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Metadata S1

NestWatch: An open-access, long-term data set on avian reproductive success

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Open Research: The complete data set is available as Supporting Information. Data (Bailey et al. 2023) are also available from Mendeley Data: [doi: 10.17632/wjf794z7gc.1].

Class I. Data Set Descriptors

A. Data set identity: NestWatch Open Data Set

B. Data set identification codes:

Nest location and summary data: attempts_locs-20230518.csv

Nest visit data: checks-20230518.csv

C. Data set description

1. Originators: Robyn L. Bailey, Lisa Larson, and David N. Bonter, Cornell Lab of Ornithology, Cornell University, 159 Sapsucker Woods Road, Ithaca, New York, USA, 14850.

2. Abstract: Long-term avian nesting data are valuable to researchers studying various aspects of avian ecology, conservation, and management. Administered by the Cornell Lab of Ornithology, NestWatch accepts nesting data from volunteers and professionals who agree to follow its protocol and submit data in a standardized form using either the website NestWatch.org, the mobile app, or a bulk upload template. These data (N = 574,288 nest records currently spanning 1874–2023) have been used to examine geographical and temporal variation in breeding success, clutch size, nesting phenology, and other metrics of interest to researchers. When combined with other data sets (e.g., climate, land cover, maps of environmental stressors), NestWatch data have been used to explore large-scale effects of anthropogenic change on nesting biology. These data can also be incorporated into investigations of status and trends for declining species and can

potentially be aggregated with other large-scale nest-monitoring data sets to explore hemispheric or even global change. By committing these data to the public domain, we aim to increase their use among researchers and stimulate novel studies. The NestWatch Open Data Set by Cornell Lab of Ornithology is licensed under CC BY-NC 4.0 (creativecommons.org); users are free to copy, redistribute, remix, transform, and build upon the material in any medium or format, but must give appropriate credit, provide a link to the license, and indicate if changes were made. Users may do so in any reasonable manner, but not in any way that suggests the licensor endorses such use, and may not use the material for commercial purposes.

D. Key words/phrases: citizen science, clutch size, fledging success, global bird nest records, nesting phenology, reproductive success

Class II. Research origin descriptors

A. Overall project description:

NestWatch is an initiative administered by the Cornell Lab of Ornithology that engages the public in observing and reporting on the reproductive activity of birds. The NestWatch protocol asks volunteers to self-train, visit nests on a regular basis, and use standardized data forms to record observations during each visit throughout the nesting cycle (Phillips and Dickinson 2009). Participants submit details on the nests of birds, including the species, location, number of eggs, number of hatched young, egg-laying date, hatch date, fledge date, and outcome of the nesting attempt—details which necessitate visiting a nest throughout a nesting cycle. Beginning in 2008, participants were asked to log the nest contents each time they visit a nest. With such data,

researchers can estimate the daily survival rates of eggs and nestlings, track changes in nesting phenology over time, and explore latitudinal and seasonal trends in clutch size, hatch rate, nesting period, and other measures of productivity.

NestWatch data are suitable for addressing a wide variety of research questions and can inform natural history accounts (Phillips and Dickinson 2009, Cooper et al. 2015). Researchers have used NestWatch data to explore diverse topics such as the effects of anthropogenic light and noise pollution on phenology and fitness (Senzaki et al. 2020), climate-driven phenological shifts in reproductive behavior (Socolar et al. 2017, Watts et al. 2018, Shipley et al. 2022), impacts of weather on nesting phenology and success (Sockman and Courter 2018, Carleton et al. 2019, Callery et al. 2022), and the ability of participants to influence nest success through management activities (Bailey and Bonter 2017, 2021). Data can also be combined with other similar national nest monitoring programs (e.g., Birds Canada's Project NestWatch, British Trust for Ornithology's Nest Record Scheme, etc.) to facilitate multi-national studies of avian reproduction.

1. **Identity:** NestWatch Open Data Set

2. **Originators:** NestWatch was developed by current and former staff at the Cornell Lab of Ornithology. Rick Bonney, Caren Cooper, André Dhondt, John Fitzpatrick, Tina Phillips, and David Winkler contributed significantly to foundational grant proposals. Previous iterations of citizen science efforts focused on nesting birds involved significant contributions from David Peakall and Jim Lowe.

3. **Period of study:** The current records span from 1874–2023, but the project is ongoing and archives historical nest records.

4. **Objectives:** NestWatch is a long-term nest-monitoring program designed to engage the public in tracking reproduction of wild birds.

5. **Abstract**: Same as above.

6. **Sources of funding:** Initial funding was provided by the National Science Foundation of the United States (Grants 9627280, 0540185) to the Cornell Lab of Ornithology. NestWatch and its predecessors (i.e., North American Nest-Record Card Program, Cornell Nest Box Network, The Birdhouse Network) were also supported by the Cornell Lab of Ornithology. The Onondaga Audubon Society initially funded the original North American Nest-Record Card Program. As of 2023, supplemental funding has been provided by the Sustainable Forestry Initiative, Cornell University Office of Community Engagement, federal capacity funds from the National Institute for Food & Agriculture (NIFA)/USDA, and by private donations (e.g., the North American Bluebird Society).

B. Specific subproject description

More than 574,000 nest attempts representing 864 taxonomic units (species, subspecies, or identifiable forms; see Table 1 for the 20 most common species) are housed in the NestWatch database as of May 18, 2023. Approximately 34,000 nest attempts are added annually (based on an average of the 3 most recent years, 2020–2022). For nests that have visit data, the mean number of nest visits is 5.95 (± 4.97 SD) per nest attempt. NestWatch accepts historical data sets

from external entities such as researchers, bird clubs, nature centers, and others such that the data set is dynamic and records are continually expanding both historically and with current nesting attempts. Although the project began with a geographic focus on the United States, data can be entered from any location and international submissions are increasing (data were from 88 countries as of May 18, 2023).

Table 1. The top 20 species in the NestWatch database are presented below to illustrate sample sizes for the most frequently reported species (all years combined, as of May 18, 2023).

Common name	Latin name	N
Eastern Bluebird	*Sialia sialis*	147,596
Tree Swallow	*Tachycineta bicolor*	122,764
House Wren	*Troglodytes aedon*	37,669
Western Bluebird	*Sialia mexicana*	30,392
House Sparrow	*Passer domesticus*	25,827
Mountain Bluebird	*Sialia currucoides*	21,282
Mourning Dove	*Zenaida macroura*	12,313
Carolina Chickadee	*Poecile carolinensis*	11,398
Red-winged Blackbird	*Agelaius phoeniceus*	11,131
Purple Martin	*Progne subis*	9,160

Black-capped Chickadee	*Poecile atricapillus*	6,383
American Robin	*Turdus migratorius*	6,100
Wood Duck	*Aix sponsa*	5,671
Northern Cardinal	*Cardinalis cardinalis*	5,307
Carolina Wren	*Thryothorus ludovicianus*	4,854
House Finch	*Haemorhous mexicanus*	4,181
Chipping Sparrow	*Spizella passerina*	3,928
Prothonotary Warbler	*Protonotaria citrea*	3,772
Violet-green Swallow	*Tachycineta thalassina*	3,560
Northern Mockingbird	*Mimus polyglottos*	3,497

From 1965 until the early 2000s, the Cornell Lab of Ornithology accepted records on all North American breeding birds in the form of paper cards as the North American Nest-Record Card Program (Pettingill 1966). At the time of writing, 90,083 cards have already been accessioned into the NestWatch database, with another ~200,000 in the process of being digitized for accessioning. From 1997–2007, the program was rebranded and narrowed its scope to solicit only nest records from cavity-nesting birds under the names “Cornell Nest Box Network” and later “The Birdhouse Network.” These 120,257 records have all been accessioned into the NestWatch database. In 2008, with funding from the National Science Foundation, the scope was

expanded to once again include all breeding birds, the name was changed to “NestWatch” to reflect this shift, and data collection became internet-based. The history of the project, its original goals, and some of its outcomes have been previously documented (Pettingill 1966, Phillips and Dickinson 2009, Cooper et al. 2015).

1. Site description

a. Site type: Data on bird nests are accepted from any location.

b. Geography: Current data are primarily from the United States and Canada, although data are accepted from any location globally.

c. Habitat: Bird nesting attempts can be reported from any location or habitat. Some local habitat variables are collected as part of the nest site description (see Table 2).

d. Geology, landform: N/A

e. Watersheds, hydrology: N/A

f. Site history: N/A

g. Climate: Primarily temperate North America, but bird nest attempts can be reported from any environment.

2. Experimental or sampling design

a. Design characteristics: Members of the public opportunistically monitor bird nests in the field. Sampling units include 1) nest-level

summaries of breeding attempts, and 2) repeated visits to nests with nest contents recorded. The protocol for monitoring nests was based on the North American Nest-Record Card Program (formerly administered by the Cornell Lab of Ornithology), which was itself based on the British Trust for Ornithology's Nest Record Scheme (Crick et al. 2003, Phillips and Dickinson 2009).

b. Permanent plots: N/A

c. Data collection period, frequency, etc.: Data are collected during the nesting season, which varies across species and geographic regions. Participants are encouraged (though not required) to report repeated observations of active nesting attempts at least weekly.

3. Research methods

a. Field/laboratory: NestWatch participants self-train by reading the Code of Conduct (https://nestwatch.org/learn/how-to-nestwatch/code-of-conduct/) and Nest Monitoring Protocol (https://nestwatch.org/learn/how-to-nestwatch/nest-monitoring-protocol/) and then completing a quiz. Participants decide where to search for and monitor nests. Many participants monitor nest boxes. Nest boxes vary in size, shape and design, and NestWatch does not collect data on nest box dimensions other than cavity entrance size. Participants are encouraged to make regular visits to nests (once or more per week), but nest check frequencies are not mandated. It is also

possible to enter summary-only data without nest check details; therefore, there is no minimum number of nest checks required for inclusion. Nests may be found at all stages of development (e.g., nest construction to near-fledging), so users of the data should filter the data set as required to answer their specific questions. The NestWatch database does not contain any data generated in a laboratory setting.

b. Instrumentation: N/A

c. Taxonomy and systematics: NestWatch collects data on any species of bird, globally. NestWatch follows the eBird taxonomy which is updated annually (Clements et al. 2022; current and past taxonomies available at https://www.birds.cornell.edu/clementschecklist/download/).

d. Permit history: Research under NestWatch is conducted under Cornell University Institutional Animal Care and Use Committee approval (protocol #2008-0083).

e. Legal/organizational requirements: N/A

4. Project personnel: As of 2023, NestWatch is managed by Robyn L. Bailey (project leader) and Holly Grant (project assistant) at the Cornell Lab of Ornithology with technical assistance from Dan Wilson, Miika Grady, and Lisa Larson.

Class III. Data set status and accessibility

A. Status

1. Latest update: May 18, 2023. Data collection is ongoing, and the public data set will be updated annually on approximately January 31. This will include the addition of new data, as well as taxonomic updates (applied retroactively to all historic records) and the correction of previous errors.

2. Latest archive date: May 18, 2023.

3. Metadata status: Last updated November 21, 2023.

4. Data verification: See Class V.A for details about data verification procedures.

B. Accessibility

1. Storage location and medium: The live database is housed in a Postgres relational database custom designed and supported by the Cornell Lab of Ornithology. Raw data are made available for public use (comma delimited files) on an annual basis on the NestWatch raw data download page [https://nestwatch.org/explore/nestwatch-open-dataset-downloads/] and in the Mendeley Data public repository (Bailey et al. 2023) with version history.

2. Contact persons: Questions about data accessibility should be addressed to the NestWatch project leader, currently Robyn L. Bailey, Cornell Lab of Ornithology, 159 Sapsucker Woods Road, Ithaca, New York, USA 14850. Phone: 1-607-254-2426, email: nestwatch@cornell.edu.

3. **Copyright restrictions:** NestWatch Open Data Set by Cornell Lab of Ornithology is licensed under CC BY-NC 4.0 (creativecommons.org). Users are free to copy, redistribute, remix, transform, and build upon the material in any medium or format, but must give appropriate credit, provide a link to the license, and indicate if changes were made. Users may do so in any reasonable manner, but not in any way that suggests the licensor endorses such use. You may not use the material for commercial purposes.

4. **Proprietary restrictions:** Because the data are collected by the public, NestWatch maintains an open-access data policy such that nearly all data and data fields are freely available to the public. In an effort to protect endangered, threatened, or otherwise sensitive species that may be exploited based on freely accessible information (e.g., parrots or raptors targeted for the illegal pet trade), detailed nesting locations are withheld from the publicly-available data sets for a small subset of the NestWatch data (~300 nest attempts at the time of publication). A list of "sensitive species" whose nesting locations have been truncated is available at: https://support.ebird.org/en/support/solutions/articles/48000803210-sensitive-species-in-ebird. Such data are available for legitimate research purposes upon request to the project leader. Information on the process for accessing data on sensitive species can be found on the NestWatch data download page [https://nestwatch.org/explore/nestwatch-open-dataset-downloads/].

In order to protect the personal information of project participants, access to the names and contact information of participants is not available, but unique

identifiers are provided (e.g., if observer identity is important for repeated measures analyses).

a. Release date: There are no release date restrictions.

b. Citation: NestWatch requests that researchers acknowledge NestWatch at the Cornell Lab of Ornithology and the contributions of the thousands of NestWatch participants who have submitted observations. Research articles using NestWatch data should cite the data set (Bailey et al. 2023) and, where appropriate, this data paper.

c. Disclaimer(s): Although we made numerous efforts to ensure data are correct, no warranties or representations are made, express or implied, with regard to the correctness, reliability, or accuracy of any NestWatch data. The NestWatch Open Data Set is provided "as-is."

5. **Costs:** None. The data are freely available for download and use.

Class IV. Data structural descriptors

A. Data set file

1. **Identity:** NestWatch Open Data Set

Nest location and summary data: attempts_locs-20230518.csv.zip

Nest visit data: checks-20230518.csv.zip

2. **Size:**

Nest location and summary data: 574,288 records, 34 fields, comma delimited, 19 MB

Nest visit data: 2,484,728 records, 22 fields, comma delimited, 31 MB

3. **Format and storage mode:** The open-access, downloadable data are stored as comma delimited files using ZIP compression.

4. **Header information:** See Class IV.B and Table 2.

5. **Alphanumeric attributes:** Data are stored numerically and in upper- and lower-case text.

6. **Special characters/fields:** None.

7. **Authentication procedures:** None.

B. Variable information

The complete list of fields and definitions of the NestWatch Open Data Set are described in Table 2. NestWatch's relational database is organized into three hierarchical levels. At the top level is the location information (e.g., latitude, longitude, nest substrate, nest height, etc.). This represents the spatial information of a specific nest site, and nest sites can be reused by birds within a season and across multiple years (or not) such that they can have a one:one or one:many relationship to nest attempts. Users can update locations, and we have provided the site descriptions that were in effect at the time of each nesting attempt.

The second level of data is the nesting attempt, which is a multi-day event by the adults in an effort to produce young. Nest attempts are typically defined as beginning when the first egg is

laid and may have one of several endpoints (e.g., success, failure, unknown outcome). Whenever a nest reaches an endpoint (whether successful or failed), the observer should summarize the outcome and end the nesting attempt. Data collected at the nest attempt level may include species, first egg date, hatch date, fledge date, clutch size, number of hatched young, etc. (see Table 2). In the provided files, nest location and summary data have been concatenated together as one standalone file which can be explored with or without the nest check data.

Finally, the third level of data contains information on what the observer found in a nest during an individual visit, commonly referred to as "nest visits" or "nest checks." A nest may be visited one or more times (or the user may choose not to add any nest visits) such that there can be a one:one or one:many relationship to the nest attempt (if any nest visits exist at all). Data collected at the nest visit level may include the number of eggs, the number of young, the behavior of the adults, etc., on a given date (see Table 2). From 1997–2007, nest visits were not collected electronically, but they may exist on older attempts as historical data sets are acquired and added to the NestWatch database. In the provided files, it is necessary to join the nest visit data to the nest location and summary data using the Attempt ID column if the investigator wishes to work with the nest visit data (i.e., they are not intended to be used independently).

The 56 data fields of the NestWatch Open Data Set are detailed in Table 2. Data types can be boolean (e.g., whether or not the first egg date was estimated or observed), categorical (e.g., nest substrate, species), continuous (e.g., latitude, longitude), integer (e.g., clutch size), or date/time (e.g., date the nest was visited), as indicated by the "Data type" column in Table 2. The data are either entered by participants (e.g., species) or assigned automatically by the database (e.g., the unique location ID), as indicated by the "Entry mode" column in Table 2. Categorical variables

entered by participants are typically constrained by user interface elements such as drop-down menus and check boxes as well as through database “check” constraints.

Table 2. The NestWatch Open Data Set consists of 2 files with 56 combined fields. The variable names and descriptions are included, as well as a label for entry mode and data type. The allowed values can help interpret codified data. Bold type indicates variables which cannot be null.

SITE DESCRIPTION AND ATTEMPT SUMMARY FIELDS				
Variable name	Entry mode[a]	Description	Data type (scale)[b]	Allowed values
Attempt ID	a	A unique identification assigned to individual nest attempts.	categorical	
Location ID	a	A unique identification assigned to individual nest locations. May be repeated within and across years.	categorical	
Latitude	p	Nest coordinate in decimal degrees	numeric (7)	
Longitude	p	Nest coordinate in decimal degrees	numeric (7)	
Subnational Code	a	The 2-letter country code joined with a hyphen to a 2-letter state/province code.	categorical	Follows ISO 3166-2. Undefined represented as "XX-"
Substrate Relationship	p	Position of the nest relative to the surface on which the nest is built.	categorical	One of: in, on, under
Substrate	p	The surface on which the nest is built.	categorical	One of: nesbox (nest box/birdhouse), buildi (building or dwelling), poptow (post/pole or platform), cliled (cliff or rock), ltrcav (cavity in live tree branch), ssdtcv (cavity in snag/dead tree), ssdtre (dead tree branch), ltrbra (live tree branch), busshr (bush/shrub/cattails), ground (ground), floveg (floating vegetation), other
Substrate Other Description	p	Free-text description (specified when Substrate is "other").	text	
Height m	p	Measurement of the height of the bottom of the nest from the ground (in meters).	numeric (4)	
Cavity	p	Diameter of the entrance to the nest,	numeric (3)	

Entrance Diameter cm		for cavity nests (in centimeters).		
Entrance Orientation	p	Compass direction that a nest hole entrance faces.	categorical	One of: n, s, e, w, ne, se, sw, nw
Elevation m	p	Elevation of nesting location above sea level as reported by the user (in meters).	numeric (4)	
Habitat 1m	p	Habitat within 1 meter of the nest.	categorical	One of the following high-level descriptors: ag (agricultural area), for (woodland/forest), grass (natural grassland and prairie), chap (shrubland and chaparral), des (desert), fw (fresh water), sw (salt water), beach (beach), tun (tundra), oth (other), human (human modified landscape). Or, if "human" was chosen, the user may optionally store one of these more specific descriptors instead: ry (yard, residential area), park (public park/green space), road (roadside), golf (golf course), pit (land fill/gravel pit/strip mine), cem (cemetery), com-ind (industrial/commercial center), pwrln (powerline corridor), campus (campus/schoolyard/church/hospital), airprt (airport), cmpgrd (campground), xmas (Christmas tree farm), orch-vin (orchard/vineyard), clrcut (recently clear cut area), burn (recently burned area).
Habitat 100m	p	Habitat within 100 meters of the nest.	categorical	Same as Habitat 1m above
Location Entry Technique	a	Codes representing various methods for site creation with varying degrees of positional accuracy. These methods continue to evolve as online mapping technologies change. See IV.B.4.e for description of precision.	text	"/GOOGLE_MAPS/ZOOM:[number]" indicates the user used a Google map at a particular zoom level to position the nest. "NestWatch Mobile App v[number]" indicates the

	nest was created via the mobile app (all versions use Google Maps and request a zoom level of 19 or higher, if available). "trail centroid" generally indicates bulk-uploaded data from large-scale nest monitoring projects that specify only a central location. "latlong" indicates coordinates are stored as the user entered them. "geocode" indicates the user entered a street address or location name that was translated to coordinates by a mapping service such as Google. "map" was used prior to 2012 if the participant chose a location via an online map. "BIRDHOUSE_HIST:ZIP " was used prior to 2008 to indicate the user entered a ZIP code that was translated to centroid coordinates. "BIRDHOUSE_HIST:SELF" was used prior to 2008 to indicate coordinates are stored as entered by the user. The North American Nest-Record Card Program uses 4 codes: "NANRCP_HIST: county_centroid" and "NANRCP_HIST: statprov_centroid" represent centroid coordinates based on county or state/province, "NANRCP_HIST: self" represents a user-reported latitude/longitude, and “NANRCP_HIST: site_match” for cards missing coordinates but using the same location name as a card with known

				coordinates. Many historical entries beginning with "other" contain user-entered free text.
Observer ID	a	A unique code identifying the observer making the submission. Note that most observers will only have one Observer ID, but it is possible for one individual to create multiple accounts. It is not possible to identify participants with multiple Observer IDs.	categorical	
Species Code	p	Taxonomic code for the identity of the nesting species.	categorical	See eBird taxonomy available at https://www.birds.cornell.edu/clementschecklist/download/
Species Name	p	Common name (in English) for the identity of the nesting species.	categorical	See eBird taxonomy available at https://www.birds.cornell.edu/clementschecklist/download/
Year	a	Year in which the nest attempt started	integer	
Predator Guard	p	For nest attempts in boxes, this field indicates whether a device intended to prevent predation was attached to the nesting structure (i.e., a predator guard). If it contains "other" then Predator Guard Other should have a value. See Bailey and Bonter 2017 for more information on predator guard types.	categorical	One or more of (comma-delimited): baffle, cone, holeExtender, no, noelGuard, other
Predator Guard Other	p	Free text entered when "other" predator guard type is selected.	text	
First Lay Date	p	Date when first egg was laid.	date	
First Lay Date Estimated	p	Whether the first lay date is estimated (1) or observed (0).	binary	0, 1
Visited During Egg Laying	p	Response to "Was the nest site visited during the egg laying period?" (1 = yes, 0 = no). This variable was originally intended to gauge the quality of the first egg date estimate during a time period when nest check data was not being collected (e.g., The Birdhouse Network). It was retained later for continuity even after nest checks	binary	0, 1

		were enabled because some participants may choose not to enter all of their nest checks. See Cooper 2014 for further detail.		
Hatch Date	p	Date when the first egg hatched.	date	
Hatch Date Estimated	p	Whether the hatch date is estimated (1) or observed (0).	binary	0, 1
Fledge Date	p	Date when the first young fledged (left the nest).	date	
Fledge Date Estimated	p	Whether the fledge date is estimated (1) or observed (0).	binary	0, 1
Young Fledged	p	Total number of young that fledged.	integer	
Clutch Size	p	Maximum number of host eggs in the nest (not including eggs of brood parasites).	integer	
Young Total	p	Maximum number of young (alive and dead) of host species in the nest (i.e., hatched young). Does not include young of brood parasites.	integer	
Unhatched Eggs	p	Maximum number of host eggs that failed to hatch for individual nest attempts (not including eggs of brood parasites).	integer	
Outcome	p	Fate of the nest attempt.	categorical	one of: f (failure), f1 (all young found dead in or nearby nest), f2 (all young disappeared from nest before fledge date; reason unknown), f3 (predator known to cause nest failure), f4 (only young of brood parasites fledged), f5 (invasive species management), f6 (no eggs hatched), f7 (failure due to nest takeover by another bird), s1 (at least one host young fledged), u1 (unknown outcome), u2 (nest monitoring stopped prior to expected fledge date while nest was still active), u3 (no breeding behavior observed), i (inactive), n (not monitored)
Attempt Entry Technique	a	Created by the application to indicate method of data entry used to initiate the nest attempt. Later	text	As of 2022, the 3 modes of data entry include the NestWatch website (field

		visits may have been entered via another method.		value indicates various versions of "Web" entry), the mobile app (field value indicates various versions of "Mobile" entry), or bulk upload (field value indicates date of uploading into database).
NEST VISIT FIELDS				
Attempt ID	a	See prior description.	categorical	
Visit ID	a	Identifier assigned for individual visits to nest attempts. A nest attempt will have as many Visit ID values as there were nest checks reported for that attempt.	categorical	
Visit Datetime	p	The date and time that individual nests were visited. Time is stored for some entry modes but not all. Time may be to nearest hour for older data, or to the second for mobile-entered data. Time is stored in the user's local time zone (but time zone itself is not stored). See Visit Time Valid to determine if the time was stored during data entry.	datetime	
Visit Time Valid	a	Whether the time portion of the Visit Datetime column was stored and should be treated as the actual time of the visit (1 = yes, 0 = no).	binary	0, 1
Nest Status	p	Condition of nest during each nest visit.	categorical	One of: no (no nest), an (another bird nest, same site), cn (complete nest), dn (damaged nest), fn (flattened nest with fecal matter), in (incomplete nest), nn (non-avian nest), rn (nest removed, remover unknown)
Adult Activity	p	Adult activity seen or heard near the nest during each nest visit. This can help determine if a nest was still active, particularly if the contents could not be seen directly.	categorical	One of: no (no adults seen or heard), aa (at/on, then flushed from nest), ba (building nest or carrying nest material), da (dead adult(s)), fa (feeding young at nest), ra (remained on the nest), va (vicinity of the nest)
Young Status	p	Developmental stage of young during each nest visit.	categorical	One of: no (no live young in nest), fy (fully feathered young), hy (hatching

				young), ny (naked young), py (partially feathered young), vy (vocal young, heard only), yy (young outside of box)
Management Status	p	Management action taken by the nest monitor.	categorical	One of: no (no management activity), am (avian competitor nest/eggs/young removed), bm (banded adults or young at nest), em (unhatched host eggs removed), nm (nest box management), pm (pest management [e.g., wasps, ants, mice, etc.])
Host Eggs Count	p	Number of host eggs counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Host Eggs Present Uncounted.	integer	
Host Eggs Present Uncounted	p	The user may indicate that host eggs were present but the exact count is unknown. In this case, Host Eggs Present Uncounted will be set to 1. Nest checks where Host Eggs Count > 0 or Host Eggs Present Uncounted = 1 may both be considered to have host eggs.	binary	0, 1
Live Host Young Count	p	Number of live host young counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Live Host Young Present Uncounted.	integer	
Live Host Young Present Uncounted	p	The user may indicate that live host young were present but the exact count is unknown. In this case, Live Host Young Present Uncounted will be set to 1. Nest checks where Live Host Young Count > 0 or Live Host Young Present Uncounted = 1 may both be considered to have live host young.	binary	0, 1
Dead Host Young Count	p	Number of dead host young counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Dead Host Young Present Uncounted.	integer	

Dead Host Young Present Uncounted	p	The user may indicate that dead host young were present but the exact count is unknown. In this case, Dead Host Young Present Uncounted will be set to 1. Nest checks where Dead Host Young Count > 0 or Dead Host Young Present Uncounted = 1 may both be considered to have dead host young.	binary	0, 1
Brood Parasite Eggs Count	p	Number of brood parasite eggs counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Brood Parasite Eggs Present Uncounted.	integer	
Brood Parasite Eggs Present Uncounted	p	The user may indicate that brood parasite eggs were present but the exact count is unknown. In this case, Brood Parasite Eggs Present Uncounted will be set to 1. Nest checks where Brood Parasite Eggs Count > 0 or Brood Parasite Eggs Present Uncounted = 1 may both be considered to have brood parasite eggs.	binary	0, 1
Brood Parasite Live Young Count	p	Number of brood parasite live young counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Brood Parasite Live Young Present Uncounted.	integer	
Brood Parasite Live Young Present Uncounted	p	The user may indicate that brood parasite live young were present but the exact count is unknown. In this case, Brood Parasite Live Young Present Uncounted will be set to 1. Nest checks where Brood Parasite Live Young Count > 0 or Brood Parasite Live Young Present Uncounted = 1 may both be considered to have live brood parasite young.	binary	0, 1
Brood Parasite Dead Young Count	p	Number of brood parasite dead young counted during a nest check. May be null if user did not provide information or was not able to count precisely. See also Brood Parasite Dead Young Present Uncounted.	integer	
Brood Parasite Dead	p	The user may indicate that brood parasite dead young were present	binary	0, 1

Young Present Uncounted		but the exact count is unknown. In this case, Brood Parasite Dead Young Present Uncounted will be set to 1. Nest checks where Brood Parasite Dead Young Count > 0 or Brood Parasite Dead Young Present Uncounted = 1 may both be considered to have dead brood parasite young.		
Visit Entry Technique	a	Method of data entry that created this visit.	text	As of 2022, the 3 modes of data entry include the NestWatch website (field value indicates various versions of "Web" entry), the mobile app (field value indicates various versions of "Mobile" entry), or bulk upload (field value indicates date of uploading into database).
Observer ID	a	See prior description	categorical	

[a] a = assigned, p = participant

[b] number of decimal places stored shown in parentheses

1. **Variable identity:** See Table 2.

2. **Variable definition:** See Table 2.

3. **Units of measurement:** See Table 2.

4. **Data type**

   a. Storage type: Data are stored as integers, decimals, and character strings as indicated in Table 2.

   b. List and definition of variable codes: Explanations for coded variables are detailed in Table 2.

   c. Range for numeric values: Indicated in Table 2.

d. Missing value codes: Missing data fields are left blank.

e. Precision: Numbers of eggs, young, or fledglings are reported as integers. Latitude, longitude, nest height, cavity entrance diameter, and elevation are decimals. The number of significant digits stored for each field is listed in Table 2. However, most numeric data fields are entered directly by users, and the method and precision they used to make particular measurements is generally unknown. Latitude and longitude represent a special case. While the database can store up to 7 decimals of precision for latitude and longitude, nest coordinates are not generally known to this level of accuracy. Where possible, the technique used to determine latitude and longitude is stored in the site "Location Entry Technique" field, and may correspond to a level of precision.

- GPS devices, including mobile phones, are generally accurate within approximately 5-10 meters (van Diggelen and Enge 2015), which corresponds to ~4 decimal places latitude and longitude (this is based on dividing the circumference of the earth by 360 degrees: each degree represents about 111 km). Older GPS devices may be less accurate.
- The accuracy of locations chosen on a Google Map will depend on the map zoom level used. The zoom level is recorded in the Location Entry Technique in the format: "/GOOGLE_MAP/ZOOM:14" (meaning a zoom level of 14). Zoom levels are related to coordinate precision based on transforming

latitude and longitude degrees via the Mercator projection and multiplying by 2 raised to the zoom level to determine meters per map pixel shown on the user's device (Google 2023). We suggest assuming the following accuracy dependent on zoom level:

Levels 17 and higher: Accurate within 11 meters, or 4 decimal places. Accuracy within 1 meter is not expected.

Levels 13-16: Accurate within 111 meters, or 3 decimal places

Levels 10-12: Accurate within 1 km, or 2 decimal places

Levels 7-9: Accurate within 11 km, or 1 decimal place

Levels 3-6: Accurate within 111 km, or 0 decimal places

Levels 0-2: Accurate within 1,111 km

- Coordinates assigned by ZIP code lookup or to a county centroid will have a precision dependent on the size of the ZIP code or county. This method is generally used for historical records, and we suggest that 0 or 1 decimal points of precision may be appropriate.
- A small percentage of nest site latitude and longitude values are truncated to 1 decimal place (within 11 km) if a sensitive species has been recorded there (see Proprietary Restrictions section above for details).
- Data users may wish to exclude nest sites whose location cannot be known to sufficient precision.

5. Data format

a. Fixed and variable-length data fields

b. Columns:

attempts_locs-20230518.csv: Start column is “Attempt ID”, end column is “Attempt Entry Technique"

checks-20230518.csv: Start column is “Attempt ID”, end column is “Observer ID"

c. Number of decimal places: Indicated in Table 2.

C. Data anomalies: Data users should consider the following known limitations of the NestWatch data set before proceeding with analysis:

- Not all nest attempts contain summary data, nor do all nest attempts include repeated visit information. Users must filter the data set as appropriate for answering focal questions.
- Data users should screen the data for biologically questionable data (e.g., clutch sizes that exceed the known maximum for the focal species, species nesting outside of the expected breeding range, or lay dates that are unusually early or late in the year for the focal species at a given location). Although the data entry interface does attempt to screen questionable data for many North American birds, these filters are not available for all species; furthermore, participants may choose to dismiss warning messages. Because the filters are merely onscreen messages that may be dismissed by the participant (that is,

they do not prevent the entry of unlikely data), data users should screen all records regardless of whether or not a quality-control filter was in place for that species or region.

- Birds are not individually identifiable. Because the data are collected primarily by volunteers, most of whom do not hold permits to individually mark birds, NestWatch lacks data on individual bird identity. Therefore, it is not possible to determine if a bird reusing a nest site is the same bird which previously used the site, nor can one quantify the reproductive effort or output of individual birds over time.
- The absence of breeding birds cannot be inferred, nor can the data be used to determine occupancy (i.e., of nest boxes) or density of breeding pairs because NestWatch lacks data on unused nest sites.
- While data on brood parasitism are collected and available in the data set, we urge extreme caution in utilizing this information. First, it is possible that many observers do not recognize brood parasitism, leading to underreporting (e.g., eggs of brood parasites can appear identical to eggs of the host species). Second, some observers may intervene to remove brood parasites but not report such activity for various reasons (e.g., because interfering with nesting birds is illegal in certain jurisdictions).
- Data on invasive species should be used with caution. Invasive species may compete for nest sites with native species (e.g., House Sparrow [*Passer domesticus*] and European Starling [*Sturnus vulgaris*] in North America, Bailey et al. 2020), prompting some observers to actively manage nests of invasive species (Larson et al. 2016, Phillips et al. 2021). Because the outcome of nests of invasive species may be influenced by human activity, data users should use caution when analyzing outcome data from these species (although data on lay date or clutch size may be used with proper caution).

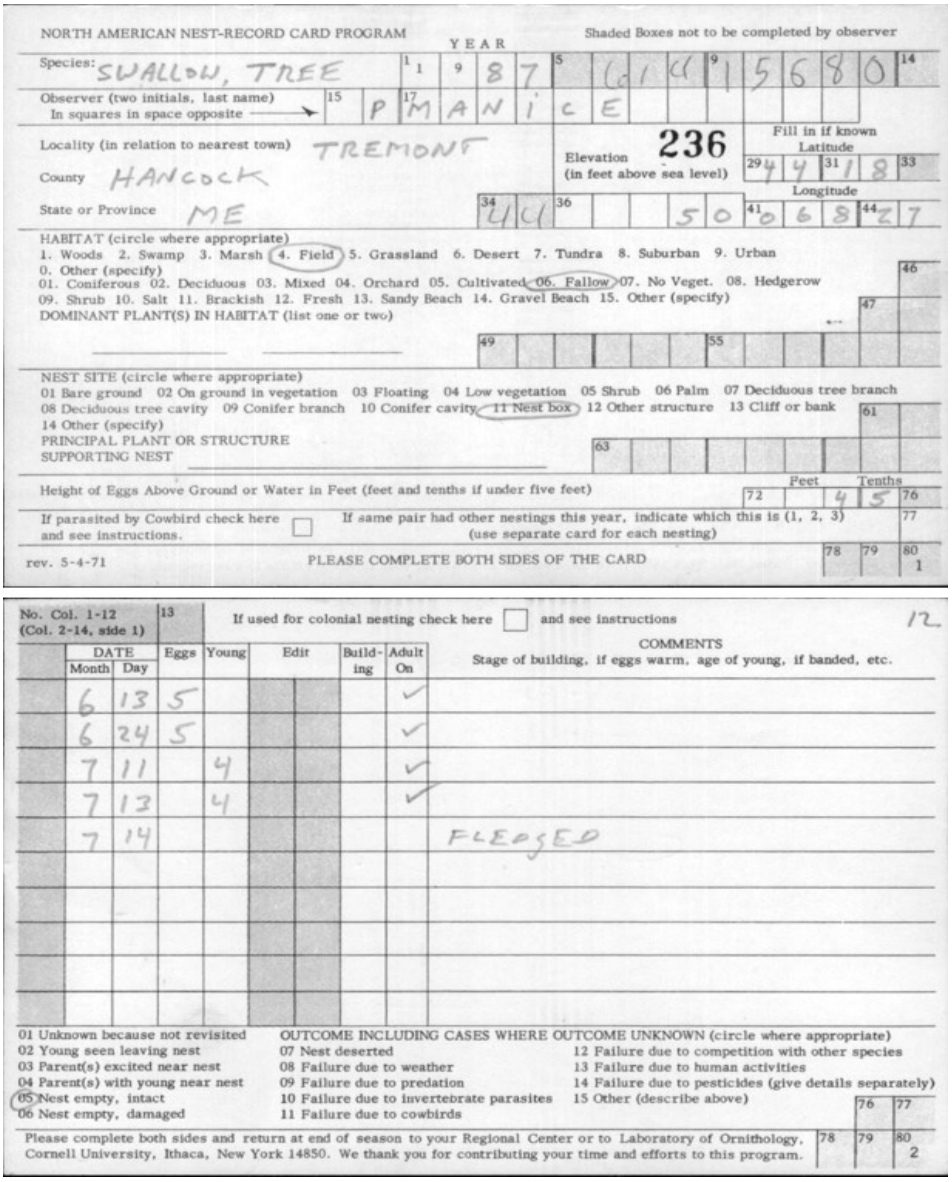
- Users should be aware that "species" information may be stored as distinct taxonomic units that are not at the level of full species. This includes potential hybrids (e.g., American Black Duck [*Anas rubripes*] x Mallard [*A. platyrhynchos*], species code: "x00004"), potential morphs within species (e.g., "Slate-colored" Junco, one of multiple color morphs within the Dark-eyed Junco [*Junco hyemalis*] species), and species that could not be identified to the species level by the observer (e.g., "Tree/Violet-green Swallow" or "*Tachycineta* sp." to indicate that the nest was tended by one of these similar and closely-related species, *Tachycineta bicolor/T. thalassina*). Given that multiple morphs of the same species may be included in the data set, data users may wish to combine records from all subspecies into the full species name as needed.
- Additionally, observers may easily misidentify similar species, and data users may want to combine reports across multiple species codes. For example, data from difficult-to-distinguish species in zones of geographic overlap may best be combined (e.g., Black-capped Chickadee [*Poecile atricapillus*] and Carolina Chickadee [*P. carolinensis*] in the hybrid zone).
- Data users should be aware that some nest attempts may be split across years (e.g., beginning in December of one year and ending in January of the subsequent year). This is sometimes legitimate (i.e., birds may nest year-round in some locales, or the nesting season may span calendar years) and is sometimes the result of an error (e.g., the participant mistypes the year as 2020 in one entry but as 2021 in the next entry). In both cases, the Year data field assigned to the nest will be the earlier of the two. In order to interpret the likely legitimacy of such nest attempts, the data user should consider the species' biology, locale, and the data consistency for questionable entries.

- Because observers tend to find and monitor nests near to where they live, areas with lower human population densities may be poorly represented.
- Research has previously identified some evidence for a "weekend bias" in the timing of nest visits among NestWatch participants (Cooper 2014).
- Other errors may exist that are not described here. It is the responsibility of the data user to review the data for accuracy before interpreting results.

Class V. Supplemental descriptors

A. Data acquisition

1. Data forms or acquisition methods: Data are contributed to the database via web-based data entry forms (www.nestwatch.org), a custom mobile phone app available for iOS and Android devices (search "NestWatch by the Cornell Lab" in app stores), or via bulk upload of standardized spreadsheets by Cornell Lab staff. Data previously submitted on handwritten paper cards to the North American Nest-Record Card Program (Fig. 1) are being transcribed via the crowdsourcing platform Zooniverse (https://www.zooniverse.org/organizations/brbcornell/nest-quest-go). This process is ongoing as of 2023, and involves reconciling multiple transcriptions, extracting and translating the fields that are represented in the present NestWatch schema, and preparing the data as comma delimited files for bulk upload.



NORTH AMERICAN NEST-RECORD CARD PROGRAM — YEAR — Shaded Boxes not to be completed by observer

Species: SWALLOW, TREE — 1 1 9 8 7 — 5 C A 9 1 5 6 8 0 14

Observer (two initials, last name) In squares in space opposite → 15 P 17 M A N I C E

Locality (in relation to nearest town) TREMONT

County HANCOCK

State or Province ME — 34 U U 36 5 0 41 0 6 8 44 Z 7

Elevation (in feet above sea level) 236 — Fill in if known: Latitude 29 4 4 31 1 8 33 — Longitude

HABITAT (circle where appropriate)
1. Woods 2. Swamp 3. Marsh (4. Field) 5. Grassland 6. Desert 7. Tundra 8. Suburban 9. Urban
0. Other (specify)
01. Coniferous 02. Deciduous 03. Mixed 04. Orchard 05. Cultivated (06. Fallow) 07. No Veget. 08. Hedgerow
09. Shrub 10. Salt 11. Brackish 12. Fresh 13. Sandy Beach 14. Gravel Beach 15. Other (specify) — 46
DOMINANT PLANT(S) IN HABITAT (list one or two) — 47
49 — 55

NEST SITE (circle where appropriate)
01 Bare ground 02 On ground in vegetation 03 Floating 04 Low vegetation 05 Shrub 06 Palm 07 Deciduous tree branch
08 Deciduous tree cavity 09 Conifer branch 10 Conifer cavity (11 Nest box) 12 Other structure 13 Cliff or bank
14 Other (specify) — 61
PRINCIPAL PLANT OR STRUCTURE SUPPORTING NEST — 63

Height of Eggs Above Ground or Water in Feet (feet and tenths if under five feet) — Feet 4 Tenths 5 — 72 76

If parasited by Cowbird check here ☐ and see instructions. — If same pair had other nestings this year, indicate which this is (1, 2, 3) (use separate card for each nesting) — 77

rev. 5-4-71 — PLEASE COMPLETE BOTH SIDES OF THE CARD — 78 79 80 1

No. Col. 1-12 (Col. 2-14, side 1) 13 — If used for colonial nesting check here ☐ and see instructions — 12

DATE Month	DATE Day	Eggs	Young	Edit		Building	Adult On	COMMENTS Stage of building, if eggs warm, age of young, if banded, etc.
6	13	5					✓	
6	24	5					✓	
7	11		4				✓	
7	13		4				✓	
7	14							FLEDGED

OUTCOME INCLUDING CASES WHERE OUTCOME UNKNOWN (circle where appropriate)
01 Unknown because not revisited
02 Young seen leaving nest
03 Parent(s) excited near nest
04 Parent(s) with young near nest
(05 Nest empty, intact)
06 Nest empty, damaged
07 Nest deserted
08 Failure due to weather
09 Failure due to predation
10 Failure due to invertebrate parasites
11 Failure due to cowbirds
12 Failure due to competition with other species
13 Failure due to human activities
14 Failure due to pesticides (give details separately)
15 Other (describe above) — 76 77

Please complete both sides and return at end of season to your Regional Center or to Laboratory of Ornithology, Cornell University, Ithaca, New York 14850. We thank you for contributing your time and efforts to this program. — 78 79 80 2

Figure 1. An example of a nest-record card submitted to the North American Nest-Record Card Program at the Cornell Lab of Ornithology.

2. Location of completed data forms: Modern NestWatch data are submitted electronically by participants and stored in a relational database; these data are no longer stored on paper or as scanned images. Historic North American Nest-Record Card Program data are stored on paper cards in a storage facility at

the Cornell Lab of Ornithology in Ithaca, New York, and digital scans of those cards are maintained on servers at Cornell.

3. **Data entry verification procedures:** The NestWatch project continues to refine and develop its validations to further improve the quality of recorded data. Validations such as those described below have been largely in place since 2014. Data created prior to 2014 generally had fewer such validations applied. NestWatch imposes validation layers at the database and user interface levels. The database structure requires that fields adhere to particular data types and, in some cases, constrains fields to particular values. For example, the species is limited to the eBird taxonomy (Clements et al. 2022); date fields and integer fields cannot contain other data types and may be limited to particular ranges. These constraints are detailed in Table 2.

The web and mobile app user interfaces provide another layer of validation. There are currently up to 26 logical and phenological validations that may be performed depending on the information available for the observed species. Logical validations include: that a nest visit or nesting event does not occur in the future; that fledge date must follow egg-laying date and hatch date; and number of live young may not be greater than clutch size. Phenological validations (available for 457 species at the time of writing) include checks that the number of eggs or chicks does not exceed a reasonable range for the observed species; that the incubation or brooding period is a reasonable number of days; and that the dates entered as egg laying, hatching, or fledging date occur at an appropriate time of year. The validation ranges are generous to account for variability, which may be

due to geography, time of year, and climate change. Implementation of these validations can be specific to the client application (i.e., website data entry or mobile app) and may include: prevention of form submission until the data is corrected (e.g., for a logical problem such as fledge date occurring before egg laying date); requiring that the user mark a checkbox to indicate that they are aware that the observation is outside the norm (e.g., for a very large clutch size); or allowing data submission, but showing the user a flag indicating that a correction is likely needed.

The NestWatch project has learned that a common misunderstanding of nest-watching protocol can lead to users reporting multiple breeding efforts over long time periods under the same attempt (i.e., not recognizing when to end a nesting attempt and begin recording a new one). To prevent data from being recorded in this fashion, the web interface checks that the number of eggs and young must not increase after having decreased. When subsequent nest checks show an egg count or young count that increases after having decreased, a flag is shown informing the user that this most likely should be considered a new nesting attempt. Participants are not forced to start a new nesting attempt, however, so users of the data should take steps to ensure that these 'run-on' nests are not inappropriately included in analyses. Equivalent checks will be added to the mobile app interface but have not been used to date.

Certain validations are applied in user interfaces invisibly to the participant. For example, it is not possible to select a nesting species that has not been observed in the geographic region of a given nest site (according to the eBird database, which

is generally inclusive of rarities and is curated by a community of expert birdwatchers); the dropdown menu for selecting species will only contain species known to be in the region. Note that these data validation and review procedures evolve over time, and historic data may not have undergone such review.

The accessioning of the historical North American Nest-Record Cards into the NestWatch database has required additional processing and validation methods.

- Cards were manually sorted and those without year, location information, or any nest checks were removed. Additionally, we removed cards having only one nest check in which an egg count was the only data reported.
- The cards were transcribed by volunteers via the Zooniverse crowdsourcing platform (https://www.zooniverse.org/organizations/brbcornell/nest-quest-go). Fields were transcribed in brief workflows such as "Latitude and Longitude" or "Nest Height."
- Transcribed entries were processed separately to determine a validated consensus value for each field on each card. In limited cases, fields are interpreted together; for example:
    - Cards lacking latitude and longitude may have their location assigned based on consensus county and state fields corresponding to county centroids stored in the eBird database. The centroids were calculated from the ESRI spatial database (Environmental Systems Research Institute [ESRI] 2002).

- Constrained card data such as nest site type and outcome are presented via constrained input fields (dropdowns or checkboxes) on Zooniverse. Transcriber responses are then translated to their equivalent NestWatch database values before consensus is calculated. In some cases, the NestWatch schema does not track the same level of detail as the cards, and multiple nest-record values are subsumed by one NestWatch value (e.g., both "Conifer tree branch" and "Deciduous tree branch" are stored in the NestWatch Substrate field as "ltrbra" which is interpreted as “live tree branch”).
- The Nest-Record Card Program allowed multiple outcome codes to be specified, but the NestWatch database requires a single outcome per nesting attempt. A processing protocol was developed to convert combinations of multiple nest-record outcome codes to a single NestWatch code.
- Text entries are cleaned and standardized for case, punctuation, whitespace, leading and trailing zeroes, and other known issues. Consensus is calculated on the result of this standardization.
- Consensus requires 60% agreement among transcribers. A curated list of trusted transcribers is also maintained to break ties when no answer exceeds 60% agreement. If consensus is still not met on a given field, the field is left blank.
- The following fields are considered required: Year, Latitude, Longitude, and (for each visit) Visit Datetime, Host Eggs Count, Live Host Young

Count. Cards must achieve consensus on all of these values to be included. Blanks are permitted for egg and young counts, but there must be at least one visit with a positive number of eggs or young for visit fields to be included.

- Non-required fields are left blank if they do not reach consensus.
- Latitude and Longitude must map to North America. Year must be a valid year from 1800 to present year. Visit dates must be valid days of the year.

In addition to the North American Nest-Record Card project, NestWatch also accepts contributions of other historical nesting data sets. Individuals and organizations interested in contributing such data sets may reach out to NestWatch staff directly or through an online form. Candidate data sets must contain a minimum set of required fields: a location identifier, latitude, longitude, substrate, species name, year, and outcome. If nest check data are to be included, attempt identifier and visit date are also required. NestWatch encourages data contributors to include more than the minimum, but due to the variable nature of historic records and study systems, not all variables will have been collected. NestWatch staff can provide an Excel template for preparing the historical data import, but manual validation is a key part of the process. We format and translate data fields to adhere to the allowed database values (see Table 2). We look for potential errors and ambiguities during this process and work with data contributors to resolve them but may miss some errors and may also exclude records or variables at our discretion if there is no clear correction for an error. Once finalized, the data set is saved as a comma-separated value file and uploaded to the NestWatch database via our bulk upload tool.

B. Quality assurance/quality control procedures: Data are offered as submitted by participants with minimal processing following submissions. Data users are encouraged to screen

all fields based on biological relevance and feasibility (e.g., ensure that clutch sizes reported are biologically feasible for the species of interest).

C. Related materials: N/A

D. Computer programs and data-processing algorithms: None**.**

E. Archiving

1. Archival procedures: The Cornell Lab of Ornithology database, which includes the NestWatch data set, is located at Cornell University. Backup procedures include weekly offsite backups of the full database, and an ongoing continuous backup of all database changes to two separate physical locations. Those changes are additionally copied every 15 minutes to a remote cloud-based offsite location.

2. Redundant archival sites: A weekly redundant export of the entire database including NestWatch data is also made and copied to both local and offsite destinations.

F. Publications and results: See the NestWatch website for a partial list: https://nestwatch.org/about/publications/

G. History of data set usage

1. Data request history: NestWatch data have always been available upon request. The data have been used in hundreds of publications. A list of historic data requests is not maintained.

2. **Data set update history:** The data set is continuously updated by contributors from the public and staff at the Cornell Lab of Ornithology (bulk data uploads). The data set available on the NestWatch website (https://nestwatch.org/explore/nestwatch-open-dataset-downloads/) will be updated around January 31 annually and copied to the Mendeley Data repository (Bailey et al. 2023) where standard version-control is implemented (i.e., old versions will remain available). Updates will include the addition of new data, as well as taxonomic updates (applied retroactively to all historic records) and the correction of previous errors.

3. **Review history:** See the NestWatch website (https://nestwatch.org/explore/nestwatch-open-dataset-downloads/) or the Mendeley Data repository (Bailey et al. 2023; doi: 10.17632/wjf794z7gc.1) for updated files and version history.

4. **Questions and comments from secondary users:** Inquiries about the data should be directed to the NestWatch project leader at the Cornell Lab of Ornithology (nestwatch@cornell.edu).

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References:

Bailey, R. L., and D. N. Bonter. 2017. Predator guards on nest boxes improve nesting success of birds. Wildlife Society Bulletin 41:434–441.

Bailey, R. L., and D. N. Bonter. 2021. Large-scale supplemental feeding alters lay date and nest survival in Eastern Bluebirds but not in two species of chickadees. Ornithological Applications 124:1–11.

Bailey, R. L., H. A. Faulkner-Grant, V. Y. Martin, T. B. Phillips, and D. N. Bonter. 2020. Nest usurpation by non-native birds and the role of people in nest box management. Conservation Science and Practice 2020:e185.

Bailey, R. L., L. Larson, and D. N. Bonter. 2023. "NestWatch Open Dataset", Mendeley Data, V1, doi: 10.17632/wjf794z7gc.1.

Callery, K. R., S. E. Schulwitz, A. R. Hunt, J. M. Winiarski, C. J. W. McClure, R. A. Fischer, and J. A. Heath. 2022. Phenology effects on productivity and hatching-asynchrony of American kestrels (*Falco sparverius*) across a continent. Global Ecology and Conservation 36:e02124.

Carleton, R. E., J. H. Graham, A. Lee, Z. P. Taylor, and J. F. Carleton. 2019. Reproductive success of Eastern Bluebirds (*Sialia sialis*) varies with the timing and severity of drought. Plos One 14:e0214266.

Clements, J. F., T. S. Schulenberg, M. J. Iliff, T. A. Fredericks, J. A. Gerbracht, D. Lepage, S. M. Billerman, B. L. Sullivan, and C. L. Wood. 2022. The eBird/Clements checklist of Birds of the World: v2022. https://www.birds.cornell.edu/clementschecklist/download/.

Cooper, C. B. 2014. Is there a weekend bias in clutch-initiation dates from citizen science? Implications for studies of avian breeding phenology. International Journal of

Biometeorology 58:1415–1419.

Cooper, C. B., R. L. Bailey, and D. I. Leech. 2015. The role of citizen science in studies of avian reproduction. Pages 208–220 *in* D. C. Deeming and S. J. Reynolds, editors. Nests, Eggs, and Incubation. First. Oxford University Press, Oxford.

Crick, H. Q. P., S. R. Baillie, and D. I. Leech. 2003. The UK nest record scheme: its value for science and conservation. Bird Study 50:254–270.

van Diggelen, F., and P. Enge. 2015. The World's first GPS MOOC and Worldwide Laboratory using Smartphones. Pages 361–369 Proceedings of the 28th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2015). The Institute of Navigation, Tampa.

Environmental Systems Research Institute (ESRI). 2002. ArcGIS Release 8.1. Environmental Systems Research Institute (ESRI), Redlands, CA.

Google. 2023. Map and Tile Coordinates. https://developers.google.com/maps/documentation/javascript/coordinates.

Larson, L. R., C. B. Cooper, and M. E. Hauber. 2016. Emotions as Drivers of Wildlife Stewardship Behavior: Examining Citizen Science Nest Monitors' Responses to Invasive House Sparrows. Human Dimensions of Wildlife 21:18–33.

Pettingill, Jr., O. S. 1966. The North American Nest-Record Card Program for 1966. The Wilson Bulletin 78:136.

Phillips, T. B., R. L. Bailey, V. Martin, H. Faulkner-Grant, and D. N. Bonter. 2021. The role of citizen science in management of invasive avian species: What people think, know, and do. Journal of Environmental Management 280:111709.

Phillips, T., and J. L. Dickinson. 2009. Tracking the nesting success of North America's

breeding birds through public participation in NestWatch. Pages 633–640 Fourth International Partners in Flight Conference: Tundra to Tropics. McAllen, TX, USA.

Senzaki, M., J. R. Barber, J. N. Phillips, N. H. Carter, C. B. Cooper, M. A. Ditmer, K. M. Fristrup, C. J. W. McClure, D. J. Mennitt, L. P. Tyrrell, J. Vukomanovic, A. A. Wilson, and C. D. Francis. 2020. Sensory pollutants alter bird phenology and fitness across a continent. Nature 2020:605–609.

Shipley, J. R., C. W. Twining, M. Mathieu-Resuge, T. P. Parmar, M. Kainz, D. Martin-Creuzburg, C. Weber, D. W. Winkler, C. H. Graham, and B. Matthews. 2022. Climate change shifts the timing of nutritional flux from aquatic insects. Current Biology 32:1–8.

Sockman, J., and J. Courter. 2018. The Impacts of Temperature, Precipitation, and Growing Degree-Days on First Egg Dates of Eastern Bluebird (*Sialia sialis*) and Tree Swallow (*Tachycineta bicolor*) in Ohio. The American Midland Naturalist 180:207–215.

Socolar, J. B., P. N. Epanchin, S. R. Beissinger, and M. W. Tingley. 2017. Phenological shifts conserve thermal niches in North American birds and reshape expectations for climate-driven range shifts. Proceedings of the National Academy of Sciences 114:12976–12981.

Watts, H. E., D. Jimenez, V. Pacheco, and T. P. Vilgalys. 2018. Temperature-correlated shifts in the timing of egg-laying in House Finches *Haemorhous mexicanus*. Ibis:1–7.