Title: Searching for and Monitoring the Nests of Imperiled Grassland Birds: Recommendations from the Grand River Grasslands of Iowa

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Abstract: Grassland birds are the most imperiled avian group in North America, with greater than 50% abundance declines since 1970. Studies examining factors that impact habitat preferences, habitat selection, and reproductive success are critical to developing effective conservation and management plans for these species. These studies often involve searching for and monitoring nests in grasslands, which requires a unique set of skills and protocols not always comparable to methods used in other habitats. In this paper, we provide recommendations and best practices for field studies of grassland birds based on our experience studying songbirds in the Grand River Grasslands of southern Iowa,We review search methods (e.g., behavioral searching and rope dragging), monitoring protocols (i.e., nest visits, filming procedures, weighing, and tarsus measurements), nest vegetation sampling, and provide descriptions to aid in nest and nestling identification, with a particular focus on six obligate grassland species. In addition, we provide photographs of nests and associated eggs and nestlings for six species, as well as time-series photos of development to aid in aging nestlings. We recommend researchers carefully consider procedures for monitoring nests of grassland birds and keeping protocols as minimally invasive as possible to protect these declining species.

Keywords: Grassland birds, nest searching, nest monitoring, nestling development, nest identification

Introduction

Grassland birds in North America face numerous conservation threats originating from habitat fragmentation, loss, and degradation (Brennan and Kuvlesky 2005). Cultivation of crops and overgrazing after European settlement have eliminated or severely altered grassland habitats (Peterjohn and Sauer 1999), with losses of upwards of 97% in the tallgrass prairie ecoregion (Herse et al. 2020). As a result, grassland bird abundance has declined by 53% since 1970, which has led to their classification as the most threatened avian group in North America (Rosenberg et al. 2019) and a “conspicuous wildlife conservation crisis” of the 21st century (Brennan and Kuvlesky 2005). It is thus critical to be proactive in supporting informed management and conservation of grassland birds, especially in the highly threatened tallgrass prairie ecoregion (Samson and Knopf 1994, Miller et al. 2012).

Effective conservation of birds relies on accurate estimates of responses to habitat alteration and restoration (Bradbury et al. 2001). Although studies on grassland bird abundance are useful for understanding responses to management, evaluating abundance alone may lead to inaccurate assessments of habitat quality (Horne 1983). There may be situations where grassland birds are attracted to areas that confer lower reproductive success (ecological traps). For example, a bird may be attracted to an area with high cover of invasive grasses but have lower fledgling production in those areas (Maresh Nelson et al. 2018). For this reason, there is thus an urgent need for high-quality research on grassland bird fitness through evaluations of reproduction and survival (Winter et al. 2003, Coon et al. 2022).

However, grassland bird reproduction can be difficult to study due to the cryptic nature of many species: their nests are often challenging to find and monitor (Winter et al. 2003, Giovanni et al. 2011, Scholten et al. 2019). The goal of this review is to facilitate field research by providing best practices for searching for and monitoring nests with minimal adverse impacts. We (1) review the natural history of grassland bird species, including reproductive timing (i.e., incubation and nestling periods) and nest identification, (2) describe nest searching and monitoring methods, (3) discuss key considerations for reducing avian stress, and (4) describe important field marks necessary to age nestlings. Many of the most-cited references on nest searching focus primarily on forest or shrubland birds (Martin and Geupel 1993, Martin et al. 1997, but see Winter et al. 2003). Our recommendations are based on applying the scientific literature to grassland contexts in combination with our experience studying the reproduction of these birds in the Grand River Grasslands of southern Iowa between 2013 and 2023 (Maresh

Nelson et al. 2018, 2020, Coon et al. 2022). While this review is intended to be generally applicable to songbirds of the tallgrass ecoregion, we will focus on species abundant in our study sites in southern Iowa–an area centrally placed within the tallgrass prairie ecoregion.

Grassland Birds of the Tallgrass Prairie Ecoregion

Pre-colonial tallgrass prairies stretched across the central-eastern Great Plains, including most of Iowa and parts of Kansas, Nebraska, Minnesota, the Dakotas, Illinois, Wisconsin, Missouri, Oklahoma, and Texas, as well as Manitoba, Saskatchewan, and Alberta in Canada (Samson and Knopf 1994). In this review, we primarily focus on six obligate passerines from this region that are listed as species of concern in Iowa's State Wildlife Action Plan and are in the seminal list of grassland birds in Vickery (1999). We also occasionally mention other grassland species where relevant. Focal species include three ground-nesting birds–Grasshopper Sparrows (*Ammodramus savannarum*), Eastern Meadowlarks (*Sturnella magna)*, and Bobolinks (*Dolichonyx oryzivorus*)–and three shrub-nesting or clump-nesting birds–Dickcissels (*Spiza americana*), Henslow's Sparrows (*Centronyx henslowii*), and Sedge Wrens (*Cistothorus stellaris*) (Coon et al. 2020; Figure 1). These species are territorial, with males defending areas with greater nesting or foraging resources through song and aggressive interactions with other birds (Rotella et al. 1999). Some are neotropical migrants (e.g., Dickcissel, Bobolink), though most migrate short distances to and from the southern United States or northern Mexico (e.g., Sedge Wren; Vickery et al. 2000).

These obligate grassland birds completely depend on grasslands for survival and the completion of their life cycles. They forage and breed in grasslands and rarely or never use other habitat types (Vickery et al. 1999); Table 1). Obligate species are considered the most threatened by loss of grassland habitat, and would be expected to go extinct without grasslands as they cannot function in other habitats. Two of the species most at risk for extinction are Bobolinks, which face population declines due to habitat loss and climate change, and

Henslow's Sparrows, which are additionally vulnerable due to a small global population size (Rosenberg et al. 2016); Table 1). Henslow's Sparrows also listed as state threatened in Iowa (Zohrer et al. 2006). Although still considered common, Grasshopper Sparrows and Eastern Meadowlarks are of conservation concern having experienced population declines of >60% in the last 40 years, and another 50% loss predicted within the next few decades (Rosenberg et al. 2016). These birds, with the addition of Dickcissels, are facing population declines within Iowa and are listed as Species of Greatest Conservation Need (Table 1).

In contrast to obligate species, facultative grassland bird species use grassland habitats for some part of their lifecycle or habitat needs, but may live and forage in other habitats (Scott et al. 2002). However, many facultative species are still specialists to habitats within or near grasslands such as shrublands, savannas, or other ecotones. Many have experienced recent population declines (e.g., Field Sparrows have declined 60% in the last 40 years, Loggerhead Shrikes 70%, and Eastern Bluebirds 38%) and studying their nesting ecologies could provide valuable information for conservation (Rosenberg et al. 2016).

Nest Descriptions for Ground-Nesting Grassland Birds: Many grassland birds are ground-nesting (Figure 2). Two species within our focal group, Grasshopper Sparrows and Eastern Meadowlarks, are ground nesters with a similar nest structure. Grasshopper Sparrows build nests made of soft grasses and plant litter, creating a domed appearance, with the entrance facing only slightly vertical to the ground (Figure 2A; (Hubbard et al. 2006). These nests are well hidden (Ehrlich et al. 1988), and are often nearly undetectable only meters away. Eastern Meadowlarks also nest on the ground, but tend to have larger nests compared to Grasshopper Sparrows (Long et al. 2009). Meadowlark nests are often built in or near grass clumps (Figure 2B) and can have openings either facing up (i.e., vertical to the ground) creating a domed appearance, some with elaborate entrance tunnels or 'runways' (Peck and James 1987, Hubbard et al. 2006). In our study region, we noticed that Eastern Meadowlark nests were frequently placed adjacent to ant hills (J. Coon, pers. obs). Both of these species demonstrate a preference for early- or mid- successional grasslands. Bobolinks also nest on the ground, but their nests are open to the top and are more likely to be found in mid- to late-successional grasslands, often in a slight depression with large amounts of grass and an abundance of litter (Figure 2C; (Bollinger 1995). These ground nesters make their open-cup nests from dead grasses and forbs and use the surrounding litter as camouflage (Renfrew et al. 2015).

Nest Descriptions for Shrub/Clump-Nesting Grassland Birds: In contrast to ground-nesting grassland birds, Dickcissels and facultative species such as Red-winged Blackbirds or Field Sparrows are associated with later-successional grasslands and tend to place their nests slightly elevated in shrubs or clumps of forbs or grasses (Ehrlich et al. 1988, Shew and Nielsen 2021). For example, Dickcissels place their loosely woven, open-cup nests in shrubs, grass clumps, and forbs, often with standing dead vegetation providing additional structure (Figure 3A; (Harmeson 1974). Given their preference for discrete clumps of vegetation, it is often possible to determine ideal nest locations for Dickcissels in a given location from some distance away, and these are some of the easier nests to locate (Temple 2002). Henslow's Sparrows build open cup-shaped nests among layers of thick litter at or near the base of thick clumps of grasses (Winter 1999). The outside of the nest is constructed from large, broad grasses and the interior is lined with finer grasses commonly found in the area (Figure 3B; Robins 1971). The density of the litter and secretive nature of the species can make Henslow's Sparrow nests very difficult to locate, with overhanging litter or vegetation sometimes creating a partial 'roof' over the nest (Ehrlich et al. 1988). Another later-successional species, the Sedge Wren, nests in clumps of dense sedges or other graminoids, often in or near ditches (Dechant et al. 2002). Their nests are also elevated off the ground and are spherical, with the nest opening facing one side (Figure 3C). The male Sedge Wrens construct the outside of these nests using grasses while the insides are lined by female Sedge Wrens with fur, feathers, and fine grasses for insulation

(McFarland et al. 2021). Importantly, research suggests that Sedge Wrens can build multiple nests within their territory, sometimes for one female or for multiple (Burns 1982, Ehrlich et al. 1988).

Nest Searching Methods for Obligate Grassland Songbirds

The first step to studying the reproductive success of grassland birds is locating their nests. Given the difficulties associated with finding these well-hidden structures, searching for grassland bird nests is an activity that requires patience, perseverance, knowledge of the breeding biology of the species, and an aptitude for avian behavioral observation (Winter et al. 2003). In addition to having variable nest structures and placement, grassland songbirds have nest care and defense behaviors that vary by species, time of day, and nest stage. It is thus unsurprising that methods used to locate nests vary in their effectiveness by species, and all methods have incomplete detectability (Giovanni et al. 2011). Several key methods and their strengths and weaknesses are described in the following sections - including systematic searching, behavioral searching, rope-dragging, incidental flushes or haphazard walking, and integrated methods (Winter et al. 2003). For all methods, we recommend nest searching between April-Aug in the morning (from sunrise to around 1100), though depending on the species and their specific nesting behaviors, later searching may still prove effective.

An important skill for all nest-searching methods is an understanding of how to differentiate whether or not a bird flushing from vegetation was likely to have been sitting on a nest (Winter et al. 2003) (often called ‘suspiciously nesty’ flushes by our research team). Flushes that are very close to the observer are more likely to lead to a nest than a flush farther from an observer, especially those within ~1-2 m. A flushed bird that flies only a short distance and/or immediately begins alarm calling can also indicate a likely nest (Martin and Geupel 1993). Flushing is used in all nest-searching methods to some degree, and is almost always necessary to find the nests of the most cryptic species (e.g., Eastern Meadowlarks, Bobolinks, Grasshopper Sparrows, Henslow's Sparrows).

1. Systematic Searching

The simplest method for nest searching is examining all potential nest sites for the presence of nests. An individual researcher may carry this out alone or a group of researchers may form a line, and walk carefully, systematically checking for nests in the vegetation. The method is improved when observers use a 'sweeping stick' that is swept back and forth across the top of the vegetation to flush birds from their nest, above the height where nests are placed to avoid harming birds (Winter et al. 2003, Conkling et al. 2015). The success of this effort depends on species-specific knowledge, and tends to be more successful when researchers have a targeted search area (e.g., where a male bird is defending a territory) and have a 'search image' of the nest in mind (Winter et al. 2003). For example, knowing that Dickcissels often construct their nests in clumps or shrubs can assist the researcher in targeting their efforts to those areas. Depending on the species, systematic searching may involve checking every clump or shrub in an area or could include examining all areas with heavy litter accumulation for species that have those preferences. We do not recommend using systematic searching for species with cryptic nests as they are challenging to spot in the vegetation even when the observer is very close by. (J. Coon, pers obs).

Systematic searching is extremely effort- and time-intensive, and without information gained through other searching methods (e.g., behavioral cues), the yield can be very low. This method is often more successful in forest or shrublands, and is generally not recommended for grassland habitats unless the search area is quite small (Winter et al. 2003). This method is most effective for species that have cup-nests in defined clumps or shrubs like Dickcissels, and facultative species such as Red-winged Blackbirds or Field Sparrows. Even in these more detectable species, the method may miss a large number of nests as their nesting substrate preferences are flexible and it is challenging to check all possible sites. There is also an increased risk of trampling a broader area of vegetation cover compared to some other methods. We recommend that researchers limit the use of systematic nest searching unless the method is combined with other approaches to increase success rates and the search area is small and well-defined.

2. Behavioral Searching

'Behavioral searching' involves using behavioral cues to track parent birds back to their nest sites. Researchers triangulate nest sites by observing parental behaviors such as chipping and calling, short-distance flights, or holding nesting material (e.g., dead leaves), arthropods, or nestling fecal sacs (Martin and Geupel 1993). When parent birds return to the same location repeatedly, researchers can use that information to target searching within the vegetation to high-probability locations. In our experience, the behaviors most likely to lead to finding a nest are when parents are holding a food item or nesting material, which often involve frequent, repeated visits to a nest site. A set of suspicious behaviors to watch for while behavioral searching are known as the 'nest dance,' or 'nesty behavior' wherein females cautiously approach the nest and move quickly between perches and rapid foraging bouts before landing on the nest which are both nervous displacement behaviors when an animal has a conflict in motivations (Martin and Geupel 1993). If an observer is standing too close to a nest site, this behavior may continue beyond 10 minutes, and the observers should relocate (Martin and Geupel 1993).

Although the literature recommends moving at least 15 m away from a suspicious bird when behavioral searching (Martin and Geupel 1993), in more open grassland habitats we recommend observing birds from a distance of 30 m or more using binoculars, ideally concealed by crouching or standing behind a shrub (Winter et al. 2003). When a bird enters a suspected nest site repeatedly, we recommend waiting for at least three visits (Winter et al. 2003) and for up to 3-5 minutes during the third visit before approaching the site and attempting to get a 'close flush.' This helps ensure a bird has settled on a nest and is not foraging. An exception to this guidance is for Grasshopper Sparrows delivering arthropod food items because this species tends to provision rapidly, sometimes in less than 5 sec (Coon, unpublished data). Moreover, during the laying or incubation phases, parent birds may visit nests less frequently and for longer durations (Martin et al. 2000), and researchers may not be able to observe repeated visits in a reasonable amount of time. Thus, if a bird remains out of sight at a given location for ~10 min, it may be fruitful to approach the location and search the area.

In general, we recommend patience when behavioral searching: more time spent watching behavior and visits to suspected nest locations increases the likelihood of correctly identifying the true nest site (Winter et al. 2003). In turn, this reduces time wasted by agitating parents after approaching an incorrectly identified site. It can be useful to memorize several plants or other features near suspected nest sites (Martin and Geupel 1993) or to mark specific areas with flagging (if habitat is homogeneous), as distance and location can be difficult to triangulate through binoculars. Behavioral searching can be easier when conducted by two to three researchers simultaneously, although it can also be done alone. In hilly environments, which can have areas that are less visible due to ridges or ditches, it is useful to spread out and communicate using hand-held radios. We recommend having only one to two people approach suspected nests, with others watching at a distance to have different perspectives and a wider view of flushes.

We have found nests of all six obligate grassland birds using behavioral searching, but the success varies by species. In our experience, behavioral searching is most successful when applied to less secretive species Dickcissels and Red-winged Blackbirds, which provide frequent and clear behavioral cues. Eastern Meadowlarks, Grasshopper Sparrows, Sedge Wrens, and Henslow's Sparrows are more cautious and less likely to approach their nest with researchers nearby, and the use of behavioral cues is less effective in determining nesting locations. Bobolinks pose a particular challenge for researchers, as female Bobolinks frequently run along the ground before flushing, making it difficult to triangulate nest locations, and many species may dip down into vegetation and walk along the ground unseen or enter and leave through alternate entrances and exit paths (Winter et al. 2003). For that reason, in our research, we have most reliably found Bobolink nests by following the cues of male birds (most often through male provisioning), though a female chipping or with a food item or nesting material could still be used to indicate presence of nestlings or fledglings nearby. In general, male Bobolinks tend to be less cautious, and following them back to the nest during the nestling phase is one of the most effective strategies (Martin and Geupel 1993).

Behavioral searching has been criticized because the method is often used in an unstructured manner, making it difficult to quantify and standardize the amount of search effort spent at each site (Conkling et al. 2015). Although not critical for all studies, when comparing nest densities between sites, standardization can be helpful. Achieving equal search effort when behavioral searching requires that time and effort spent searching should be proportional to the number of birds breeding on a site. To accomplish this, we developed a systematic behavioral search protocol wherein we walk along line transects and spend 5 min observing each territorial male bird or suspicious female from any of our target species detected. We prefer unlimited distance line transects limited only by observer perception, but researchers could also choose a limited distance transect (e.g., 50 or 100 m). If there is no evidence of a female bird or other behavioral cues that indicate a nest is present (e.g., chipping, holding food items or nesting material) within that five-minute period, we walk once through the bird's apparent territory to try and detect additional evidence of breeding (e.g. "female flushes"). If no additional evidence presents, we move to the next bird in the transect. If female birds or any suspicious 'nesty' behavioral cues are present, we back away from the birds and watch for up to 30 min to try and determine the location of the nest, though care should be taken not to keep female birds away from their nests more than 15 min (Martin and Geupel 1993). Study sites have a proportional number of transects with respect to their area, and all trasects are sampled an equal number of times ensuring equal sampling effort among sites.

Behavioral searching, especially when applied systematically, has several strengths. Researchers can spend more effort on sites with more birds present, and for some species (e.g., Dickcissels), behavioral searching can produce a higher yield compared to methods that only target birds that are actively sitting on or shading nests (e.g., rope dragging; see following section). However, behavioral searching can pose challenges when studying species that are cautious about exposing their nest locations, which includes most grassland obligate songbirds. Behavioral searching can have less impact on vegetation compared to other methods, with researchers watching parental space use from a distance and only approaching when the nest site is likely to be found. This method, however, is more successful for researchers with high levels of experience observing behavioral cues, especially for the more cryptic species. Finally, this method is most effective during the building and nestling phases of reproduction, when parent birds are actively carrying items in and out of nests, and is less effective during incubation (Martin and Geupel 1993). Importantly, abandonment of nests is thought to be more common earlier in the nest cycle, especially during the building phase, so researchers should take care not to overly disturb these nests (Martin and Geupel 1993, Winter et al. 2003). Also of note, behavioral searching often leads researchers to fledglings (or evidence of fledglings) instead of nests, which can be useful in studies examining reproductive success. We recommended primarily using behavioral searching for species like Dickcissels, Red-winged Blackbirds, and Field Sparrows, and using the method in combination with other techniques for more secretive species.

3. Rope or Chain Dragging

A third method used to find nests in grassland habitats is the rope-drag method, alternatively called the chain-drag method (Martin and Geupel 1993, Lokemoen and Beiser 1997). This method involves dragging a rope or chain at high tension over the top of vegetation, locating nests as a result of 'close flushes' from birds quickly leaving their nests sites as the rope moves over them (Figure 4). We recommend having two individuals dragging the rope and 1-3 others (depending on rope or chain length) walking behind in the middle to detect and triangulate flush locations (Koford 1999). Ropes often have cans, bells, or other objects tied to them which drag through the vegetation and create noise, which is thought to increase the chance of flushing birds off the nest (Koford 1999, Winter et al. 2003). Some studies have instead used all-terrain vehicles to drag chains (Lokemoen and Beiser 1997). When a bird is seen flushing close to the rope or chain, dragging should immediately stop, a flag should be placed close to the perceived flush site, and individuals should systematically search the area up to about 5 m behind and in front of where the flush was seen, though typically the nest will be found behind where the bird is first seen.

The researchers dragging the rope should place flags in the ground every ~20 m (depending on topography) to track progress across the site, aid in walking in a straight line, and prevent leaving gaps in the search area. Flags can be picked up as researchers walk by on subsequent passes. We recommend walking at a brisk pace, which can help prevent birds from flushing prematurely when they detect the rope at a distance. Many studies recommend completing 1-3 complete drags of each study site during each breeding season, which is intended to result in a random sample of nests (Lokemoen and Beiser 1997, Koford 1999, Conkling et al. 2015).

There is no standard design for nest ropes. Nest ropes can have varying lengths, with some researchers using ropes or chains up to 50 m (Lokemoen and Beiser 1997). To rope-drag in our grassland system, which has a large amount of topographical variation, ditches, and shrubs, we used a shorter 20 m rope following Koford et al. (1999) and Conkling et al. (2015), which allowed us to more easily weave or toss the rope over obstacles like trees and shrubs (Figure 4). We recommend tying brightly-colored flagging at each meter along the rope using alternating colors to track exactly where each flush occurred and tying cans or chains every ~2 m along the rope (Conkling et al. 2015).

Although rope-dragging is considered to be more effective in grasslands with shorter vegetation, like short-grass and mixed-grass prairies, or grazed grasslands (Winter et al. 2003, Conkling et al. 2015), we have also had success finding nests in ungrazed tallgrass prairies using this method. The rope-drag method can cover large distances relatively quickly, and it allows researchers to achieve equal search effort between sites, with the method intended to find a random sample of birds incubating or brooding on their nests. We have found nests with this method for all grassland obligate songbirds present in the Grand River Grasslands except Sedge Wrens, which often nest in ditches, limiting observer access (Dechant et al. 2002).Because rope-dragging does not rely on observing behavioral cues, it can yield relatively large numbers of nests of cryptic species. However, when searching for Bobolink nests, researchers should expand their search area to up to 10 m behind the rope given the species' tendency to run before flushing, and perhaps in front of the rope as well. The rope can also be used to find nests of species like the Dickcissel, which are also easily found using behavioral searching (Conkling et al. 2015).

Rope-dragging also seems to cause less trampling than methods like systematic searching, and most herbaceous plants bend and recover from dragging the rope directly over them. However, shrubs, especially those with thorns, catch the rope and may break as the rope is pulled over them, destroying potential or actual nest sites. We recommend carefully tossing the rope over woody vegetation for this reason, and nest ropes are likely inappropriate on sites with many tall trees or shrubs.

Despite its advantages, rope-dragging also has several key limitations. First, rope-dragging can be very effort-intensive, including traversing areas where researchers may have no reason to suspect any birds are nesting. Behavioral searching may be more time-effective, as all search efforts can be targeted on places where breeding behavior is present. Second, it is only possible to find nests that parent birds are actively tending, so a large proportion of nests will remain undetected simply because parents were away at the moment the rope passed over.

The efficacy of rope-dragging is thus impacted by time of day, as incubation and brooding behavior may be more common in the early morning when it is cold, and in the midday when it is hottest (Conway and Martin 2000). Another consideration is that the researchers pulling the rope are often distracted from watching for flushes by the act of dragging, so the method may be most successful when individuals with the greatest observational skill are following behind watching for flushes.

4. Incidental Flushes or Haphazard Walking

Another common way to find nests in grasslands is through accidentally disturbing a bird off of their nest while researchers are conducting some unrelated activity, called an incidental flush (Rodewald 2004, Conkling et al. 2015). This can happen while conducting standard nest checks or vegetation monitoring procedures. Incidental flushes are often very close to the researcher, and we recommend remaining stationary immediately after the flush while carefully looking for the nest, as the researcher who flushed the bird is likely very close to the nest site and trampling is a possibility (Winter et al. 2003). Incidental flushes are some of the most common ways to find the inconspicuous nests of cryptic species with close flush distances, like Eastern Meadowlarks (Bent 1958). Some researchers use a method called 'haphazard walking' where an individual walks without a predetermined route, using behavioral cues when available to guide walking (Winter et al. 2003). In contrast to incidental flushes, in haphazard walking there is an intention to find nests.

A downside of both incidental flushes and haphazard walking is that search effort is typically uneven across sites as it is difficult to control the area searched with these methods (Winter et al. 2003). For example, a site with more nests will be visited more often due to nest monitoring, increasing the chance for incidental flushes. Researchers aiming to produce equal search effort between sites could consider conducting extra 'walkthroughs' of sites with less than half the nests per hectare of their most abundant sites to compensate for the uneven effort.

5. Integrating Methods

In practice, these methods are often used in combination, and nest searching efficacy is improved when behavioral cues are used in conjunction with other methods. For example, while rope dragging, a bird may flush off a nest site, but researchers may be unable to locate the nest. If the parent bird is present and chipping, it can be effective to back away and observe the bird for 5-10 minutes to see if it returns to the suspected nest site. In addition, sometimes a researcher may not have an exact location as a result of an incidental flush, but behavioral searching may be used to more accurately determine the location. In both cases, leaving several pieces of flagging to mark specific areas can help researchers triangulate the location from a distance through binoculars as they observe bird behavior from afar. Systematic searching can also be used in conjunction with other methods when a flush is not seen very clearly, especially for shrub- and clump-nesting species. Across all methods, angle of approach may also matter. For species like Grasshopper Sparrows or Eastern Meadowlarks that build nests that often open to the side (Figure 5) (Long et al. 2009), nests are more easily sighted when researchers crouch, maintain a position close to the ground, and look for the nest entrance from different cardinal directions while searching.

In general, we recommend that researchers tailor their nest-searching methods and follow best practices specific to their research question, study location, and target species to prevent disruption of nesting birds (Bibby et al. 2000). For example, in our study region, using a shorter 20-m rope allows us to reduce damage to the woody vegetation that is common on our sites. If a study is focused on early successional specialists, like Grasshopper Sparrows and Eastern Meadowlarks, primarily using rope-drag would be recommended, augmented by occasional use of behavioral searching. In contrast, we would recommend a study focusing on Dickcissels in shrubby habitats to rely on behavioral searches, which are less destructive and effort-intensive. Ensuring that researchers with a high level of bird observation experience are present can also increase the effectiveness of the methods and reduce harmful impacts from trampling vegetation.

Nest Monitoring for Obligate Grassland Songbirds

After finding nests, the next step is to monitor them to determine success (e.g., fledging) or failure (e.g., predation or abandonment). Marking grassland bird nests for easy relocation is critical, as it is easy to lose track of these nests, especially when vegetation is homogenous (Winter et al. 2003). It is common practice to use flagging tape tied to plants ~2-5 m to the North and South of the nest (Figure 5; (Lokemoen and Beiser 1997, Martin et al. 1997, Winter et al. 2003) but flagging can be lost in storms, covered by growing vegetation, or eaten by cows on grazed sites. Although recording a point with a GPS unit is highly recommended, user error and variable accuracy of units can make precise nest relocation unreliable, significantly increasing the time needed to monitor nests. We recommend drawing detailed nest diagrams at the time of nest discovery, labeling salient plants and other landscape features (e.g., ant mounds, topography) close to the nest (within ~5 m). Additionally, it is useful to write a location description that includes distance and directions to 2-3 close landmarks (within ~10-20 m) and 2-3 larger landmarks (within ~50-500 m), including shrubs, unique herbaceous plants, fences, roads, signs, ridges, slopes, or ditches (Martin et al. 1997). In our research, we also add orange tent stakes ~0.5-1 m to the north and south of nests, which are especially helpful on grazed sites since flagging is frequently eaten by cows. Data commonly collected from nests in grassland bird research include daily nest survival and Brown-headed Cowbird (*Molothrus ater*) brood parasitism rates (from nest visits); nestling condition (e.g., age, mass, tarsus length); provisioning rates and predator identities (from video footage); and vegetation composition and structure. We discuss each of these data types in the following sections and include relevant example datasheets as supplementary materials (Appendices B and C).

1. Nest Identification and Aging

One important component of all nest monitoring activities is successful aging of the nest. Researchers can use candling, or carefully shining light through eggs to check for development, to determine whether nests are in the laying or incubation phases (Lokemoen and Koford 1996). To reduce potential negative impacts on eggs from imperiled species, we recommend using candling only when necessary for the research question, and preferentially selecting Brown-headed Cowbird eggs when available, as this species is not of conservation concern. Brown-headed Cowbirds are obligate brood parasites, and their eggs are commonly found in both obligate and facultative grassland bird nests across the tallgrass prairie ecoregion and on our study sites in the Grand River Grasslands (Figures 2A, 2B, 3B).

Across all bird species, developmental milestones can be used to determine nestling age, but there is variability and complexity in aging practices. For example, one of the clearest signals of a nestling's age is when down feathers are still 'wet' from the egg. In this case, the nest can be confirmed as 'day 1' (hatch day), and all subsequent visits and photos can be used to track development. However, after a few hours, down feathers will dry, and so it is often challenging to differentiate between 'older' day 1 and 'younger' day 2 nestlings. Stages can vary by species and even within species in different geographic areas. In addition, there can be hatching asynchrony where not all nestlings hatch on the same day (Frei et al. 2010). We recommend taking photos of nestlings during every nest visit, learning the developmental milestones unique to a particular context and species, and comparing to known-age nestlings to aid in efforts to age nests (Frei et al. 2010).

Despite some complexity, there are some milestones that seem relatively common across contexts within a given species, including in our study region in Iowa. Importantly, some characteristics are most easily seen in person, so we provide both brief descriptions of key milestones for species and chronological photos of nests available from our study site in Iowa (Appendix A).

Dickcissels (Figure A1)***:*** The eyes of nestling Dickcissels begin to open on days 3 and 4 after hatching, pin feathers extend on day 5 and begin to emerge from the tips on day 6 with substantial emergence by day 7, and fledging tends to occur between days 8 and 10 (Winter 1999, Giocomo et al. 2008, Jones et al. 2017). Dickcissels have distinct yellow gapes, compared to white gapes of Brown-headed Cowbirds.

Eastern Meadowlarks (Figure A2)***:*** Eyes of Eastern Meadowlarks start to open around day 3-4 after hatching and are fully open by day 5, and pin feathers can start to emerge from sheaths around day 6 (Bent 1958). Eastern Meadowlarks have distinct buffy crown stripes (Figure A2) often visible by day 6-7. Though the meadowlarks are larger and bill shape (with white gape) is more elongated than Brown-headed Cowbirds, crown stripes may still aid in nestling identification. Fledglings leave the nest between 10-12 days after hatching, when the body is fully covered by feathers (Kershner et al. 2004, Giocomo et al. 2008, Jaster et al. 2022).

Bobolinks (Figure A3): Bobolink pin feathers may begin to emerge from sheaths on day 6 and 7, and by days 7 and 8, all feathers are expanding from their sheaths (Renfrew et al. 2015). Bobolinks also have distinctive buff crown stripes (Figure S3G) that are quite apparent around day 7. These crown strips can be useful in differentiating Bobolink nestlings from Brown-headed Cowbirds in the same nest, especially since both species have white gapes.

Grasshopper Sparrows (Figure A4): Pin feathers of Grasshopper Sparrows may emerge as early as day 4, with body feathers emerging from sheaths on day 6-7 (Bent and Austin 1968). The literature reports that Grasshopper Sparrows may have a crown stripe that emerges as early as day 7 (Banks 1969, Frei et al. 2010), though in our experience (Figure A4), crown stripes may not be visible until later stages, such as day 9. Grasshopper Sparrow chicks, which have pale yellow gapes, remain in the nest for about 9 days before fledging on days 9-10 and are fully feathered by the time they leave the nest (Smith 1963, Bent and Austin 1968).

Red-winged Blackbirds (Figure A5): This common facultative grassland bird has eyes that begin to open on day 3-5, with fully open eyes and wing feathers emerging from their sheaths on days 6-7 (Holcomb and Twiest 1971, Yasukawa and Searcy 2019). Head feathers do not emerge from their sheaths until day at least 7 days, and Red-winged Blackbirds stay in the nest longer than other grassland passerines, up to 11-12 days (Holcomb and Twiest 1971). Red-winged Blackbird chicks are larger than Brown-headed Cowbirds, and though both have white gapes, Red-winged Blackbird bills are more elongate and often grow to have a slightly grayish tinge (J. Coon, pers. obs).

2. Nest Visitation

Many studies monitoring grassland birds perform visits every 1-4 days to check for predation, fledging, or nest abandonment (Fogarty et al. 2017, Shew et al. 2019, Williams and Boyle 2019, Herakovich et al. 2021). When the research question allows, visits should be spaced at least 3 days until the nestling phase when it becomes important to age nests daily and disentangle predation from fledging, thus warranting more frequent visits (Martin et al. 1997). Nests should not be visited during rain or cold weather to avoid interrupting brooding birds that are aiding eggs or nestlings thermoregulate. Limiting nest visitation to the minimum also helps reduce trampling of vegetation (Martin and Geupel 1993), a particular concern in grasslands where herbaceous plants are easily damaged. One visitor, once arriving at the nest, should keep their visit brief and, if possible, wait until the person is away from the nest to record data such as the observer(s), time of day, stage of reproduction (i.e., building, laying, incubating, or nestling), abundances of host and parasite eggs/nestlings, and whether the female was present on the nest (see Appendix B for example data sheet). Additionally, when no nestlings or eggs are present, researchers should check for signs of predation or fledging using parental behaviors, fledgling presence in nearby vegetation, or nest conditions. It may also be worthwhile to search for fledglings in the immediate vicinity around the nest, though care should be taken to correctly identify the species of the fledgling, especially to confirm host fledging (versus Brown-headed Cowbird fledging; see Figure A6 in Appendix A).

Nest fates can be determined using researcher-determined nestling ages in combination with species-specific pre-determined nestling stage length obtained from the literature (Table 2). There are two main methods of determining nest fates. One common method is using a ‘last seen threshold’ nestling survival age for fledgling. For this method, if the nestlings survive at least until a predetermined fledgling age threshold, you would assume the nestlings fledged even if the nest is empty at the next visit, assuming there are no signs of predation.(Streby and Andersen 2013, Smith et al. 2024). We provide these thresholds for our six focal grassland passerines in the GRG in Table 2, although it is important to highlight that there can be variation of fledgling thresholds in different geographic areas. As an example, it is safe to assume that a Dickcissel nest in our study system has been depredated if host nestlings are absent within 7 days of hatching (Maresh Nelson et al. 2018). However if nestlings are seen alive on day 8, but the nest is empty on day 9, it is possible that fledging has occurred (typical range is Day 7-10). For some species, assuming fledging may positively bias the estimated number of successful nests (Streby and Andersen 2013), so researchers may rely on a second method using additional observations of nest condition and parental cues, such as calling, chipping, or provisioning to evaluate fledging (Martin and Geupel 1993). This may be particularly true if the range of potential fledging age is large. In our experience, using behavioral cues can be quite challenging for some species, such as Eastern Meadowlarks and Grasshopper Sparrows, and is more successful for Dickcissels, Bobolinks, and Sedge Wrens, which are more likely to exhibit behavioral cues after fledging (J. Coon, pers. obs). Regardless, using such cues, when possible, can strengthen the confidence of determining nest fates. If a nest is old enough to have fledged and no nestlings are present, we recommend standing at the empty nest site for 5-10 minutes to observe parental behavior.

3. Filming Grassland Bird Nests

Both continuous 24-hour camera monitoring and short-term filming over several hours allow researchers to obtain vital data related to predation or avian behaviors at the nest. Continuous monitoring systems can take still photos, time-lapse video footage, or real-time footage and are often used with triggering mechanisms such as infrared sensors (Bolton et al. 2007, Cox et al. 2012). These setups have become increasingly affordable, portable (Sabine et al. 2005, Pierce and Pobprasert 2007), and can help determine the fates of nests and identify predators (Staller et al. 2005), as well as quantify nocturnal behaviors (Slay et al. 2012). Alternatively, short-term filming can provide high-definition footage to gain detailed behavioral data on parent and nestling interactions at the nest. Parental behaviors observed at the nest can include provisioning nestlings, brooding, removing fecal sacs, and defending the nest and nestlings (Tori et al. 2023). Nestling behaviors, like begging and nest-mate interactions, can also be observed if visibility allows.

However, filming near a nest site can be disruptive to adult and nestling birds (Brown et al. 1998). Researchers should take all possible precautions and care to reduce time and disturbance near the nest, especially during the building, laying, and incubating phases, when birds are most likely to abandon nests. Some continuous monitoring protocols (Pierce and Pobprasert 2007, Cox et al. 2012) may alter the vegetation and area around the nest to accommodate the camera, while some short-term filming methods may involve only temporary additions of the camera and tripod. If research questions relate to provisioning (and not predation), short-term filming may be sufficient and less disruptive. If possible, nests can be filmed for two consecutive days to collect data at different ages and to allow for the birds to become accustomed to the camera's presence (Coon et al. 2018). In our experience using short-term filming sessions, we have found that placing cameras >1-2 m from nests reduced the probability that parents would abandon the nests. Additionally, in the rare cases where parents did not return to care for nestlings during the filming sessions, we found that birds always returned to the nest after the cameras were removed. Importantly, filming should take place on days with low wind (<10 mph) and no rain to avoid affecting parental care during times when nests are more vulnerable and to prevent cameras from being blown over (Mitchell et al. 2012, Coon et al. 2022).

4. Measuring Nestlings

In addition to determining nest success and fledgling production, nestlings can be measured either once at a standardized age (e.g., days 5-7 after hatching) or multiple times to assess nestling growth and development. When possible, it is recommended to measure nestlings at least 2 days before the fledgling threshold to reduce the chances of force fledgling (prematurely fledging young from nests; Anderson and Anderson 1961), which might lower their probability of survival (Anderson and Anderson 1961, Ferretti et al. 2005, but see Streby et al. 2013). Mass (putting individual nestlings inside small vessels such as a small plastic container to weigh on a digital scale) and tarsus length (using digital calipers) are common measurements used to assess body condition (Buxton et al. 2018). Researchers may also photograph nestling wings at or near the time of fledging to quantify feather development and estimate impacts on post-fledging survival (Jones et al. 2017).

To minimize disturbance at the nest (e.g. vegetation trampling and leaving scent that can attract predators), we recommend researchers avoid locating the "measuring station" in the immediate neighborhood of the nest (>20 m). In grassland habitats, nestlings should be protected from the sun during measuring. We recommend the use of an umbrella or laptop tent to shade nestlings while they are being measured. It is also standard procedure to always leave at least one nestling in a nest during measuring so parents do not visit their nest during the measurement process, assume it has been depredated, and abandon. If only one nestling is present, a researcher should stand at the nest to prevent the parent from returning for the duration of the measuring session (Pietz et al. 2012), which should be as brief as possible.

5. Assessing Vegetation Near Nests

After a nest has fledged or failed, it can be useful to assess the vegetation composition and structure near nests or within broader territories. One common method to assess habitat preferences and how they might relate to nest success is to determine the percent cover of functional plant groups, including both native and invasive vegetation within 0.5- m^2 quadrat frames (Daubenmire 1959). Many studies first place the quadrat frame directly over the nest, and then place a quadrat in each cardinal direction at a randomly assigned distance within 1-5 m of the nest (Maresh Nelson et al. 2020). To systematically assess a broader area around the nest, we recommend adding 4 additional quadrats; 25 m away from the nest cup in each cardinal direction (Dieni and Jones 2003, Hovick et al. 2011). In addition to compositional measurements, structural measurements are often useful. Many researchers use a "Robel pole" to determine the highest decimeter interval that is more than 50% obscured by vegetation when viewed from 4 m away with the observer’s eye level at 1 m off the ground in each cardinal direction (Robel et al. 1970).

Recommendations for Reducing Impacts of Research on Imperiled Grassland Birds

Although nest monitoring can provide invaluable information about bird populations, it also puts researchers in repeated close contact with the birds being monitored. As such, it is important to consider the effects nest monitoring could have on the stress and behavior of focal species, as well as any potential impacts on predation rates and nest survival, particularly with sensitive and threatened species (Martin and Geupel 1993). Some studies have found no impact on or even a reduction of predation rates due to regular nest monitoring (MaCivor et al. 1990, Weidinger 2008), suggesting predators may be deterred by the presence of humans, especially when monitoring happens at frequent intervals. However, there is also evidence that the impact of monitoring can increase predation rates and varies depending on the time of year and type of nest (Kurucz et al. 2014). Frequent disturbances near nests, especially in the building, laying, or incubation phases, can also lead to nest abandonment (Winter et al. 2003). In grassland habitats, trampling of vegetation and the creation of trails are likely to alter predator behavior

(Martin and Geupel 1993). Regardless, study design should take the effect of nest monitoring into account and make efforts to reduce any negative impacts on birds.

After finding a nest, the amount of time spent nearby should be limited, moving to a distance >20 m away as soon as possible (Winter et al. 2003). When performing a nest check, researchers should limit the number of observers to the minimum necessary to reduce the amount of trampled vegetation. Additionally, observers should take large, careful steps, avoiding the creation of trampled trails, and should approach and depart from the nest in different directions, such that the trail bypasses the nest and does not ‘dead end’ at the nest (Martin et al. 1997, Winter et al. 2003). This is to ensure that trampled vegetation, scent, or other signs of travel do not make a path with the nest located at the end, potentially leading predators directly to the nest.

In addition to physical trails, some researchers have suggested that potential nest predators may follow scent trails left by humans and recommend using methods to mask human scent (Yahner et al. 1993, Martin et al. 1997, Johnson and Oring 2002). Various scent-masking techniques have been tested, including wearing rubber boots when visiting nests, washing clothing with a scent-neutralizing agent, and putting a scent shield spray on the bottom of shoes. However, these studies have failed to find a difference between nest predation rates and whether scent-masking techniques were used or not (Skagen et al. 1999, Donalty and Henke 2001).

Every visit to the nest has the potential of forcing the parent to leave, sometimes not returning until several hours later. Parents may brood or feed more frequently when there are more young (Wright et al. 1998), and females modulate their nest visitation time in all stages in accordance to precipitation and temperature patterns (Coe et al. 2015). Our data have shown that feeding intervals can be as short as 1-2 min for some species (Coon et al., unpublished data), so even short periods away from the nest may affect feeding patterns. We recommend minimizing time observers spend at the nest by developing an efficient protocol and training new researchers before approaching the nest. Whenever possible, move at least 20 m from the nest before recording data or measuring nestlings (Winter et al. 2003). Researchers should minimize monitoring frequency, especially when nestlings are younger and require more frequent feedings. Later visits should be quick, with researchers taking care to not force fledge the young. They should also take the necessary precautions to reduce the risk of force fledging at later stages in the nesting cycle–unless the research demands handling late-stage nestlings, researchers should avoid handling nestlings once they reach an age where they are capable of force fledging (which may be earlier than the ages listed in Table 2). If handling late-stage nestlings, it is advisable to carry a cloth that can be placed over the nest if the nestlings attempt to force fledge. The gentle weight combined with the dark environment may contain the nestlings until they are calm (place nestlings back in the nest and leave cloth in place for >10 min).

Birds can also be unnecessarily stressed by researcher presence after nestlings leave the nest. Fledglings can stay near the nest for an extended period of time after fledging, continuing to be fed by their parents. Grassland species may stay in the general vicinity of the nest for weeks after fledging, though they move farther away from the nest site as time goes on (Kershner et al. 2004, Jones et al. 2018). For this reason, we recommend collecting nest vegetation data several days to a week after fledging to reduce impacts and stress whenever possible. Moreover, collecting nest vegetation data requires significant trampling of the surrounding vegetation and could endanger fledglings.

Conclusion

Most grassland obligate songbirds found in the central U.S. have declined greater than 50% in the last 40 years and are expected to decline another 50% in the next half-century (Rosenberg et al. 2016). Due to ongoing concerns about grassland bird declines, monitoring the reproductive impacts of restoration and management on these species has emerged as a top research priority (Vickery et al. 2000, Coon et al. 2022). Such studies, though effort-intensive compared to abundance monitoring, can help researchers and managers determine whether management benefits populations of imperiled species. We recommend that researchers evaluating the reproductive success of grassland birds, tailor nest searching for their study species and systems according to the guidance in this review and other published research manuals (Martin and Geupel 1993, Bibby et al. 2000, Winter et al. 2003), and use multiple methods of searching if studying multiple species. We further recommend that researchers approach these studies with caution and care, limiting unintended impacts on grassland birds by research activities–especially during nest monitoring.

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Figures & Tables

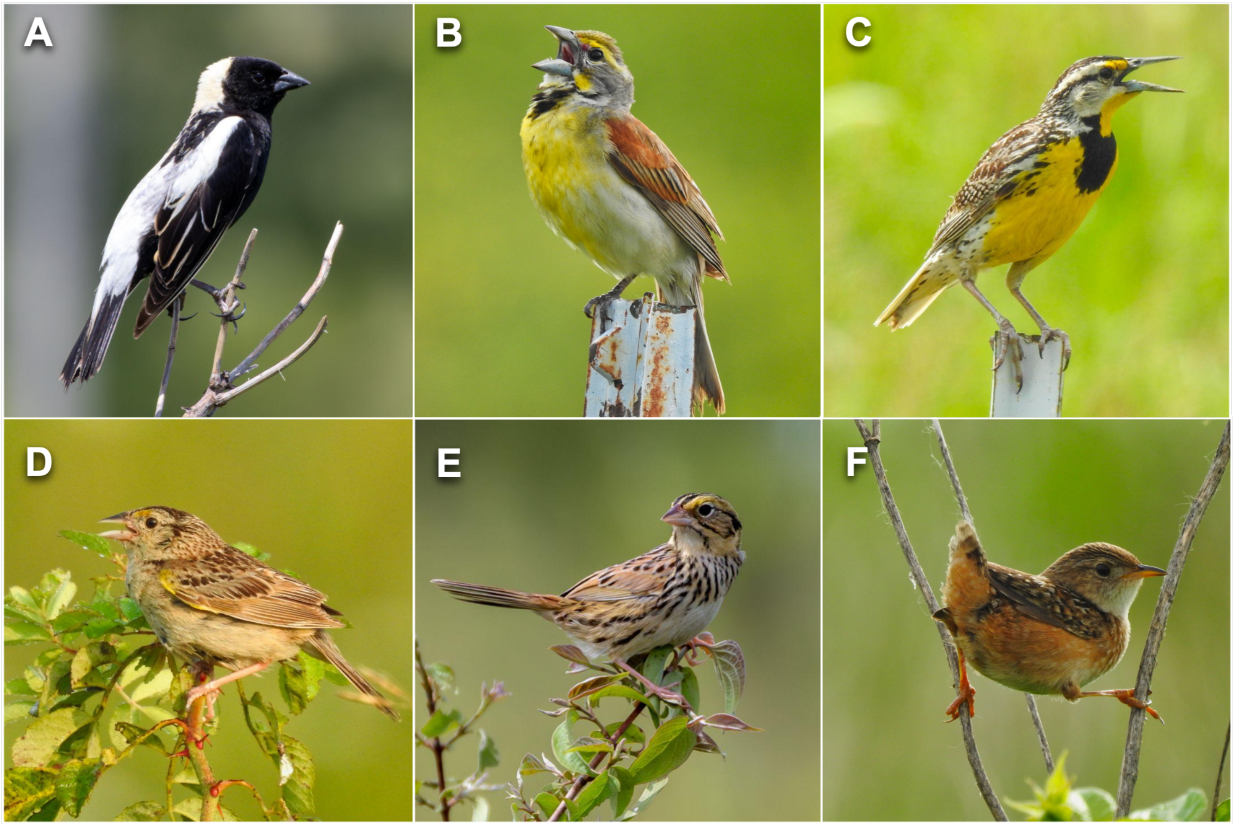

Figure 1. Obligate grassland bird species found in the tallgrass prairies of the Grand River Grasslands of southern Iowa: Bobolink (A), Dickcissel (B), Eastern Meadowlark (C), Grasshopper Sparrow (D), Henslow’s Sparrow (E), and Sedge Wren (F).

Figure 2. Nests of ground-nesting obligate grassland birds (left column) with closeups of eggs (middle column) and nestlings (right column): Grasshopper Sparrow (row A), Eastern Meadowlark (B), and Bobolink (C). Where possible, comparisons with Brown-headed Cowbirds are shown and noted with an asterisk.

Figure 3. Nests of near-ground nesting grassland birds (left column) with closeups of eggs (middle column) and nestlings (right column): Dickcissel (row A), Henslow's Sparrow (B), and Sedge Wren (C). Where possible, comparisons with Brown-headed Cowbirds are shown and noted with an asterisk.

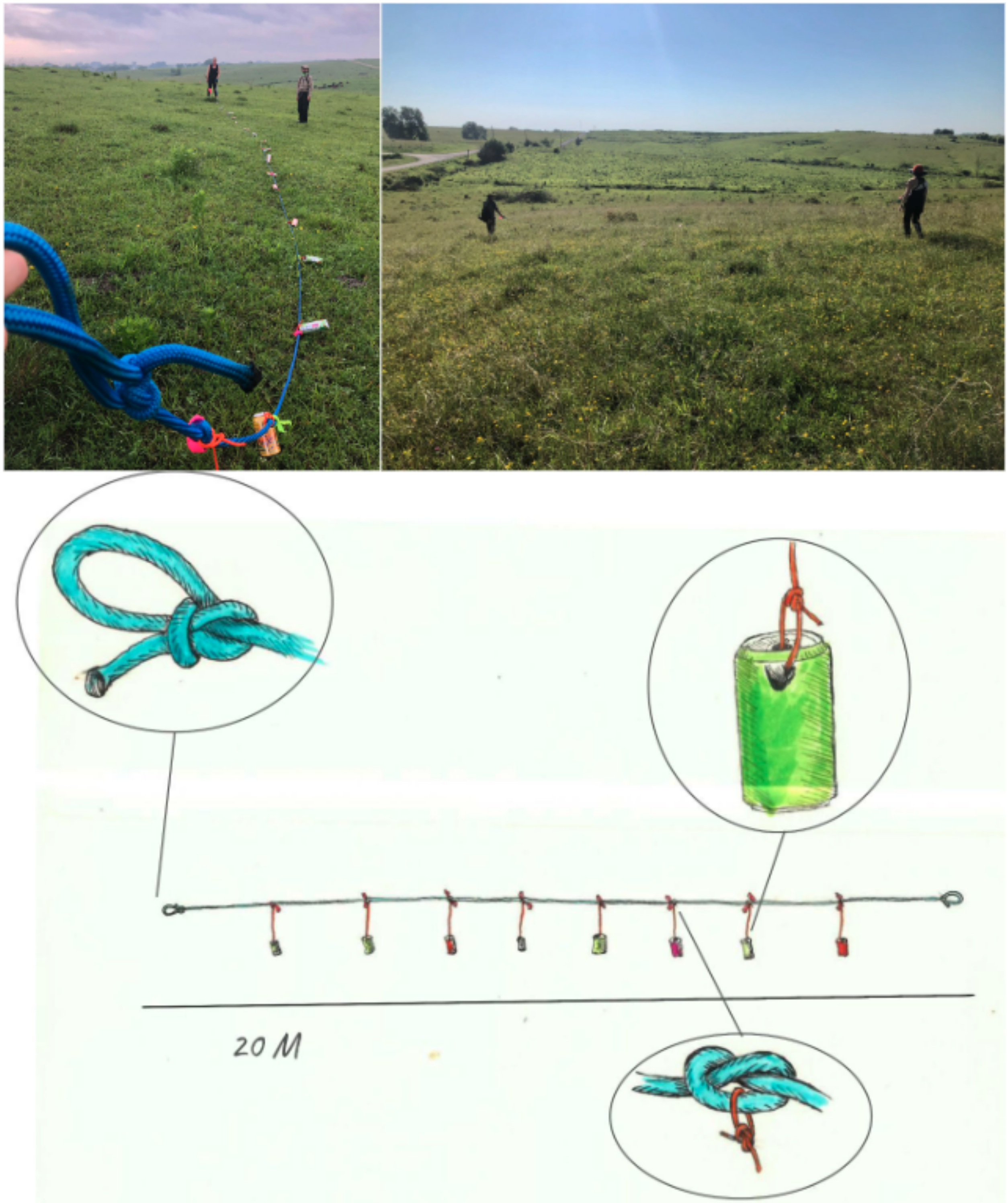

Figure 4. A ‘nest rope’ used to locate grassland bird nests by dragging the rope through the vegetation and flushing birds off of their nests.

Figure 5. A nest site diagram of an Eastern Meadowlark depicting relocation aids. First, pink marking flags are placed 1-2 m north and south of the nest, labeled with nest ID. Second, bright orange tent stakes are placed 0.5-1 m north and south of the nest.

Table 1. Information about temperate breeding grassland songbirds listed in Vickery (1999) that are present in the Grand River Grasslands of southern Iowa (Duchardt et al. 2016). National conservation status refers to the Partners in Flight Landbird Conservation Plan (2016) and Iowa conservation status refers to the conservation status/es published in the Iowa Wildlife Action Plan (2015).

	Common name	Scientific name	National Conservation Status	Iowa Conservation Status	Nest Placement
Obligate species	Bobolink	*Dolichonyx oryzivorus*	Yellow watch list	SGCN[1]	Ground cup nest
	Dickcissel	*Spiza americana*	Grassland Priority Species	SGCN	Shrub/Clump cup nest
	Eastern meadowlark	*Sturnella magna*	Common birds in steep decline	SGCN	Ground, usually domed
	Grasshopper sparrow	*Ammodramus savannarum*	Common birds in steep decline	SGCN	Ground, usually domed
	Henslow's sparrow	*Centronyx henslowii*	Yellow watch list	Threatened, SGCN	Close to ground, cup nest
	Sedge wren	*Cistothorus stellaris*	Least concern	SGCN	Close to ground, spherical nest
Facultative species	Eastern kingbird	*Tyrannus tyrannus*	Least concern	SGCN	Shrub/tree cup nest
	Red-winged blackbird	*Agelaius phoeniceus*	Least concern	None	Shrub/Clump cup nest
	Field sparrow	*Spizella pusilla*	Common birds in steep decline	SGCN	Close to ground, clump nest
	Brown-headed cowbird	*Molothrus ater*	Least concern	None	N/A Parasitic
	Loggerhead shrike	*Lanius ludovicianus*	Common birds in steep decline	SGCN	Shrub/Tree cup nest

[1] Species of Greatest Conservation Need

Table 2. Ranges of nestling stage for six obligate grassland passerines according to published literature,as well as the threshold age at which chicks may be assumed to have fledged if the nest is found empty but chicks were in the nest the previous day.

Common name	Nestling Stage Range (Days)	Last Seen Threshold (Days)	Sources
Bobolink	8-14	9	1. Ehrlich, P., Dobkin, D. S., & Wheye, D. (1988). Birder's handbook. Simon and Schuster. 2. Martin, S. G., Gavin, T. A., Renfrew, R., Strong, A. M., & Perlut, N. G. (2015). Bobolink (Dolichonyx oryzivorus). Birds of North America. 3. Pietz, P. J., Granfors, D. A., & Grant, T. A. (2012). Hatching and fledging times from grassland passerine nests. Video surveillance of nesting birds, 43, 47-60.
Dickcissel	7-10	8	1. Ehrlich, P., Dobkin, D. S., & Wheye, D. (1988). Birder's handbook. Simon and Schuster. 2. Giocomo, J. J., Moss, E. D., Buehler, D. A., & Minser, W. G. (2008). Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. The Wilson Journal of Ornithology, 120(1), 111-119. 3. Gross, A. O. (1921). The Dickcissel (Spiza americana) of the Illinois prairies. The Auk, 38(1), 1-26. 4. Winter, M. (1999). Nesting biology of Dickcissels and Henslow's Sparrows in southwestern Missouri prairie fragments. The Wilson Bulletin, 515-526.
Eastern meadowlark	9-12	10	1. Bozzo, J.M., (2023). Eastern Meadowlark migration, nest success, and response to land use change in Illinois (Doctoral dissertation, University of Illinois at Urbana-Champaign). 2. Giocomo, J. J., Moss, E. D., Buehler, D. A., & Minser, W. G. (2008). Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. The Wilson Journal of Ornithology, 120(1), 111-119. 3. Kershner, E. L., Walk, J. W., & Warner, R. E. (2004). Postfledging movements and survival of juvenile Eastern Meadowlarks (Sturnella magna) in Illinois. The Auk, 121(4), 1146-1154.
Grasshoppe r sparrow	6-12	8	1. Giocomo, J. J., Moss, E. D., Buehler, D. A., & Minser, W. G. (2008). Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. The Wilson Journal of Orn 2. ithology, 120(1), 111-119. 3. Jones, S. L., Dieni, J. S., & Gouse, P. J. (2010). Reproductive biology of a grassland songbird community in northcentral Montana. The Wilson Journal of Ornithology, 122(3), 455-464. 4. Kaspari, M., & O'Leary, H. (1988). Nonparental attendants in a north-temperate migrant. The Auk, 105(4), 792-793. 5. Smith, R. L. (1963). Some ecological notes on the Grasshopper Sparrow. The Wilson Bulletin, 75(2), 159-165.
Henslow's sparrow	9	8	1. Ehrlich, P., Dobkin, D. S., & Wheye, D. (1988). Birder's handbook. Simon and Schuster. 2. Giocomo, J. J., Moss, E. D., Buehler, D. A., & Minser, W. G. (2008). Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. The Wilson Journal of Ornithology, 120(1), 111-119. 3. Winter, M. (1999). Nesting biology of Dickcissels and Henslow's Sparrows in southwestern Missouri prairie fragments. The Wilson Bulletin, 515-526.
Sedge wren	11-16	13	1. Mousley, H. (1934). A study of the home life of the Short-billed Marsh Wren (Cistothorus stellaris). The Auk, 51(4), 439-445. 2. Walkinshaw, L. H. (1935). Studies of the short-billed Marsh Wren (Cistothorus stellaris) in Michigan. The Auk, 52(4), 362-369.