

one college campus. Eastern bluebirds nest in man-made nest boxes at each of these sites, making their reproductive success easy to monitor.

We attached small (less than 1 gram) radio-transmitters to 156 eastern bluebird nestlings while they were still in the nest. The birds then were allowed to fledge naturally (usually about two to six days later), and we followed their movements for 40 days after they fledged. We relocated each bird at least every other day, until the bird died, the transmitter died, or we lost the signal. Each time a bird was relocated, we took a global positioning systems (GPS) point to use for future analysis. Like the GPS system in automobiles, this provided us with spatial information accurate to a few meters. Fledglings suffer high mortality during this period, since they aren't yet proficient at flying (and so are easily caught by predators) and not yet good at foraging (and so starve if food is not abundant). Because of high mortality and transmitter loss due to other causes, we were able to track a total of 83 fledglings to 40 days postfledging.

We uploaded our fledgling GPS points into ArcGIS, (the Geographic Information System designed by ESRI Inc.) in order to combine the fledgling points into a home range on a map. In order to fully understand how the fledglings moved around in their environment, we first had to digitize aerial photographs so we could analyze the fledgling movements in terms of what type of habitat they were using. We took aerial photographs of Williamsburg and turned them into a digital map of the following habitat types: forest, park-like forest, impervious (i.e. man-made) surface, mid-level vegetation, short grass and water. We calculated the percentage of each type of habitat type around each nest box, within a 302 millimeter buffer (the size chosen because it encompassed 95 percent of all fledgling movements; Jackson 2010).

We calculated the home-range size for each fledgling, based on a "minimum convex polygon," which is the shape resulting from connecting the outer points among all those for each fledgling. We then compared the home-range size of birds on golf course and reference sites, to test our prediction that golf

course birds required more space than their reference counterparts.

Results and discussion

Home-range size varied considerably between fledglings, with a minimum home-range size of 0.3 hectate (ha) and a maximum of 51.3 ha. The average home range size was 5.9 ha. Fledglings on reference sites averaged larger home range sizes, but not significantly so (independent samples t-test, $t = 1.541$, $p = 0.127$). This could have been driven by a few reference sites with birds that moved much more than birds at other sites. Though no statistical differences were found between golf course and reference birds, there was a trend for larger home ranges in reference birds compared to golf course residents.

When we compared habitat types between each site, we found there was variation in the availability of each habitat type on each site, regardless of whether it was a golf or reference site. This indicates that differences in habitat occurred even among golf course and reference sites, and there was some overlap. In other words, the most naturalistic golf course resembled the most developed reference site.

When home-range size was compared between sites, we found there was variation between sites. The more natural/forested reference sites had the largest home ranges while the more urbanized sites, whether a golf course or a reference site, had the smallest home ranges. Therefore, as an area becomes more forested, the home-range size of eastern bluebird fledglings increases. This correlation could be caused by a combination of two different factors. First, considering that highly forested areas have less of the preferred open habitat that bluebirds use to forage, this may cause increased dispersal to locate suitable habitat. Conversely, urbanized areas may not have enough attractive surrounding habitat for the birds to disperse into and so the fledglings are confined to the area near their nest box.

Interestingly, many of the birds that fledged from golf courses left the site at some point before 40 days post-fledging. At one

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Little evidence suggests that bluebird fledgling home range differs between golf course and reference habitat.

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golf course site, almost all fledglings from all parts of the golf course moved onto an adjacent horse pasture. Here they created a large flock of 30 to 50 fledglings and foraged from fence posts and trees lining the pasture. Anecdotaly, it appeared that the fledglings were much less disturbed by human activity here and so could concentrate more on learning how to forage on their own. At this site, the birds had a good option of where to go in the space surrounding the golf course. However, at another site there is much less suitable habitat surrounding the golf course, so birds that dispersed away from the golf course spent many days in the grassy area around the off ramp to a major interstate highway (not an idyllic situation).

In conclusion, we found little evidence that bluebird fledgling home range differs between golf course and reference habitat, indicating that bluebirds use the golf course habitat in the same way as reference habitats. However, many birds disperse away from the golf course habitat, indicating that it may be sub-optimal in some ways. We don't fully understand what would happen to these birds had there not been suitable habitat surrounding the golf course (e.g. in a more urban golf course).

This is just the first step in understanding how birds use golf course habitat. Future research should focus on how adult birds use the golf course habitat. For example, do large golf tournaments affect the home range of nesting birds? Do birds that nest on golf courses spend their time foraging on the turf or do they go elsewhere to find food? These questions are very useful to provide us with information about how to better organize golf courses to help wildlife. By setting aside more out-of-bounds areas, managers can provide wildlife the opportunity to avoid the activity and disturbance of the golf course, yet keep them close enough to be enjoyed by golfers.

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GOLFDOM (ISSN 1526-4270) is published monthly (12 issues per year) by Questex Media Group LLC, 306 W Michigan Street, Suite 200, Duluth, MN 55802. Corporate office: 275 Grove St., Suite 2-130, Newton, MA 02466. Accounting, Advertising, Production and Circulation offices: 306 W. Michigan St., Suite 200, Duluth, MN 55802-1610. **Subscription rates:** One year \$43 (U.S. and possessions), \$65 (Canada and Mexico) and \$98 (all other countries). Air expedited service is available in countries outside the U.S. and Canada for an additional \$75 per year. Current issue single copies (prepaid only) \$5 (U.S. and possessions), \$7 (Canada and Mexico) and \$8 (all other countries). Back issues (if available, prepaid only) \$10 (U.S. and possessions), \$14 (Canada and Mexico) and \$16 (all other countries); add \$6.50 per order shipping and handling for both current and back issue purchases. Periodicals postage paid at Duluth MN 55806 and additional mailing offices.

POSTMASTER: Please send address changes to *Golfdom*, P.O. Box 1268, Skokie, IL 60076-8268. Canadian G.S.T. Number: 840033278RT0001, Publications Mail Agreement number 40017597. Printed in the U.S.A. **Copyright 2010 by Questex Media Group LLC.** All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Questex Media for libraries and other users registered with the Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01923, phone 978-750-8400, fax 978-750-4470. Call for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. For those not registered with the CCC, send permission request to questexpermissions@theysgroup.com or 800-494-9051, ext 100.

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The Sand Trap

And you thought bunker maintenance was a headache before the PGA Championship boondoggle? Think again!

I'm sure those of you not busy keeping your own bunkers up to today's absurd standards might have been wondering long before the Dustin Johnson disaster marred an otherwise entertaining PGA Championship. In case you missed it, Johnson was penalized two shots for grounding his club in a "bunker," which knocked him out of a PGA playoff. But Johnson thought he was hitting off a dirt patch, not a maintained bunker.

My question: How can bunkers inside the ropes be prepared one way, and sandy pits outside the ropes maintained another way — and all under the umbrella of a bunker?

Actually, most of us didn't wonder because we just assumed the stuff outside the ropes was played as through the green. Not until Johnson sprayed his tee shot right, only to find himself surrounded by hordes of fans with almost no official or marshal support, did the issue come up. And, boy, did it come up.

But the PGA had every warning of this happening for several years, starting in 2004 when Stuart Appleby took four penalty shots for a similar infraction. So this time around, the guys charged with selling America protein bars and Pinnacles made sure to post a "Supplementary Rules" notice on the locker-room mirror, figuring all of the tour's preening types wouldn't miss it.

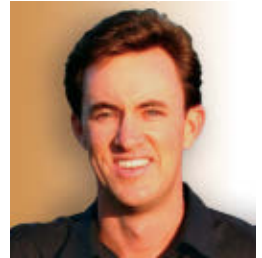
The PGA also sent out five walking rules officials Sunday to help the leaders. But when it came time for the official to

NATURALLY, WHAT HAPPENED AT WHISTLING

STRAITS HAS SET OFF ALARM BELLS THROUGHOUT

GOLF, AS IT SHOULD HAVE

BY GEOFF SHACKELFORD



prevent such a debacle, he was busy trying to keep the crowd from trampling Johnson, who claimed he didn't know he was in a bunker. Neither did on-course reporter David Feherty, since the bunker was teeming with fans and its edges were hard to see.

Afterwards, most media ripped Johnson for not reading the rules sheet. But plenty of blame was cast on the PGA, Whistling Straits architect Pete Dye and the voluminous excess the rules of golf have become. But this is also about what bunkers have become and where they will go. And what does this episode mean for the most overthought, over-prepared and most ridiculous element of modern-day maintenance?

Things could go two ways post-PGA. Whistling Straits may go in and get a hard count on the number of these sandy pits it has, order drainage and fresh sand for all, and set a horrific example by treating them all the same. And then during major tournament play, each bunker could be raked daily thanks to help from the local National Guard. And officials could rope off sand pits during the 2015 PGA Championship to keep kids from playing and building sand castles in them, as one writer noted they were doing during this year's tournament.

Naturally, what happened at

Whistling Straits has set off alarm bells throughout golf, as it should have. Here we have a course trying to maintain as many as 1,200 bunkers to comply with the bloated rules of golf — all because of the ridiculous notion that a bunker needs to offer a reasonable lie.

A more attractive solution for the next tournament held at Whistling Straits is to go in a direction that Dye needs to endorse. Take away the rakes! Also, clean up the main, in-play bunkers Sunday before the tournament and then tell players, "Fellas, you're on your own. You can ground your clubs, and kids you can build castles."

We know this wouldn't only resolve the issue of what's a bunker and what's a through-the-green pit at Whistling Straits, but, more selfishly for the golf maintenance industry, it would be a high-profile example for golfers, showing that daily unraked bunkers is far from a bad thing. In fact, it's as it should be both to restore hazards to their rightful places, and bunker budgets to within reason.

It's just a shame we'd have to wait until 2015 for progress in the War On Bunkers.

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