PROGRESS REPORT
Submitted Dec. 4th, 2009

Title: Understanding sources of variation in detectability among sites and across the breeding season in golden-cheeked warblers (Dendroica chrysoparia).

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Introduction: Occupancy and binomial mixture models have been used by Hunt, Ott, and Weckerly (in prep) to provide independent estimates of golden-cheeked warbler (GCWA) abundance and density during the breeding season for five (2008) and seven (2009) of the eight study plots used yearly by COA biologist to estimate population density. Occupancy models account for imperfect detection during surveys and thus potentially increase reliability of population density estimates. Detection probabilities of GCWA however, are likely not static for any study plot followed throughout a season or across multiple seasons and are not necessarily equivalent among populations within years for any set of study plots considered. In fall 2008 Drs. Ott and Weckerly were funded by COA (PA# MA2200 NI070000006). The funded research seeks to measure detectability of GCWA's across six 1km sq. grids within which the COA's 100-ac study plots are nested. Two simultaneous estimates of population density provided by ongoing research by Weckerly and Ott and COA biologist will allow us to test the null hypothesis of no correlation between average GCW density/grid and detectability/grid once all data collection is complete.

Importance of the research: If the detectability-density correlation coefficient is not significantly different from zero then the occupancy analysis previously funded by COA provides unbiased estimates of GCW population density/grid across the range of densities present at COA study plots. If however, the null hypothesis is rejected then the correlation detected is direct evidence that an implicit assumption of occupancy models (i.e., that detection probability is independent of population density), has been violated. A significant correlation (either positive or negative and either linear or nonlinear) leads to systematic over- or under-estimates of both occupancy and population size. Regardless of the direction of the correlation, a significant correlation between density and detectability dictates that the occupancy model selected for use must be able to incorporate among grid heterogeneity in detection probabilities. The information to be uncovered by the ongoing research has two primary applications. First, it will be used to adjust occupancy model estimates of GCWA territory density. Second a finding of among population heterogeneity in detection probabilities means that sampling protocols used to collect the presence/absence data must be adjusted to decrease heterogeneity and/or efforts are needed to identify covariates that might influence the probability of detection.

The four specific questions to be addressed are

1) Does the rate of male singing correlate with variation in density of GCW among the six grids (BCP localities)?
2) Does the rate of male singing vary temporally during the season?
3) How does seasonal variation interact with density?
4) How do rates of singing vary during the day?

Methods: We have recorded the rate of singing by GCWA males on each of six BCP localities (Ivanhoe, 3M/St. Edward's, Forest Ridge, Bohl's, JJ&T, Emma Long) (Figs. 1-6) for which independent density estimates are available. Song rate is defined for this study as the number of songs per 5-min. interval or the proportion of recording intervals with ≥1 GCWA songs recorded at a location. To record singing rate we have used autonomous [digital sound] recording units (ARUs) that continuously recorded GCWA songs from daylight to dusk/day. These devices have captured song data that constitute a time-specific record of male singing for every hour of every day that units were deployed during the breeding season. At each of 14 stations/grid (see attached maps) one sound recorder was deployed for two-day recording session. The devices were moved to a randomly selected grid location at each property every two days. Data are being collected from these recordings by visually scanning sonograms and manually counting GCWA songs. Weather and other relevant data will also be documented for each recording. With the data stream provided by the six digital recorders we are able to access the influence of population density on singing rate per grid. We will use an information–theoretic model selection procedure to select the model that best describes variation in song rate among sites. We will use a Poisson regression to explicitly estimate both the correlation between song rate (detections/station) and density, time of day, and timing within a season.

Progress update: We successfully implemented the study design in spring 2009 and were able to collect high quality sound recordings at each of 14 stations for each of the six study plots. This has yielded approximately 2,182 hours of recordings (i.e., 14 stations x13 hr/station x 6 study sites). We have duplicated and stored all digital recordings stored 84 DVDs and an external hard drive. We are on track with respect to our timeline of collecting the data from recordings. Approximately one hour of recordings can be scanned in ten minutes. Ultimately it will require 218.2 hours or, at 10 hours/week, ~22 weeks of scanning to gather all relevant GCWA data from these recordings.

Results: Formal presentation of the data is not warranted at this time as data collection is in progress. Currently all recordings at two of the six sites, Ivanhoe and Bohl's, have been assessed and provide us with a preliminary window into singing behavior at a high- (Ivanhoe) and low- (Bohl's) density sites. At stations with ≥1 GCWA songs recorded, the mean number of songs per 5-min. interval was found to be significantly greater at the high-density site (mean at high density = 5.857 songs/interval, mean at low = 1.084 songs/interval; $t = 22.248$, $p = <0.0001$). Similarly, the proportion of 5-min. intervals with ≥1 GCWA songs recorded was also higher in the high-density site (high = 0.46, low = 0.097; $t = 5.397$, $p < 0.0001$,). Both measures of song rate indicate that rate was

approximately 5x greater within the high-density site. While the Bohl's surveyor for the Occupancy Model project recorded GCWAs at 47.22% of stations, collectively with the ARUs we recorded GCWAs at 61.11% of stations at Bohl's. Therefore, while the Bohl's site may still be a transitional site it must be noted that >60% of stations within the $1km^2$ grid were occupied in 2009. These occupied stations also included 8 out of 10 stations that fell within the 100ac spot-mapping plot. Our final report will be available for Aug. 31, 2010.

Table 1. Recording dates and grid locations for the six BCP sites recorded in 2009. See maps for station locations (Figs. 1-6).

Site	Date	Station #
St. Edwards	3/15-3/16	30
	3/19-3/20	35
	3/22-3/23	9
	3/26-3/27	28
	3/29-3/30	21
	4/02-4/03	18
	4/05-4/06	33
	4/09-4/10	12
	4/12-4/13	13
	4/16-4/17	22
	4/19-4/20	3
	4/23-4/24	1
	4/26-4/27	14
	4/30-5/01	2

Site	Date	Station #
Bohl's	3/17-3/18	18
	3/21-3/22	9
	3/24-3/25	27
	3/28-3/29	10
	3/31-4/01	28
	4/04-4/05	20
	4/07-4/08	22
	4/11-4/12	8
	4/14-4/15	23
	4/18-4/19	32
	4/21-4/22	6
	4/25-4/26	14
	4/28-4/29	13
	5/02-5/03	5

Forest Ridge	3/15-3/16	11
	3/19-3/20	12
	3/22-3/23	16
	3/26-3/27	24
	3/29-3/30	23
	4/02-4/03	35
	4/05-4/06	18
	4/09-4/10	34
	4/12-4/13	4
	4/16-4/17	29
	4/19-4/20	5
	4/23-4/24	2
	4/26-4/27	33
	4/30-5/01	8

Emma Long	3/17-3/18	13
	3/21-3/22	26
	3/24-3/25	12
	3/28-3/29	20
	3/31-4/01	17
	4/04-4/05	4
	4/07-4/08	21
	4/11-4/12	27
	4/14-4/15	19
	4/18-4/19	32
	4/21-4/22	11
	4/25-4/26	25
	4/28-4/29	33
	5/02-5/03	23

Ivanhoe	3/15-3/16	18
	3/19-3/20	7
	3/22-3/23	35
	3/26-3/27	17
	3/29-3/30	27

JJ&T	3/17-3/18	32
	3/21-3/22	36
	3/24-3/25	18
	3/28-3/29	13
	3/31-4/01	22

4/02-4/03	1
4/05-4/06	11
4/09-4/10	25
4/12-4/13	21
4/16-4/17	12
4/19-4/20	31
4/23-4/24	32
4/26-4/27	2
4/30-5/01	9

4/04-4/05	29
4/07-4/08	14
4/11-4/12	35
4/14-4/15	34
4/18-4/19	11
4/21-4/22	4
4/25-4/26	19
4/28-4/29	25
5/02-5/03	3