Migration and Wintering Areas of American Bitterns (*Botaurus lentiginosus*) that Summer in Central North America as Determined by Satellite and Radio Telemetry, 1998-2003

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Abstract.—Twenty adult male American Bitterns (*Botaurus lentiginosus*) were marked on summer range in central North America with satellite tracking Platform Transmitter Terminals (PTTs) to document migration routes and wintering range. Nineteen complete fall migration routes were documented for 17 individuals. Of the successful migrations, 63% (n = 12) went to southern Florida, 32% (n = 6) to southern Louisiana, and 5% (n = 1) to the Gulf coast of Texas. Spring migrations for nine birds were documented, and 78% (n = 7) showed fidelity to breeding range. Two complete migrations for two individuals were documented, and they demonstrated fidelity to winter range. The longest, fastest movement documented was 2,300 km in less than 74 hr. Extensive, post-breeding dispersal was not observed in the adult male American Bitterns in this study. Six male American Bitterns were marked with PTTs on winter range in Florida and Texas. Spring migration for these birds was documented to Nebraska, North Dakota, Saskatchewan, Manitoba and Ontario. Sixty-seven American Bitterns were marked with Very High Frequency radio transmitters on summer ranges, and 16% (n = 11) were located on wintering grounds used by the satellite-tracked birds, further documenting the importance of the Everglades and the Louisiana coast as winter habitat for American Bitterns that breed in Central North America. *Received 29 October 2012, accepted 20 February 2013.*

Key words.—American Bittern, *Botaurus lentiginosus*, breeding range, dispersal, Everglades, Louisiana coast, migration, Platform Transmitter Terminals, winter range.

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American Bitterns (*Botaurus lentiginosus*) are widespread throughout North America. Their regular breeding range includes the United States north of central Nevada and Colorado, east through southern Wisconsin to eastern Pennsylvania and the New England states, and the southern half of Canada (Palmer 1962; Gibbs and Melvin 1992; Alderfer 2006). In the southern tier of states, breeding is sporadic and local (Lowery 1960; Palmer 1962) and occasional in Mexico (Banks and Dickerman 1978). American Bitterns migrate from northern areas where winter temperatures remain below freezing (Gibbs *et al.* 1992). American Bitterns winter along the southern tier of coastal states, Mexico and south to Panama, Cuba, Puerto Rico, Jamaica, Hispaniola and the Bahamas. American Bitterns also winter on the temperate Pacific coast as far north as British Columbia and along the Atlantic coast north to Virginia, Delaware and occasionally New Jersey (Pearson 1923; Bent 1926; Palmer 1962; Root 1988; Gibbs and Melvin 1992).

Migration routes are unknown, but Gibbs *et al.* (1992) stated that major river systems and coastal belts are probably important. American Bitterns are considered to be mainly nocturnal migrants (Forbush 1955; Palmer 1962; Gibbs *et al.* 1992). Spring migration occurs in March and April and reaches the northern range limits in April. Fall migration occurs in September through October with some individuals occasionally not leaving southern Canada until November (Bent 1926; Forbush 1955; Palmer 1962). Several sources suggest that American Bitterns do a considerable amount of wandering or extensive post-breeding dispersal in late summer (Palmer 1962; Gibbs and Melvin 1992). This post-breeding dispersal is based on observation records in Greenland and Europe. These trans-Atlantic vagrants were attributed by Cramp (1977) to being caught up in westerly storm tracks during post-fledging dispersal. The objectives of this study were to document migration routes and winter-

ing grounds for American Bitterns breeding in central North America using satellite and Very High Frequency (VHF) telemetry.

Methods

Adult male American Bitterns were captured on the breeding range during May and early June with mirror traps (Huschle *et al.* 2002) and marked with VHF transmitters in conjunction with an ongoing study of ecology (Lor 2007). During July and early August, when radio-marked males were molting and incapable of long flights (Brininger 1996; Azure 1998), they were recaptured by hand or with a long-handled net after being located with a VHF receiver either on foot or with the use of an airboat. VHF transmitters were replaced with Platform Transmitter Terminals (PTTs). The 20-g Model 100 PTT (Microwave Telemetry, Inc.) was used with the harness loops removed and the PTT glued and sewn to a Herculite bib worn around the neck (Brininger 1996; Amstrup 1980). PTT package weight was between 22 and 23 g and less than 3% of the birds' body weight. On the winter range, American Bitterns were captured using a net gun as they flushed in front of a moving airboat (Huschle *et al.* 2002). Sex was determined by size criteria (Azure *et al.* 2000), and only males over 900 g were fitted with a PTT.

During the summers of 1998, 1999 and 2000, the primary breeding range study site was Agassiz National Wildlife Refuge (NWR), in northwestern Minnesota. Agassiz NWR is a large (24,889 ha) wetland complex with 26 managed impoundments ranging in size from 12 to 3,642 ha (Huschle and Knutsen 2007). American Bitterns were also instrumented during summer at six other sites representative of small freshwater wetlands typical of those found in the Prairie Pothole Region (PPR) (Weller 1987; Mitsch and Gosselink 1993); specifically a Waterfowl Production Area near Wahpeton, Minnesota, four Waterfowl Production Areas in eastern North Dakota and Mead Wildlife Management Area, Wisconsin. The PPR consists of grasslands with small naturally regulated wetlands formed in moraines of undulating glacial till. The site in Wisconsin is not in the PPR proper but for our analysis these six sites are referred to collectively as the PPR sites. During the winter, one American Bittern was captured at Water Management District 3A in the Everglades region of Florida and five were captured at McFaddin NWR, Texas. The Everglades is the single largest marsh system in the United States and includes Lake Okeechobee and the brackish marshes and mangrove swamps to the south (Mitsch and Gosselink 1993). The northern portion of the Everglades includes drained areas that have been converted to agriculture. McFaddin NWR is a 22,260-ha refuge 20 km west of Louisiana along the Texas Gulf coast and contains both freshwater and brackish marshes. Both of these winter capture sites represent expansive complex wetlands in the southern coastal plains.

PTTs were programmed for four duty cycles to maximize locations during migration based on our estimated timing of migration (Table 1). Location data were obtained from ARGOS (ARGOS 1996). Both standard service locations (quality classes 1, 2, and 3 with estimated 1-sigma location accuracy of < 1000 m, < 350 m, and < 150 m, respectively) and auxiliary processing locations (classes 0, A, B, and Z with no estimate of location accuracy) were obtained (ARGOS 1996). A filtering algorithm (Douglas *et al.* 2012) was used to exclude improbable locations. Filtering criteria considered location quality class, distance moved, movement rate and turning angle. Locations were retained if their location class was 1, 2, or 3. Auxiliary locations within 15 km of a preceding or subsequent location were retained by virtue of spatial redundancy, and remaining auxiliary locations were included only if resultant movement rates were < 22.2 m s^{-1} and the internal angles (α, in degrees) formed by preceding and subsequent vectors (of lengths d1 and d2 km) were not suspiciously acute ($\alpha > -25 + \beta \times \ln[\text{minimum } (d1,d2)]$, where $\beta = 15$). We assigned $\beta = 15$ because it performed well for our specific tracking data both before and during migration.

All locations were examined to determine departure dates and maximum length of migration. Departure was considered to have occurred when new locations showed a significant southern (fall) or northern (spring) movement and directional movements continued to occur. Winter range or breeding range was determined to be reached on the first date after which movements became localized and did not continue to move north or south. The range of departure dates was determined by taking the difference between the last date at the breeding range or winter range and the first date of significant movement. The maximum duration of migration was the difference between the last date at the breeding range or winter range and first date of localized movements at the new location.

Table 1. Duty cycles for satellite platform transmitter terminals used for July and February deployments to maximize locations during migration.

	July Deployment			February Deployment		
Duty Cycle	Hrs On	Hrs Off	# Cycles	Hrs On	Hrs Off	# Cycles
1	2	240	8	6	240	4
2	8	48	18	6	48	25
3	8	240	14	6	240	15
4	8	240	Until failed	6	48	Until failed

In January and February 1999 and 2001, an attempt was made to locate American Bitterns in Florida and Louisiana that had been captured the previous spring during the breeding season in Minnesota (Azure 1998; Laney 2003; Lor 2007) and collared with VHF transmitters. The locations from PTT-marked birds were used as a guide for areas to search. A pickup-mounted antenna was used from the ground for a week each year in Louisiana and for a week in Florida in 1999 and a month in 2001. Flights were also made each year in Louisiana and in Florida by collaborating with State and Federal agencies making flights for other purposes.

An attempt was made in 1998 to determine the departure times of VHF-marked American Bitterns at Agassiz NWR. For 2 weeks in October, frequencies were scanned from a set location from an hour before sunset until mid-morning the following day. Birds were determined to be high in the air when their frequency was received and then they were checked for movement.

Banding data for the American Bittern (U.S. Geological Survey 2011) were reviewed for encounter documentation that might contribute to the interpretation and discussion of our tracking data.

RESULTS

Fourteen individual adult male American Bitterns were captured at Agassiz NWR and PTT-marked 17 times, and six American Bitterns were PTT-marked on the PPR sites (Table 2). Twenty-one American Bitterns were successfully tracked through the summers to a significant southern movement and 19 were successfully tracked through fall migration to a localized winter location. Ten were successfully tracked through the winter and nine of them completed spring migrations.

Nineteen complete fall (southward) migration routes were documented for 17 individuals (Fig. 1). Of the successful migrations, 63% ($n = 12$) went to southern Florida, 32% ($n = 6$) to southern Louisiana, and 5% ($n = 1$) to the Texas Gulf coast (Table 2).

There were nine return (northward) migrations to breeding range documented (Fig. 2). Eight were birds marked at Agassiz NWR and 75% ($n = 6$) returned there for the subsequent breeding seasons. One of the two birds that did not return to Agassiz NWR was on its second tracked migration and spent 8 to 11 days at Agassiz NWR before moving 310 km northwest into Manitoba to the area between Lake Winnipeg and Lake Manitoba for the breeding season. The wetland this bird used for its breeding territory the previous 2 years at Agassiz NWR was dry due to a management draw down. It returned to Agassiz NWR in late June (pre-molt) for the remainder of the summer. The other bird that did not return to Agassiz NWR for the breeding season also went to the area between Lake Winnipeg and Lake Manitoba approximately 317 km northwest of Agassiz NWR. A PPR bird returned to central Minnesota, approximately 150 km east of the breeding range where it was captured, but before the end of May it moved to within 16 km of the area where it spent the summer

Table 2. Data on number of successfully-tracked birds, destination, and range fidelity for 23 adult male American Bitterns (*Botaurus lentiginosus*) marked with satellite platform transmitter terminals on their breeding range in the north central United States.

	Location Birds Were Marked			
	Agassiz National Wildlife Refuge	Prairie Pothole Region	Total	*n*
Number Marked	17	6	23	
Successfully Tracked				
Summer	16	5	21	23
Fall Migration	14	5	19	21
Winter	9	1	10	19
Spring Migration	8	1	9	10
Destination				
Florida	9	3	12	19
Louisiana	5	1	6	19
Texas	0	1	1	19
Fidelity				
Breeding Range	6	1	7	9
Winter Range	2	0	2	2

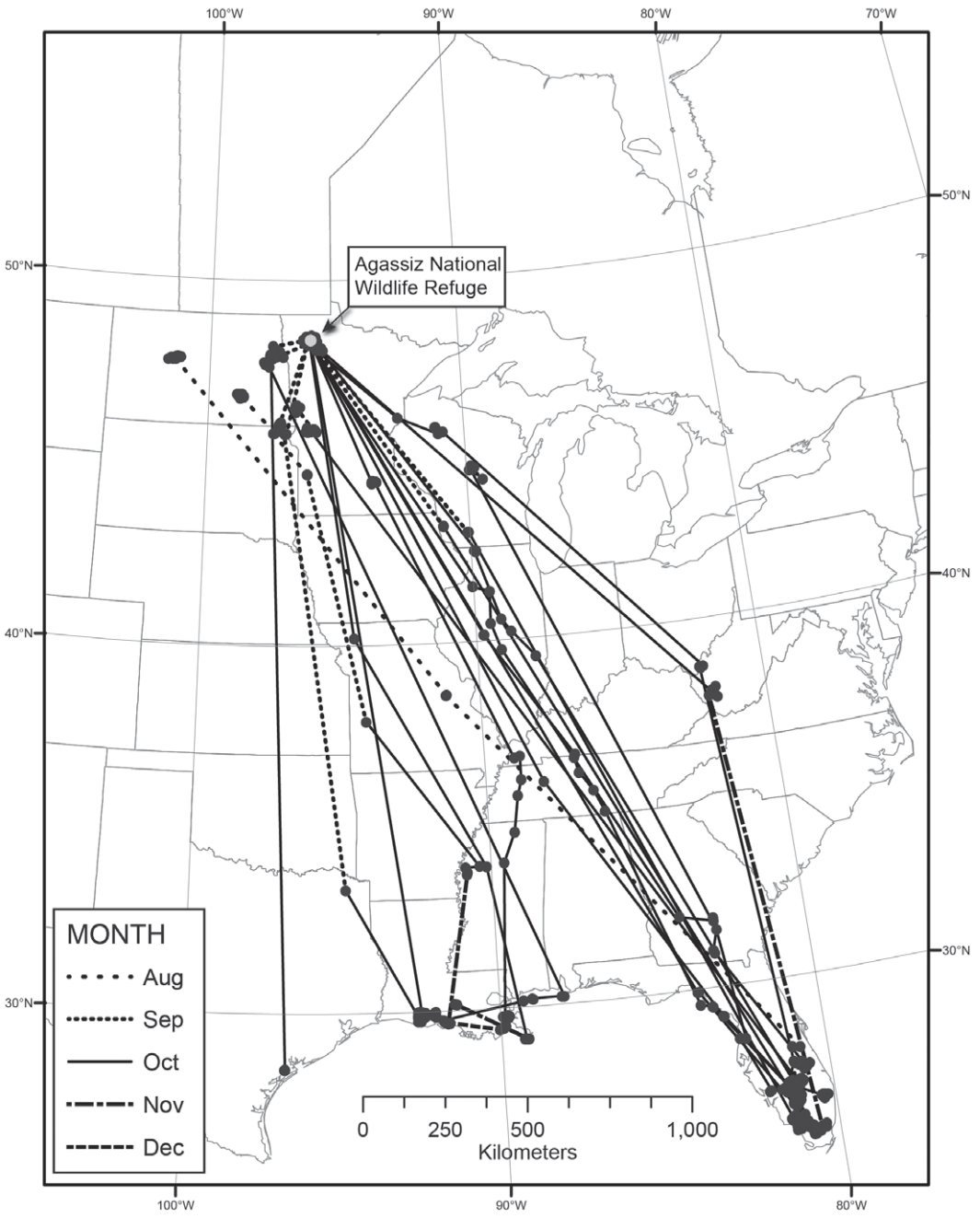

Figure 1. Nineteen southward migrations by 17 adult male American Bitterns (*Botaurus lentiginosus*) marked with satellite platform transmitter terminals on their breeding grounds in the Agassiz National Wildlife Refuge and the Prairie Pothole Region of the north central United States. Line style of each movement vector denotes the month of its respective arrival date.

and post-breeding season the previous year. Breeding range fidelity for Agassiz NWR and PPR birds combined was 78% ($n = 7$; Table 2).

Over a 4-year period, we recaptured one individual and instrumented him with a PTT three times. He made two successful com-

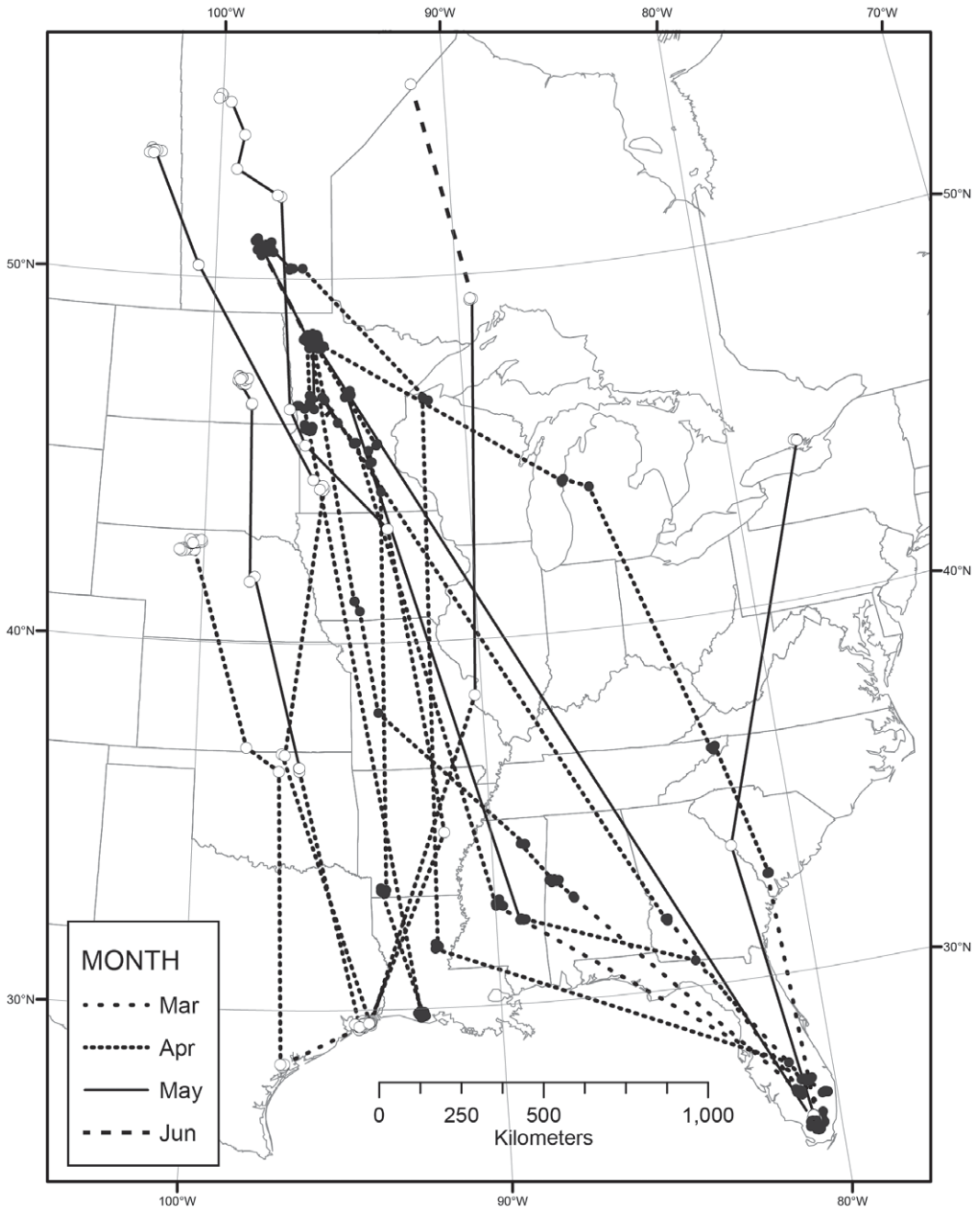

Figure 2. Nine northward migrations by seven American Bitterns (*Botaurus lentiginosus*) marked with satellite platform transmitter terminals on their breeding grounds in the Agassiz National Wildlife Refuge and the Prairie Pothole Region of the north central United States (black dots) and by six American Bitterns marked on their wintering grounds in east Texas (5) and Florida (1) (white dots). Line style of each movement vector denotes the month of its respective arrival date.

plete migrations and was a mortality or PTT failure on his third fall migration. One other bird was recaptured twice and made two complete migrations (Fig. 3). These two individuals spent the winters in the same general area each year (one in Louisiana and

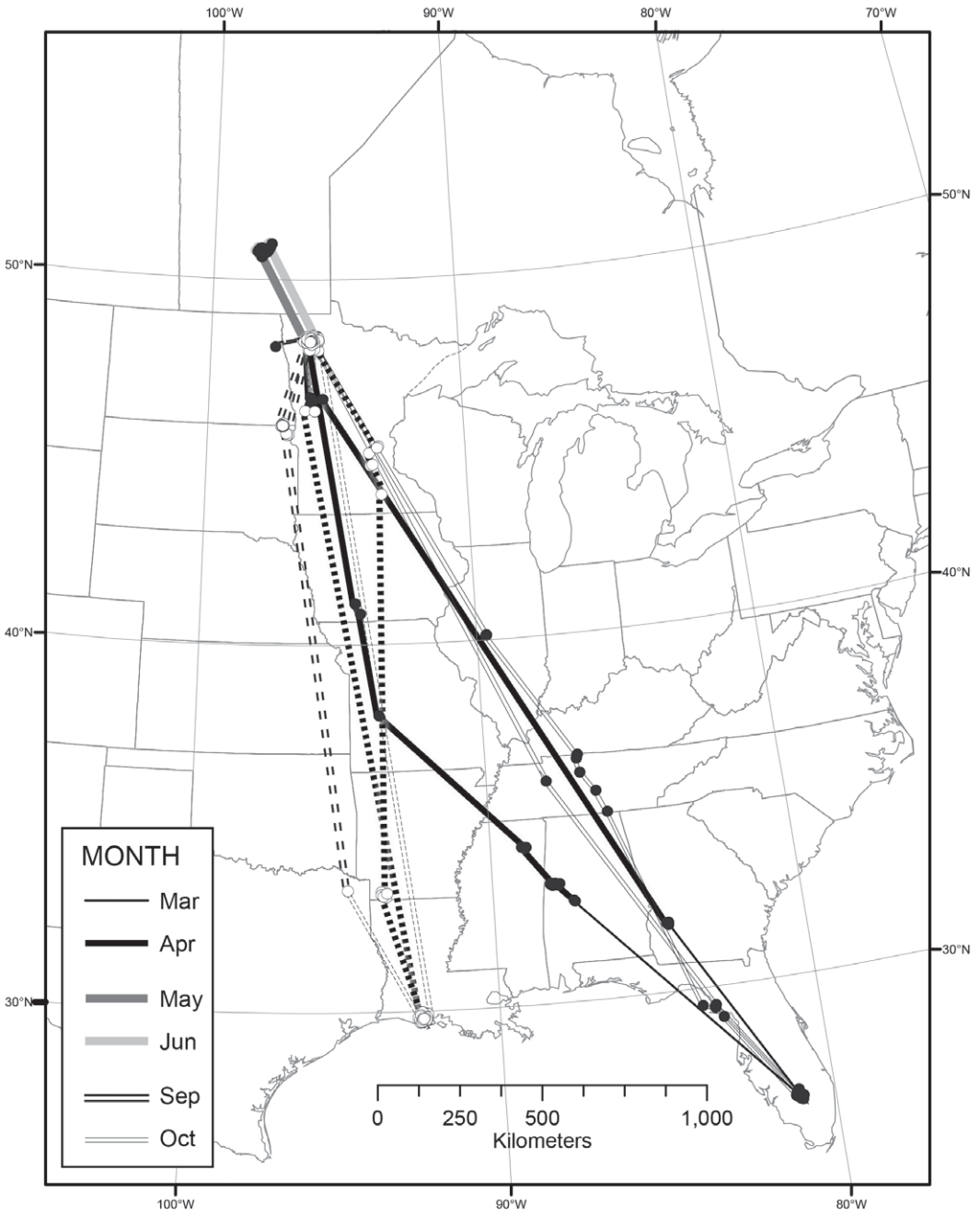

Figure 3. Two complete annual migrations by each of two adult male American Bitterns (*Botaurus lentiginosus*) that were marked with satellite platform transmitter terminals on their breeding grounds in the Agassiz National Wildlife Refuge. Line style of each movement vector denotes the month of its respective arrival date. The two bitterns are distinguished by solid (broken) movement vectors connecting black (white) locations.

one in Florida). Locations for both winters are intermingled in areas of approximately 1,200 km^2, showing fidelity to winter range (Table 2).

Six male American Bitterns were PTT-marked on the winter range, one in the Everglades and five at McFaddin NWR. All six made spring migrations (Fig. 2). The bird

marked in Florida migrated to Ontario, Canada. Two of the individuals marked at McFaddin NWR migrated to northern Manitoba, Canada, 175 km north of Lake Winnipeg and 470 km northeast of Lake Winnipeg. One went to eastern Saskatchewan, Canada, 250 km west of Lake Winnipeg. The other two birds migrated to North Dakota and Nebraska in the United States.

Lapses in receiving transmissions from the PTTs prevented making narrow departure determinations for many of the birds. Fall departure dates were determined for eight Agassiz NWR and five PPR American Bitterns to within 11 days or less (Table 3). The range of departure was 7 August to 22 October, and the average maximum duration of migration was 23.5 days. However, these departure dates were not evenly distributed; 85% (n = 11) of these departure dates occurred between 29 September and 22 October. The average length for fall migration for these 11 birds was only 10.7 days. The other 15% (n = 2) were PPR birds that left between 7 and 18 August and took 84 and 104 days to reach their winter range.

Spring departure dates were determined for 12 birds, including five that were marked during the winter at McFaddin NWR (Table 3). The range of departure was 23 February to 28 April, and the average maximum duration was 35.6 days. These departures were evenly distributed with one in late February, five in March and six in April.

Departure times were documented for three VHF marked birds leaving Agassiz NWR. The three birds left at dusk with strong northwest winds in October. One bittern was radio-tracked during the night, 350 miles to southern Minnesota where it landed when the winds subsided. In-flight satellite tracking was documented for two bitterns migrating south through central Illinois and for two bitterns passing southward through central and western Tennessee (Fig. 1). Similarly, the in-flight locations of all four individuals were recorded during late evening (18:00-22:00 local time), with an average tracking velocity of 52.5 km hr^{-1} (± 8.6 sd, n = 4). The longest, fastest movement documented was approximately 2,300 km in less than 74 hours (Agassiz NWR to northern Gulf coast of Florida between 19 and 22 October 1998).

Of the six PPR birds, 17% (n = 1) made a pre-molt (June) summer movement of 228 km in North Dakota and 17% (n = 1) made a post- molt (August) movement of 82 km in Minnesota. This is in contrast to 7% (n = 1) of Agassiz NWR birds that made a pre-molt movement mentioned earlier and 7% (n = 1) making a post-molt movement of 150 km into North Dakota.

Sixty-seven American Bitterns were marked on Minnesota study areas during the breeding season with VHF transmitters during 1998 and 2000 and survived into the fall migration period. Only one of these was located during the winter of 1998/1999. It was located on the north side of White Lake in southern Louisiana and returned to Agassiz NWR in the spring of 1999. Ten birds were located in Florida in 2001. Three in Florida were determined to be dead. None of the other seven were found on the breeding range study sites in 2001.

There were 82 encounter records in the banding data (U.S. Geological Survey 2011), of which 39 were juveniles, local and hatch-year American Bitterns. For these immature birds, 69% (n = 27) of the encounters occurred during the same year the bird was banded, but only 13% (n = 5) were in a different State or Province from the original banding sites. These five birds showed a basic north to south movement typical of

Table 3. Departure dates and maximum duration of migration for American Bitterns (*Botaurus lentiginosus*) marked with satellite platform transmitter terminals on breeding and winter ranges.

	Departure Dates to within 11 Days or Less			Maximum Duration of Migration	
Season	n	Calendar Dates	Range	Average	Range
Fall	13	7 Aug-22 Oct	76 days	23.5 days	7-104 days
Spring	12	23 Feb-28 Apr	64 days	35.6 days	9-55 days

what we found for fall migration of PTT-marked birds. American Bitterns did tend to disperse to different breeding ranges from where they were hatched, as only 25% (n = 3) of 12 encounters of juveniles, local and hatch-year birds that occurred in subsequent years during the breeding season were near the original banding site.

Discussion

An important finding of this study is the significance of the Everglades in Florida to American Bitterns that breed in the central part of North America. Approximately 63% (n = 12; Table 2) of PTT-marked birds went to Florida, and all of those that survived the winter to start spring migration were in the Everglades region. This was further emphasized by finding 10 VHF radio-marked birds in the same region of Florida. The highest concentration of wintering American Bitterns reported by Root (1988) was also the Everglades. The second most important area to the PTT-marked birds was the coast of Louisiana, which Root (1988) listed as an area where wintering birds were fairly common.

PTT-marked American Bitterns demonstrated fidelity to breeding range (78%) and winter range (100%; Table 2). In previous studies, breeding range fidelity for VHF-marked American Bitterns to Agassiz NWR was 53% (n = 9), 47% (n = 7), and 14% (n = 9; Brininger 1996; Azure 1998; Lor 2007) and was 67% (n = 4) to a PPR study site (Laney 2003). Among those American Bitterns that returned to Agassiz NWR, Azure (1998) and Lor (2007) found fidelity to the same home range to be 57% and 44% (n = 4), respectively, further demonstrating fidelity to specific areas within the breeding range. Since VHF-marked birds can easily be missed due to radio failure and limited range, fidelity determined by PTT-marked birds provides a more complete picture.

Termination of PTT signals among successfully tracked birds was higher in the winter (47%, n = 9) compared to the summer (9%, n = 2; Table 2). This compares to spring and summer mortality documented in earlier studies for VHF-marked birds on the breeding range study sites of 13% (n = 3; Brininger 1996), 5% (n = 1; Azure 1998), 3% (n = 2; Lor 2007). Of the 10 VHF-marked birds found in Florida, three were confirmed dead and of the remaining seven, none were documented to have returned to Agassiz NWR the following spring. Loss among the PTT-marked birds was by far the highest during winter, but winter also had higher expectation of loss due to PTT failure as batteries weakened. Premature battery failure has been reported in other studies using PTTs (Petrie and Rogers 1997; Britten *et al.* 1999). American Bittern populations have been declining since at least 1966 (Hands *et al.* 1989; Gibbs and Melvin 1992), and the species is listed as a Bird of Conservation Concern throughout parts of its range (U.S. Fish and Wildlife Service 2008). Loss of wetland habitats is given as the primary cause of population decline. The loss of wetlands and human-caused alterations in water regimes on the wintering ranges (Hendrix and Morehead 1983; Turner 1990; Boesch *et al.* 1994) may be more important to the decline of American Bitterns than the loss of wetlands on the summer range.

We found only small differences in migration movements between the American Bitterns utilizing the small wetlands in the PPR habitat versus the large wetland complex at Agassiz NWR. While 33% (n = 2) of PPR birds made summer movements, 14% (n = 2) Agassiz NWR birds also made a summer movement. Brininger (1996) and Azure (1998) also documented 25% (n = 7) and 23% (n = 5) adult males, respectively, leaving Agassiz NWR in the summer post-molt. The biggest difference between the PPR birds and the Agassiz NWR birds may be in how early they began moving south. The two American Bitterns that took the longest to migrate in the fall were PPR birds that left in August. The summer wet-to-dry cyclical nature of small wetlands in the PPR region may account for these differences.

Extensive, post-breeding (June, July, August) dispersal was not observed in adult male American Bitterns in this study. While

some of the marked birds made relatively short (less than 228 km) movements in late summer, American Bitterns in this study had fairly direct routes to their wintering areas, and most migrated in less than 2 weeks. Even the two PPR birds that left in August and spent a maximum of 84 and 104 days to reach their winter range followed more or less direct routes to Florida and Louisiana. Limited band return data for juveniles, local and hatch-year American Bitterns do not suggest that extensive post-fledging dispersal occurs in this population segment either. Extensive, post-breeding dispersal is probably rare and likely the result of migrating birds being caught in strong winds and swept off course, rather than a deliberate common occurrence. Dispersal may be more likely in the first spring migration.

American Bitterns are thought to be mostly night migrants (Forbush 1955; Palmer 1962; Gibbs *et al.* 1992). Radio tracking of three VHF-marked birds leaving Agassiz NWR and in flight locations for four PTT-marked birds corroborated this.

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LITERATURE CITED

Alderfer, J. (Ed.). 2006. National Geographic complete birds of North America. National Geographic Society, Washington, D.C.

Amstrup, S. C. 1980. A radio collar for game birds. Journal of Wildlife Management 44: 214-217.

ARGOS. 1996. ARGOS User's manual. ARGOS Service, Landover, Maryland. http://www.argosinc.com, accessed 1 November 2012.

Azure, D. A. 1998. Aspects of American Bittern ecology in northwest Minnesota. M.S. Thesis, University of North Dakota, Grand Forks.

Azure, D. A., D. E. Naugle, J. E. Toepfer, G. Huschle and R. D. Crawford. 2000. Sexing American Bitterns, *Botaurus lentiginosus*, using morphometric characteristics. Canadian Field-Naturalist 114: 307-310.

Banks, R. C. and R. W. Dickerman. 1978. Mexican nesting records for the American Bittern. Western Birds 9: 130.

Bent, A. C. 1926. Life histories of North American marsh birds. United States National Museum Bulletin No. 135. Government Printing Office, Washington, D.C.

Boesch, D. F., M. N. Josselyn, A. J. Mehta, J. T. Morris, W. K. Nuttle, C. A. Simenstad and D. J. P. Swift. 1994. Scientific assessment of coastal wetland loss, restoration and management in Louisiana. Journal of Coastal Research Special Issue No. 20: i-v, 1-103.

Brininger, W. L., Jr. 1996. The ecology of the American Bittern in northwest Minnesota. M.S. Thesis, Saint Cloud State University, St. Cloud, Minnesota.

Britten, M. W., P. L. Kennedy and S. Ambrose. 1999. Performance and accuracy evaluation of small satellite transmitters. Journal of Wildlife Management 63: 1349-1358.

Cramp, S. (Ed.). 1977. Handbook of the birds of Europe, the Middle East, and North Africa. The Birds of the Western Palearctic. Vol. 1: Ostrich to Ducks. Oxford University Press, Oxford, England, U.K.

Douglas, D. C., R. Weinzierl, S. Davidson, R. Kays, M. Wikelski and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3: 999-1007.

Forbush, E. H. 1955. A natural history of American birds of eastern and central North America. Revised by J. B. May. Bramhall House, New York, New York.

Gibbs, J. P. and S. M. Melvin. 1992. American Bittern, *Botaurus lentiginosus*. Pages 51-69 *in* Migratory Nongame Birds of Management Concern in the Northeast. (K. J. Schneider and D. M. Pence, Eds.). United States Fish and Wildlife Service, Newton Corner, Massachusetts.

Gibbs, J. P., S. M. Melvin and F. A. Reid. 1992. American Bittern (*Botaurus lentiginosus*). No. 18 *in* The Birds of North America (A. Poole, P. Stettenheim and F.

Gill, Eds.). Academy of Natural Sciences, Washington, D.C. and The American Ornithologists' Union, Philadelphia, Pennsylvania.

Hands, H. M., R. D. Drobney and M. R. Ryan. 1989. Status of the American Bittern in the northcentral United States. Unpublished report, United States Fish and Wildlife Service, Twin Cities, Minnesota.

Hendrix, G. and J. Morehead. 1983. Everglades National Park: an imperiled wetland. Ambio 12: 153-157.

Huschle, G. and G. Knutsen. 2007. Habitat management plan for Agassiz National Wildlife Refuge. Unpublished report, Untied States Fish and Wildlife Service, Middle River, Minnesota.

Huschle, G., J. E. Toepfer, W. L. Brininger, Jr. and D. A. Azure. 2002. Capturing adult American Bitterns. Waterbirds 25: 505-508.

Laney, T. L. 2003. Ecology of the American Bittern (*Botaurus lentiginosus*) in the prairie pothole region of westcentral Minnesota. M.S. Thesis, University of Missouri, Columbia.

Lor, S. 2007. Habitat use and home range of American Bitterns (*Botaurus lentiginosus*) and monitoring of inconspicuous marsh birds in northwest Minnesota. Ph.D. Dissertation, University of Missouri, Columbia.

Lowery, G. H. 1960. Louisiana birds. Louisiana State University Press, Baton Rouge, Louisiana.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. 2nd ed. Van Nostrand Reinhold, New York, New York.

Palmer, R. S. (Ed.). 1962. Handbook of North American birds, Vol. 1. Yale University Press, New Haven, Connecticut.

Pearson, T. G. (Ed.). 1923. Birds of America. Vol. 1. The University Society Inc., New York, New York.

Petrie, S. A. and K. H. Rogers. 1997. Satellite tracking of white-faced whistling ducks in a semiarid region of South Africa. Journal of Wildlife Management 61: 1208-1213.

Root, T. 1988. Atlas of wintering North American birds: an analysis of Christmas bird count data. University of Chicago Press, Chicago, Illinois.

Turner, R. E. 1990. Landscape development and coastal wetland losses in the northern Gulf of Mexico. American Zoologist 30: 89-105.

U.S. Fish and Wildlife Service. 2008. Birds of conservation concern. United States Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia.

U.S. Geological Survey. 2011. Bird Banding Laboratory banding data. Unpublished data, Bird Banding Laboratory, Patuxent Wildlife Research Center, Laurel, Maryland. Retrieved 9 September 2011.

Weller, M. W. 1987. Freshwater marshes, ecology and wildlife management. 2nd ed. University of Minnesota Press, Minneapolis, Minnesota.