

Notes

Database of Bird Flight Initiation Distances to Assist in Estimating Effects from Human Disturbance and Delineating Buffer Areas

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Abstract

U.S. Fish and Wildlife Service biologists determine effects from disturbance to threatened and endangered bird species, and staffs of federal and state agencies estimate these effects when delineating protective buffers around habitat of bird species of concern on land management areas. These efforts can be informed by the distances at which human activities cause birds to react or move away. To that end, here we present a database of published alert distances (distances at which birds exposed to an approaching human activity exhibit alert behavior), flight initiation distances (distances at which birds exposed to an approaching human activity initiate escape behavior), and minimum approach distances (distances at which humans should be separated from wildlife). The database distinguishes between nesting and nonnesting situations. The nesting database includes 578 alert distances and 2,177 flight initiation distances from 45 studies representing 11 orders, 27 families, and 49 species of birds. The nonnesting database comprises 1,419 alert distances and 34,775 flight initiation distances from 50 studies representing 19 orders, 89 families, and 650 species.

Keywords: alert distance; biological opinion; buffer area; disturbance; Endangered Species Act; flight initiation distance; minimum approach distance

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Introduction

Birds display many behaviors that indicate their level of tolerance or sensitivity to humans and their activities. For example, authors have distinguished among 1) no

visible reaction; 2) “scanning behavior” (head-turning); 3) “alert,” “react,” or “agitation” behaviors (e.g., bird raises its head, tenses its body, turns to look at the humans, flaps its wings, takes a few steps); and 4) “escape,” “flush,” or “flight” behaviors (bird walks,



jumps, runs, flies, swims, or dives away; Brown 1990; Anthony et al. 1995; Delaney et al. 1999; Fernández-Juricic et al. 2001; Swarthout and Steidl 2001). Depending on the species and the circumstance, some of these exposures to human activities may result in adverse effects to the birds, eggs, or young. What matters is not if a bird shows alert behavior or moves away, but whether and how the behavior affects the birds or the species as a whole (Gill et al. 2001; Gill 2007). Adverse effects from human disturbance include reductions in feeding rates (e.g., Bélanger and Bédard 1989; Burger 1994; Merkel et al. 2009; Velando and Munilla 2011), reproductive success and productivity (e.g., Beale and Monaghan 2004; McClung et al. 2004; Medeiros et al. 2007; Zuberogitia et al. 2008), and survival (Anderson and Keith 1980).

Biologists of U.S. Fish and Wildlife Service (USFWS) must estimate the distance between a human activity and endangered or threatened species at which an adverse effect is reasonably certain to occur when conducting consultations on the effects of proposed federal actions pursuant to section 7 of the U.S. Endangered Species Act (ESA 1973, as amended). In addition, staff of federal and state agencies must consider adverse effects when establishing protective buffer areas (spaces where human activity is minimized to reduce disturbance to wildlife; e.g., Madsen 1998a, 1998b; Madsen et al. 1998) around habitat of species of concern in land management areas and refuges (Fernández-Juricic et al. 2005; Whitfield et al. 2008; Weston et al. 2009; Glover et al. 2011). These efforts can be informed by minimum approach distance (MAD), which is the distance at which humans should be separated from wildlife (Fernández-Juricic et al. 2005; a linear buffer distance). Estimates of MADs can be informed by two other distances: 1) alert distance (AD), which is the distance at which a bird exposed to an approaching human activity exhibits alert behavior, and 2) flight initiation distance (FID), which is the distance at which a bird exposed to an approaching human activity initiates escape behavior (e.g., walking, running, flying, diving; see Cooper and Blumstein 2015 for a complete review; methods to determine FIDs are provided in Blumstein 2006a, Møller 2010a, and Glover et al. 2011). To help make these estimates, here we present a database of all published ADs, FIDs, and MADs known to us. The database distinguishes between nesting and nonnesting situations.

Methods

From 2009 to 2015, we gathered all published ADs, FIDs, and MADs (buffers) we could find worldwide by 1) inputting “disturbance” into the EBSCO search engine (17,647 results) and obtaining copies of all pertinent publications, 2) checking the literature cited in these publications for additional references, and 3) including all pertinent publications known by E.F.-J. and D.T.B., who have many publications in this field and are personally acquainted with many of its researchers. We placed summary statistics and other information (e.g.,

percent flushing, taxonomy) into a four-part database. We included species from around the world because data from ecologically analogous species can be used to supplement those from North American species and because managers worldwide need to estimate distances at which human activities affect wildlife. We grouped studies when complete data sets were used in more than one publication. We separated data obtained from birds sitting on nests vs. those away from nests because ADs and FIDs may be different between these two groups (e.g., incubating birds may be reluctant to move or leave the nest). We calculated weighted-mean FIDs and MADs for all studies that provided sample size per species per source of disturbance (Tables 1 and 2). Fernández-Juricic et al. (2005) reviewed many methods to calculate MADs. Of these, one method relied solely on FIDs; the others used ADs, standard deviation of FIDs, or the distance at which 95% of the birds alerted and flushed. Since few studies in our database reported data other than FIDs, we used the method that used only FIDs to calculate MADs (Fox and Madsen 1997; $MAD = 1.5 \times \text{mean FID}$; Tables 1 and 2).

Results

The nesting data include 578 ADs and 2,177 FIDs from 45 studies representing 11 orders, 27 families, and 49 species of birds (*Supplemental Material Data S1*; Table 1). The nonnesting data comprise 1,419 ADs and 34,775 FIDs from 50 studies, 19 orders, 89 families, and 650 species (*Supplemental Material Data S2*; Table 2). Types of disturbance were: pedestrian, dog, bicycle, motorcycle, vehicle (car, truck, bus, all-terrain vehicle, farming vehicle), nonmotorized watercraft (canoe, raft, sailing dinghy, windsurfer), motorized watercraft (jet ski, airboat, rigid-hull inflatable, metal-hull boat, commercial ship), aircraft (fixed-winged, helicopter, jet, simulated jet), construction, sonic boom, light weapon (small arms, automatic weapon), heavy weapon (artillery, mortar, missile), and explosion. Nesting-bird MADs were from 21 studies of birds of 8 orders, 15 families, and 31 species (*Supplemental Material Data S3*), and nonnesting MADs were from 18 studies, 7 orders, 18 families, and 60 species (*Supplemental Material Data S4*).

Discussion

An advantage in using this database is that if an MAD needs to be estimated but there are no ADs or FIDs for the species in question, data may be sorted to use taxonomically related or ecologically similar species to help inform the decision (Caro 2010). However, before assuming, for example, that all species within an order, family, or genus behave similarly, it is pertinent to note that many species- (Blumstein et al. 2003) and site-specific factors influence how humans affect birds. These factors include the bird's level of virulent blood parasites (Møller 2008b), body mass (Blumstein et al. 2005; Blumstein 2006a; Taylor 2006; Glover et al. 2011), basal metabolic rate (Møller 2009), eye size (Møller and Erritzøe 2010), clutch size and fecundity (Blumstein 2006a; Møller



Table 1. Nesting bird flight initiation distances (FIDs) worldwide, weighted-mean FIDs, and an example of minimum approach distances (MADs) by source of disturbance and taxonomic order. Original published data were gathered from 2009 to 2015.

Disturbance	Order	<i>n</i> (families)	<i>n</i> (species)	<i>n</i> (FIDs) ^a	<i>n</i> (mean FIDs) ^b	Weighted mean FID (m)	MAD (m) ^c
Pedestrian	Anseriformes	1	3	212	12	32.5	48.8
	Charadriiformes	3	70	476	16	14.9	22.3
	Ciconiiformes	3	7	106	7	31.2	46.8
	Falconiformes	1	1	34	1	476.0	714.0
	Galliformes	1	1	44	2	79.7	119.6
	Passeriformes	6	6	442	5	8.4	12.6
	Pelicaniformes	2	3	101	2	21.4	32.1
	Sphenisciformes	1	1	186	1	22.8	34.2
Nonmotorized watercraft	Pelicaniformes	2	2	23	2	31.1	46.7
Motorized watercraft	Charadriiformes	1	1	145	14	67.5	101.3
	Ciconiiformes	2	7	123	7	17.2	25.9
	Opisthocomiformes	1	1	214	2	31.3	47.0
	Pelicaniformes	3	3	37	3	17.2	25.8
Aircraft	Falconiformes	1	1	6	1	70.0	105.0
	Strigiformes	1	1	28	1	55.0	82.5
Total				2,177	76		

^a *n* (FIDs) = total FIDs (per row in the database, i.e., per study, source of disturbance, and species) recorded for all species in this taxonomic order for this type of disturbance.

^b In addition, the database (*Supplemental Material Data S1*) includes 12 mean FIDs without sample sizes: 11 for pedestrian, Charadriiformes and 1 for pedestrian, Pelicaniformes.

^c Following Fox and Madsen (1997): $MAD = 1.5 \times \text{mean FID}$; each site-specific core area (e.g., nesting colony, group of nest trees) would be encircled in a buffer with a width of 1 MAD. Core areas are “where all (or virtually all) the distributional effects of human disturbance are completely excluded” (Fox and Madsen 1977:5).

and Garamszegi 2012), whether the bird is singing (Møller et al. 2008), whether the population is hunted (Madsen 1995, 1998a, 1998b; Madsen and Fox 1995; Laursen et al. 2005; Weston et al. 2012), presence of a predator (Adams et al. 2006; Møller and Liang 2012), nest density (Burger and Gochfield 1998), whether the species breeds cooperatively (Blumstein 2006a), experience of individual birds with people (Fraser et al. 1985), starting distance (Blumstein 2003; Glover et al. 2011; McLeod et al. 2013) and group size of the approaching pedestrian(s) (Geist et al. 2005; McLeod et al. 2013), horizontal and vertical distances between the person and the bird (Møller 2010a), static vs. mobile pedestrians (Weston et al. 2011), urban vs. rural locations (Cooke 1980; Møller 2008a, 2009, 2010b; Blumstein 2014), distance to human settlements (Bjørnvik et al. 2015) and escape habitat (Guay et al. 2013a; Dear et al. 2014 for ADs), and weather (Møller et al. 2013), among others (Glover et al. 2011, 2015; McLeod et al. 2013; Møller 2015). Although many factors affect FIDs, neither previous experience (Guay et al. 2013b) nor height of people (Van Dongen et al. 2015) recording FIDs appears to do so. In addition to estimating MADs using observable ADs and FIDs, MADs may need to incorporate effects not visible to us, such as increases in corticosterone (Cyr and Romero 2007; Ellenberg et al. 2006, 2007; Thiel et al. 2011; Seltnmann et al. 2012), heart rate (Ackerman et al. 2004; Holmes et al. 2005; Weimerskirch et al. 2002), and body temperature (Regel and Pütz 1997).

Decisions concerning lengths of MADs are based on many factors. The first two critical steps are to define what human activities potentially are causing disturbance (Fernández-Juricic et al. 2004, 2005), and what an acceptable level of disturbance is. These acceptable

levels have been represented by various MADs including mean FID (Burger and Gochfeld 2007), mean FID + 1 standard deviation of the mean FID + 40 m (Rodgers and Smith 1995, 1997; Rodgers and Schwikert 2003), $1.5 \times \text{mean FID}$ (Fox and Madsen 1997; Tables 1 and 2), maximum FID + 50 m (Vos et al. 1985), and mean AD (Fernández-Juricic et al. 2001; *Supplemental Material Data S3 and Data S4*). Other MADs were based on percentages of birds that would be flushed, including those aimed to protect 90% (Holmes et al. 1993), 95% (McGarigal et al. 1991; Anthony et al. 1995; Swarthout and Steidl 2001; Taylor 2006), 99% (Stalmaster and Newman 1978), and 100% (Delaney et al. 1999) of the birds from flushing (*Supplemental Material Data S3 and Data S4*). Whether managers should use some of the published methods or generate new estimates depends on anticipated risks and effects to the species in question.

Estimating distances at which human activities adversely affect species of concern and delineating buffer areas to protect them require staff of federal and state agencies to justify precise distances (e.g., 50 m vs. 55 m). These are not abstract exercises—they directly determine how, when, and where these activities are permitted. These important decisions must be made, even when the data to thoroughly justify them are lacking. Using FID data from this database for the species in question (and, if appropriate, similar species), and then producing MADs from these FIDs, should make it easier to estimate these distances and support these decisions.

Supplemental Material

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Table 2. Nonnesting bird flight initiation distances (FIDs) worldwide, weighted-mean FIDs, and an example of minimum approach distances (MADs) by source of disturbance and taxonomic order. Original published data were gathered from 2009 to 2015.

Disturbance	Order	<i>n</i> (families)	<i>n</i> (species)	<i>n</i> (FIDs) ^a	<i>n</i> (mean FIDs) ^b	Weighted mean FID (m)	MAD (m) ^c
Pedestrian	Anseriformes	1	21	1,120	61	47.4	71.0
	Apodiformes	1	1	9	3	38.0	57.1
	Caprimulgiformes	2	2	3	2	7.7	11.6
	Charadriiformes	7	68	4,244	143	28.1	42.2
	Ciconiiformes	3	25	1,015	68	36.8	55.3
	Columbiformes	1	15	1,101	27	14.2	21.2
	Coraciiformes	5	10	307	17	16.8	25.2
	Cuculiformes	1	6	90	9	20.7	31.0
	Falconiformes	2	17	246	24	89.7	134.5
	Galliformes	3	9	958	16	28.6	42.9
	Gruiformes	2	11	377	20	28.5	42.8
	Passeriformes	47	230	17,037	547	10.8	16.2
	Pelicaniformes	3	11	693	29	35.7	53.6
	Piciformes	1	4	113	8	14.3	21.4
	Podicipediformes	1	2	39	5	30.9	46.4
	Psittaciformes	2	17	525	24	11.3	17.0
	Strigiformes	1	1	94	2	5.1	7.7
	Struthioniformes	1	1	6	1	58.7	88.1
	Trochiliformes	1	1	54	2	6.8	10.2
Pedestrian/dog ^d	Passeriformes	3	3	1,083	16	–	–
Dog	Charadriiformes	2	5	11	5	45.9	68.8
Bicycle	Anseriformes	1	8	64	8	74.4	111.6
	Ciconiiformes	1	1	5	1	58.3	87.5
	Gruiformes	1	3	6	3	68.5	102.8
	Pelicaniformes	3	5	25	5	54.4	81.6
	Podicipediformes	1	1	1	1	16.6	24.9
Motorized vehicle	Anseriformes	1	8	285	21	82.1	123.2
	Charadriiformes	5	13	289	16	22.3	33.5
	Ciconiiformes	2	9	94	19	62.1	93.1
	Falconiformes	2	6	164	6	79.7	119.5
	Gruiformes	1	5	86	10	58.2	87.3
	Pelicaniformes	2	5	74	12	46.8	70.2
	Podicipediformes	1	3	4	4	33.8	50.7
Nonmotorized watercraft	Anseriformes	1	3	14	4	42.0	62.9
	Charadriiformes	4	11	31	11	24.7	37.1
	Ciconiiformes	2	6	14	7	40.5	60.7
	Falconiformes	1	1	177	2	152.1	228.2
	Gruiformes	1	1	7	1	19.0	28.5
	Passeriformes	1	1	2	1	7.0	10.5
	Pelicaniformes	2	3	7	3	55.7	83.6
	Podicipediformes	1	1	2	1	26.0	39.0
Motorized watercraft	Anseriformes	1	3	17	3	98.4	147.6
	Charadriiformes	6	18	656	24	35.2	52.8
	Ciconiiformes	3	11	1,624	25	61.8	92.7
	Falconiformes	2	3	348	6	86.8	130.2
	Pelicaniformes	3	3	571	10	60.8	91.2
Total				33,692	1,233		

^a *n* (FIDs) = total FIDs (per row in the database, i.e., per study, source of disturbance, and species) recorded for all species in this taxonomic order for this type of disturbance.

^b In addition, the database (*Supplemental Material Data S2*) includes 23 mean FIDs without sample sizes: 3 for pedestrian, Anseriformes; 13 for pedestrian, Charadriiformes; 1 for dog, Charadriiformes; 4 for motorized vehicle, Charadriiformes; 2 for aircraft, Charadriiformes.

^c Following Fox and Madsen (1997): $MAD = 1.5 \times \text{mean FID}$; each site-specific core area (e.g., foraging area, roosting area) would be encircled in a buffer with the width of 1 MAD. Core areas are “where all (or virtually all) the distributional effects of human disturbance are completely excluded” (Fox and Madsen 1977:5).

^d In addition, the database (*Supplemental Material Data S2*) includes 1,083 FIDs and 16 mean FIDs for three Passeriform species in response to pedestrians (on trail; off trail) and dogs (on leash, on trail; on leash, off trail; alone, on trail; alone, off trail) from one study (Miller et al. 2001). This study provided sample sizes for each species for all disturbances combined, and mean FIDs for each species for each type of disturbance, but did not report sample sizes for each species per type of disturbance, so weighted means could not be calculated. Adding these FIDs to the total above equals a grand total of 34,775 FIDs in the nonnesting database.

supplemental material. Queries should be addressed to the corresponding author for the article.

Data S1. Published ADs and FIDs for nesting birds gathered from 2009 to 2015. Presented data: authors, study location, continent, source of disturbance, specific group or test (if applicable), taxonomic order and family, scientific name, common name, and reference. For ADs and FIDs, data include (when provided) mean, SD of mean, standard error (SE) or mean, range, median, and *n*. In addition, data include (when provided) distance without flushing (and *n*) and percent flushed (and *n*).

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Data S2. Published ADs and FIDs for non-nesting birds gathered from 2009 to 2015. Presented data: authors, study location, continent, source of disturbance, specific group or test (if applicable), taxonomic order and family, scientific name, common name, and reference. For ADs and FIDs, data include (when provided) mean, SD of mean, SE or mean, range, median, and *n*. In addition, data include (when provided) distance without flushing (and *n*) and percent flushed (and *n*).

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Data S3. Published MADs for nesting birds gathered from 2009 to 2015. Presented data: authors, study location, continent, source of disturbance, specific group or test (if applicable), taxonomic order and family, scientific name, common name, MAD, formula and purpose of MAD, and reference.

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Data S4. Published MADs for nonnesting birds gathered from 2009 to 2015. Presented data: authors, study location, continent, source of disturbance, specific group or test (if applicable), taxonomic order and family, scientific name, common name, MAD, formula and purpose of MAD, and reference.

Found at DOI: <http://dx.doi.org/10.3996/082015-JFWM-078.S4> (28 KB XLSX).

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