Guidelines for the Use of Wild Birds in Research
2021 Literature Update

Drones Supplement
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The list below includes references relevant to this chapter published after this edition's release in 2018 or were not included in the 2018 edition. References that are significant or note-worthy are so indicated in bold with a short summary.

NEW REFERENCES

Afán, I., M. Máñez, and R. Díaz-Delgado. 2018. Drone monitoring of breeding waterbird populations: The case of the glossy ibis. Drones 2 https://doi.org/10.3390/drones2040042.

Barnas, A., R. Newman, C.J. Felege, M.P. Corcoran, S.D. Hervey, T.J. Stechmann, R.F. Rockwell, and S.N. Ellis-Felege. 2017. Evaluating behavioral responses of nesting lesser snow geese to unmanned aircraft surveys. Ecology and Evolution https://doi.org/10.1002/ece3.3731.
One of the few studies that looked directly at potential behavioral disturbance of nesting birds from drones and for a taxa (waterfowl) that has few published studies regarding the use of drones.

Barnas, A.F., D. Chabot, A.J. Hodgson, D.W. Johnston, D.M. Bird, and S.N. Ellis-Felege. 2020. **A standardized protocol for reporting methods when using drones for wildlife research. Journal of Unmanned Vehicle Systems https://doi.org/10.1139/juvs-2019-0011.**
While not addressing disturbance of birds, the paper presents an approach to standardizing the collection and reporting methods when using drones for wildlife/avian research.

Barr, J.R., M.C. Green, S.J. DeMaso, and T.B. Hardy. 2020. Drone surveys do not increase colony-wide flight behaviour at waterbird nesting sites, but sensitivity varies among species. Scientific Reports 10 https://doi.org/10.1038/s41598-020-60543-z.
Excellent overview of colony and species-specific disturbance of drone operations on various species of nesting terns, gulls, egrets, herons, ibis, spoonbill, and anhinga.

Barreto, J., L. Cajaíba, J.B. Teixeira, L. Nascimento, A. Giacomo, N. Barcelos, T. Fettermann, and A. Martins. 2021. Drone-Monitoring: Improving the Detectability of Threatened Marine Megafauna. Drones 5 https://doi.org/10.3390/drones5010014.

Bech-Hansen, M., R.M. Kallehauge, J.M. Lauritzen, M.H. Sørensen, B. Laubek, L.F. Jensen, C. Pertoldi, and D. Bruhn. 2020. Evaluation of disturbance effect on geese caused by an approaching unmanned aerial vehicle. Bird Conservation International https://doi.org/10.1017/S0959270919000364.
Good assessment of impacts to foraging geese from various drone flight altitudes with recommendations for drone operations.

Bell, M. and P. Harborne. 2019. The use of an Unmanned Aerial Vehicle to census large breeding colonies of black-billed gull (*Larus bulleri*) and white-fronted tern (*Sterna striata*) at the Ashburton River/Hakatere River mouth. Notornis 66: 95-97.

Bevan, E., S. Whiting, T. Tucker, M. Guinea, A. Raith, and R. Douglas. 2018. Measuring behavioral responses of sea turtles, saltwater crocodiles, and crested terns to drone disturbance to define ethical operating thresholds. PLoS ONE https://doi.org/10.1371/journal.pone.0194460.
Good documentation of effects on behavior of a colony of resting terns from drone overflights.

Blight, L.K., D.F. Bertram, E. Kroc. 2019. Evaluating UAV-based techniques to census an urban-nesting gull population on Canada's Pacific coast. Journal of Unmanned Vehicle Systems https://doi.org/10.1139/juvs-2019-0005.

Bohlander, J.. 2020. Assessment of Disturbance to Hawaiian Monk Seals and Birds in the Northwestern Hawaiian Islands by the APH-22 Hexacopter. NOAA UAS News. https://uas.noaa.gov/News/Articles/ArtMID/6699/ArticleID/870/Assessment-of-Disturbance-to-Hawaiian-Monk-Seals-and-Birds-in-the-Northwestern-Hawaiian-Islands-by-the-APH-22-Hexacopter.

Borrelle, S.B. and A.T. Fletcher. 2017. Will drones reduce investigator disturbance to surface-nesting seabirds? Marine Ornithology 45: 89–94.
Review of studies addressing the variability in observed physiological and behavioural responses to nesting seabirds from drone operations, and whether the studies evaluated the risk of malfunction or crashes, common with off-the-shelf drone platforms.

Brooke, S., D. Graham, T. Jacobs, C. Littnan, M. Manuel, and R. O'Conner. 2015. Testing marine conservation applications of unmanned aerial systems (UAS) in a remote marine protected area. Journal of Unmanned Vehicle Systems https://doi.org/10.1139/juvs-2015-0011.

Collins, S.A., G.J. Giffin, and W.T. Strong. 2019. Using flight initiation distance to evaluate responses of colonial−nesting Great Egrets to the approach of an unmanned aerial vehicle. Journal of Field Ornithology https://doi.org/10.1111/jofo.12312.
Good assessment of behavioral responses of nesting egrets to drone operations.

Díaz-Delgado, R., M. Mañez, A. Martínez, D. Canal, M. Ferrer, and D. Aragonés. 2017. Using UAVs to Map Aquatic Bird Colonies. Pages 277-291 *in* R. Díaz-Delgado, R. Lucas, and C. Hurford, eds. The Roles of Remote Sensing in Nature Conservation. Springer, Switzerland.

Dundas, S.J., M. Vardanega, P. O'Brien and S.R. McLeod. 2021. Quantifying Waterfowl Numbers: Comparison of Drone and Ground-Based Survey Methods for Surveying Waterfowl on Artificial Waterbodies. Drones 5 https://doi.org/10.3390/drones5010005.

Dunn, M.J., S. Adlard, A.P. Taylor, A.G. Wood, P.N. Trathan, and N. Ratcliffe. 2021. Un-crewed aerial vehicle population survey of three sympatrically breeding seabird species at Signy Island, South Orkney Islands. Polar Biology https://doi.org/10.1007/s00300-021-02831-6.

Edney, A.J. and M.J. Wood. 2021. Applications of digital imaging and analysis in seabird monitoring and research. Ibis https://doi.org/10.1111/ibi.12871.

Francis, R.J., M.B. Lyons, R.T. Kingsford, and K.J. Brandis. 2020. Counting Mixed Breeding Aggregations of Animal Species Using Drones: Lessons from Waterbirds on Semi-Automation. Remote Sensing 12 https://doi.org/10.3390/rs12071185.

Frixione, M.G. and C. Salvadeo. 2021. Drones, Gulls and Urbanity: Interaction between New Technologies and Human Subsidized Species in Coastal Areas. Drones 5 https://doi.org/10.3390/drones5020030.

Gallego, D. and J.H. Sarasola. 2021. Using drones to reduce human disturbance while monitoring breeding status of an endangered raptor. Remote Sensing in Ecology and Conservation https://doi.org/10.1002/rse2.206.
One of the few studies to specifically assess drone disturbance on a tree-nesting raptor species.

Germany, Portugal, Spain, and Scientific Committee on Antarctic Research. 2019. An update to the state of knowledge of wildlife responses to unmanned aerial vehicles. IP 10. 42nd Antarctic Treaty Consultative Meeting and 22nd Committee for Environmental Protection, July 1-11, 2019, Prague, Czech Republic.
Although focused on Antarctic species, provides relevant overview of general effects of drone operations that can be applied to other species and habitats. Includes table of recommended operating altitudes for birds and mammals based upon existing data.

Goebel, M.E., W.L. Perryman, J.T. Hinke, D.J. Krause, N.A. Hann, S. Gardner, and D.J. LeRoi. 2015. A small unmanned aerial system for estimating abundance and size of Antarctic predators. Polar Biology https://doi.org/10.1007/s00300-014-1625-4.

Green, M.C., T. Hardy, S. DeMaso, B. Vermillion, and J. Barr. 2017. Surveying mixed-species waterbird colonies with unmanned aerial systems (UAS): Visibility bias, disturbance, and protocol recommendations. Final Report. Texas State University and Gulf Coast Joint Venture.
Supporting report for Barr et al. (2020).

Hadjikyriakou, T.G., N. Kassinis, D. Skarlatos, P. Charilaou, and A.N.G. Kirschel. 2020. Breeding success of Eleonora's Falcon in Cyprus revisited using survey techniques for cliff-nesting species. Ornithological Applications https://doi.org/10.1093/condor/duaa045.

Hayes, M.C., P.C. Gray, G. Harris, W.C. Sedgwick, V.D. Crawford, N. Chazal, S. Crofts, and D.W. Johnston. 2021. Drones and deep learning produce accurate and efficient monitoring of large-scale seabird colonies. Ornithological Applications https://doi.org/10.1093/ornithapp/duab022.

Holldorf, E. 2018. Avifauna Ethological Response to Unmanned Aircraft Systems. MS Thesis, University of San Francisco, CA. May. https://repository.usfca.edu/capstone/771/.
Although a Master's thesis, provides a good summary of existing information on behavioral responses of birds to drone operations as well as recommended best practices.

Irigoin-Lovera, C., D.M. Luna, D.A. Acosta, and C.B. Zavalaga. 2019. Response of colonial Peruvian guano birds to flying UAVs: effects and feasibility for implementing new population monitoring methods. PeerJ https://doi.org/10.7717/peerj.8129.

Good assessment of effects of drone operations on pelicans, boobies, and cormorants. Assessed noise, visibility, speed, and altitude of drones.

Israel, M. and A. Reinhard. 2017. Detecting nests of lapwing birds with the aid of a small unmanned aerial vehicle with thermal camera. Pages 1199-1207 *in* Proceedings of the 2017 International Conference on Unmanned Aircraft Systems (ICUAS), Miami, FL; June 13-16, 2017.

Jarrett, D., J. Calladine, A. Cotton, M.W. Wilson, and E. Humphreys. 2020. Behavioural responses of non-breeding waterbirds to drone approach are associated with flock size and habitat. Bird Study https://doi.org/10.1080/00063657.2020.1808587.
Provides assessment of drone operations on a number of non-breeding shorebird and waterfowl species.

Korczak-Abshire, M., A. Kidawa, A. Zmarz, R. Storvold, S.R. Karlsen, M. Rodzewicz, K. Chwedorzewska, and A. Znój. 2016. Preliminary study on nesting Adélie penguins disturbance by unmanned aerial vehicles. CCAMLR Science. 23: 1–16.

Krause, D.J., J.T. Hinke, M.E. Goebel, and W.L. Perryman. 2021. Drones Minimize Antarctic Predator Responses Relative to Ground Survey Methods: An Appeal for Context in Policy Advice. Frontiers in Marine Science https://doi.org/10.3389/fmars.2021.648772.

Lachman, D., C. Conway, K. Vierling, and T. Matthews. 2020. Drones provide a better method to find nests and estimate nest survival for colonial waterbirds: a demonstration with Western Grebes. Wetlands Ecology and Management https://doi.org/10.1007/s11273-020-09743-y.

Lyons, M., K. Brandis, C. Callaghan, J. McCann, C. Mills, S. Ryall, and R. Kingsford. 2017. Bird interactions with drones, from individuals to large colonies. Australian Field Ornithology https://doi.org/10.20938/afo35051056.
This paper presents field observations and offers preliminary guidance for drone-monitoring exercises and future research to develop guidelines for safe and effective monitoring with drones. Over 40 species addressed from the following families: Threskiornithidae, Accipitridae, Corvidae, Artamidae, Charadriidae, Sturnidae, Meliphagidae, and Hirundinidae.

Lyons, M., K. Brandis, J. Wilshire, N. Murray, J. McCann, R. Kingsford, and C. Callaghan. 2019. A protocol for using drones to assist monitoring of large breeding bird colonies. EcoEvoRxiv Preprints https://doi.org/10.32942/osf.io/p9j3f.
Although unpublished, provides excellent preliminary protocols for the use of drones in monitoring nesting ibis species that can be applied to other bird species.

Magness, D.R., T. Eskelin, M. Laker, and H.M. Renner. 2019. Evaluation of small unmanned aerial systems as a census tool for Aleutian Tern *Onychoprion aleuticus* colonies. Marine Ornithology 47: 11-16.
Excellent overview of the effects of drone operations on nesting terns, with recommendations on drone altitude, flight pattern, and timing of surveys, in both single and mixed-species colonies.

Mapes, K.L., N.G. Pricope, J.B. Baxley, L.E. Schaale, and R.M. Danner. 2020. Thermal Imaging of Beach-Nesting Bird Habitat with Unmanned Aerial Vehicles: Considerations for Reducing Disturbance and Enhanced Image Accuracy. Drones https://doi.org/10.3390/drones4020012.

McClelland, G.T.W., A.L. Bond, A. Sardana, and T. Glass. 2016. Rapid population estimate of a surface-nesting seabird on a remote island using a low-cost unmanned aerial vehicle. Marine Ornithology 44: 215–220.

McKellar, A.E., N.G. Shephard, and D. Chabot. 2020. Dual visible−thermal camera approach facilitates drone surveys of colonial marshbirds. Remote Sensing in Ecology and Conservation https://doi.org/10.1002/rse2.183.

Mesquita, G.P., J.D. Rodríguez-Teijeiro, S.A. Wich, and M. Mulero-Pázmány. 2021. Measuring disturbance at swift breeding colonies due to the visual aspects of a drone: a quasi-experiment study. Current Zoology https://doi.org/10.1093/cz/zoaa038.
One of the few studies of the effects of drone operations on Apodidae. See also Scholten et al. (2020).

Mustafa, O., A. Barbosa, D.J. Krause, H.U. Peter, G. Vieira, and M.C. Rümmler. 2018. State of knowledge: Antarctic wildlife response to unmanned aerial systems. Polar Biology https://doi.org/10.1007/s00300-018-2363-9.
Although focused on Antarctic species, provides relevant overview of general effects of drone operations that can be applied to other species and habitats.

New Zealand Department of Conservation. 2021. Drone use on conservation land: Flying drones near birds. https://www.doc.govt.nz/get-involved/apply-for-permits/drone-use-on-conservation-land/flying-drones-near-birds/.
Good brief recommendations for drone operations around birds from a federal natural resource management agency.

Oosthuizen, W.C., L. Krüger, W. Jouanneau, and A.D. Lowther. 2020. Unmanned aerial vehicle (UAV) survey of the Antarctic shag (*Leucocarbo bransfieldensis*) breeding colony at Harmony Point, Nelson Island, South Shetland Islands. Polar Biology https://doi.org/10.1007/s00300-019-02616-y.

Pfeifer, C., A. Barbosa, O. Mustafa, H.-U. Peter, M.-C. Rümmler, and A. Brenning. 2019. Using Fixed-Wing UAV for Detecting and Mapping the Distribution and Abundance of Penguins on the South Shetlands Islands, Antarctica. Drones https://doi.org/10.3390/drones3020039.

Potapov, E.R., I.G. Utekhina, M.J. McGrady, and D. Rimlinger. 2013. Usage of UAV for Surveying Steller's Sea Eagle Nests. Raptors Conservation 27: 253-260.

Pöysä, H., J. Kotilainen, V.M. Väänänen, and M. Kunnasranta. 2018. Estimating production in ducks: a comparison between ground surveys and unmanned aircraft surveys. European Journal of Wildlife Research https://doi.org/10.1007/s10344-018-1238-2.

Radiansyah, S., M.D. Kusrini, and L.B. Prasetyo. 2017. Quadcopter applications for wildlife monitoring. IOP Conference Series: Earth and Environmental Science https://doi.org/10.1088/1755-1315/54/1/012066.

Ratcliffe, N., D. Guihen, J. Robst, S. Crofts, A. Stanworth, and P. Enderlein. 2015. A protocol for the aerial survey of penguin colonies using UAVs. Journal of Unmanned Vehicle Systems https://doi.org/10.1139/juvs-2015-0006.

Reintsma, K.M., P.C. McGowan, C. Callahan, T. Collier, D. Gray, J.D. Sullivan, and D.J. Prosser. 2018. Preliminary Evaluation of Behavioral Response of Nesting Waterbirds to Small Unmanned Aircraft Flight. Waterbirds https://doi.org/10.1675/063.041.0314.
This study tested the behavioral response of a mixed-species rookery (egrets and ibis) and a ground-nesting colony of Common Terns at various altitudes.

Rischette, A.C., T.J. Hovick, R.D. Elmore, and B.A. Geaumont. 2020. Use of small unmanned aerial systems for sharp-tailed grouse lek surveys. Wildlife Biology https://doi.org/10.2981/wlb.00679.
One of the only studies to assess drone disturbance on grouse (Phasianidae).

Rümmler, M.-C., O. Mustafa, J. Maercker, H.U. Peter, and J. Esefeld. 2018. Sensitivity of Adélie and Gentoo penguins to various flight activities of a micro UAV. Polar Biology https://doi.org/10.1007/s00300-018-2385-3.

Rush, G.P., L.E. Clarke, M. Stone, and M.J. Wood. 2018. Can drones count gulls? Minimal disturbance and semiautomated image processing with an unmanned aerial vehicle for colony−nesting seabirds. Ecology and Evolution https://doi.org/10.1002/ece3.4495.
Behavioral analysis of drone effects on nesting lesser black-backed gulls with recommended flight protocols.

Sardà-Palomera, F., G. Bota, N. Padilla, L. Brotons, and F. Sardà. 2017. Unmanned aircraft systems to unravel spatial and temporal factors affecting dynamics of colony formation and nesting success in birds. Journal of Avian Biology https://doi.org/10.1111/jav.01535.

Scarton, F. and R.G. Valle. 2020. Drone assessment of habitat selection and breeding success of Gull-billed Tern *Gelochelidon nilotica* nesting on low-accessibility sites: a case study. Rivista Italiana di Ornitologia - Research in Ornithology 90(2): 69-76.

Scarton, F. and R.G. Valle. 2020. Could we assess the hatching success of Pied Avocets (*Recurvirostra avosetta* Linnaeus, 1758) by drone monitoring? A pilot study. Società Veneziana di Scienze Naturali 45: 139-142.

Scholten, C.N., A.J. Kamphuis, K.J. Vredevoogd, K.G. Lee-Strydhorst, J.L. Atma, C.B. Shea, O.N. Lamberg, and D.S. Proppe. 2019. Real-time thermal imagery from an unmanned aerial vehicle can locate ground nests of a grassland songbird at rates similar to traditional methods. Biological Conservation https://doi.org/10.1016/j.biocon.2019.03.001.

Scholten, B.D., A.R. Beard, H. Choi, D.M. Baker, M.E. Caulfield, and D.S. Proppe. 2020. Short-term exposure to unmanned aerial vehicles does not alter stress responses in breeding tree swallows. Conservation Physiology https://doi.org/10.1093/conphys/coaa080.
One of the few studies of the effects of drone operations on Apodidae. See also Mesquita et al. (2021).

Shah, K., G. Ballard, A. Schmidt, and M. Schwager. 2020. Multidrone aerial surveys of penguin colonies in Antarctica. Science Robotics https://doi.org/10.1126/scirobotics.abc3000.

Strebel, N., T. Roth, and D. Weber. 2016. The existence of a model flight zone does not affect the distribution of Skylarks *Alauda arvensis* during breeding season – a case study. Ornithologische Beobachter 113: 53–60.

Thomas, S. 2014. 2013 & 2014 UAS Seabird Survey Test Flights Draft Report. USFWS Washington Maritime Refuge Complex.

Valle R. and F. Scarton. 2018. Uso dei droni nel censimento degli uccelli acquatici nidificanti nel Nord Adriatico. Bollettino del Museo di Storia Naturale di Venezia 69: 69-75. (Italian with English summary)

Valle, R.G. and F. Scarton. 2019. Effectiveness, efficiency, and safety of censusing Eurasian oystercatchers *Haematopus ostralegus* by unmanned aircraft. Marine Ornithology 47: 81-87.

Valle, R.G. and F. Scarton. 2019. Drones improve effectiveness and reduce disturbance of censusing Common Redshanks *Tringa totanus* breeding on salt marshes. Ardea 107: 275-282.

Valle, R.G. and F. Scarton. 2020. Feasibility of counting breeding Pied Avocets and Black-winged Stilts using drones. Wader Study 127 https://doi.org/10.18194/ws.00204.

Valle, R.G. and F. Scarton. 2021. Drone-conducted counts as a tool for the rapid assessment of productivity of Sandwich Terns (*Thalasseus sandvicensis*). Journal of Ornithology https://doi.org/10.1007/s10336-020-01854-w.
All of the Valle and Scarton references provide a good overview of behavioral disturbance to colonial nesting shorebirds and wading birds from drone operations, with an assessment of various drone flight parameters (e.g., lawn mower surveys vs targeted nest surveys) and altitude, as well as colony size and single- vs multi-species colonies.

Weston, M.A., C. O'Brien, K.N. Kostoglou, and M.R. Symonds. 2020. Escape responses of terrestrial and aquatic birds to drones: Towards a code of practice to minimize disturbance. Journal of Applied Ecology https://doi.org/10.1111/1365-2664.13575.
Excellent study looking at escape responses of 22 avian species to an approaching drone to inform the development of a code of practice to manage drone-induced disturbance. Parameters included drone altitude and take-off distance from a colony.

Zbyryt, A., L. Dylewski, F. Morelli, T.H. Sparks, and P. Tryjanowski. 2021. Behavioural responses of adult and young White Storks *Ciconia ciconia* in nests to an unmanned aerial vehicle. Acta Ornithologica https://doi.org/10.3161/00016454AO2020.55.2.009.