eastern" form, while 7 could not be confidently distinguished (Table 1). "Eastern" Type 10 was tallied only twice from 20 August 2017 through 4 June 2018, and then much more frequently 13 June to 9 August 2018 (Figure 2). Meanwhile, "western" Type 10 showed a different trend, occurring more prominently from November 2017 to early June 2018 (Figure 2). The only "western" Type 10 records after early June were from the same Bayfield site on 26 June and 7 August.

"Eastern" Type 10 was found in 4 ELs, including primarily the North Central Forest and Superior Coastal Plain, whereas "western" Type 10 was found in 3 ELs, especially the Northwest Sands. Interestingly, "western" Type 10 was more often found with Types 2 and 4 at dry sites dominated by red and jack pine, while "eastern" Type 10 tended to occur at mesic or wet sites with more conifer diversity typically consisting of spruce, fir, tamarack, and perhaps white or red pine. However, this relationship may have been influenced by the primary season of occurrence for each, i.e. summer for "eastern" and winter/spring for "western" Type 10, and seasonal differences in seed availability among conifer species (Benkman and Young 2019). Foraging observations were too few to characterize tree species preferences.

Only two checklists included "eastern" and "western" forms together. Types 1–5 all occurred at some point on checklists with Type 10. For example, coauthor Brady noted two "eastern" Type 10 with two Type 2 and five Type 4 birds foraging together at tamarack cones in Sawyer County on 13 June 2018. The only confirmed breeding activity for this type was a family group of adults and juveniles recorded in Burnett on 5 July 2018. The spectrogram matched the "eastern" form.

## ADDITIONAL NOTES ON BREEDING

Wisconsin birders documented, as part of the WBBA II effort, 291 probable or confirmed records of breeding Red Crossbills from 31 counties primarily in the state's northern quarter (Figure 8). The most commonly observed behaviors that "confirmed" breeding were FL-Fledged Young (63 records), CN-Carrying Nest Material (23), FY-Feeding Young (11), NB-Nest Building (9), and ON-Occupied Nest (6). "Probable" breeding was established primarily through P-Pairs (110 records) and C-Courtship display/copulation (50), the latter including copulation events, male flight song displays, and male-fe-





Figure 8. Levels of breeding activity detected for all Red Crossbill call types in Wisconsin during the 2017–18 irruption. Categories follow protocols of Wisconsin Breeding Bird Atlas II.

male feeding or billing interactions (Benkman and Young 2019).

**Breeding Phenology.** Except for three outlying records from 9 July to 11 August 2017 that were likely unrelated to this irruption event (due to their disjunct, early timing), no breeding behaviors were observed until the first singing male was reported on 25 November. Singing became moderately more prevalent in males throughout

December into early January. On 2 December, B. McCaffery noted the first courtship behavior in Bayfield when a male sang to an adjacent female and the pair gently billed. McCaffery also reported the first male flight displays on 19 December, and pairs, territorial chases and flight songs on 22 December. However, crossbills at other sites around the same time showed no breeding behaviors suggesting that activity was sporadic at this time, a pattern



# Red Crossbill

#### Date (Month/Day)

Figure 9. Chronology of breeding activity by evidence code for all Red Crossbill call types in Wisconsin during the 2017–18 irruption. Breeding codes follow protocols of Wisconsin Breeding Bird Atlas II. Confirmed codes include PE = Physiological Evidence; FL = Recently Fledged Young; FY = Feeding Young; NY = Nest with Young; ON = Occupied Nest; NB = Nest Building; and CN = Carrying Nesting Material. Probable codes include N = Visiting Probable Nest Site; A = Agitated Behavior; C = Courtship, Display or Copulation; P = Pair in Suitable Habitat; T = Territorial Defense; M = Multiple (7+) Singing Males; and S7 = Singing Male Present 7+ Days.

that continued into mid-January. In late January 2018, singing males became more isolated and widely dispersed, pairs were more frequent, and courtship behaviors intensified (Figure 9).

The first breeding confirmation came on 8 February when a female was photographed carrying nesting material (CN) in Douglas. coauthor Brady then found a nest-building (NB) pair in Bayfield on 14 February, which was followed by 15 additional records of CN or NB across 5 counties into early March. Females on nests, presumably with eggs, were first found 4 March and 14 March in Bayfield, and the former produced the first known nestlings on 22 March. Two freshly fledged juveniles in Douglas on 24 March were exceptionally early, the next juveniles not being found until 7 April in Bayfield and more consistently thereafter (Figure 9). Reports of fledged young increased through late April while courtship and nest building activities sharply declined at that time (Figure 9). Family groups with juvenile birds dominated in May, June, and early July, with no new nesting activity detected during that period. The last recently fledged young were reported on 19 July 2018, while no probable or confirmed breeding behaviors were noted in August.

*Breeding by Call Types.* Among the total of 291 probable or confirmed breeding records (which may include a small proportion of repeat observations), 123 could be attributed to a specific call type. These included 93 Type 2, three Type 3, 26 Type 4, and one "eastern" Type 10 (Table 1). No breeding activity was observed for Types 1 or 5 (but see Type 5 account above). Breeding confirmations for Type 3 (one record) and Type 4 (seven records) were the first documented for the state.

Type 2 was the most widespread and frequently documented breeder with at least probable nesting records in 15 counties across the north woods south to Portage, Fond du Lac, and even the Kettle Moraine State Forest near the Jefferson, Walworth, and Waukesha county lines. Type 4, the second most commonly documented call type, occurred as at least a probable breeder primarily in the northwestern corner of the state from Polk to Bayfield to Ashland counties, with single confirmations in each of Douglas, Sawyer, and Bayfield. Notable, however, were confirmed breeding attempts of this type in

Florence, Fond du Lac, and Waukesha. Type 3 had probable breeding records in Bayfield and Douglas and a confirmed nest in Ashland, while the only breeding evidence for Type 10 stemmed from the confirmed family group in Burnett.

Phenology of breeding did not noticeably differ among types. Observers also did not detect any instance of mixed pairs consisting of different call types, although this was difficult to assess because nesting birds infrequently gave diagnostic flight calls and the high number of crossbills often made it challenging to track specific pairs.

*Nest Site Characteristics.* Six observers documented 13 nests in five counties between 14 February and 21 April, including eight attributed to Type 2, one Type 3, and four of unknown call type (Table 2). Nine were found during the nest building phase and four with eggs or nestlings, all but one of the latter likely involving eggs based on early dates. Of seven nests that were checked subsequent to initial discovery, five failed and two fledged young. The fate of the other six nests was not determined.

Stand-level habitat for breeding was similar to that used for other aspects of Red Crossbill life history, i.e. dominated by mature conifers, especially red, white, or jack pine, although sometimes with a strong hardwood component. Most trees in stands with nests were at least 40 feet tall. Five nests were found in red pine, four in white pine, and three in jack pine (Table 2). All nests were estimated at 25–60 feet above ground level, some occurring at half the tree's height but most occurring in the upper third or quarter where tree structure allowed for greater



Figure 10. Active Red Crossbill nest in jack pine, Bayfield County, 4 March 2018. Photo by Ryan Brady.



Figure 11. Close-up of active Red Crossbill nest with adult female in jack pine, Bayfield County, 4 March 2018. Photo by Ryan Brady.

concealment. Four nests were in a crotch against the tree's main trunk, while nine were located on an outer limb (Figure 10). Most were on the outer third of that limb and many were placed among a dense area of branches, needles, or even clusters of cones (Figure 11).

Short sticks broken from nearby trees formed the bulk of nests (Figure 11) but observers regularly observed adult birds gathering shreds of bark or dried lichens from tree branches, as well as grasses and fallen conifer needles from the ground. Observers reported a very consistent behavioral pattern of females gathering all nest materials while males perched or followed nearby and softly uttered muted songs and other vocalizations. In fact, these soft mutterings were a good clue of nest building in the vicinity.

One observation deserves special mention. On 27 March 2018, coauthor Brady visited a Bayfield County site where a nest-building pair was discovered on 26 February. Unfortunately, the nest had apparently failed but a female continued to visit the nest, only now she was removing materials and transferring them to a new nest site about 30 meters away. On several occasions during these repeated visits she flew from the old nest with something bright white and paper-like in her beak. As she began to intersperse other forays for new materials elsewhere, the item's identity was revealed: shreds of toilet paper from the floor of a nearby outhouse!

#### DISCUSSION

The 2017–18 irruption of Red Crossbills into Wisconsin was part of a major continental event that extended well into the northeastern United States, where all six call types recorded in Wisconsin were also found (eBird 2019; coauthor Young, T. Spahr, N. Pieplow,

	Comments			Nest #10 was nearby and at least partially constructed of materi- als from this failed nest; unknown if same pair	Occupied Nest on 3/14	Nest with Young on 3/22		Occupied Nest on 3/26			See comment for Nest #3		Nest #7 was nearby but unknown if this was renest attempt by same pair	
-10 III n puoti.	Nest Placement	Main trunk	Main trunk	65% out limb	65% out limb	80% out limb	80% out limb	Main trunk	75% out limb	90% out limb	Main trunk	90% out limb	<25% out limb	50% out limb
mg me zui /-	Nest Distance from Tree Top (ft)	57-8 8-72	10	25	30	15-20	10	10	10–15	10–20	5-10	5	10	5-10
ISCOUSIII AUI	Nest Height Above Ground (ft)	45	35	25	30	30	40	40	20-25	40	45	60	40	20-25
	Nest Tree Type	Red pine	Jack pine	Jack pine	White pine	Jack pine	Red pine	Red pine	White pine	White pine	Red pine	White pine	Red pine	Unknown
CHALACTERISTICS OF 1.5 NECT OF 0880111 HESIS 1	Stand Habitat	Red pine plantation with nearby jack pine	Red/jack pine mixed with hardwoods	Mostly red and jack pine	White/red pine	Red/jack pine mixed with hardwoods	Thinned red pines	Red pine plantation & Norway spruce	Pines and hardwoods	Large white and red pines, not plantation	Mostly red and jack pine	White/red pine with some hardwoods	Red pine plantation & Norway spruce	Park setting with pines and hardwoods
	Fate?	Failed	Failed	Failed	Failed	Fledged young	No follow up	Failed	No follow up	No follow up	No follow up	Fledged young	No follow up	No follow up
	Breeding Code	NB	NB	NB	NB	NO	NO	NB	NB	NO	NB	NO	NB	NB
c, and suc	Call Type	64	2	Unknown	2	2	5	5	Unknown	60	2	2	Unknown	Unknown
g evidence	County	Bayfield	Bayfield	Bayfield	Bayfield	Bayfield	Bayfield	Fond du Lac	Oconto	Ashland	Bayfield	Bayfield	Fond du Lac	Waukesha
Jes, Dreeum	Observer	R. Brady	R. Brady	T. Oksiuta	R. Brady	R. Brady	R. Brady	N. Reinartz	A. Szymczak	R. Brady	R. Brady	B. McCaffery	N. Reinartz	A. Szymczak
2. Call ty	Date of Obs (all 2018)	14-Feb	22-Feb	26-Feb	2-Mar	4-Mar	18-Mar	19-Mar	25-Mar	25-Mar	27-Mar	28-Mar	11-Apr	21-Apr
Iable	Nest #	1	5	60	4	5	9	7	8	6	10	11	12	13

and site characteristics of 13 Red Crossbill nests found in Wisconsin during the 2017–18 irruntion đ nabina muipe 4 ğ Table 2. Call type pers.obs.). The reason for this flight was widespread cone failure of western hemlock, ponderosa pine and coastal Douglas-fir in the western U.S. and Canada. While this irruption was documented better than any before, some evidence suggests an event of this magnitude and diversity of call types in the East may occur at roughly 20-year intervals (coauthor Young unpublished data).

Differences in effort and documentation make it difficult to compare the Wisconsin portion of the flight to those past. Robbins (1991) describes a "heavy flight" in 1960-61, "strong influx" in 1968-69, and "better-than-average totals" in 1973–74, while Berner (2011) reported a "sustained irruption in 1995-96" and Tessen (1997) indicated "excellent numbers" at the onset of spring 1997. Christmas Bird Counts (CBC) provide the best quantitative comparisons across years for this species. The 671 birds and 26 count circles with Red Crossbills during the 2017 CBC were second only to the 759 birds found in 1960 and the 32 counts reporting Red Crossbill on the 2012 CBC (Domagalski 2013b). However, factoring in effort, the 0.14 birds per partyhour in 2017 fell short of five CBCs, all occurring between 1960 and 1973 (National Audubon Society 2019). Collectively these data suggest the magnitude of this year's flight was far above an average year but likely not without precedent.

Numbers aside, Red Crossbill call types were not described until recent decades (Groth 1988, Groth 1993, Irwin 2010, Young and Spahr 2017), and the lack of simple, widely owned digital recording equipment precluded the field recording efforts possible today. Indeed, the eBird database included only 45 recordings of Red Crossbills in Wisconsin prior to this irruption, compared to 1,467 recordings from July 2017 to August 2018 alone.

These 2017–18 recordings revealed the most diverse flight of call types ever documented in Wisconsin, including at least six of the species' 11 known types and three first state records in Types 1, 4, and 5. Further context is provided below.

Type 1. Wisconsin's 17 Type 1 records were joined only by single observations from Minnesota, Arkansas, Montana, and Arizona outside their typical range in the eastern U.S. and Pacific coast (eBird 2019). While its occurrence was not unexpected, the number of records was impressive, especially compared to other interior states, and undoubtedly a result of the intense recording effort here.

Type 2. As often the case, this was the most widespread and abundant call type in Wisconsin and most areas from the Great Lakes westward, including common breeding activity here. No-table, however, was the high estimated proportion of "kinked" Type 2 of probable western origin.

*Type 3.* This call type was less common than in other recent irruptions, likely occurring in lower numbers than the 2012–13 flight (eBird 2019). Many appeared to settle into the northeastern United States, possibly due to an exceptional seed crop produced by soft-coned conifers there (Young and Spahr 2017, eBird 2019).

*Type 4.* Although not surprising as a first state record, Type 4 ultimately proving to be the second most common call type in the state was indeed remarkable. Unlike in Type 3, the majority of Type 4 stopped their eastward movement in the upper Midwest, oc-



Figure 12. Relationship between all Red Crossbill observations during the 2017-18 irruption (n = 1,716) and (a) pine cover types (red shading; red, white, and jack pine combined; Wisconsin Department of Natural Resources 2016), and (b) Wisconsin's ecological landscapes (gold boundaries; Bartelt et al. 2015).

curring commonly in Minnesota, Iowa, and Wisconsin yet rarely east of Lake Michigan (only eight records; eBird 2019).

*Type 5.* Prior to this irruption, Type 5 had been recorded only once in North America east of the Mississippi River (Young 2010). We documented 11 records during this irruption in Wis-

consin alone, while three others were found in New York and Massachusetts. Iowa and Minnesota each hosted several records as well (eBird 2019).

*Type 10.* Overall, Type 10 was surprisingly scarce during this irruption. "Western" Type 10 occurred in small numbers throughout the flight, while "eastern" Type 10 became prevalent by summer (and fall) of 2018. We believe the latter surge was unrelated to the eastward irruption event initiated in 2017 and was instead the result of a post-breeding dispersal of this type after spring nesting in the northeastern U.S. (Young and Spahr 2017).

Types not recorded. We did not detect Type 6 (Sierra Madre Crossbill), Type 8 (Newfoundland Crossbill), Type 11 (Central American Crossbill), or Cassia Crossbill (formerly Type 9), nor have any of these types previously been recorded in or near Wisconsin because each is uncommon and local with limited movements compared to other types (Benkman and Young 2019). We also did not confirm any individuals of Type 7, although as mentioned above the "eastern" form of Type 10 may be this call type (Benkman and Young 2019). If future work proves this to be true, then Wisconsin will have many records of Type 7 from this irruption and numerous prior recordings.

The geographic distribution and habitat associations of Red Crossbills during this irruption were consistent with previous knowledge of the species here in that highest numbers were found across northern Wisconsin and sightings were strongly tied to pine tree species statewide (Figure 12). The Northwest Sands, Northeast Sands, Northern Highlands, and northwest portion of the North Central Forest ELs (Bartelt et al. 2015) held the majority of observations in the north, while southern observations were scattered outside of regular occurrence in the Kettle Moraine State Forest (Figure 12). Relatively few observations (15) stemmed from the Western Coulees and Ridges EL of western Wisconsin, with only slightly more (19) coming from the Central Sand Hills and Central Sand Plains ELs (Figure 12). Suitable habitat is limited in the Western Coulees and Ridges region, while the Central Sands are rich in pines but poor in coverage by birders, meaning crossbills were likely present there in significantly higher numbers than reported.

Drawing conclusions about the distribution of call types is especially difficult due to the strong bias of audio recordings toward the northwest corner of the state. 1,178 of 1,467 recordings (80%) came from Bayfield County alone, with another 168 from adjacent portions of Douglas, Ashland, and Sawyer. Vilas and Oneida contributed only 14, and Forest, Florence and Marinette totaled only 25 recordings. Lower yet were the six recordings from the two Central Sands ELs. As a result, the most common types, Types 2, 3 and 4, were the most widely distributed, while the rarest types, Types 1, 5, and 10, were most limited. We posit that a similar intensity of audio recording outside of northwestern Wisconsin would have resulted in additional records of the rare types elsewhere.

Documentation of Red Crossbill breeding activity was greatly enhanced by this irruption's occurrence during data collection efforts of the second Wisconsin Breeding Bird Atlas (WBBA II). Observers spent far more time in the field during winter and early spring, in many cases specifically targeting evidence of nesting by this notoriously early breeding species. This elevated effort continued through June and July at a statewide scale. As a result, the total of 151 atlas blocks with probable or confirmed breeding records during this event was 87% of the 173 probable/confirmed blocks currently reported in WBBA II and 3.9 times

higher than the 31 probable/confirmed blocks recorded in the entire six years of the first Wisconsin Breeding Bird Atlas (1995–2000; Baughman 2006). In addition, while only five Red Crossbill nests had been previously documented in Wisconsin (Robbins 1991, Bielefeldt and Rosenfield 1994, Baughman 2006), observers documented 13 nests in 2018 alone.

Data on nesting phenology was particularly improved, especially early in the nesting cycle beginning with pair formation and courtship as early as December and January. The earliest previously documented nesting confirmation for the state was a 13 March bird carrying nest material (Robbins 1991, Harriman 2007) yet we recorded multiple cases of nest construction and at least one instance of incubation prior to that date, as well as a nest with young on 22 March and first fledged young by 24 March. In fact, observers in 2018 tallied 12 records of fledged young before 10 May, the date listed by Harriman (2007) as the state's all-time early date for fledglings.

Overall, the bulk of confirmed breeding behaviors were earlier this year than previously documented, although it is difficult to know if this resulted from better survey effort or an actual earlier nesting cycle. End-of-season data are more similar as we tallied juvenile-plumaged birds into mid-late July as in the first atlas (Baughman 2006, Harriman 2007) and other observers have noted mass departure during summer months on the heels of spring breeding (Robbins 1991, Bielefeldt and Rosenfield 1994). This pattern of fall arrival, January-April breeding, and summer departure is shown more broadly by the species as part of several regular movement and nesting peaks, suggesting that the phenology of migration and breeding across nomadic call types may not be as haphazard as once thought (Benkman and Young 2019).

The findings described here on the occurrence, timing, distribution, relative abundance, and breeding behavior of various call types will provide an important baseline for comparison to future irruptions of Red Crossbills and are especially important if one or more types is ultimately given full species status. Moreover, these data help fill major gaps in the understanding of the species, which the Wisconsin Department of Natural Resources lists as a Species with Information Needs and species with unrankable breeding status due to lack of sufficient information (Wisconsin Department of Natural Resources 2015).

Despite these advances, much remains to be learned about Red Crossbills in the state, including at least the following questions:

- At what interval do irruptions occur, particularly those comprised of such a diversity of call types?
- How frequent are Types 1, 4, and 5 found in Wisconsin? Do Types 1 and 5 nest here?
- Is the "eastern" Type 10 actually a different call type? Is this, or Type 2, our most common type in a non-irruption year?
- What is truly happening in the pinerich Central Sands ELs, especially related to breeding activity, which has been scarcely recorded there despite an abundance of apparently suitable habitat?
- What tree species are important here as food or nesting resources for each call type?

• Are populations stable or at risk? The nomadic tendencies of Red Crossbills lead to great annual variability in both numbers and geographic source of origin, making it difficult at best to generate populate estimates, monitor population trends, and assess limiting factors.

Moving forward it will be highly beneficial to obtain audio recordings annually across the various coniferous landscapes of Wisconsin, including non-irruption years when some birds remain present. Technology has made doing so easier now than ever. With your help, we can unravel even more mysteries of this fascinating species.

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Male and female Red Crossbills (Type 2 by audio) photographed on 1 December 2017 in Bayfield County by Ryan Brady.