Repeats, Returns, and Estimated Flight Ranges of Neotropical Migratory Birds in Utah Riparian Habitat[1]

Dan A. Roberts,[2] Jimmie R. Parrish,[2,3] and Frank P. Howe[2]

Abstract

We present data on capture and recapture of neotropical migrants at constant-effort mist net sampling locations in Utah between 1994 and 2002. Data were collected in accordance with MAPS (Monitoring Avian Productivity and Survivorship) protocols. Since 1994, a total of 23,789 birds have been captured (i.e., total captures include new captures, recaptures, and unbanded individuals) representing 149 species. Data collected thus far provide some measure of site fidelity and longevity for species breeding in and migrating through Utah. Of the 18,358 birds banded, 2,367 (12.9 percent) were subsequently recaptured at least once. The longest interval between initial capture and recapture was over eight years.

Assessments of subcutaneous fat carried by each bird captured were also made in accordance with MAPS protocols. Using Yellow Warbler (*Dendroica petechia*) as an example, we calculated an estimated maximum travel distance (EMTD) that migrants can fly from Utah on the energy derived from fat metabolism. Based on our calculations, juvenile Yellow Warblers could potentially outdistance adults and travel almost 1,000 km from Utah without refueling.

Key Words: captures, estimated maximum travel distance (EMTD), fall migration, fat metabolism, Mist netting, recaptures, spring migration, Yellow Warbler (*Dendroica petechia*).

Introduction

The extent to which neotropical migrants return annually to specific localities for breeding is poorly understood. The premise has been that successful breeding in a given locality one year will enhance the likelihood that individuals will return to that locality for breeding in subsequent years (Nolan 1966, Darley et al. 1977, Pinkowski 1979). Loftin (1977), Ely et al. (1977), and Rogers et al. (1982) have summarized fidelity to wintering grounds, although data are still lacking for many species of neotropical migrants for both wintering and breeding grounds. Our data provide some measure of site fidelity and longevity for species using Utah riparian areas during breeding and migration seasons.

Subcutaneous fat accumulates in birds, particularly before and during periods of migration. Fat weight as related to theoretical maximum flight ranges has been investigated at least since the 1950s (Odum and Perkinson 1951, Odum and Connell 1956, Odum 1958, Odum et al. 1961, Odum et al. 1965, Rogers 1965, Rogers and Odum 1966, Rogers et al. 1982). Most of these studies have dealt with existence energy requirements, flight energy needs, flight speed calculations, and the caloric value of total fat in determining the likelihood that passerines could complete long-distance migrations. Odum and Perkinson (1951), Odum and Connell (1956), Odum (1958), and Rogers (1965) extracted total fat from tower-killed migrants to determine caloric values of fat which were used to estimate maximum potential flight ranges. It has been estimated that birds could travel several hundred if not thousands of miles on the energy available from fat metabolism during flight, although comprehensive estimates for a number of species remains unavailable.

We present data for neotropical migrants captured at constant-effort mist net sampling locations in Utah between 1994 and 2002. While the study was initiated to investigate breeding season demographics in Utah riparian habitat, an assessment of subcutaneous fat was recorded as part of the overall data collection procedure for each bird captured. Fat data collected for Yellow Warblers (*Dendroica petechia*) was used to estimate potential travel distances to and from Utah that birds can fly without refueling.

---

[1]A version of this paper was presented at the **Third International Partners in Flight Conference, March 20-24, 2002, Asilomar Conference Grounds, California.**
[2]Utah Division of Wildlife Resources, 1594 West North Temple, Salt Lake City, UT 84116.
[3]Corresponding author. E-mail: jimparrish@utah.gov.

Study Area and Methods

Study Area

The Utah Division of Wildlife Resources has been monitoring birds in riparian habitat for the past 10 years (see Howe 1992). Beginning in 1994, constant-effort mist net sampling has been conducted annually at a randomly selected number of these sites in accordance with MAPS (Monitoring Avian Productivity and Survivorship) protocols (DeSante and Burton 1994 and subsequent annual updates) (*fig. 1*).

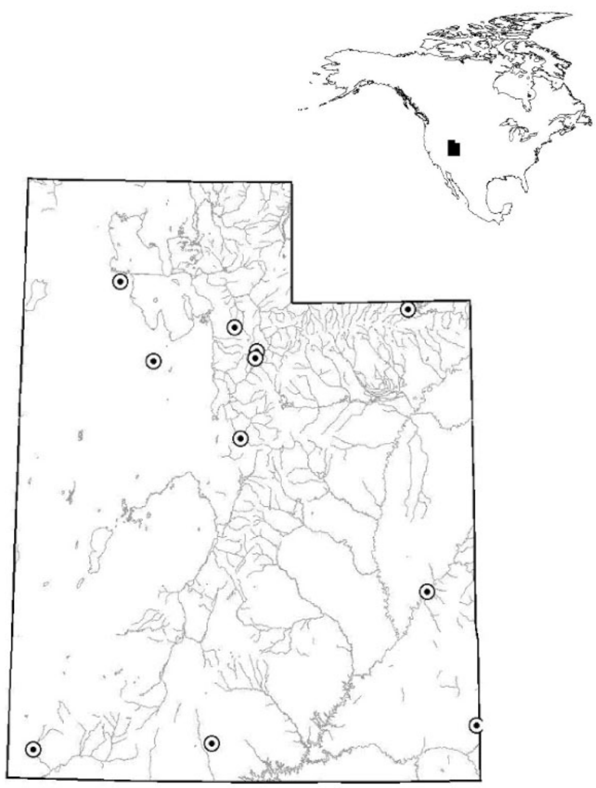

Figure 1— Location of 1994-2002 mist net sampling areas in riparian habitat in Utah.

Methods

Mist net sampling at each location was conducted once each 10-day period between 1 May and 28 August annually from 1994-2002 by field biologists trained in MAPS survey protocols and data collection techniques. A total of ten mist nets were operated continuously for 6 hours at each monitoring station beginning ca. one-half hour before official sunrise on each scheduled sampling day.

Data collected from captured birds included sex, age, weight, breeding condition, fat score, wing chord measurement, feather wear, molt condition, date and time of capture, and general observations (see Pyle 1997). The breeding condition of males (e.g., cloacal protuberance) and females (e.g., condition of brood patch) was also recorded. Captured birds were weighed to the nearest 0.1-g on a digital balance calibrated before each sampling event and banded with a U.S. Fish and Wildlife Service numbered leg band.

New, Repeat, and Return Captures

In order to estimate how many of the banded individuals returned to the same area to breed each year (i.e., site fidelity), we established criteria using several factors. Among these were 1) date of capture, 2) the number of recaptures, 3) the frequency of recapture, 4) the time interval between initial capture and subsequent recapture, and 5) rate of return to the same area in subsequent years. Birds were categorized as being either new captures, repeat captures, or return captures. New captures were those individual birds which were unbanded when captured. Repeat captures were designated as those individuals recaptured within <90 days after initial capture, and return captures were those individuals recaptured after at least 90 days or more (Rogers et al. 1982). Occasionally, individual new captures would escape before being banded and those individuals were designated as unbanded birds.

Fat Score

As assessment of the amount of subcutaneous fat present in captured Yellow Warblers was recorded as a numerical 'fat score' in accordance with MAPS protocols (DeSante and Burton 1994 and subsequent annual updates) (*table 1*). Fat weights for each observed fat score for adult male, adult female, and juvenile Yellow Warblers were then pooled for each respective age and sex category (*table 2*).

Breeding and Migration Season Chronology

We wanted to determine whether an individual bird captured was a resident or a migrant. We used Julian date vs. calendar date to maintain consistency in plotting capture results for multiple years. Breeding and migration season chronology estimates were calculated based on observed fat scores and breeding condition of individual birds captured (*fig. 2*). The assumption was that breeding birds carry less fat and are less likely, and indeed less capable, of traveling for extended periods or distances away from the area where they were captured.

Table 1— *Description of fat scores (see DeSante and Burton 1994) assigned to each individual bird captured which were used for calculating a fat free weight and the amount of subcutaneous fat available for conversion to flight energy.*

Fat Score	Description
0	No fat visible in the furculum or anywhere on the body.
1	A very small amount of fat in the furcular hollow (<5% filled) but not enough to cover the bottom of the furculum. None or just a trace of fat under the wing, on the abdomen, or anywhere else on the body.
2	The bottom of the furculum is completely covered but the furcular hollow is less than 1/3 filled. A small amount of fat may be present under the wing, or abdomen, or both.
3	The furcular hollow is about half full (actually anywhere from 1/3 to 2/3). A covering pad of fat is definitely present under the wing pit and usually on the abdomen.
4	The furcular hollow is full (actually anywhere from 2/3 full to level with the clavicles). A thick layer of fat also occurs under the wing and on the abdomen.
5	The furcular hollow is more than full; that is, the fat is bulging slightly above the furculum. The fat under the wing as well as that on the abdomen is also well mounded.
6	Fat is bulging greatly above the furculum. Large mounds of fat occur under the wings and on the abdomen.
7	The fat pads of the furculum, wing pit, and abdomen are bulging to such an extent that they join. Nearly the entire ventral surface of the body is thus covered with fat, and fat even extends onto the neck and head.

Table 2— *Fat scores, fat weight, energy estimates, and distance calculations for Yellow Warblers captured during mist net surveys in Utah during 1994-2002. Distance estimates are based on a flight energy of 0.79 Kcal/hr for adult males, 0.76 Kcal/hr for adult females, and 0.78 Kcal/hr for juveniles (see text for explanation).*

Age/Sex	Fat score	N	Weight[1] (g)	Fat weight[2] (g)	Fat energy (Kcal/hr)	Est. flight time (hrs)	EMTD[3] (km)
Adult males	0	155	8.79	0.00	0.00	0.00	0.00
	1	66	9.03	0.23	2.08	2.63	146.14
	2	30	9.26	0.46	4.16	5.26	292.28
	3	35	9.49	0.69	6.24	7.89	438.43
	4	29	9.72	0.92	8.32	10.51	584.57
	5	15	9.95	1.16	10.40	13.14	730.71
	6	2	10.18	1.39	12.48	15.77	876.85
Adult females	0	219	8.43	0.00	0.00	0.00	0.00
	1	102	8.68	0.25	2.26	2.98	165.64
	2	56	8.93	0.50	4.52	5.96	331.27
	3	37	9.18	0.75	6.78	8.94	496.91
	4	44	9.44	1.00	9.04	11.92	662.55
	5	11	9.69	1.26	11.30	14.90	828.18
	6	3	9.94	1.51	13.56	17.87	993.82
Juveniles	0	88	8.63	0.00	0.00	0.00	0.00
	1	37	8.86	0.24	2.03	2.75	152.84
	2	30	9.10	0.47	4.27	5.50	305.69
	3	37	9.34	0.71	6.40	8.25	458.53
	4	38	9.58	0.95	8.54	11.00	611.38
	5	8	9.81	1.19	10.67	13.74	764.22
	6	2	10.05	1.42	12.81	16.49	917.06
	7	1	10.29	1.66	14.94	19.24	1069.91

[1]Weights for fat score 0 represent the mean fat free weight (FFW) for each age/sex category.
[2]Weights for each fat score represent the difference between the total weight at the time of capture and FFW for each age/sex category.
[3]EMTD = Estimated Maximum Travel Distance.

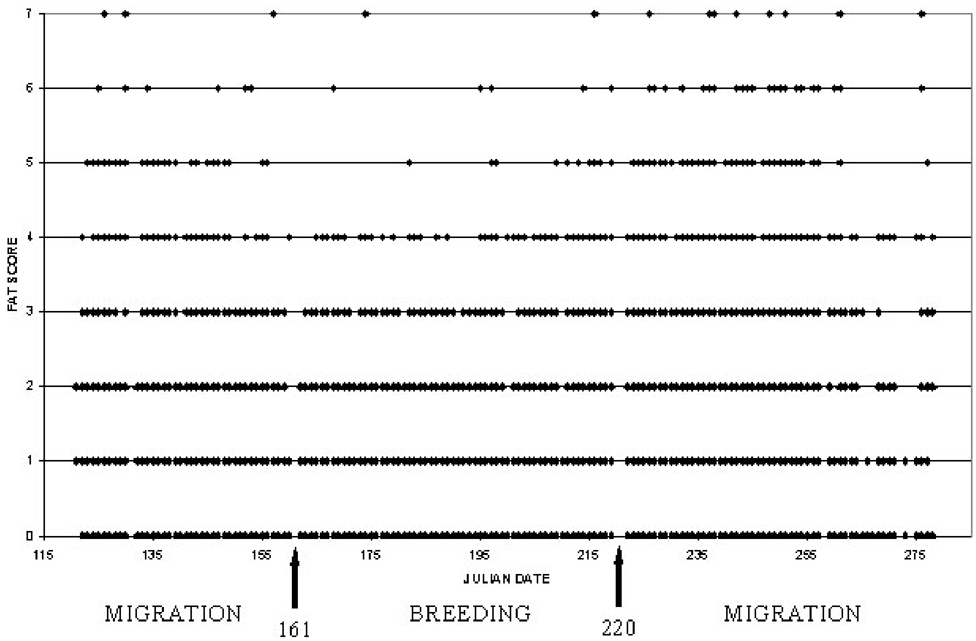

Figure 2— Fat scores recorded for each individual bird captured during mist net surveys conducted in Utah riparian habitat. Julian date versus calendar date was used to more accurately reflect seasonal variation in the fat scores recorded (see text for details).

Fat Score/Fat Weight Regression

Simple linear regression equations (e.g., Y = β0 + (β1 • X, where β0 = fat free weight (FFW), β1 = increase in fat weight for each increase in fat score, and X = recorded fat score) were used to estimate the average increase in fat weight with an increase in fat score for each age and sex category. For example, the linear regression equation for adult male Yellow Warblers is Y = 8.79 + 0.23X, where the FFW is 8.79 g, and the increase in weight for a fat score of 1 (and each additional increase in fat score) is 0.23 g (*table 2*). Calculated linear regressions were then plotted for further evaluation using Program MINITAB (V. 12.23) (*fig.3* presents an example using data for adult male Yellow Warblers). It was assumed that if the resulting R^2 values obtained were reasonably high and the slope was positive, then the caloric values could be used to calculate the potential distance that birds could travel during spring and fall migration periods without refueling by metabolizing subcutaneous fat.

Flight Distance Estimates

The existence metabolic rate (EMR) for passerine birds has been estimated to be 0.04 – 0.05 Kcal/gram of FFW/hr (Rogers 1965). For data presented in this paper, we established an EMR of 0.045 Kcal/gram of FFW/hr (i.e., the median of values reported by Rogers 1965). In addition to our EMR value, our flight distance estimates are based on the following assumptions: 1) the flight metabolic rate (FMR) for passerines is estimated to be approximately twice that of the EMR (i.e., 0.09 Kcal/gram of FFW/hr) (see Rogers 1965), 2) the flight speed of passerines is approximately 30 knots (55.6 km/hr) (Nisbet et al. 1963), 3) the caloric value of fat is 9 Kcal/gram (Rogers 1965), 4) potential maximum hours of flight time is the total energy derived from fat divided by the FMR, and 5) maximum potential flight distance is the product of the potential hours of flight based on available flight energy from fat multiplied by flight speed.

Once the potential energy had been determined, we calculated the estimated maximum travel distance (EMTD) that male, female, and juvenile Yellow Warblers could travel from Utah without refueling. Variations in EMTD would be expected to increase with an increase in fat score. For example, individual Yellow Warblers with higher fat scores would be expected to have a higher EMTD capability to and from a given capture location.

Results and Discussion

New, Repeat, and Return Captures

Since 1994, a total of 23,789 captures have been recorded (i.e., total captures include new captures, repeat captures, return captures, and individual birds that were not banded) representing 149 species. Of the 18,358 (77 percent) birds banded, 2,367 (12.9 percent) birds representing 75 species were subsequently recaptured at least once (*table 3*). In contrast, 15,991 (87.1 percent of new captures) individual banded birds have yet to be recaptured at least once since their initial banding.

The total number of new captures increased steadily from 1994 until 2000 and has ranged from a low of 810 to a high of 3,507 (*table 3*). The number of repeat captures ranged from 66 (7.9 percent of new captures within the year) to a high of 327. The highest yearly percentage of repeat captures was 12.3 percent which occurred in 1998. The total number of recaptures (including returns and birds recaptured more than once) ranged from 66 to 709 (*table 3*).

Of the total recaptures, 830 (35.1 percent) individual birds were recaptured at least 1 year after their original capture date, 367 (15.5 percent) were recaptured at least 2 years after initial capture, 137 (5.8 percent) were recaptured at least 3 years after initial capture, and 47 (2.0 percent) individuals were recaptured at least 4 years after initial capture. Only 13 (0.5 percent) recaptured birds have been recaptured at least 5 years from their original capture date.

Table 3— *Total new captures, recaptures, repeat captures, and return captures of neotropical migrants in Utah during 1994-2002 (see text for further explanation).*

Year	New captures[1]	Repeat captures[2]	Return captures[3]	Total recaptures[4]
1994	834	66	0	66
1995	810	67	42	109
1996	1,545	165	138	305
1997	2,377	205	197	401
1998	2,204	270	260	533
1999	2,258	214	280	496
2000	3,507	327	372	709
2001	2,388	224	359	591
2002	2,435	189	245	437

[1]Total banded for each year (i.e., birds unbanded at time of initial capture).
[2]Total recaptures within 90 days of initial capture.
[3]Total recaptures 90 days and greater from initial capture from previous year(s).
[4]Total of repeats + returns for each year (includes birds recaptured more than once)

The greatest single longevity record from this study belongs to a male Yellow Warbler recaptured during the 2002 field season at the same location where initial banding occurred in 1994. A total of 2,937 days (8.05 years) had elapsed between the time of initial capture and the 2002 recapture.

Breeding and Migration Season Chronology

We determined that birds captured between 10 June (Julian Date 161) and 8 August (Julian Date 220) were considered as residents (breeders) and that birds captured prior to 10 June and after 8 August were considered as migrants. Adult males captured prior to June 10 or after August 8 had little or no cloacal protuberance (MAPS score of 1 or 0), and females captured during the same period showed little or no evidence of a brood patch presence (MAPS score of 0), or the brood patch area was molting (MAPS score of 5). Nearly all (98.4 percent) of the fat scores recorded during the potential breeding season were at 4 or below. In fact, most fat scores were at 2 or below (87.2 percent), and nearly half (49.1 percent) had fat scores of 0 (*fig. 2*).

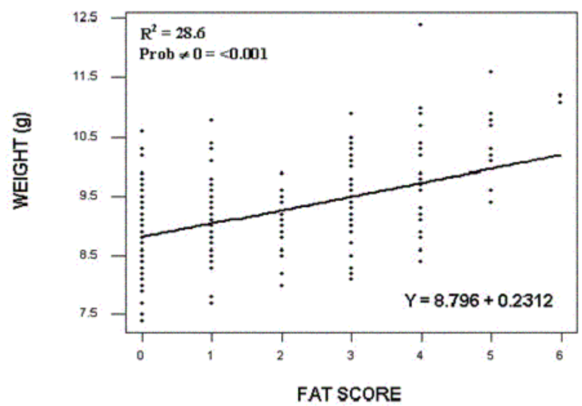

Figure 3— Regression of fat score and weight (in grams) of migrant adult Male Yellow Warblers captured in Utah riparian habitat. Regression calculated from field data collected during mist net surveys conducted in Utah riparian habitat.

Estimated Maximum Travel Distance (EMTD) Calculations

At least 7,894 birds (43 percent of birds banded) representing 125 species met the above criteria for consideration as migrants. After eliminating species known to be winter residents in Utah, only 10 migratory species had sufficient sample sizes (e.g., at least 100 individuals) to be considered for EMTD calculations. Of these, Yellow Warblers were selected for EMTD calculations for this paper based on fat scores recorded for captured individuals.

Typically, adult Yellow Warblers are sexually dichromic enough to distinguish between sexes when captured during migration periods. The highest fat score recorded for both adult males and females during field surveys was 6 and the highest fat score recorded for juveniles was 7. The fat score versus weight regression yielded an R^2 of 28.6 ($P < 0.001$) for adult male Yellow Warblers, an R^2 of 28.9 ($P < 0.001$) for adult female Yellow Warblers, and an R^2 of 25.1 ($P < 0.001$) for juveniles.

Adult male Yellow Warblers with a fat score of 6 (e.g., 1.4 g of available fat, EMTD 877 km) could potentially travel less distance than adult female Yellow Warblers with a fat score of 6 (e.g., 1.5 g of available fat, EMTD 994 km) (*table 2*). EMTD for juveniles with a fat score of 6 (e.g., 1.7 g of available fat) was 917 km.

Using one of our northernmost mist net sampling stations as a potential starting point, we determined that adult male Yellow Warblers could potentially travel from northern Utah as far south as southern Arizona and southern New Mexico without refueling during fall migration (*fig 4*). Further, birds were capable of traveling as far north as the northern portions of the Idaho panhandle and northern Montana during spring migration without refueling. Adult female Yellow Warblers could potentially travel a bit farther south than males to the northern border of Mexico during fall migration and to the southern border of Canada during spring migration (*fig. 4*). Assuming birds began migration with a fat score of 6, individual females could be arriving in Utah from as far away as northern Montana in the fall and southern Arizona in the spring without refueling.

Juvenile Yellow Warblers could potentially travel farther than adults to as far south as the northern portions of Sonora and Chihuahua Mexico during fall migration without refueling and as far north as southern portions of Alberta and Saskatchewan during spring migration (*fig. 5*).

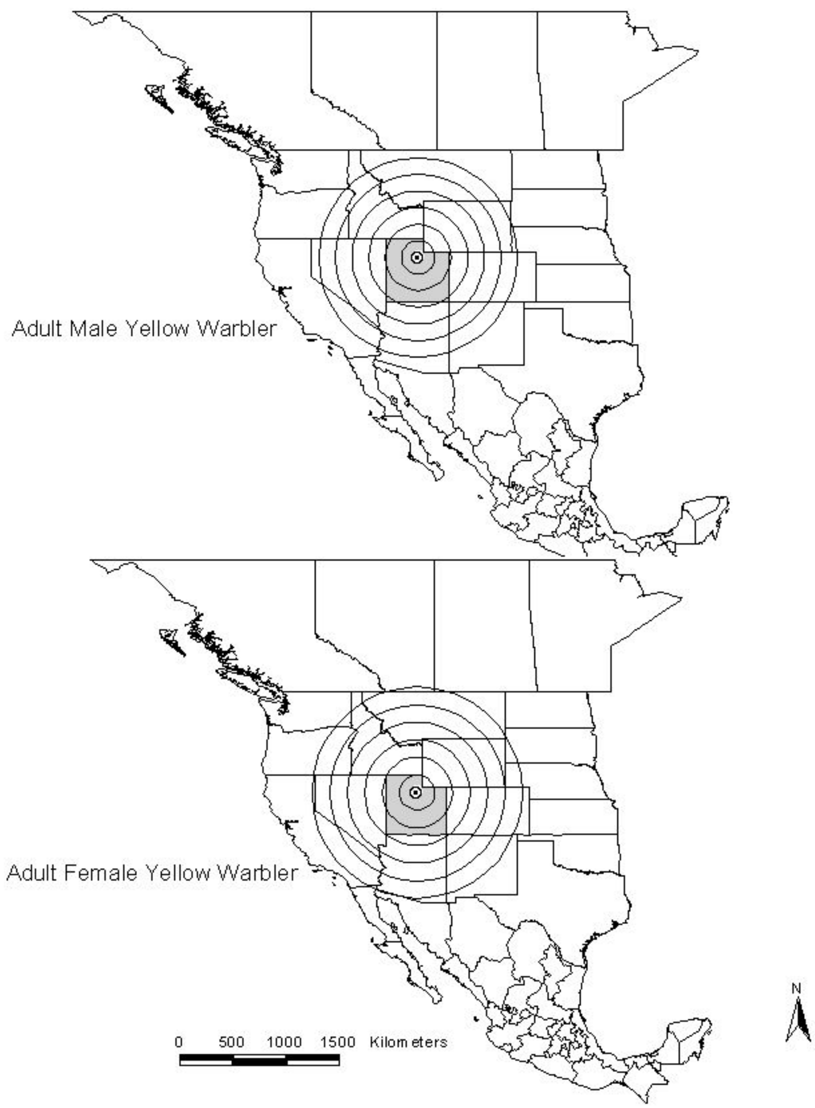

Figure 4— Potential distances traveled to and from north-central Utah by adult Yellow Warblers during spring and fall migration periods. Concentric circles represent potential maximum distances individuals could travel from north-central Utah with fat scores ranging from 1 (lowest potential distance/smallest circle) to 6 (highest potential distance/largest circle).

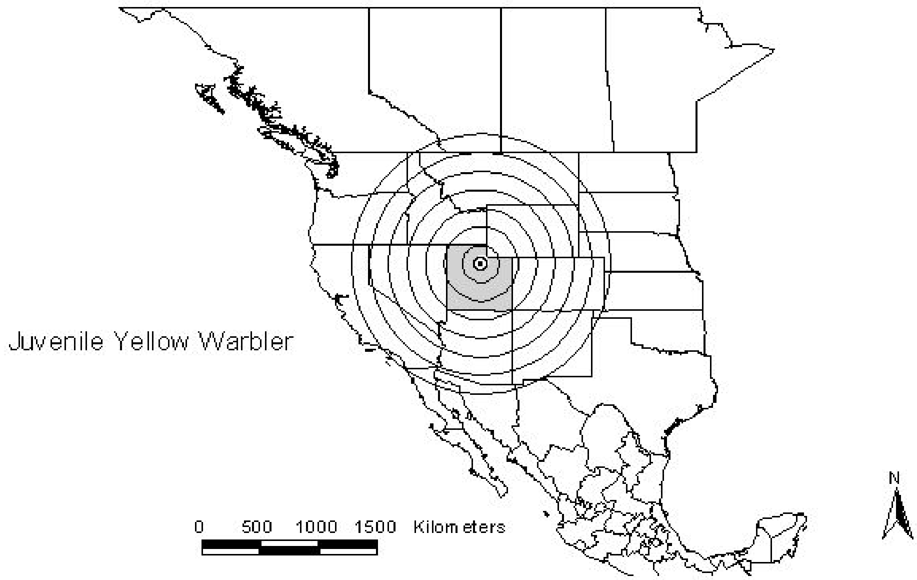

Figure 5— Potential distance traveled to and from north-central Utah by juvenile Yellow Warblers during spring and fall migration periods. Concentric circles represent potential maximum distances individuals could travel from north-central Utah with fat scores ranging from 1 (lowest potential distance/smallest circle) to 7 (highest potential distance/largest circle).

Summary

Of 23,789 total captures representing 149 species of neotropical migrants recorded in Utah riparian habitat during 1994-2002, only 2,367 (12.9 percent) birds representing 75 species were subsequently recaptured at least once. Recapture percentage ranged from a high of 35.1 percent within 1 year of initial capture to a low of 0.5 percent after 5 years. Over one-half (50.6 percent) of the recaptures occurred within 2 years of initial capture. Site fidelity may vary for a given species, and additional factors such as mortality rate (where known), sex, and age should also be considered in future studies of this kind. However, our results indicate that some individuals return to the same breeding grounds for much longer than 5 years.

Estimated maximum travel distance (EMTD) calculated for Yellow Warblers ranged from a low of 817 km for adult males to a high of 994 km for adult females, with juveniles potentially traveling further than adult males but less than adult females. We recognize that EMTD is dependent upon published values for the estimated flight speed of passerines and existence metabolic rate (EMR) or flight metabolic rate (FMR). Obviously, an increase in the estimated flight speed results in a proportional increase in flight distance, and an increase in EMR results in a proportional decrease in flight distance. It seems unlikely, that flight speeds or EMR values are identical for all neotropical migrants. Future studies should attempt to refine estimates of flight speed and EMR or FMR, which would allow for more accurate EMTD calculations. Studies are also needed for additional breeding as well as wintering locales. More comprehensive EMTD calculations could provide substantial benefit to wildlife managers in attempting to identify critical staging and foraging areas used during spring and fall migration periods.

Acknowledgments

Constant-effort mist net sampling in Utah has been made possible through the consistent support of the Utah Division of Wildlife Resources and numerous cooperators in the Utah Partners in Flight Program, including U. S. Forest Service, U. S. Bureau of Land Management, U. S. Fish and Wildlife Service, U. S. Bureau of Reclamation, Utah Reclamation, Mitigation, and Conservation Commission, and the Department of Defense. We also thank C. M. White, T. Rich, and R. Norvell for reviewing the manuscript and providing helpful comments.

Literature Cited

Connell, C. E. 1956. **Lipid levels in migrating birds.** Science 123: 892-894.

Connell, C. E. and H. L. Stoddard. 1961. **Flight energy and estimated flight ranges of some migratory birds.** Auk 78(4): 515-527.

Darley, J. A., D. M. Scott and N. K. Taylor. 1977. **Effects of age, sex, and breeding success on site fidelity of Gray Catbirds.** Bird-Banding 48: 145-151.

DeSante, D. and K. Burton. 1994. **Monitoring Avian Productivity and Survivorship (MAPS) protocol.** The Institute for Bird Populations, P. O. Box 1346, Point Reyes Station, California 94956.

Ely, C. A., P. J. Latos, and R. R. Lohoefener. 1977. **Additional returns and recoveries of North American bird in southern Mexico.** Bird-Banding 48: 275-276.

Hicks, D. L., E. W. Wischusen, and J. R. Parrish. 1982. **Repeats, returns, and estimated flight ranges of some North American migrants in Guatemala.** Journal of Field Ornithology 53(2): 133-138.

Howe, F. P. 1992. **Population monitoring of Utah neotropical migratory birds in riparian habitats: 1992 progress report.** Utah Division of Wildlife Resources Publication, December 2, 1992. Salt Lake City, UT: Utah Division of Wildlife Resources; 13 p.

Loftin, H. 1977. **Returns and recoveries of banded North American birds in Panama and the tropics.** Bird-Banding 48: 253-258.

Marshall, S. G. and T. G. Marples. **The caloric content of migrating birds.** Ecology 46(6): 901-904.

Nisbet, I. C. T., W. H. Drury, Jr., and J. Baird. 1963. **Weight-loss during migration; Part I: Deposition and consumption of fat by the Blackpoll Warbler, *Dendroica striata*.** Bird Banding 34: 107-138.

Nolan, V., Jr. 1966. **Fidelity to the breeding site in Prairie Warbler *Dendroica discolor*.** Abstracts of the 14th International Ornithological Congress: 90-91.

Odum, E. P. 1958. **The fat deposition picture in the White-throated Sparrow in comparison with that in long-range migrants.** Bird-Banding 29: 105-108.

Perkinson, J. D., Jr. 1951. **Relation of lipid metabolism to migration in birds: seasonal variation in body lipids of the migratory white-throated sparrow.** Physiological Zoology 24: 216-230.

Pinkowski, B. C. 1979. **Annual productivity and its measurement in a multi-brooded passerine, the eastern bluebird.** Auk 96(3): 562-572.

Pyle, P. 1997. **IdentificationgGuide to North American birds. Part 1: Columbidae to Ploceidae.** Bolinas, CA: Slate Creek Press; 732 p.

Rogers, D. T., Jr. 1965. **Fat levels and estimated flight-ranges of some autumn migratory birds killed in Panama during a nocturnal rainstorm.** Bird Banding 36: 115-116.

Rogers, D. T., Jr. and E. P. Odum. 1966. **A study of autumnal postmigrant weights and vernal fattening of North American migrants in the tropics.** Wilson Bulletin 78(4): 415-433.