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Status and distribution of an introduced population of European Goldfinches (*Carduelis carduelis*) in the western Great Lakes region of North America

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Abstract

Monitoring introduced species is important because of possible effects on native species and ecosystems. Here, we report on European Goldfinch observations from North America between 2001–2021, focusing on a population in the western Great Lakes region. We compiled over 7000 records of European Goldfinches from multiple sources for this time period. Over 3300 records were from the western Great Lakes region. We believe the primary founding event of this population to be release or escape from a cage bird importer in northern Illinois. European Goldfinches were initially reported widely in the region, but over time birds were most consistently reported between Milwaukee, Wisconsin and Chicago, Illinois. They have been breeding in this area continuously since 2003, are currently present in numbers that have established them as part of the local avifauna, and show evidence of a recent increase in numbers. More study is needed on this population of European Goldfinches, including their ecology, their potentially increasing range and population, and an evaluation of the potential for impacts on native ecosystems.

Keywords establishment, naturalization, non-native species, pet trade, release, songbird

Introduction

Humans have been moving birds from their native ranges to locations around the globe for centuries. Most species fail to develop permanent populations in their new environments (Zenni and Nuñez 2013, Aagaard and Lockwood 2016). Those species which have become successfully established have interacted with many other taxa, with varying impacts on the recipient ecosystem (Blackburn et al. 2009). For birds, the most important impacts include predation; competition for resources, including food and nest sites; hybridization; and interaction with other non-native species, usually the spread of invasive plants via frugivory (Baker et al. 2014, Evans et al. 2016). Despite the potential for disruption, relatively few introduced bird species have had severe impacts, especially outside of island settings (Bauer and Woog 2011, Strubbe et al. 2011, Baker et al. 2014). However, the rate of non-native bird introductions is rising, driven by globalization (Dyer et al. 2017, Seebens et al. 2017). This increase is characterized by shifts in the taxonomic composition and region of origin of new avian introductions, specifically a shift from intentional releases of mostly Nearctic and Palearctic species to accidental releases of species from the cage bird trade that often originate from the Southern Hemisphere (Blackburn et al. 2010). There is much we do not know about the dynamics of previous introductions of non-native birds (Blackburn et al. 2015), and our ability to manage potential contemporary avian invasions requires increased vigilance and monitoring.

The history and circumstances of avian translocations reveal 2 broad eras: the period of intentional bird releases by acclimatization societies, and the more recent, ongoing, often accidental releases of birds by actors in the global pet trade (Cassey et al. 2015). The acclimatization movement peaked in the mid– to late 19th century, mostly coincident with the European diaspora seeking to bring familiar plants and animals to their new homelands for sport or pleasure (Duncan et al. 2003, Ritvo 2014). The acclimatization movement declined in the early 19th century, falling out of favor due to many failures as well as some alarming successes (Palmer 1899, Dunlap 1997).

The keeping of cage birds, however, did not wane, and birds were the most common American pets by the early 20th century (Oldys 1907, Pollack 2013). Despite a World War and the Great Depression, the number of birds imported into the U.S. from 1901–1942, exclusive of parrots and game birds, was ~1.3 million; from 1968–1972, this figure approached 3.7 million (Banks 1976). Today, the trade volume of songbirds is largely unknown, as most species are not

included in the Convention of International Trade in Endangered Species (CITES), which regulates exports of listed wildlife (Mulliken et al. 1992, Hughes 2021). Gilardi (2006) estimated that 5–10 million birds are taken from the wild for the pet trade, and many countries have vast domestic markets comprised of hobbyists, larger private aviculturists, and commercial breeders (FAO 2011, Lockwood et al. 2019). There are ample opportunities for release or escape as birds move through the commodity market (Lockwood et al. 2019). The pet trade is now considered the primary pathway for the introduction of non-native birds worldwide (Carrete and Tella 2008, Cassey et al. 2015, Garrett 2018, Lockwood et al. 2019). The hotspots of non-native bird species in North America are southern California, Florida, and New York City (Burnett and Allen 2020). This paper describes an introduced population of a popular cage bird, the European Goldfinch (*Carduelis carduelis*), in a different part of the continent, the western Great Lakes region of the United States.

A brief history of European Goldfinch introductions

The efforts of the acclimatization movement of over a century ago are perhaps best known for the introduction and establishment in many countries of 2 bird species that developed into serious pests: the House Sparrow (*Passer domesticus*) and European Starling (*Sturnus vulgaris*). Another species was also widely introduced during this period, the European Goldfinch (*Carduelis carduelis*). An iconic species depicted in art for centuries, being particularly celebrated in Renaissance religious paintings, European Goldfinches have a long history as a cage bird (Friedmann 1946, Rodenhauser 2010). These attractive, distinctive, and hardy members of the Fringillidae are native to Europe, western Asia, and extreme northern Africa. Multiple subspecies are divided into 2 groups, the western, black-crowned *C. c. carduelis* group of west and central Europe, and the eastern, gray-crowned *C. c. caniceps* group of west and central Asia (Cramp and Perrins 1994, Clement et al. 2020).

European Goldfinches were introduced to the Azores around 1860 (Clarke 2006), Australia in 1863 (Acclimatisation Society of Victoria 1863, Ryan 1906), New Zealand in 1864 (Anonymous 1864), and Uruguay in 1913 (Dias 2000). In Bermuda, single birds were recorded in 1849 and 1850 (Hurdis 1897) and in 1875 (Reid 1877), but the founding population more likely came from a shipwreck in 1885 or 1893 (Prentiss 1896, Verrill 1902). Populations in all these areas persist

today, some of which have spread to nearby islands or countries (Dias 2000, Codesido and Drozd 2021).

The first introduction of European Goldfinches to North America is often reported as occurring in 1846 in Brooklyn, a borough of New York City, New York, facilitated by Thomas S. Woodcock (Phillips 1928, Long 1981). This claim can be traced to a short piece in a popular magazine (Anonymous 1878) which was then cited by Palmer (1900). Woodcock's own correspondence (Woodcock 1852, 1853), however, detailed his involvement in the importation of British songbirds. He explained that based on an earlier success of the introduction of the Eurasian Skylark (*Alauda arvensis*) in Brooklyn, he was facilitating an "experiment on a more extended scale" (Woodcock 1852). In late 1852, Woodcock brought 168 songbirds, among them 48 European Goldfinches, to New York which were held in captivity over the winter (Woodcock 1853). Those that survived, including 16 European Goldfinches, were released on 20 April 1853 in Green-Wood Cemetery in Brooklyn (Woodcock 1853, Cleaveland 1866). None of the released birds was seen past late summer (Cleaveland 1866).

The sources, numbers, and dates of introductions of additional European Goldfinches in the New York region are unclear, but this species first appeared in New York City's Central Park in 1879 (Adney 1886). These were purported to have come across the Hudson River from Hoboken, Hudson County, New Jersey, where birds were said to have been released the previous year (Eaton 1914, Cruickshank 1942), perhaps based on a specimen taken there in March 1878 (Austin 1963). Soon they were reported as common in Central Park and nearby areas of New York City, with a maximum report of 50 in winter 1902 (Abbott 1902). Griscom (1923) wrote they were gone from the park by 1907, and that very few were reported anywhere in the New York City region by the early 1920s. The most consistent reports came from Long Island in Nassau County (Nichols 1936, Lincoln 1998). The highest numbers published for that area were 17 in 1938 (Eynon 1940) and ~24 in the mid-1940s (Lincoln 1998). The population there persisted until the 1950s when they apparently disappeared due habitat changes related to development (Elliott 1968). European Goldfinches were also reported as common in eastern Massachusetts by 1880, attributed at least in part to intentional releases in the Cambridge area (Allen 1880). Other sources do not substantiate this (Brewer 1879, Brewster 1906, Strohbach et

al. 2014), so birds in Massachusetts may have come from the New York populations, escaped cage birds, or releases by private parties.

Elsewhere in North America, a temporarily successful introduction occurred in Oregon, where 40 or more pairs were introduced around Portland in 1889, 1892, and 1907 and thrived for some years but did not persist (Anthony 1891, Pfluger 1896, Jewett and Gabrielson 1929). Unsuccessful attempts to establish European Goldfinches in North America occurred in St. Louis, Missouri in 1870 (Widmann 1907), Cincinnati, Ohio in 1872–1874 (Langdon 1881), and Vancouver, British Columbia in 1908 or 1910 (Carl and Guiguet 1972). Thomson (1922), Elliott (1968), Long (1981), and Lever (2005) give many dates of releases, escapes, and introductions worldwide, but inaccuracies have been discovered in these publications and primary sources should be consulted (Pipek et al. 2015, Andrew and Griffith 2016, King and Reed 2016).

Over the latter portion of the 20th century, scattered European Goldfinch sightings in North America were routinely considered released or escaped birds. In the western Great Lakes region, Wisconsin had 4 published records prior to the 1990s that were considered of questionable origin (Jung 1936, Lound and Lound 1956, Frank 2004). In Illinois, a small group of up to 7 European Goldfinches was reported in September 1953 in Chicago's Lincoln Park, Cook County, including an adult feeding a young bird and a group of 2 adults and 3 young (Binford 1993). This furnished the first Illinois sight and breeding records (contra Smith and Parmalee 1955); the adults were considered escaped birds.

Around 2001, sightings of European Goldfinches in the western Great Lakes region of the United States began to increase beyond occasional reports, a situation suspected at the time to originate from a cage bird dealer in Illinois (Dinsmore and Silcock 2004). Craves (2008) compiled records through 2006 from this region, revealing nest building activity in 2003, and successful fledging of young in 2005. In the decades since, European Goldfinch numbers have increased and they appear to have established themselves as regular breeders in this region. Here we provide baseline data on the 1) distribution, 2) breeding status and phenology, 3) natural history, 4) presumed source, and 5) potential impacts of this emerging population with the goal of documenting the early phase of establishment and prompting further study of this species in North America.

Methods

To assess the recent distribution of European Goldfinches in North America and their breeding status in the western Great Lakes region, we assembled a database of European Goldfinch occurrences for the years 2001–2021, inclusive, for the United States and Canada. We compiled this dataset of observations from multiple sources. Three were citizen science projects: eBird (https://ebird.org), Project FeederWatch (https://feederwatch.org), and iNaturalist (https://www.inaturalist.org). Additional records were obtained by searching the gray literature and online sites; and from observations received directly by JAC that were solicited for an earlier publication (Craves 2008). Descriptions of these sources follow.

eBird is a database of observations contributed by bird watchers (Sullivan et al. 2009). We downloaded the eBird Basic Dataset (eBird 2022) which contains all records marked as approved for public output, either because they passed through a local checklist filter, or because they were manually approved by volunteer regional reviewers. In some localities European Goldfinch sightings were not approved by eBird reviewers due to their introduced status and therefore not viewable to the public; we requested these additional records as well. We recognize that non-native bird species suffer from reporting biases. Many bird watchers do not consider introduced species as countable on lists they maintain according to rules defined by the American Birding Association (Skrentny 2012, American Birding Association 2020), and do not enter them into eBird at all. Some users may enter introduced species in a way that they will not show up on their lists, such as not entering to the species level (e.g., as finch sp. or goldfinch sp.) or using a count of zero. In order to capture additional observations, we requested these types of records and extracted those that noted the record referred to European Goldfinch in any of the comment fields.

The iNaturalist platform allows contributors to submit photos or other media of any taxa and propose or request an identification, which is then verified and/or discussed by the community (Di Cecco et al. 2021). Project FeederWatch collects observations at feeding stations by participants across North America from November through the end of April (Bonter and Greig 2021). We extracted European Goldfinch records from both of these sources.

We searched the gray literature, such as journals and newsletters of state ornithological societies and birding clubs. We also searched online websites including state and regional ornithological societies, birding listservs, forums, chat groups, social media, and the photo sharing site Flickr (https://www.flickr.com). Finally, we integrated records received directly by JAC that were solicited for an earlier publication (Craves 2008). These sources were particularly important for providing data from the earlier years of interest. eBird did not launch until 2002 and iNaturalist debuted in 2008. While both allow for input of historical records, bird sightings were more routinely reported to state seasonal survey compilations or online venues such as listservs or forums through the early 2000s. We manually screened all records for accuracy, including inspecting any associated media (photographs, videos, audio recordings). Citizen science records had pre-existing geocoordinates, and we georeferenced all other records as specifically as possible using the locations provided. Duplicate records between data sources were removed with the record containing the most data retained (e.g., eBird records generally contained more complete spatial and temporal data than iNaturalist records). We also removed all but one in a group of identical eBird checklists that were shared among multiple observers, but did not attempt to identify or remove records of what may have been the same bird at the same place submitted by different observers. Each resulting record is an observation of ≥1 European Goldfinch(es) at a particular time and place. Thus, the dataset represents European Goldfinch distribution, not abundance.

From this continent-wide dataset, we delineated the western Great Lakes region as the area between 51˚ and 37.5˚ latitude, and -96˚ and -81˚longitude. This included all observations from the U.S. states of Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio, and adjacent parts of the Canadian province of Ontario. To describe the current known western Great Lakes breeding range, we reviewed all records within this geographic area from the months of March through August and assessed them for evidence of breeding. We applied standardized breeding evidence codes used by eBird (eBird 2021), which are adapted from codes utilized by North American breeding bird atlas projects (Beck et al. 2018). These codes are grouped in categories based on the strength of evidence, from merely Observed, to Possible, Probable, and Confirmed. We focused on the higher-level categories of Probable and Confirmed. Codes for which we had records in the Probable category are C (Courtship Display or

Copulation), N (Visiting Probable Nest Site), P (Pair in Suitable Habitat), S7 (Singing Bird Present 7+ Days), A (Agitated Behavior), and T (Territorial Defense). Codes for which we had records in the Confirmed category are CN (Carrying Nesting Material), FL (Recently Fledged Young), FY (Feeding Young), NB (Nest Building), and ON (Occupied Nest). The eBird dataset included records from Wisconsin's second Breeding Bird Atlas for the years 2015–2019. These data represent more even geographical coverage and precise estimates of breeding activity during this time window. We summarized breeding records to the highest breeding category and plotted them within U.S. Geological Survey 7.5-minute quadrangles, a standard basis for most North American breeding bird atlases. We also plotted breeding codes by day of year to understand breeding phenology.

From media associated with records, we noted breeding behaviors not captured by the breeding codes, such as nesting materials or details of the nest site. We also documented instances of European Goldfinches feeding on natural food sources, identifying plant taxa when possible, for any records in eastern North America in order to record as many potential food plants as possible that are likely to occur in the western Great Lakes region.

To identify possible sources (both foreign origin and domestic entities) for European Goldfinches in the United States, we obtained import data from the U.S. Fish and Wildlife Service's (USFWS) Law Enforcement Management Information System (LEMIS) database. These data come from declaration forms submitted to the USFWS for all incoming shipments of wildlife, filled out by the importer. The LEMIS data is only held by USFWS for 5 years and must be obtained by a Freedom of Information Act (FOIA) request. We obtained the available archived data for the years 2000–2014 maintained by the EcoHealth Allliance (Eskew et al. 2019, Eskew et al. 2020) by using the 'lemis' package (Ross et al. 2019) in R (R Core Team 2021) to query the LEMIS Wildlife Trade Database.

Results

Distribution

We compiled 7120 records of European Goldfinches across North America from 2001–2021 (Fig. 1). Overall, 82% were eBird records, although they only accounted for 25% of the records from 2001–2010. During that decade, 46% of the records were those reported directly to author

JAC, with the rest found on online listservs, rare bird alerts, regional websites, social media, and in the gray literature.

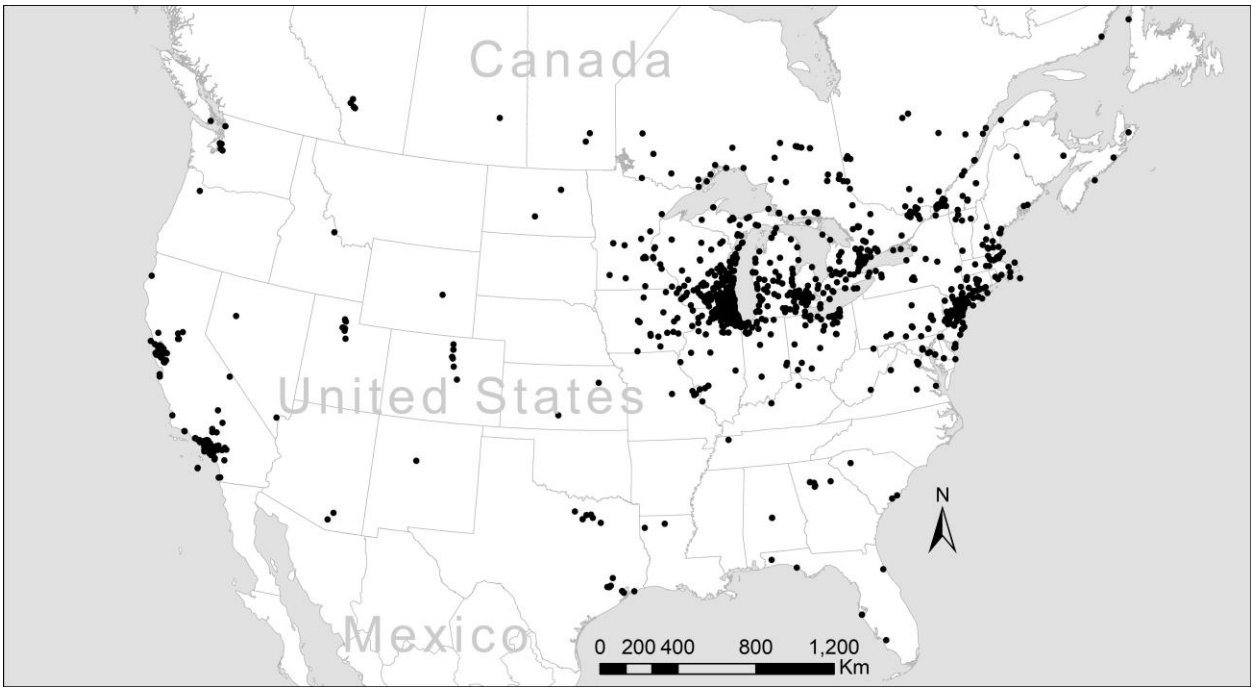
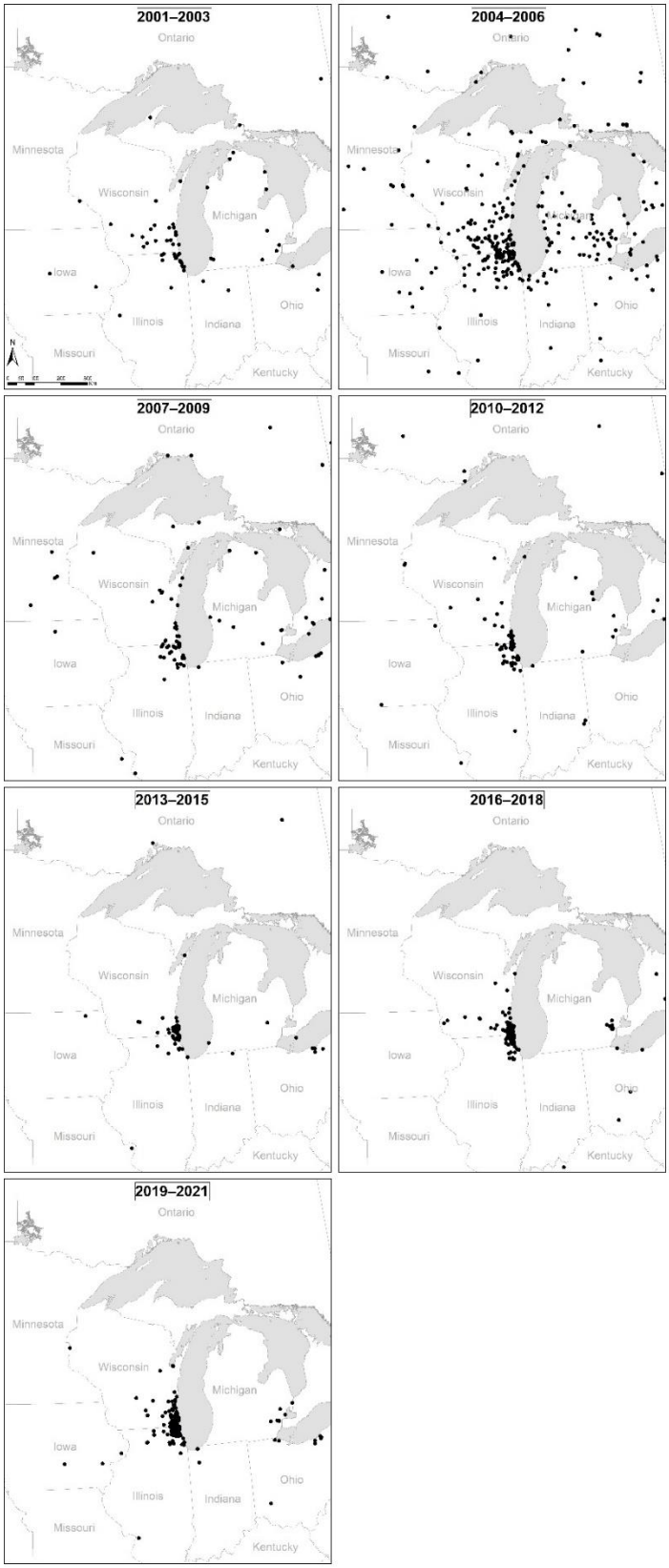


Figure 1. Locations of records of European Goldfinch in North America, 2001–2021. A table of the number of records by U.S. state and Canadian province and county is found in Suppl. material 1: Table S1.

Observations were recorded in 41 U.S. states and 9 Canadian provinces (Suppl. material 1: Table S1). Ten percent of all records came from California, where there were concentrations in the San Francisco and Los Angeles areas. While breeding has occurred in the state, populations are considered small and ephemeral (Garrett 2018, California Bird Records Committee 2022). New York had 25% of the records, the majority of which occurred after 2015 in Kings County, which is home to Brooklyn. Quite a few photos from Brooklyn locations attached to eBird observations showed European Goldfinches with colored leg bands, indicating recent captivity. New York began field work for its third state breeding bird atlas in 2020 (https://ebird.org/atlasny) which may clarify the status of this recent local proliferation.

Forty-seven percent of all records were from the western Great Lakes region. Initial records were clustered in northeastern Illinois and southeastern Wisconsin with scattered outliers in


2001–2003
2004–2006
2007–2009
2010–2012
2013–2015
2016–2018
2019–2021
Ontario
Minnesota
Wisconsin
Michigan
Iowa
Illinois
Indiana
Ohio
Missouri
Kentucky

249

Figure 2. Records of European Goldfinch in the western Great Lakes region grouped in 3-year increments. Some points in these panels are outside our geographic boundaries of this region due to map projection distortions.

neighboring states. From 2004–2006, there was a spike in records across the entire region radiating from the initial cluster, after which outlying records declined, eventually concentrating in the vicinity of the original cluster (Fig. 2). An animated depiction of the accumulating records over time can be viewed at <https://tinyurl.com/bdz8vxt3>. The distribution since 2018 is concentrated between, but not including, the cities of Milwaukee, Wisconsin, and Chicago, Illinois, and is mostly within 15 km of Lake Michigan.

While our dataset depicts distribution, records that included counts of European Goldfinch in flocks can give some idea of local abundance. All counts of European Goldfinch ≥20 individuals were in Illinois or Wisconsin, most were in winter and ≥2016, although a few dated back to 2011. Six different locations had counts ≥30 birds, with the highest single count being 95 European Goldfinch on 1 January 2021 in Lake County, Illinois.

Breeding status and nesting ecology in the western Great Lakes region

We assigned breeding evidence codes for 2320 records in the western Great Lakes region from the months of March through August. The majority of these records were assigned codes in the Observed or Possible categories and therefore did not provide strong evidence of breeding. The remainder (N = 274) were coded in the Probable or Confirmed categories. None of these birds was noted as the eastern, gray-crowned *C. c. caniceps* race either by the observer or in our review of media, and overall *C. c. caniceps* made up <1% of the entire dataset. The majority (N = 266) of Probable or Confirmed records were located in northeast Illinois and southeast Wisconsin (Fig. 3). There was a single breeding record in the state of Ohio that falls outside the extent of Fig. 3: a pair of European Goldfinches frequented a feeder in Cuyahoga County in 2015, with an adult and immature bird photographed on 22 August 2015. We plotted 7 Probable records coded P (Pair in Suitable Habitat) from 2006 separately in Fig. 3; although pairs were initially present in these quadrangles, no breeding confirmations were ever reported in these areas and no records of multiple birds even occurred in years after the initial reports. They are not included in the totals below.

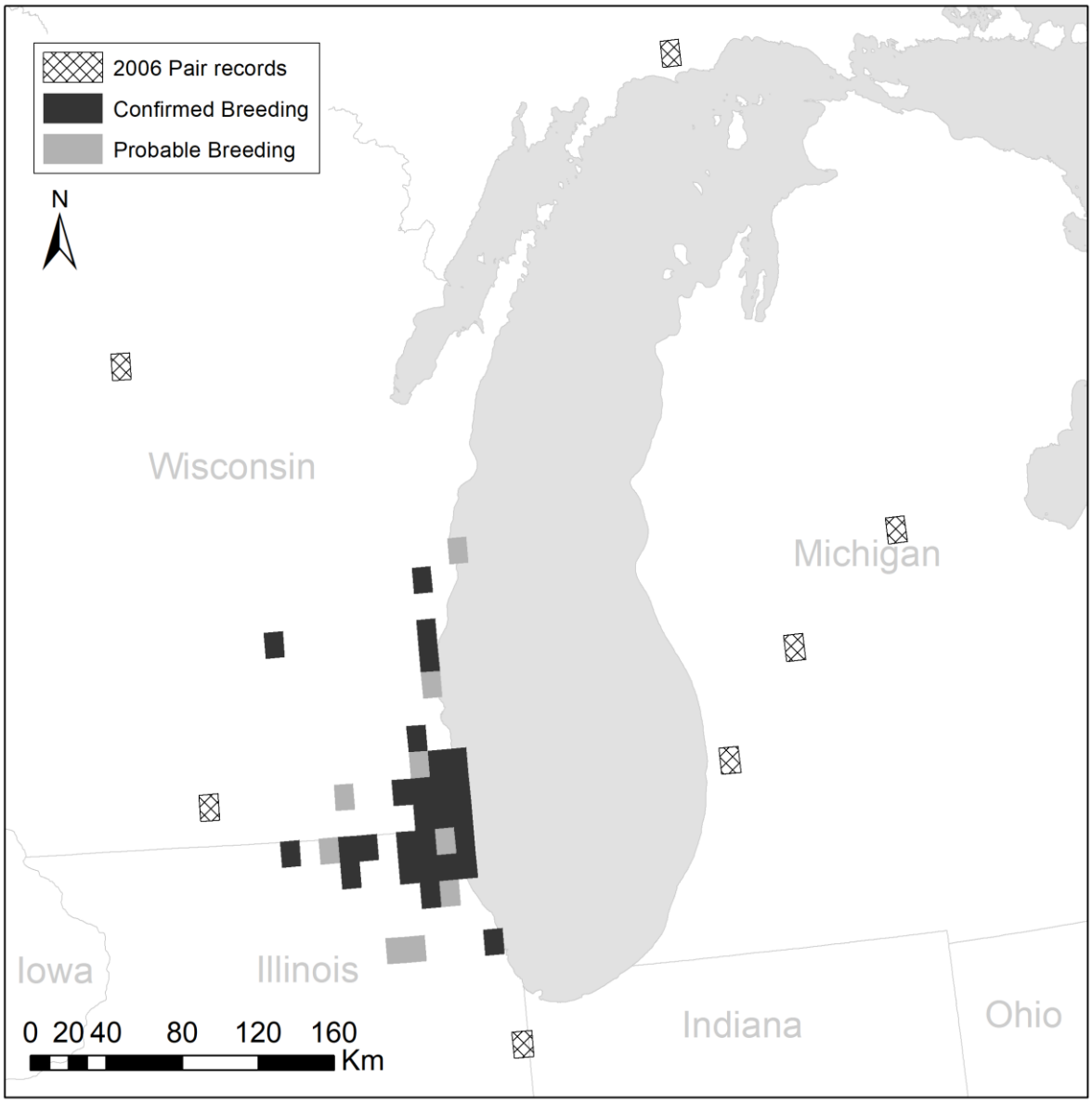


Figure 3. Breeding evidence of European Goldfinches in the western Great Lakes region. From records categorized as Probable or Confirmed, the highest breeding evidence plotted in USGS 7.5-minute quadrangles (~140 km^2). One confirmed breeding record in Ohio is outside the map boundaries and not shown (see Results). The crosshatched quadrangles represent European Goldfinch pairs (Probable evidence) recorded in 2006 in quadrangles where no records of multiple birds occurred in later years.

Illinois had 155 records with high-level breeding evidence. European Goldfinches were confirmed in 13 quads in 4 counties and coded as probable in 5 additional quads and 2 more

290 counties. The majority of the records (*N* =141) were from Lake County. Breeding evidence, a
291 pair constructing a nest, was first reported in the state in 2003, there have been Probable and/or
292 Confirmed records in the state every year since.

293 In Wisconsin, there were 113 records coded Probable or Confirmed. European Goldfinches were
294 confirmed breeding in 18 quads in 7 counties. They were coded as probable in 7 additional quads
295 and 3 additional counties. Most records were from Racine County (*N* = 62) and neighboring
296 Kenosha County (*N* = 31). Breeding evidence was first reported in Wisconsin in 2004 and there
297 have been Probable and/or Confirmed records in the state every year since 2009. A link to a map
298 file showing the Confirmed records with county boundaries is in the Suppl. material: File S1.

299 Records showed that nest building was initiated as early as 1 March, with nest building records
300 up to 27 July (Fig. 4). Occupied nests were reported from 13 May though 8 July, and fledged
301 young were reported from 12 May through 30 August (Fig. 4).

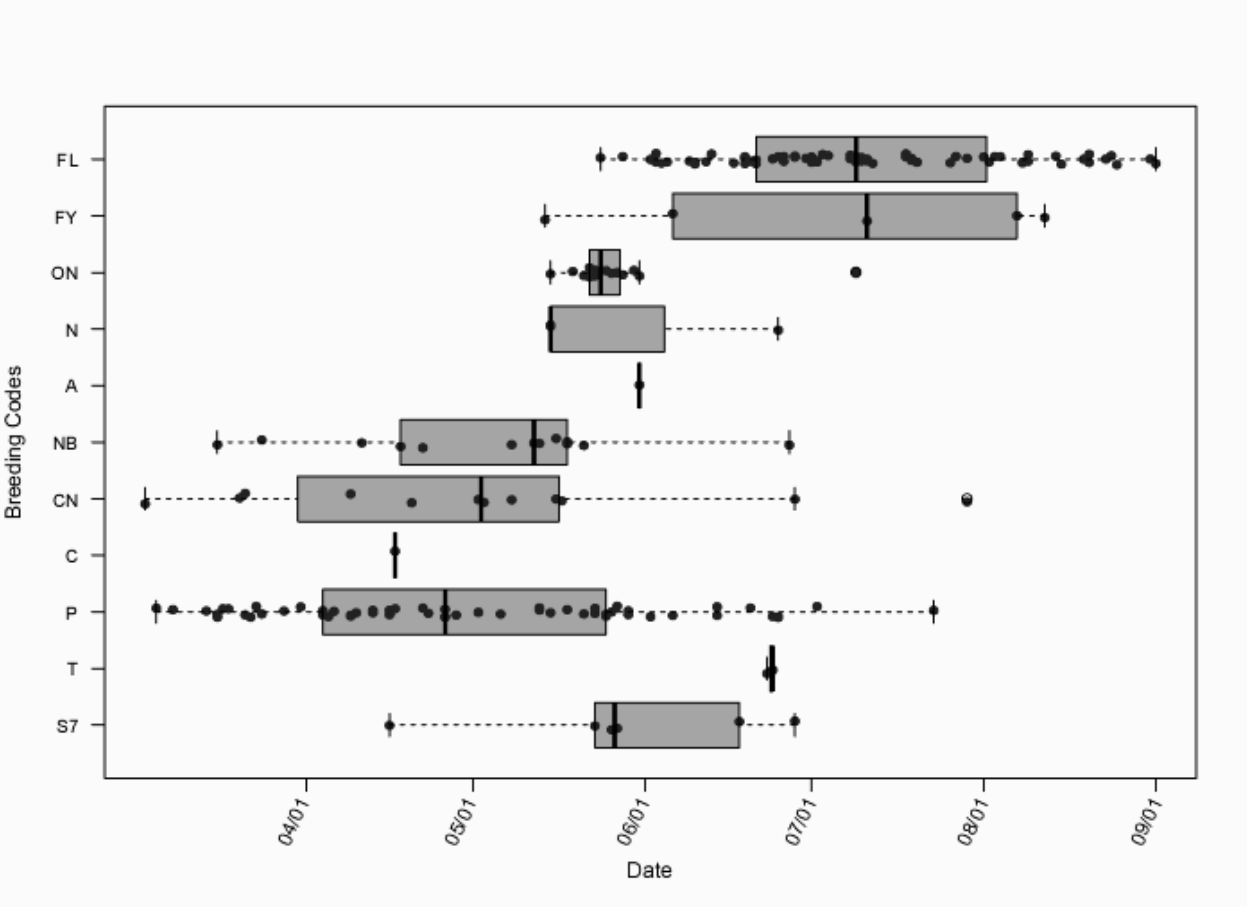


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Figure 4. Phenology of breeding activities of European Goldfinches in the western Great Lakes region. Black vertical lines represent median dates. Boxes represent 1st and 3rd quartiles. Whiskers represents minimum and maximum dates, with dots representing outliers. Breeding codes are as follows: FL (Recently Fledged Young), FY (Feeding Young), ON (Occupied Nest), N (Visiting Probable Nest Site), A (Agitated Behavior), NB (Nest Building), CN (Carrying Nesting Material, C (Courtship Display or Copulation), P (Pair in Suitable Habitat), T (Territorial Defense), S7 (Singing Bird Present 7+ Days).

We extracted the following observations of nests or nesting behavior from observer comments or media during our review of records.

- Eleven nests in pines, *Pinus* spp.; 1 in maple, *Acer* sp.; 1 in locust, *Gleditsia* sp.
- Mean height of 6 nests: 9 m (range 3–21 m).
- Two nests described as being near the end of pine branches.
- Materials used in nest construction: 5 described or shown as fluff, 1 of which was described as cattail fluff; 2 described as fibrous material.
- Nest material sources: 2 noted as being removed from old nests, 1 of which was described as that of a Red-winged Blackbird, *Agelaius phoeniceus*; 1 description of a bird gathering material “off a window”; 1 video showing a European Goldfinch peeling strips of bark from a grapevine, *Vitis* sp.
- Three observations suggesting conspecific tolerance or coloniality: a pair of birds accompanying another pair as the female was collecting nest material, 5 birds accompanying a female collecting nest materials and adding them to a nest, and ~7 pairs feeding several recently fledged young in a small, isolated group of pine trees.
- One observation of a female Brown-headed Cowbird (*Molothrus ater*) visiting a nest in the same tree where a female European Goldfinch was constructing a nest; the observer speculated the European Goldfinch abandoned the first nest and was making a new one.

Natural food sources

Our review of photographs and videos associated with European Goldfinch records resulted in 125 observations of European Goldfinches utilizing natural food sources (Table 1, which provides scientific names). Most observations noted European Goldfinches eating weedy, herbaceous plants. About half the observations were of European Goldfinches feeding on

334 burdock. Three species of thistles and the thistle-like spotted knapweed were well-represented, as
335 were teasels. All of these species are introduced in North America. European Goldfinches were
336 also found feeding on tree seeds, including seeds from the cones of the non-native Scots pine and
337 black alder, and the native blue spruce. Seeds of the native sweetgum were also eaten. The only
338 record we found of a European Goldfinch eating a plant part that was not a seed was a photo of a
339 bird eating the flower buds of a bigtooth aspen. Although our sampling was incidental, this
340 compilation suggests European Goldfinches may have a preference for the seeds of plant species
341 not native to North America, but indigenous to the native range of European Goldfinch.

342

Plant taxa	*N*	Months recorded	Locations
***Arctium* L.** (Burdock, Asteraceae) primarily *A. minus* (Hill) Bernh., some *A. lappa* L.	60	Jan, Feb, Mar, Jun, Oct, Nov, Dec	IL, MA, NY, QC, WI
***Carduus nutans* L.** (Nodding thistle, Asteraceae)	12	Jun, Jul	IL, WI
Helianthus L. (Sunflower, Asteraceae) 60% of the records were of cultivated *H. annuus* L.	10	Aug, Sep, Oct, Nov	MA, NY
***Dipsacus* L.** (Teasel, Caprifoliaceae) *D. fullonum* L. or *D. laciniatus* L.	8	Jan, Feb, Sep, Oct, Dec	IL, WI
Liquidambar styraciflua L. (Sweetgum, Altingiaceae)	8	Jan, Feb, Nov, Dec	CT, GA, NY, OH
***Taraxacum officinale* F.H. Wigg.** (Dandelion, Asteraceae)	5	Apr, May	IL, NY
***Cirsium vulgare* (Savi) Ten.** (Bull thistle, Asteraceae)	5	Aug, Oct, Nov, Dec	MA, NY, ON
***Cirsium arvense* (L.) Scop.** (Canada thistle, Asteraceae)	4	Jul	IL, NY
Oenothera biennis L. (Evening primrose, Onagraceae)	4	Jan, Jul, Dec	IL, NY
***Alnus glutinosa* (L.) Gaertn.** (European black alder, Betulaceae)	2	Nov, Dec	NY, WI
***Pinus sylvestris* L.** (Scots pine, Pinaceae) Feeding on cones that dropped to the ground	2	Mar	IL

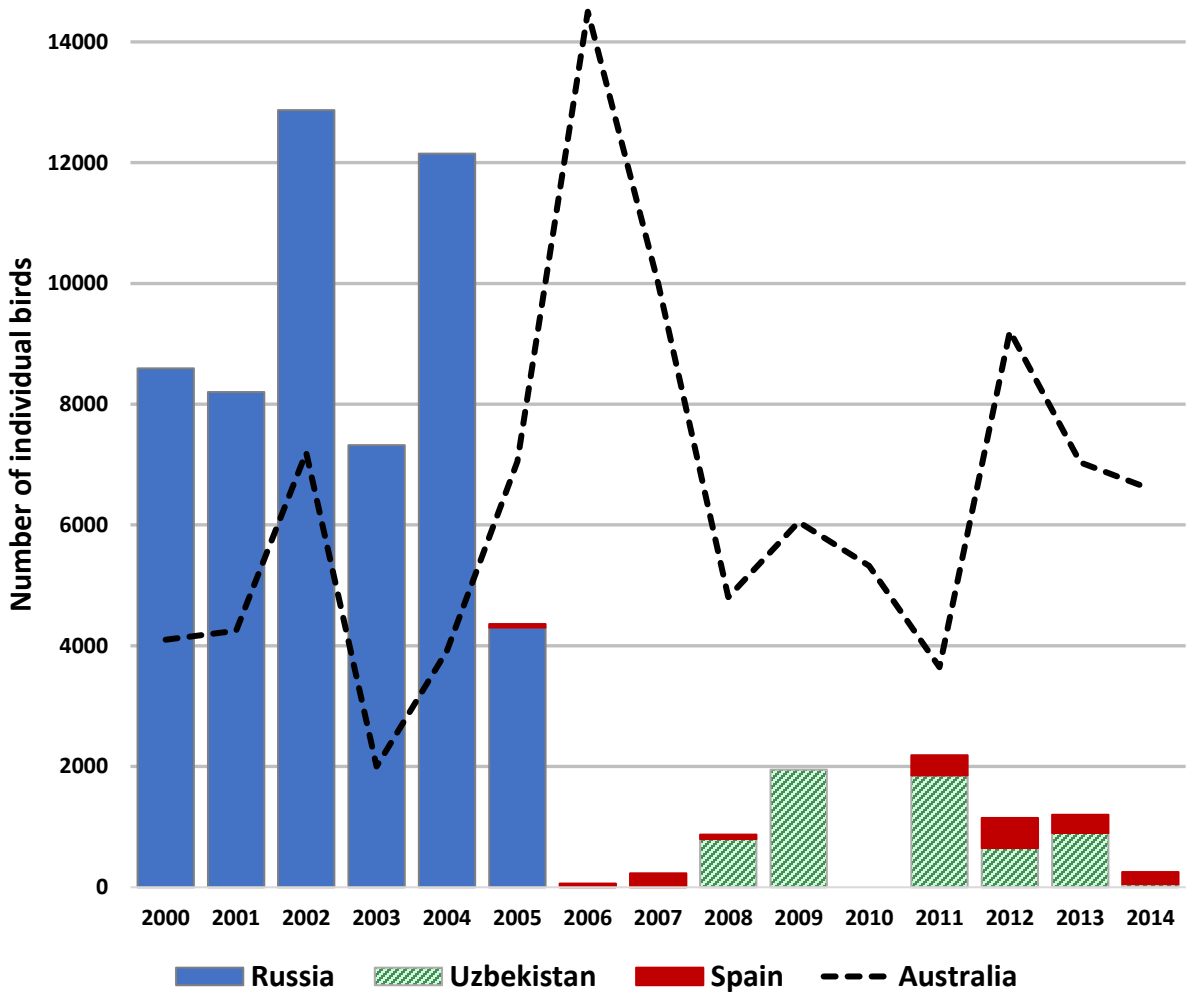
***Bromus inermis* Leyss**. (Smooth brome grass, Poaceae)	1	Jun	IL
***Centaurea stoebe* L.** (Spotted knapweed, Asteraceae)	1	May	WI
Picea pungens Engelm. (Blue spruce, Pinaceae) ~30 birds feeding on cones on several trees	1	Dec	IL
Populus grandidentata Michx. (Bigtooth aspen, Salicaceae) Feeding on flower buds	1	Apr	VA
Symphyotrichum novae-angliae (L.) (New England Aster, Asteraceae) G.L.Nesom	1	Oct	ON

Table 1. Natural food sources of European Goldfinches in eastern North America. Compilation is based on photographic records of birds actively foraging of plant material, not birds merely perched on food plants. Records that included multiple photos of a foraging bird were counted only once. Bold indicates a taxa not native to North America. Taxonomy follows the World Checklist of Vascular Plants version 8 (WCVP 2022), nativity data from U.S. Department of Agriculture's PLANTS Database (USDA, NCRS 2022). Abbreviations: CT = Connecticut, GA = Georgia, IL = Illinois, MA = Massachusetts, NY = New York, OH = Ohio, ON = Ontario, QC = Quebec, VA = Virginia, WI = Wisconsin.

Potential sources

Import data from LEMIS indicate that nearly 159,000 European Goldfinches were imported into the U.S. for the purpose of commercial trade from 2000–2014. This number is conservative, as it does not include potential European Goldfinches which may have been among the >16,000 birds listed under *Carduelis* sp. or the thousands of birds listed under even more generic terms. The country of origin of most birds, 60%, was given as Australia, all of which were coded as captive-bred. Another 34% were from Russia, of which 67% were coded as captive-bred and the rest having been taken from the wild (Fig. 5). It should be noted that information on the forms that are the basis for the import data is self-reported by the importer, with little opportunity for

353 verification (Smith et al. 2017, Eskew et al. 2020).



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355 **Figure 5.** Number of European Goldfinches imported into the United States for the purpose of
356 commercial trade. Dashed line represents birds imported from Australia by two California
357 companies. Bars represent birds imported by a single Illinois company. Not shown are <1700
358 birds imported from Canada, China, and New Zealand by four other entities.

359

360 Over 99% of the European Goldfinches were imported by 3 entities. The largest quantity, 39%,
361 was imported by a company headquartered in Illinois that was incorporated in 2000 (Office of
362 the Illinois Secretary of State 2022). This company was the sole importer of the European
363 Goldfinches from Russia, receiving >53,000, all in the years prior to 2006. From 2008–2013, the
364 Illinois company received ~6100 wild birds from Uzbekistan, and 50 captive-bred birds from the

same country in 2014. They also received a small number, <3% of their total imports, of captive-bred birds from Spain ≥2005. All the birds imported by this company arrived via Los Angeles, California with the exception of the wild birds from Uzbekistan, which arrived via New York.

Another 30% of the total were imported by a California company associated with the Illinois company (California Secretary of State 2022a, 2022b; see Discussion for details), all were from Australia. A second California company received 30% of total imports, which were also all from Australia, with the exception of 500 captive-bred birds from New Zealand. All of the birds imported by these 2 companies arrived via Los Angeles.

Discussion

Our dataset is the first attempt to delineate the status of European Goldfinch in North America in the 21st century. Even considering that it likely contains a substantial number of duplicates (the same bird at the same place submitted by different people), we believe the >7,000 records in our dataset to be conservative due to the strong bias against reporting introduced bird species. Ornithology has benefited from the efforts of amateur collaborators for many decades (Greenwood 2007), yet it suffers from a peculiarity of its most avid contributors: a disinterest or even loathing toward non-native species (Pranty and Garrett 2011). Two-thirds of birders that keep a life list of species they observe do not include uncountable exotic species (Callaghan 2017). This bias likely led to European Goldfinches being under-reported. For example, the majority of our records came from eBird, where 90% of checklists are submitted from the most active 10% of users (Wood et al. 2011). Active participants are also those that tend to be motivated by achievements, such as keeping a life list (Rosenblatt et al. 2022). While eBird has encouraged users to enter introduced species, it has been estimated that 36% of eBird users only input those that are countable and 11% do not report them at all (Callaghan and Brooks 2020). Garrett (2018) provides an excellent overview of the difficulties of non-native bird monitoring, especially via citizen science initiatives. In the case of eBird, this challenge may be mitigated by upcoming developments in the way exotic species are treated on user lists (M. Iliff, personal communication), but that depends on the willingness of users to report the birds in the first place.

We also obtained European Goldfinch records from many online sources. Due to the large number of these types of sites, their variable membership or privacy settings, and their often-

ephemeral nature, this search was not exhaustive. Nonetheless, our dataset reveals that European Goldfinches have occurred across the continent over many years. Isolated sightings are likely escaped or released pet birds, but the number of observations in some regions implies that there are areas of repeated introductions or escapes, reproduction in the wild, and/or environmental conditions favorable to more persistent occupation.

Breeding status and nesting ecology in the western Great Lakes region

With well over a decade of continuous breeding in Illinois and Wisconsin, it seems European Goldfinches are establishing a self-sustaining population in this area. Our data indicate the nesting ecology of European Goldfinches in the western Great Lakes region is similar in many respects to that of previous North American populations as well as in the native range.

Cruickshank (1942) gave egg dates ranging from 26 April to 4 June for birds in the New York region in the 1930s and 1940s. Our records of nest construction activities in March (Fig. 4) suggests a slightly earlier commencement of breeding for at least some birds, perhaps due to an advancement in egg laying over the ensuing decades. This has occurred in Britain, where the mean laying date of European Goldfinches has moved up 20 days over the period 1968–2019 (Walker et al. 2020). Cruickshank (1942) and Elliott (1968) reported several nests being built or with eggs in July. From this, Cruickshank concluded European Goldfinches were single-brooded, while Elliott felt these late nests indicated double-brooding. We had only 2 records of nests being constructed or occupied after late June, perhaps suggesting re-nesting after nest failure rather than double-brooding.

Cruickshank (1942) and Elliott (1968) noted that European Goldfinches in the New York area placed early nests in April and May in conifers and later nests in deciduous trees, with maples often favored. Most of the nest trees noted in our data were in pines, and all of the nests in pines were found from March through May. Only 1 nest, which was in a maple, was found in June or later, either due to few birds nesting in mid-summer, difficulty in finding nests concealed in thick foliage, or lack of dedicated nest-finding effort. Nest heights were higher than the ~1.5–9 m range cited for New York nests (Adney 1886, Nichols 1936, Cruickshank 1942, Elliott 1968) or the average height in Europe of ~4–6 m (Cramp and Perrins 1994). However, our data had

estimates for the heights of just 6 nests, and further study should confirm or resolve this disparity.

Nest placement at the outer portions of branches is typical of European Goldfinches around the world (Conder 1948, Elliott 1968, Middleton 1970a, Cramp and Perrins 1994). The use of fluffy material and spiderweb silk in nest construction is apparently also universal (Middleton 1970a, Campbell 1972, Cramp and Perrins 1994). The latter is likely what was reported being gathered "off a window" by an observer in Illinois. Similar incidents of birds collecting spider webs off structures were described in New Zealand by Burrows (1955) and Gibb (2000) from the wall of a shed and power poles, respectively; and in Germany by Conder (1948) from under the eaves of a watch tower in the prisoner of war camp where he conducted his observations.

European Goldfinches are also known to nest in small, loose colonies (Campbell 1972, Cramp and Perrins 1994, Newton 1997) as implied in several observations in the western Great Lakes region.

Fewer than 20% of the records coded Probable or Confirmed in our dataset were submitted by observers specifically tasked with documenting breeding behavior (for the Wisconsin Breeding Bird Atlas II). While some baseline metrics have been summarized here, we have no information on important aspects of nesting ecology such as clutch size, parental care, or nest success. Our data should be considered a starting point for further studies in North America.

Natural food sources

Our survey of photographs documents 16 plant taxa eaten by European Goldfinches in eastern North America (Table 1), all of which occur in the western Great Lakes region (USDA, NRCS 2022). Ten non-native plant taxa, all of Eurasian origin, made up 80% of the observations, and all except the grass *Bromus inermis* have been reported as food items by European Goldfinches in their native range (Newton 1967, Newton 1972, Cramp and Perrins 1994). The remaining 6 plant taxa are native to North America and represent species or genera that have been introduced from North America into the native range of European Goldfinches (Royal Botanical Gardens Kew 2022).

European Goldfinches are nearly entirely granivorous, specializing in the seeds of composites (Asteraceae) in their native range, strongly favoring thistles, burdocks, knapweeds, dandelions,

and groundsels and ragworts (*Senecio* spp.) (Newton 1967, Newton 1972, Cramp and Perrins 1994, Holland et al. 2006). We recorded all of these taxa with the exception of *Senecio* spp. being consumed by European Goldfinches. Half of the plant taxa were composites.

Burdocks comprised nearly half the total observations. Burdock seeds are highly profitable, allowing for high nutrient intake in short periods of time (Glück 1985). They are particularly important to European Goldfinches in their native range in fall and winter when energy demands are increased (Newton 1967). The same is true for teasels. Based on our compilation, European Goldfinches make substantial use of burdocks and teasels in fall and winter in eastern North America, where these plants are not native.

Tree seeds are also important to European Goldfinches during winter in their native range when herbaceous plant seeds may be depleted or covered by snow (Newton 1967, Cramp and Perrins 1994). European black alder and pine are frequently mentioned as primary sources in Europe, where they are native (Newton 1967, Holland et al. 2006) and we recorded both of these in winter here in eastern North America, where they are introduced. Sweetgum was the most frequently recorded tree species. It is native to North America, but has been introduced in parts of Europe (Royal Botanic Gardens Kew 2022).

During the breeding season, European Goldfinches rely more on milky ripe seeds, those with nearly mature endocarps prior to hardening of seed coat. Important taxa in their native range include dandelion, thistles, knapweeds, common groundsel (*Senecio vulgaris*), and coltsfoot (*Tussilago farfara*) (Newton 1967, Glück 1985, Cramp and Perrins 1994, Holland et al. 2006). Dandelions, spotted knapweed, and 3 species of thistles were noted in our compilation during nesting season. The most frequently recorded plant in the breeding season in our compilation was the introduced nodding thistle, a member of the genus for which *Carduelis carduelis* is named and a common food plant in the native range (Cramp and Perrins 1994).

Unfortunately, little data is available on the diet of European Goldfinches that were previously established in North America in the New York region. Elliott (1968) lists burdocks, thistles, grasses, various garden composites, grasses, sweetgum, and larch (*Larix* spp.).

A reliance on introduced Eurasian plants and composites is a pattern noted in other areas where European Goldfinches have become established. In Australia, Middleton (1970b) found that 32

of the 33 plants in the diet of European Goldfinches there were non-native, including all 19 species of composites. Many of the plants were the same as those used in Europe. Sweetgum, introduced in Australia, provided the only tree seeds eaten in his study. In New Zealand, all 28 species listed as food plants by Campbell (1972) were non-native.

Data is scanty for other regions. In Bermuda, European Goldfinches are reported to use non-native thistles and the native composites *Borrichia arborescens* and *Solidago sempervirens* (Bermuda Audubon Society 2022). In Brazil, where the birds are apparently colonizing from their introduced range in Uruguay, Dias (2000) observed European Goldfinches feeding on the introduced bull thistle.

Our review finds European Goldfinches exploiting Eurasian plant species that are also heavily used in their native range. The native plant taxa they consumed here are all close relatives of Eurasian species or have been introduced themselves into Eurasia.

Potential domestic source

We believe there is substantial evidence that the source of the European Goldfinches in the western Great Lakes region was a company located in McHenry County, Illinois, ~80 km northwest of the city of Chicago (Office of the Illinois Secretary of State 2022). Google Earth imagery shows what appears to be a large outdoor aviary at the company address as of 1998. This company was the largest importer of European Goldfinches into the U.S. for the years 2000–2014 (Eskew et al. 2019), and the only one with a direct connection to this region. Although this company has been publicly named by others, we are choosing not to name it here as our evidence is circumstantial.

When the Illinois company was established in 2000, it also registered in California; the listed agent is same person that owns the company that was the second largest importer of European Goldfinches (California Secretary of State 2022a, 2022b). In late 2006 or early 2007, the Illinois company debuted a new website, which linked to the California company as their sales office, with all birds being shipped directly from California. This suggests that the California company facilitated the importation of nearly all birds for the Illinois company and until around 2007 at least some birds may have been transferred to Illinois to fulfill sales. After this time, the California company also handled sales and shipping, indicating many birds would have been

509 housed in California. Where the ~6100 birds the Illinois company received from Uzebekistan via
510 New York from 2008–2013 were housed is unknown.

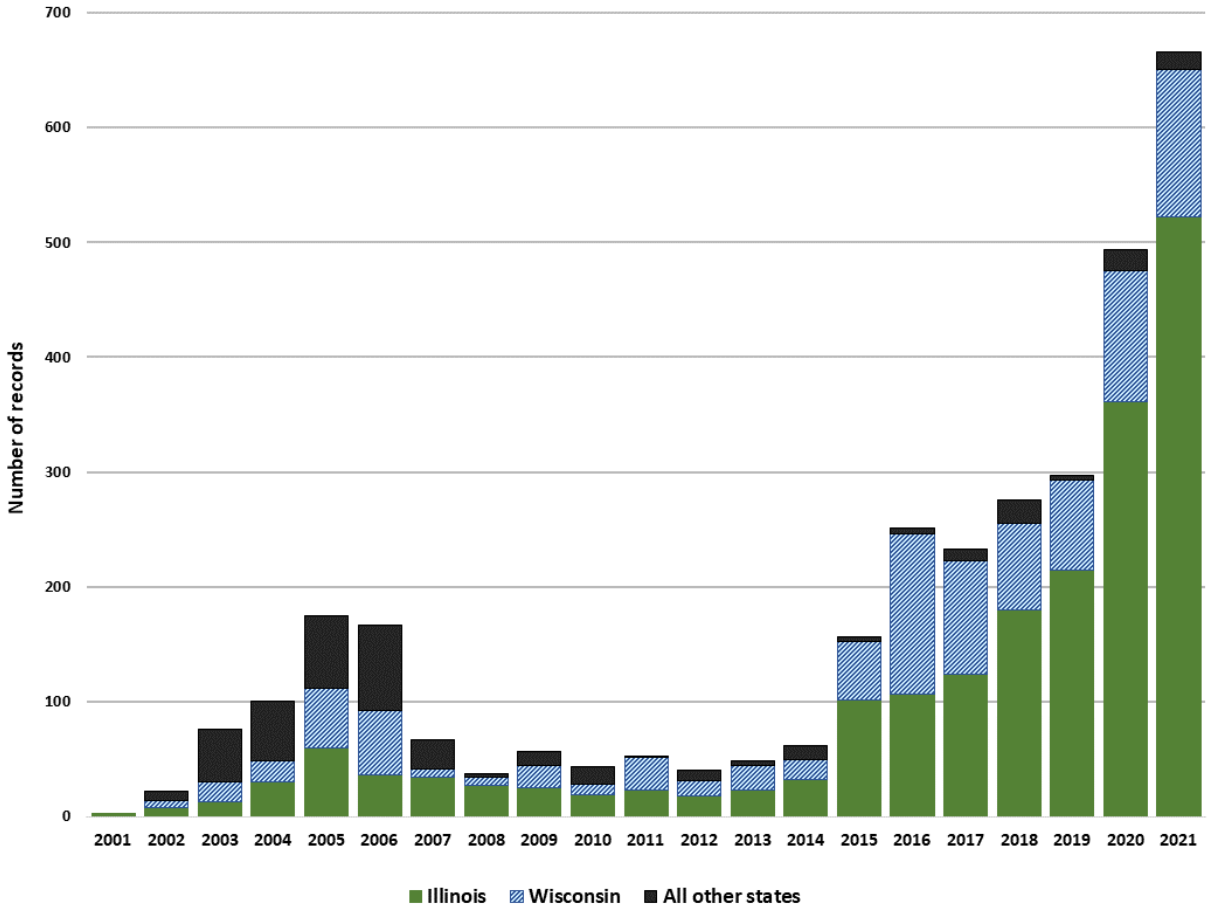
511 ***Potential foreign origins***

512 In the years leading up to 2001, the sporadic reports of European Goldfinch in the region were
513 most often in or around Chicago, but in April 1998 there was a report from Walworth County,
514 Wisconsin from a rural home <10 km from the McHenry County address of the Illinois importer
515 (Frank 1998). Between 2001 and 2004, there were also records of Common Chaffinches
516 (*Fringilla coelebs*), Eurasian Blue Tits (*Cyanistes caeruleus*), and Great Tits (*Parus major*) in
517 McHenry and Walworth counties, and in nearby Racine County, Wisconsin; these and other cage
518 bird species were generally found <200 km from the importer's location (David 2002, David
519 2004, Craves 2008). In her report of nesting Great Tits in McHenry County in 2003, Fiske
520 (2004) suggested that the source of the birds was a McHenry County bird importer either
521 accidentally or intentionally releasing exotic birds. All of the reported foreign bird species were
522 had been advertised for sale on the company website.

523 Figure 5 shows that the majority of European Goldfinches imported into the U.S. from 2000–
524 2005 were from Russia; all of these birds were imported by the Illinois company. The country of
525 origin listed in import records may not have been where wild caught birds were actually
526 collected, but rather the export location where birds harvested across a wider area are
527 consolidated and shipped (Eskew et al. 2020, Sinclair et al. 2021). It seems likely that many of
528 the European Goldfinches imported by the Illinois company prior to 2006 were collected
529 somewhere in eastern Europe and central Asia.

530 The abrupt cessation of Russian imports after 2005 was due to an embargo on imports of birds
531 from Russia due to a global outbreak of highly pathogenic avian influenza H5N1; embargos from
532 other countries began in early 2004 (HHS/CDC 2006). This outbreak may have played a role in
533 the considerable uptick in the number of European Goldfinch records in the Great Lakes region
534 over the years 2004–2006 (Figs 2, 6). There was also an increase in reports of other non-native
535 cage birds in the region during this time (David 2005, Craves 2008). We speculate that a
536 substantial number of European Goldfinches and other species may have been released by the
537 Illinois company during this period due to concerns about captive birds having, getting, or

538 transmitting avian influenza; difficulty in isolating birds in outdoor aviaries from wild birds; the
539 potential need for additional inspections or health screening; and/or possible restrictions on sales
540 (Gilardi 2005, Senni 2005). Incidences of dealers releasing imported birds to avoid quarantine
541 restrictions or to get rid of unwanted stock is not rare (Romagosa 2015). The number of records
542 suggest a sizeable influx of European Goldfinches (and other species) during these years in
543 northeastern Illinois, adding to the earlier presumed releases. The evidence suggests this
544 company as a plausible source.



545

546 **Figure 6**. Number of records of European Goldfinches in the western Great Lakes region, 2001-
547 2021. Stacked bars show proportions from the core population in Illinois and Wisconsin, and all
548 other states (Minnesota, Iowa, Missouri, Indiana, Michigan, Ohio, and Ontario west of
549 -81˚longitude).

550

551 The 2005 avian influenza outbreak disrupted international bird trade, and there was a decrease in
552 imports of European Goldfinches into the U.S. from countries other than Australia after that year

(Fig. 5). The Illinois company imported birds after 2005 exclusively from Spain and Uzbekistan, and in much smaller numbers. We obtained 2 additional years of LEMIS data, 2015 and 2016, from the archives of FOIA requests made by the Center for Biological Diversity (Center Biological Diversity 2016). LEMIS data provided via FOIA is tailored to the specific request (Eskew et al. 2020) and these 2 years were not directly comparable to our larger dataset, notably lacking quantities of individual birds. However, these data show that the Illinois company received just 2 shipments of European Goldfinches in early 2015 from Uzbekistan and did not import any in 2016.

Despite the decrease in imports, the number of European Goldfinch observations began to increase in the western Great Lakes region in 2015 and showed accelerated growth after 2017, mostly in Illinois and Wisconsin (Fig. 6). We believe this may represent the start of a period of rapid population growth after a lag phase (Crooks 2005, Aagaard and Lockwood 2014). This situation may be similar to that of the introduction of the House Finch (*Haemorhous mexicanus*) into eastern North America ~1940. After a ban on the sale of these protected migratory birds, which were acquired from California, at least one Brooklyn, New York, area bird dealer apparently released their illegal stock (Elliott and Arbib 1953). The founding population was estimated at just 80 birds (Veit and Lewis 1996). The eastern population of House Finches grew for the first 20 years but occupied only a small area in New York, New Jersey, and Connecticut (Veit and Lewis 1996). Range expansion then accelerated abruptly, and in the next 30 years House Finches occupied much of the United States east of the Mississippi River (Veit and Lewis 1996). Currently, the concentration of European Goldfinch records is along the Lake Michigan shoreline in southern Wisconsin and northern Illinois, although in part this may reflect the number of records submitted from the many popular birding sites in this area. Accurately determining range expansion and population growth will likely require standardized surveys, rather than relying on unstructured or semi-structured data gathered for largely recreational purposes (Bayraktarov et al. 2019, Callaghan and Brooks 2020).

Potential impacts

Among the most important reasons for studying non-native species is to assess the effects of introductions on native ecosystems. European Goldfinch seems unlikely to have as negative an

effect as species that aggressively compete for nesting cavities (e.g., House Sparrow or European Starling). However, more study is needed on their potential effects, both positive or negative.

Our review of photos showed they are common at feeding stations alongside native birds, usually American Goldfinches (*Spinus tristis*), Pine Siskins (*Spinus pinus*), and House Finches (*Haemorhous mexicana*). Comments on eBird checklists indicated European Goldfinches were only occasionally aggressive towards other birds, and they were more often described as associating with other finches, especially American Goldfinches.

Hybridization is considered a potential threat introduced birds may impose on native species (Baker et al. 2014). While European Goldfinches are frequently crossed with other finches in captivity for song or show, these hybrids are apparently nearly always sterile and wild hybrids are rare (Hinde 1956a, Hinde 1956b, McCarthy 2006), suggesting the potential for negative impacts is low. The asynchrony in the breeding cycles of American and European Goldfinches may reduce the opportunity for hybridization between these species; in eastern North America, American Goldfinch do not begin nesting in until late June with a peak in the second half of July (Nickell 1951, Middleton 1978, McGraw and Middleton 2020).

The primary natural food sources we documented being used by European Goldfinches in eastern North America are common weedy species, and additional species recorded as being used in their native range have also been introduced in the Great Lakes region (USDA, NRCS 2022). Given the large variety of widespread, abundant plants suitable for European Goldfinches and native granivorous birds, it seems doubtful that competition for food resources could be problematic.

Given their apparent preference for seeds of invasive plants such as teasels, knapweed, burdocks, and many thistles European Goldfinches could be considered beneficial in some cases. This depends on whether the timing of their foraging destroys seeds before they can be spread, or results in dispersing the seeds. Although some native birds also eat many of the same species, European Goldfinches may be more likely to consume seeds prior to dispersal. In Europe, Newton (1967) found most finches only ate thistle seeds when they could pull them out by the loose pappus at a stage when uneaten seeds could be released and dispersed, but European Goldfinches could pierce the bracts of flowers to access the unripe seeds. In New Zealand,

611 European Goldfinches were responsible for most pre-dispersal seed destruction of nodding
612 thistles, providing an ecological service in agricultural settings (McCallum and Kelly 1990,
613 Wenny et al. 2011). European Goldfinches are also one of the only species whose bills are long
614 enough to access the seeds of teasels (Newton 1967); it is thought the stiff red facial feathers of
615 European Goldfinches are an adaptation to feeding on these spiny seed heads (Newton 1972).

616 ***Conclusions***

617 Our data clearly demonstrate that European Goldfinches are currently resident in an area
618 between Milwaukee, Wisconsin and Chicago, Illinois. They have been breeding in this area
619 continuously since 2003 and are now present in numbers that have established them as part of the
620 local avifauna.

621 Despite their presence in the western Great Lakes region for at least 20 years and their breeding
622 success, more detailed research is needed on European Goldfinches to fully assess their
623 potentially increasing population and distribution, understand their basic ecology, and evaluate
624 their potential for range expansion and impacts on native species and ecosystems. The data we
625 present here provide a foundation to build upon and an outline for further studies.

626 The lack of comprehensive data on a non-native species is not unique to European Goldfinches;
627 insufficient knowledge is a common theme in non-native bird literature (e.g., Blackburn et al.
628 2015). Full understanding of the dynamics of non-native species successes and failures would
629 benefit greatly from a change in the mindset of the birding community and likely require
630 motivating birders to no longer disregard the non-native species they encounter. This mindset
631 can hamper our understanding of how non-native species become part of our avifauna. This is
632 particularly true for the early stages of non-native species presence, given that birders are
633 discouraged from counting species that have not been present in a self-sustaining population for
634 at least 15 years (American Birding Association 2020). With the pet trade now the main source
635 of avian introductions, even occasional presumed escaped cage birds should not be ignored. The
636 field urgently needs a change of culture whereby birders report and document non-native species
637 so that source localities and founding numbers of potential new populations are correctly
638 identified. To be most useful to researchers, documentation should include notes, photos, and
639 breeding codes or behavioral tags across all types of surveys, field notes, and communications.

Understanding the sources and origins of new populations, the phases of naturalization, and how and why some bird species expand their ranges successfully while other introductions fail are important goals that are increasingly achievable with the tools now available to researchers and the public.

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