MOVEMENTS OF AMERICAN WHITE PELICANS BREEDING AT MEDICINE LAKE NATIONAL WILDLIFE REFUGE, MONTANA

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INTRODUCTION

The status of American white pelicans *Pelecanus erythrorhynchos* is improving across North America. After reaching population lows in the 1960s, existing colonies are increasing in size and new colonies are being established (Evans and Knopf 1993). Continentally, however, white pelicans remain species of moderate conservation concern (Kushlan et al. 2002), primarily because of the high degree of concentration of breeding colonies. These large colonies contain thousands of nesting pairs and without adequate local protection, they remain vulnerable to human disturbance, environmental contaminants, and loss of habitat. From a regional standpoint, the concentration of colonies in the northern prairie and parkland regions of North America also affords the species a rank of "moderate" conservation concern, and action plans call for monitoring of these large colonies to understand site dynamics (Beyersbergen et al. 2004).

Medicine Lake National Wildlife Refuge (MLNWR) in northeastern Montana is home to one of the largest colonies of American white pelicans in the United States (Sidle et al. 1985). This colony has been in existence since the late 1930s, and the number of breeding pairs has grown steadily (current 10-yr average = 3700 nests) (Madden and Restani 2005). Despite the presence of this significant "trust" resource, managers at MLNWR possess little information on the ecology of these birds and therefore are unable to identify and address management concerns or conservation threats.

For example, the colonial waterbirds objectives of the draft MLNWR Comprehensive Conservation Plan (USFWS 2002) requires that refuge personnel obtain information on the foraging activities and habitat use of pelicans to ensure protection of important habitat. These data are currently lacking but could be used to target conservation efforts in the surrounding Northeast Montana Wetland Management District. Although nearly 10,000 pelicans nest on MLNWR (Madden and Restani 2004), most foraging appears to take place away from the refuge as birds travel into surrounding private lands. Nothing is known about the daily activities of pelicans away from the breeding colony. For example, which wetlands or streams are important foraging areas, how far do pelicans range, and what prey is taken? Pelicans can travel over 300 kilometers one way to forage during the breeding season (Johnson and Sloan 1978, McMahon and Evans 1992), so analyzing foraging movements requires a landscape perspective and techniques.

Of secondary interest is how data on local and long-range movements could be used by managers to address a major conservation challenge. First, throughout Montana anglers have voiced concerns that pelicans are having a detrimental effect on sport fisheries in the vicinity of breeding colonies, and there now exists some desire to reduce the size of large colonies (Montana Partners in Flight). This attitude poses a direct challenge to management because it conflicts with statewide conservation efforts - pelicans are a "Species of Concern" in Montana (MFWP 2004). Second, conflict between the aquaculture industry in the southeastern U.S. and pelicans has increased since the 1990s, and administrative lethal control of depredating pelicans now occurs at aquaculture facilities (King 1997). Most depredation occurs during the non-breeding season and the origin of problem pelicans is largely unknown but is suspected to be within the Great Plains. If this problem continues unabated, killing of eggs or young at nesting colonies may become a possibility – similar actions already take place to reduce conflict between the aquaculture industry and depredations by double-crested cormorants *Phalacrocorax auritus* (e.g., Bedard et al. 1995).

Beginning in 2002, we and our associates used satellite telemetry and banding to monitor the wide-ranging and local movement of pelicans breeding at MLNWR. Satellite telemetry is the most cost-effective and feasible method to monitor wide-ranging foraging movements of birds (Rodgers 2001). Another advantage of satellite telemetry is that birds can be tracked regularly during migration and in wintering areas, so a complete picture of annual movements and use areas is gained. Determining the origin of wintering pelicans is important because of the growing conflicts with the aquaculture industry: simultaneous increases are occurring in both catfish farming along the Gulf Coast and in the continental pelican population (Belant et al. 2000, Sauer et al. 2004). Identifying breeding ground origins of depredating pelicans and their winter use areas along the Gulf Coast will aid management of this emerging conflict.

Project objectives for pelicans associated with MLNWR include:

1) determine home ranges and foraging areas
2) identify migration routes and wintering areas
3) identify management and conservation issues, and assess need and possibilities for initiating long-term demographic work on breeding colony population dynamics
4) through a refuge outreach program, use satellite tracking of pelicans to inform the local community about migratory bird issues

STUDY AREA AND METHODS

MLNWR is located in Sheridan County, Montana (48° 27' N, 104° 23' W), and consists of two parcels. The north tract totals 11,492 ha and includes Medicine Lake (3,320 ha), five smaller lakes, and many wetlands. The smaller south tract (1,321 ha) includes Homestead Lake (518 ha). Climate is continental and characteristic of the northern Great Plains, with cold winters, hot summers, peak rainfall during the early-mid growing season (mean 33 cm per year), and variable and often extreme weather.

The MLNWR Complex includes the 3-county Northeast Montana Wetland Management District. This Complex is bounded on the south by the Missouri River, on the north by Saskatchewan, and on the east by North Dakota. It lies within the highly productive prairie pothole region of the northern Great Plains and has relief typical of the glacial drift prairie, relatively gentle rolling hills with numerous shallow wetland depressions. The Big Muddy valley is central to the MLNWR Complex, with the Big Muddy River flowing south out of Canada and into the Missouri River.

The pelican colony is located on an island and a nearby peninsula of Medicine Lake (Fig. 1). Prior to establishment of the refuge in 1935, lake water levels fluctuated and regularly receded in late summer, exposing extensive alkaline mudflats. During the 1930s, Worker's Progress Administration and Civilian Conservation Corps crews installed water control structures throughout the refuge. USFWS now maintains Medicine Lake at an average depth of 1-3 m, which provides breeding and stopover habitats for migratory birds, inhibits terrestrial predator access to nesting islands, and maintains a northern pike *Esox lucius* sport fishery. The fish prey base in refuge lakes fluctuates because the shallow lakes and marshes are prone to periodic winter-kills.

Pelicans arrive at Medicine Lake in mid-April, lay and incubate eggs during late April and May, and care for young from June through August. Young pelicans begin flying during August, and autumn migration takes place from mid-September through mid-October (USFWS

unpubl. data). During 1990-2002, mean number of young produced per pair was 0.51 (SE = 0.07) (Madden and Restani 2005).

We used padded leghold traps placed in shallow shoreline water (King et al. 1998) near the largest breeding colony to capture adult pelicans in June 2002. We fitted each captured pelican with a 95 g platform transmitter terminal (PTT) (Northstar Science and Technology, Baltimore, MD), which was attached as a backpack (Kenward 2001) with teflon ribbon (Bally Ribbon Mills, Bally, PA). We used measurements [mass (kg), wing chord (mm), culmen(mm)] to determine gender of pelicans (Evans and Knopf 1993). Processing time averaged 30 minutes and pelicans were released at capture sites.

We programmed PTTs to transmit 8 hours every 26 hours from March through October, which included the breeding season and both migrations. To conserve battery life, duty cycles were reduced to 8 hours of transmission every 110 hours during winter (November through February). Average estimated transmission time for each transmitter was 3000 hours. PTT location estimates were obtained from the ARGOS satellite system. Each location estimate has an associated accuracy estimate, or "location class (LC):" LC 0 was accurate to > 1000 m, LC 1 accurate from 350-1000 m, LC 2 from 150-350 m, and LC 3 within 150 m. Lettered LCs (A, B, and Z) were reported without error estimates.

We used LCs 3, 2, 1, 0, and A to map and describe wintering and migration movements; and LCs 3, 2, and 1 for breeding movements. Although LCs 0 and A have high error, we used these locations for migration and wintering movements because the continental scale of maps and information gained outweighed the error. Moreover, a target pelican may have been moving over the several minute period required by ARGOS to fix a location – if so, reported error would have been high. We did not use LCs B and Z because they had unacceptable potential for error. Migration maps contained state and provincial boundaries and locations of pelicans by date. Breeding and wintering area maps also included federal land ownership as part of the base map, except for pelicans that wintered in Mexico (ESRI).

We used LC 3, 2, and 1 locations to produce local movements maps. For one pelican's locations while in the Canada, we used LC 0 and A because higher quality locations were lacking. In the US, base maps included roads, wetlands information where available [National Wetland Inventory (NWI)], and a GIS layer of major water bodies (ESRI). NWI data were unavailable for some US areas and all of Canada. In Canada, we used data from BSRI and the Canadian government Generalized Landcover data.

To supplement the movement information gained from the telemetry data, we also analyzed recoveries of pelicans banded as nestlings at MLNWR from 1957 to 1968. We used "Report to Bander" forms from the Bird Banding Laboratory to plot recovery locations to the nearest 10-minute block. "How" and "Present Condition" codes were summarized for encounters to obtain a general description of mortality agents.

We reinitiated annual banding of nestling pelicans at MLNWR in 2002. Each year, banding took place on Big Island during one morning in late June or early July, depending on age of young. Refuge personnel and volunteers (6-22) surrounded large groups (approximately 25-75) of flightless young pelicans. Pelicans were then banded with USFWS bands and released. We began banding in early morning and were off of the island by 1000 MST to reduced heat stress to young pelicans. We provide general recovery locations of these recently banded pelicans (2002-2004) and discuss encounter circumstances (e.g., found dead, shot) relative to historical recoveries (1957 – 1968).

We accessed websites of the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture, to obtain information on aquaculture, specifically catfish production. We identified and then ranked catfish producing states based on water surface hectares used in production. Data were compiled for 2003 and provided perspective on the opportunity for conflict between pelicans associated with MLNWR and catfish facilities along migration and in wintering areas.

RESULTS

We captured and satellite-tagged five adult pelicans over a two-day period in June 2002 (Table 1). We activated PTTs approximately 15 minutes prior to attachment of the backpack harness. Owing to small sample size, we have first chosen to describe the movements of individual pelicans throughout the life of their satellite transmitter. Figures at the end of this report augment written descriptions. A word of caution regarding interpretations of movements during the breeding season– although we interpret back and forth trips to Medicine Lake by individual pelicans as 'foraging trips,' presumably to feed young, we lack information on reproductive attempts for any of the tagged pelicans.

Table 1. Capture and morphological data of American white pelicans tagged with satellite transmitters at Medicine Lake National Wildlife Refuge, Montana, 2002.

PTT ID	Date and Time Captured, Last Transmission Date	Band Number	Chord (mm)	Bill (mm)	Mass (kg)	Sex
36753	18/06/02 – 1830 29/08/03	649-11501	635	380	8.0+bag	Male
36754	18/06/02 – 1830 31/10/02	649-11502	617	365	7.1+bag	Male
36755	19/06/02 – 0815 27/09/03	649-11503	617	315	6.5+bag	Male
36756	19/06/02 – 0900 02/10/03	649-11504	604	345	7.1+bag	Male
36757	19/06/02 – 0900 Turned off 9/03 (bird died 6/03)	649-11505	527	265	4.7+bag	female

Pelican 36753

Movements of pelican 36753 from June to early July 2002 were confined to areas near Medicine Lake, portions of the Yellowstone River, and near the confluence of the Missouri and Yellowstone Rivers, including Lake Sakakawea in North Dakota (Figs. 2-3). The second week of July 2002, Pelican 36753 moved north into southern Saskatchewan, and used areas at or near Old Wives Lake, Qu'Appelle Lake, Last Mountain Lake, and Moosamin (Fig. 4). The pelican remained in Saskatchewan until 20 September, after which it began its southward migration. We assumed this pelican either did not breed or failed during the early breeding season because it did not return to the Medicine Lake colony after 1 July 2002.

Pelican 36753 migrated south through the central Great Plains and reached its wintering area along the Texas Gulf Coast in mid-October 2002 (Fig. 5). The pelican spent one week along the Kansas-Oklahoma border, between Wellington, Kansas and Blackwell, Oklahoma. It then migrated farther and spent another week in Oklahoma, approximately 8 km east of Noble before proceeding into Texas. It wintered on Galveston Bay and Lake Livingston (located approximately 90 km north), moving back and forth between these two areas until its spring migration (Fig. 6). Pelican 36753 left its wintering area and began spring migration in mid-April 2003. Its northward migration took it across the central Great Plains (Fig. 7). It spent several days in late April in western Nebraska along the Platte River before reaching Medicine Lake by 1 May.

As during summer 2002, the foraging activities of Pelican 36753 in 2003 covered eastern Montana (Medicine Lake and the Yellowstone River), western North Dakota (Missouri River, Lake Sakakawea), and southern Saskatchewan (Old Wives Lake, Qu'Appelle Lake, Last Mountain Lake, Moosamin) (Fig. 8). Back and forth movements between Medicine Lake and areas in Montana and North Dakota during May and June 2003 revealed a close tie to Medicine Lake. As it did in 2002, at the end of June Pelican 36753 left Medicine Lake and moved into Canada. Last transmissions of the satellite transmitters occurred near Moosamin, Saskatchewan on 29 August 2003.

Pelican 36754

The PTT on Pelican 36754 ceased functioning during autumn migration 2002 prior to its reaching a wintering area, and we obtained little useful information on the long-range movements of this individual. However, this pelican's movements during summer 2002 revealed use areas in eastern Montana and western North Dakota (Fig.9). Pelican 36754 consistently alternated activity on Medicine Lake with use of the Missouri and Yellowstone Rivers and Big Muddy Creek in Montana, and Lake Sakakawea in North Dakota (Figs. 10-11). This pelican left Medicine Lake the second week of August 2002 and began its autumn migration (Fig.12). It spent several weeks in late August and early September near Aberdeen, South Dakota before continuing into Texas by the end of October when the PTT quit transmitting.

Pelican 36755

Pelican 36755 used the area near Medicine Lake during 19-25 June 2002 and then spent time south along the Missouri River on the Fort Peck Indian Reservation and Fort Peck Reservior (Fig. 13). It did not return to Medicine Lake, but instead focused its activity in the Big Dry Fork of Ft. Peck Reservoir (Fig. 14). It remained there throughout the month of July and most of August before moving briefly to Lake Sakakawea in North Dakota. Pelican 36755 then used water bodies scattered throughout the northeastern portion of Montana (especially Manning and Homestead Lakes in the Big Muddy valley) until mid-September before it began its autumn migration.

Pelican 36755 migrated south across the central Great Plains slightly west of the routes taken by Pelicans 36753 and 36754 (Fig. 15). It covered more than 250 km on 19 September 2002, flying from northwestern South Dakota into central Nebraska. The pelican reached its wintering area along the Gulf Coast of Mexico by late October, where it wandered from late October to December over a large geographic area in Mexico, mostly in the state of Tamaulipas. During January and February it moved inland and north to the Rio Grande valley along the U.S.-Mexico border (Fig. 16). The PTT on this bird quit transmitting consistently beginning in March

2003, and we obtained no location data until 28 May 2003 when the bird was back in the Big Dry Arm of Fort Peck Reservoir (similar to 2002) (Fig. 17). Intermittent locations showed that it remained there until 8 August. No locations of this pelican occurred at Medicine Lake during summer 2003. By mid-September it moved into northern South Dakota and then through central Nebraska on a similar fall migration route taken in 2002 (Fig. 18). Last transmission was on 30 September 2003.

Pelican 36756

Pelican 36756 moved back and forth from Medicine Lake to primary use areas in Montana along Big Muddy Creek (especially Manning and Homestead Lake areas), Poplar River, and Lake Sakakawea in North Dakota throughout summer 2002 (Figs.19-23). It left Medicine Lake in early August and moved into North Dakota and then south through Iowa, Missouri and Arkansas just west of the Mississippi corridor, a migratory route east of those taken by Pelicans 36753, 36754, and 36755 (Fig. 24). The pelican arrived on its wintering ground along the Mississippi Delta in Louisiana by mid-October 2002. Winter use was confined to a relatively small area near the delta (Fig. 25).

Pelican 36756 began its spring migration on 4 April 2003 and arrived back at Medicine Lake by mid-May. It took a northward migration route that corresponded closely with its previous autumn's migratory path, through the Mississippi flyway (Fig. 26). The bird remained at Medicine Lake for only two weeks during 2003. The remainder of summer its activity occurred over an enormous geographic area, encompassing areas in Montana, North Dakota, Saskatchewan, and Minnesota (Fig. 27). Despite this expanse, Pelican 36756 foraged in areas used by other satellite-tagged pelicans from Medicine Lake [e.g., Fort Peck Reservoir (MT), Lake Sakakawea (ND) and Last Mountain Lake (SK)]. This pelican spent July, August, and most of September 2003 in southwestern Minnesota near Lac Qui Parle, which is home to a very large pelican colony on Marsh Lake (King and Grewe 2001).

Pelican 36756 left Minnesota on 23 September 2003 and reached its wintering area along the Mississippi Delta in about a week (Fig. 28). This return to the delta region demonstrated wintering site fidelity, the only such information we have for the five satellite-tagged pelicans.

Pelican 36757

Pelican 36757 alternated use between Medicine Lake and areas west of Plentywood, Montana (on Plentywood Creek, a small third-order prairie stream) until early July 2002 (Figs. 29-30) . It continued to use Plentywood Creek, and also moved into northwestern North Dakota (presumably using small prairie potholes on the Missouri Coteau) for a week in mid-July (Fig. 31). By the end of July it was using Plentywood Creek, Homestead Lake of MLNWR, and two areas in Saskatchewan (Jim Crane Lake and an area near Khedive) (Fig. 32). It returned to Medicine Lake in mid-September before initiating autumn migration in early October 2002.

This pelican also migrated south through the central Great Plains, along a route similar to those taken by Pelicans 36753, 36754, and 36755 (Fig. 33). It spent more than 10 days near Tulsa, Oklahoma. It continued south through Texas and well through Mexico, before reaching a wintering area along the Pacific Coast of Chiapas, Mexico, in early December (nearly 5000 km from Medicine Lake). It remained in this area until mid-March when it moved north and inland to the Atlantic coast state of Tabasco, Mexico for a month (Fig.34). It initiated spring migration the second week of April 2003, and followed a route northward similar to its autumn route (Fig. 35). During spring it spent over a week in southeastern Nebraska, approximately 12 km north of

Stratton. Pelican 36757 arrived back in Montana 23 May 2003 and returned to the Plentywood Creek area as in 2002 (Fig. 36). It did not visit Medicine Lake. Repeated satellite locations in the same location soon after its return indicated it was likely dead. The carcass, with functioning transmitter, was found in a pasture near Plentywood Creek in September 2003, and its proximity (30 m) to a power line suggested wire collision as cause of death.

Recoveries of Banded Nestlings

From 1957-1968, 3848 nestling pelicans were banded at MLNWR. Of these, 253 were recovered, with the last encounter occurring in 1991. Forty-nine pelicans were recovered in Montana, 182 from elsewhere in the U.S., 42 in Mexico, 28 in Canada, and 1 in Nicaragua (Fig 37). Most pelicans (n=170, 67%) were found dead, followed by 47 (19%) that were shot, 24 (9%) that were captured by hand, and "Other" (n=12, 5%). Only 10 (4%) banded pelicans were recovered in the primary catfish producing states of Alabama, Arkansas, Louisiana, and Mississippi.

From 2002-2004, we banded 3200 nestling pelicans at MLNWR (1200 in 2002, 1500 in 2003, and 500 in 2004). As of April 2005, 87 have been recovered. The vast majority (n=84, 97%) were found dead - most (n=57) at the nesting colony and therefore provided us no information on habitat use or long-range movements. Of the 30 young pelicans that survived to move away from MLNWR, most were recovered in South Dakota (8), followed by North Dakota (5), Montana and Oklahoma (4 each), Texas (3), Mexico (2), and Nebraska, Kansas, Arkansas and Saskatchewan (one each). Three (3%) pelicans were captured by hand because of an existing injury or entanglement in fishing gear, and the rest (n=27, 97%) were found dead without cause of death identified. None of the pelicans banded in 2002-2004 were reported as being shot.

Post-banding mortality at the MLNWR colony from 2002-2004 was much higher than suggested by the 57 recoveries. Of the 3200 bands we applied, 828 were collected from dead pelicans at the colony within 90 days of banding, and thus were not reported to the Bird Banding Lab. Therefore, a minimum 885 (28%, 828 + 57) of the 3200 pelicans we banded died before leaving MLNWR. Pre-migratory mortality of nestlings at the colony was much higher in 2003 (44%) and 2004 (38%) than in 2002 (4%), coincident with the arrival of West Nile Virus (USFWS unpublished data). Carcasses testing positive for the virus (30 in 2004 and 4 in 2003 out of 73 birds submitted to the Wildlife Health Laboratory) suggested that cause of death was directly related to presence of West Nile Virus. Starvation, either through abandonment and/or permanent separation from adults, probably contributed to some nestling deaths, as it has in other large nesting colonies (e.g., Bunnell et al. 1981).

Aquaculture Industry

Alabama, Arkansas, Louisiana, and Mississippi are the four primary catfish producing states (NASS 2005). Over 800 catfish producing operations exist within these states and account for approximately 40,500 surface ha (174,900 surface acres). Mississippi has 3X as many operations and surface hectares as each of the other states. Nearly 70% of the producers in the U.S. reported losses to or damage caused by wildlife (NASS 2004). Most losses occurred in Arkansas (79% of reports, averaging $14,300)), followed by Alabama (74%, $5400) and Mississippi (69%, $8800). Great blue herons *Ardea herodias* and double-crested cormorants were implicated in most losses (64% and 41%, respectively).

Outreach Programs

Our partner organization, Earthspan, Inc. developed a web-based educational program using the telemetry data gathered on the Medicine Lake pelicans, as a module of their Eye of the Falcon (EOF) program. EOF is an interdisciplinary environmental science curriculum for middle and high school students that utilizes GIS and satellite tracking of wildlife to teach core concepts in the life sciences and to involve students in cutting-edge scientific research and technology applications (see www.earthspan.org/EOF/EOF.htm). Through EOF, students are engaged in authentic, ongoing research and are challenged to use the research results to solve real-life conservation issues.

The EOF curriculum includes an interactive web site and a Teacher's Resource Guide with student worksheets. Through the EOF website, students access satellite tracking data for a wide range of species and can use GIS to generate maps to examine the relationships between animal movements and a variety of landscape and environmental variables. The pelican project module of the EOF program involved two major components: development of a lesson plan based on the satellite tracking data, and the training of teachers in Montana in the use of the EOF program. As part of this training, teachers were introduced to satellite telemetry, GIS, and wildlife conservation, including the white pelican project. Goals of the program were for students 1) to understand habitat selection in animals, 2) to investigate a conflict between industry and wildlife, 3) to use satellite tracking data to resolve the conflict between industry and wildlife, and to 4) develop habitat management plans based on research results. The curriculum has been used in several Montana middle schools, as well as in schools around the U.S.

DISCUSSION

Satellite Telemetry

Local Movements (Summer 2002 and 2003)

Pelican movements during summer 2002 and 2003 encompassed an extensive portion of the upper Great Plains, from Montana north to Saskatchewan and east to North Dakota and Minnesota. Much variability existed in movements among individuals, and even by individuals across the two summer seasons. All birds used areas immediately adjacent to Medicine Lake and Lake Sakakawea in western North Dakota. Other areas that received heavy use by most pelicans included Big Muddy Creek in Montana, which flows south out of Saskatchewan into the Missouri River. Manning and Homestead Lakes along Big Muddy Creek were also hotspots of pelican use. Several individuals foraged extensively along the Missouri and Yellowstone Rivers in Montana, and in Saskatchewan on Last Mountain and Qu'Appelle Lakes. In addition to foraging within the large riverine systems, pelicans foraged in isolated wetlands, some of which were small and geographically widely spaced.

Pelicans routinely commuted 75 km one way from Medicine Lake to foraging areas during summer. Although these back-and-forth movements suggested trips to foraging sites with returns to MLNWR to feed young, we lack information on reproductive attempts for any of the tagged pelicans. On several occasions during the summer, several of the satellite-tagged pelicans moved distances significantly greater than 75 km to forage before returning to the breeding colony. For example, Pelicans 36753 and 36754 flew back and forth from MLNWR to foraging sites on the Yellowstone River, traveling one-way distances of 125-200 km. Pelican 36756 flew 175 km one way back and forth from MLNWR to Lake Sakakawea and the Little Missouri River in North Dakota. These long range foraging movements provided additional support to

observations made by Johnson and Sloan (1978) that pelicans breeding at Chase Lake, North Dakota frequently foraged 128 km one way from the colony. One Chase Lake pelican had a round trip foraging trip of 611 km.

In general, the satellite-tagged pelicans showed an early summer tie to the breeding colony, followed by a mid-late summer regional dispersal into Canada and other parts of the northern Great Plains, before initiating their autumn migration during September and October.

Long Range Movements (Migrations and Wintering Areas)

The five satellite transmitters provided information for eight different autumn migrations involving the five tagged pelicans. Four of the five pelicans migrated south within the Central Flyway, traveling along routes that roughly bisected the states of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. When we obtained information for both the 2002 and 2003 autumn migrations of the same pelican, the same general route was chosen. Pelicans that used the Central Flyway wintered in Texas and Mexico. Only one pelican (36756) migrated south within the Mississippi Flyway, and this bird wintered along the Delta of the Mississippi River in Louisiana.

Timing of departure from Medicine Lake and initiation of autumn migration varied among pelicans and small sample size makes generalizations equivocal. All satellite-tagged pelicans left MLNWR, usually in late June or July, before initiating autumn migration (i.e., exhibited directed flights south). Two pelicans first went north into Saskatchewan for a variable amount of time before beginning to fly south in either September or October. Pelicans that left MLNWR without first flying north into Canada began southward flights in August or September. Departures in September correspond with dates reported from Yellowstone National Park, Wyoming (Schaller 1964).

Arrival on wintering areas depended upon the date southward migration was initiated and distance traveled. The two pelicans that wintered in the U.S. arrived on Texas and Louisiana wintering areas by mid-October. The two pelicans that wintered in Mexico arrived there in either October or December. Maximum distance traveled between summering and wintering areas was approximately 5000 km.

In spring, birds selected the same migratory Flyway and general route as they had during the previous autumn migration (three migrations involving three pelicans). Of the three pelicans for which we have initiation of spring flights, each left wintering areas in early to mid-April and arrived back in Montana from 1-23 May. Arrival in Montana corresponded closely with arrival dates in Wyoming (Schaller 1964) and Manitoba (Evans and Cash 1985).

It was difficult to place our findings of migratory routes and timing of migration into perspective because we failed to locate any published literature addressing these two topics for radio or satellite-tagged pelicans. Our data appear to be the first collected on landscape scale movements and therefore provide much needed baseline information for conservation. Most information concerning location of pelican migratory routes and crude estimates of timing have been inferred from band recoveries, discussed below.

Banding

Long Range Movements

Distribution of historic and recent band recoveries of nestlings produced at MLNWR strongly corroborated movements suggested by the much smaller sample of satellite-tagged pelicans. The large proportion of band recoveries in North Dakota, South Dakota, Nebraska,

Kansas, Texas, and Mexico revealed that the vast majority of pelicans from MLNWR migrated along the Central Flyway during autumn and spring . Most pelicans from MLNWR wintered in Texas and Mexico; only a very few wintered farther east in Louisiana, Alabama, and Florida.

It appears that northeastern Montana lies just within the eastern limit of the Central Flyway for migrating pelicans. For example, pelicans produced at Marsh Lake, Minnesota, 800 km east of MLNWR, migrate within the Mississippi Flyway and winter in Arkansas, Louisiana, and Mississippi (King and Grewe 2001). In contrast, pelicans produced in central Montana (Canyon Ferry Reservoir and Arod Lake) west of MLNWR migrate both within the Central and Pacific Flyways (Hendricks and Johnson 2002). Moreover, pelicans produced from a colony at Riverside Reservoir, Colorado (104º 15' W), which lies almost directly due south of MLNWR (104º 23' W), migrate within the Central Flyway and winter predominantly in Texas and Mexico (Ryder 1981) as do pelicans from MLNWR. Only a few pelicans from Colorado winter in the Gulf Coast region east of Texas.

Mortality

Nestling mortality at the MLNWR colony, as indicated by band recoveries, was a minimum 28%. This figured corresponds with nest abandonment/nestling mortality reported from pelican colonies in British Columbia (17-22%, Bunnell et al. 1981), California (50%, Boellstorff 1988), North Dakota (31-75%, Johnson and Sloan 1978), and Utah (25%, Knopf 1979). Disturbances at breeding colonies, caused either by humans or predators, greatly reduce productivity (Boellstorff et al. 1988, Bunnell et al. 1981, Evans and Knopf 1993), and colony visits to count nests and/or band young may contribute to mortality and should be justified from a scientific and management perspective (Evans and Knopf 1993).

Cause of death for the vast majority (nearly 70%) of pelicans recovered after they left MLNWR could not be determined. Shooting, collisions with power lines, and entanglement with fishing gear were positively identified as contributing to death in a small number of cases. It was encouraging to note that the reporting of pelican deaths from shooting has decreased over time, from an occurrence of 19% historically to 0% from recently banded pelicans. The causes of mortality we reported mirrored those reported by Ryder (1981) for Colorado and King and Grewe (2001) for Minnesota.

We have confirmed that West Nile Virus killed many nestling pelicans at the MLNWR colony prior to migration. Lack of rigorous sampling prevents us from estimating the magnitude of any population impact, however the virus has demonstrated its potential to devastate other avian populations. For example, 72% of an American crow *Corvus brachyrhynchos* in Oklahoma population perished within a single year after exposure to the virus (Caffrey et al. 2005). The number of pelican nests counted at MLNWR in May 2005 (3200 nests) is the lowest recorded since 1992. Research on the impacts of the virus on the colony will continue through at least 2006, in conjunction with the USGS Northern Prairie Wildlife Research Center and Wildlife Health Laboratory.

CONSERVATION IMPLICATIONS

Management of pelicans associated with MLNWR must consider ecological aspects of the annual cycle (i.e., temporal scale) and areas over which pelicans occur (i.e., spatial scale). For example, it might be necessary to apply different conservation prescriptions during nesting (colony scale), foraging (regional scale), migration (continental scale), or wintering (local scale).

Historically, pelican management at MLNWR and elsewhere focused on colony protection, which was necessary to halt population declines caused by disturbances to breeding pairs. In most areas, protection has succeeded and regional populations are again increasing (Evans and Knopf 1993). Conservationists must now consider activities away from the colony, particularly where pelican foraging areas have become degraded or where pelicans have come into conflict with humans, particularly at aquaculture facilities (King 1997). Satellite telemetry and band recovery data on long-range movements from MLNWR provides insight which can be used to steer future management.

At the local scale, protecting the MLNWR nesting colony from disturbance should probably remain the primary goal during the nesting season. Fortunately, federal land ownership permits placement of administrative closures on Medicine Lake which protect the colony from human disturbance, and fencing along Bridgerman Point excludes terrestrial predators, such as coyotes and foxes, from the colony (Madden and Restani 2005). A potential long-term threat to the colony concerns the impact of West Nile Virus on adult and nestling pelicans. During summer 2003 and 2004, young pelicans collected from the MLNWR colony tested positive for the virus. The virus has had devastating effects on American crow populations (Caffrey et al. 2005), and this year the lowest count of pelican nests at MLNWR since 1992 argues for management-oriented research devoted to disease ecology.

Anglers in Montana have voiced concerns that pelicans are depleting sport fisheries near nesting colonies. Although it is difficult to assess the impact of pelicans associated with MLNWR on sport fisheries, satellite-tagged pelicans appeared to spend a large proportion of time foraging away from the colony, foraging both on large water bodies and small isolated wetlands. We suspect that most pelicans foraged in small groups, and therefore had minimal, if any, negative effects on sport fisheries. Moreover, during banding we made casual observations of prey, most often seeing remains of rough fish, minnows, crayfish, and salamanders rather than sport fish. A more focused study, incorporating conventional telemetry (i.e., increasing sample size), would be necessary to address directly any conflicts to local sport fisheries. Local public outreach, similar to the school program initiated with this research, focused on pelican movements and food habits could assuage many of the concerns of Montana anglers.

Our results on regional movements by pelicans during the breeding season lend strong support to the concept that “wetland connectivity” (Haig et al. 1998) at the landscape scale is important for waterbird conservation. Pelicans nesting at MLNWR foraged throughout a large region of Montana, North Dakota, and Saskatchewan from May to August. Clearly, environmental heterogeneity, in the form of healthy large rivers and small isolated wetlands, must be conserved to provide prey to sustain the nesting colony. Managing these habitats will require coordination among several federal, state, and tribal agencies within the U.S. and Canada, in addition to having the support of private landowners. Some initiatives already exist to facilitate landscape scale management in the northern Great Plains, for example, the Prairie Pothole Joint Venture (PPJV) of the Northern American Waterfowl Management Plan. Since the 1990s, the PPJV has put into practice an integrated approach to wetland management that combines the needs of waterfowl and nongame species such as pelicans and shorebirds. The plan is to "stabilize or increase populations of declining wildlife species that depend on wetland/grassland complexes, with special emphasis on nongame migratory birds.” Through a host of government, non-profit, and private organizations in both the U.S. and Canada, the PPJV is working toward the protection of 2 million acres of wetland and associated upland habitat, restoration of 745,000 acres of wetland and associated upland habitat, enhancement of 3.7

million acres of wetland and associated upland habitat in the northern Great Plains. Our data on the habitat use of white pelicans help identify and target wetland and riparian areas for conservation.

Pelicans migrated several thousand kilometers one way across North America during spring and autumn. Migrations lasted several weeks and often pelicans used individual stopover areas for 7-10 days to refuel prior to continuing migration. Stopovers occurred both along large rivers and reservoirs, and at small isolated wetlands within a matrix of agricultural or prairie habitat. As with summer foraging habitat, conservation of migratory stopovers will also require a coordinated effort among agencies and landowners at the landscape scale. Fortunately, conservationists have already begun to formulize landscape scale planning to manage migratory shorebirds and Neotropical landbirds across Canada, the U.S., and Mexico, (e.g., Skagen and Knopf 1993, Hutto 2002, Moore 2000, Heglund and Skagen 2005), and some of this framework could be applied to pelicans.

Pelicans use stopovers for refueling and, like other migrants, appear to select food-rich areas where weight gain is maximized (Shmueli et al. 2000). Unfortunately, aquaculture facilities contain an abundance of suitable prey, and migrant pelicans may come into direct conflict with producers at these facilities. However, we believe this is a minor concern for pelicans from MLNWR because the vast majority (97%) migrated and wintered within the Central Flyway, well west of the primary catfish producing states of Alabama, Arkansas, Louisiana, and Mississippi.

To extend battery life during the pelican breeding season, we had programmed satellite transmitters to provide fewer locations during winter. Although data are limited, it appears that winter home ranges of pelicans are significantly smaller than summer home ranges. Pelicans also appeared to focus use areas along the coast in estuarine and saltwater habitats rather than the freshwater areas exploited during summer and migration. Conservation of these areas along the U.S. and Mexican Gulf Coast will pose significant challenges because coastal properties typically have very high development value.

ACKNOWLEDGMENTS

We thank Tommy King and Tom Maechtle for expertise in trapping and satellite-tagging pelicans. Mike Assenmacher (2002) and Nick Larson (2004) contributed to Montana field efforts. Jack Cibor produced the report figures. Marsha Sovada coordinated surveillance and testing for West Nile Virus and provided perspective on pelican ecology within the Great Plains. Sharri Lunde expedited contract paperwork in a timely manner. Finally, Ted Gutzke and Mike Rabenberg kindly supported our research activities at Medicine Lake National Wildlife Refuge. This study was funded by the U.S. Fish and Wildlife Service under CCS Agreement Number DCN 61530-1-J026.

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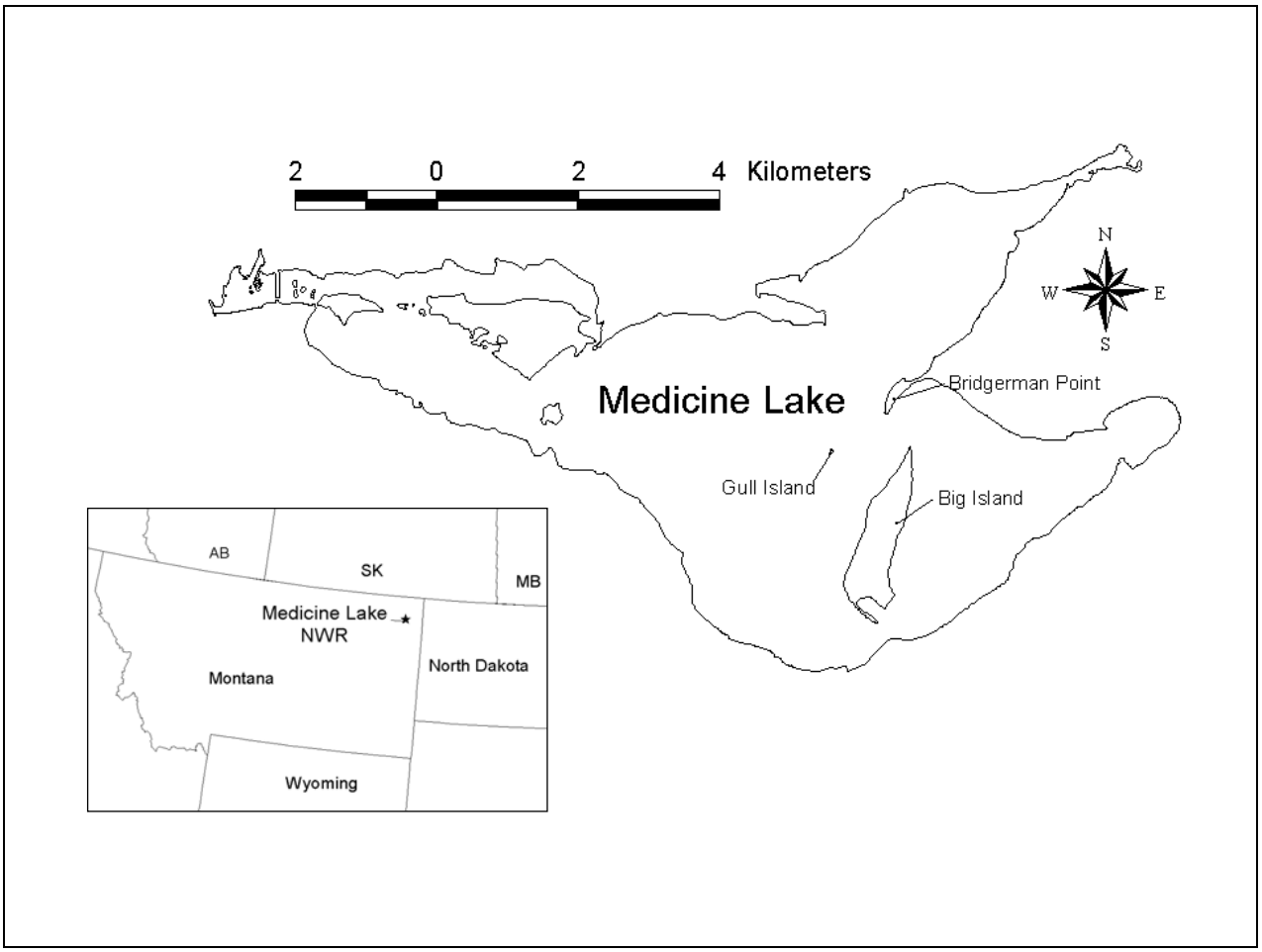


Figure 1. Locations of American white pelican breeding sub-colonies on Medicine Lake National Wildlife Refuge, Montana.

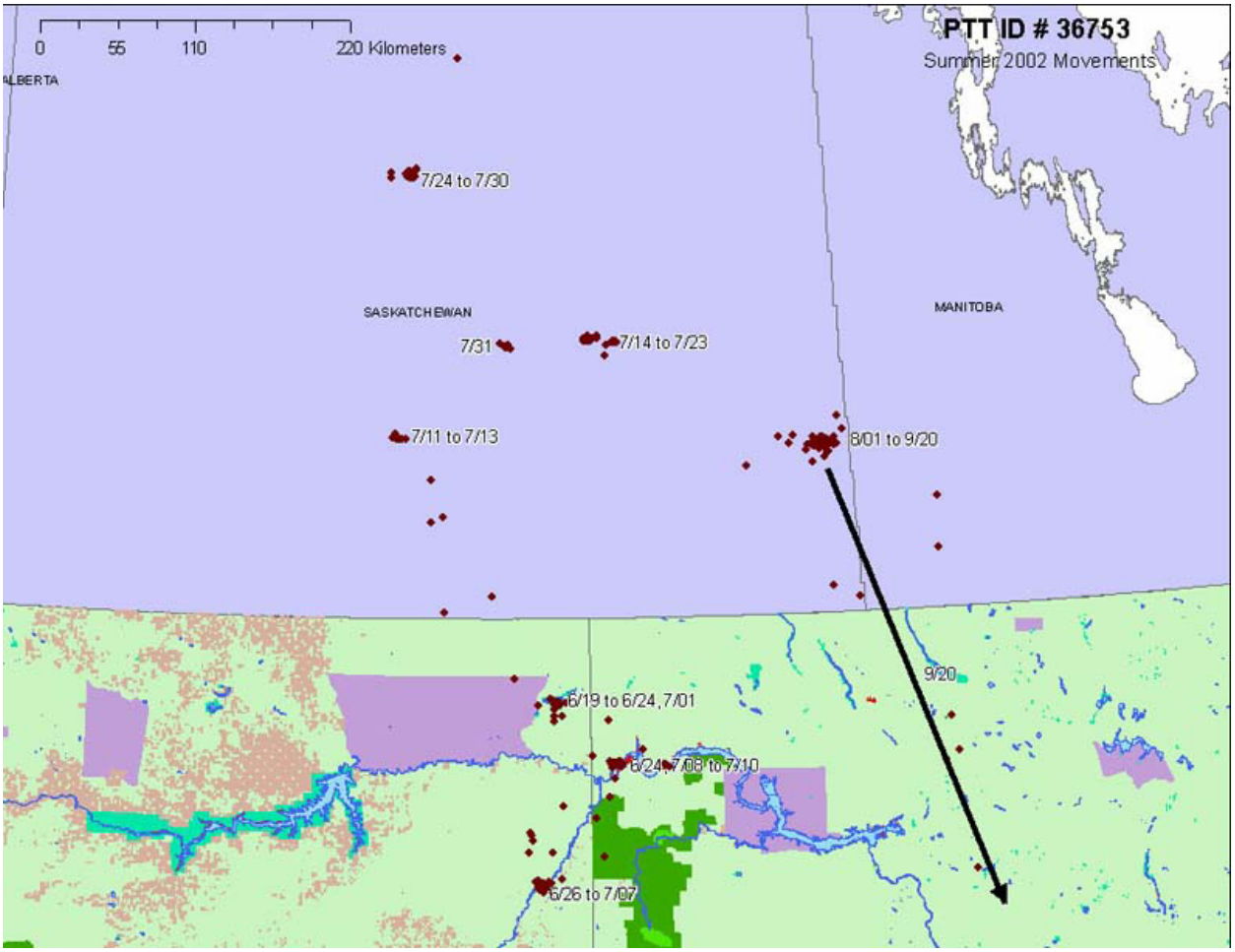


Figure 2. Movements of American white pelican 36753 in the northern Great Plains during summer 2002.

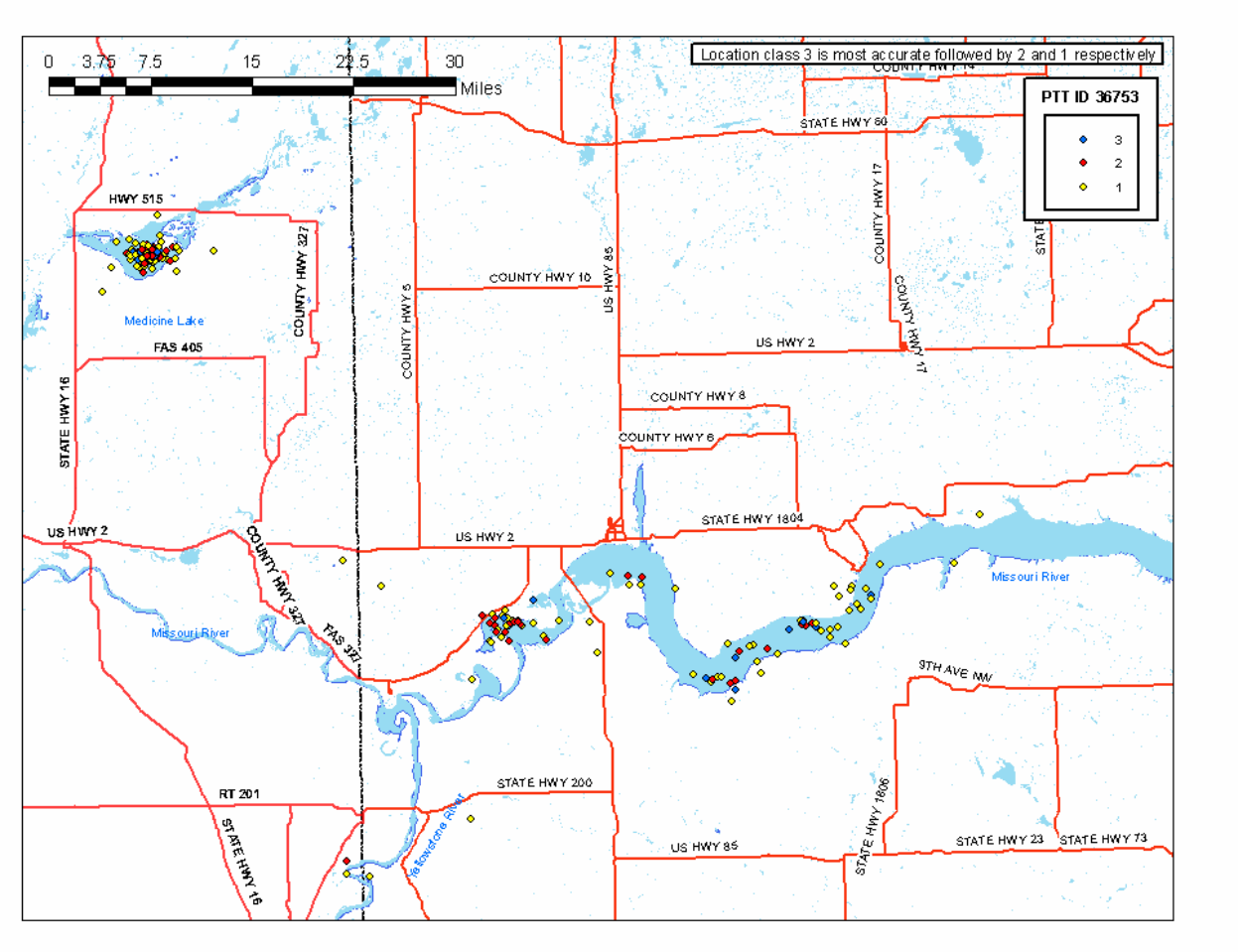


Figure 3. Movements of American white pelican 36753 in northeastern Montana and northwestern North Dakota during summer 2002.

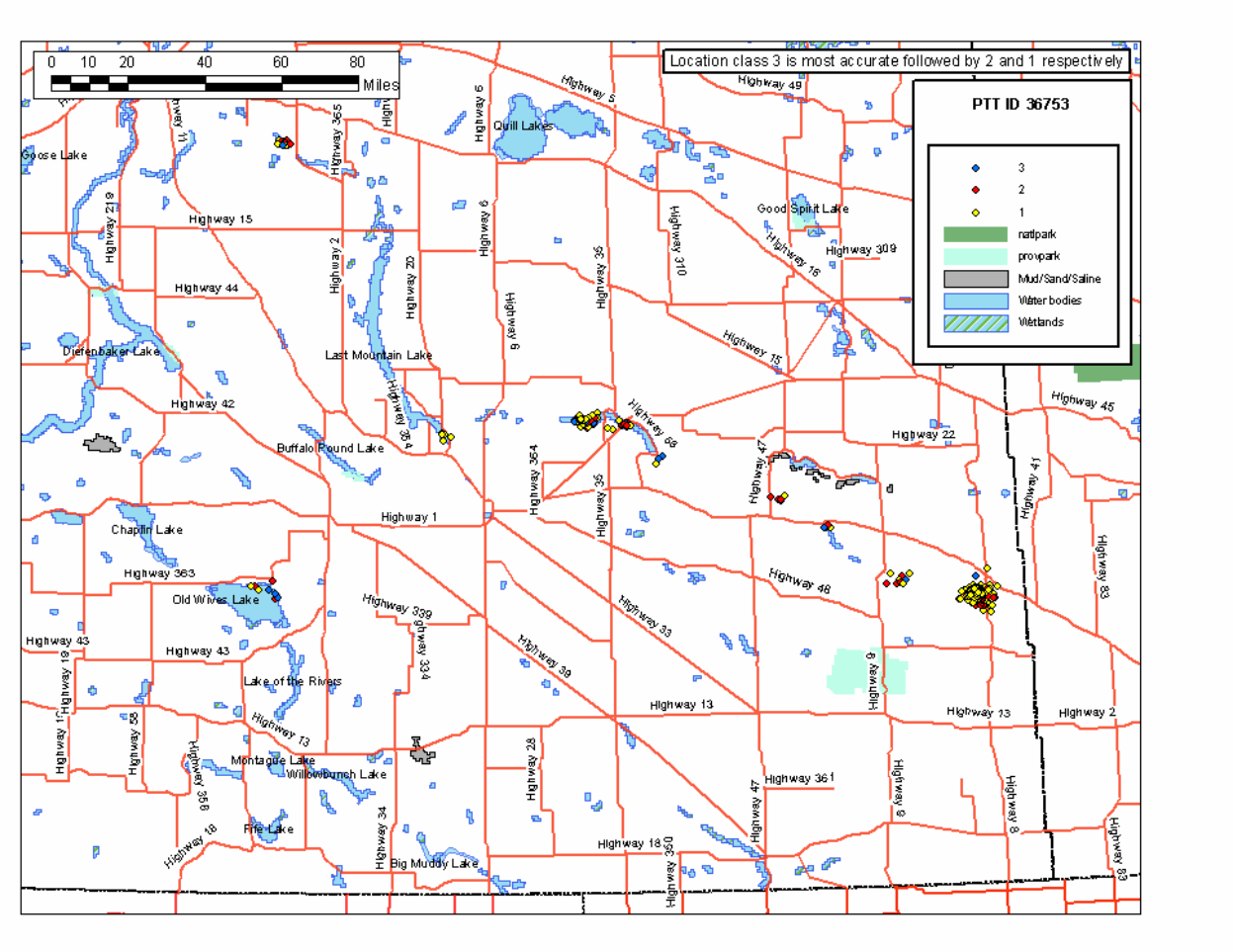


Figure 4. Movements of American white pelican 36753 in southern Saskatchewan during summer 2002.

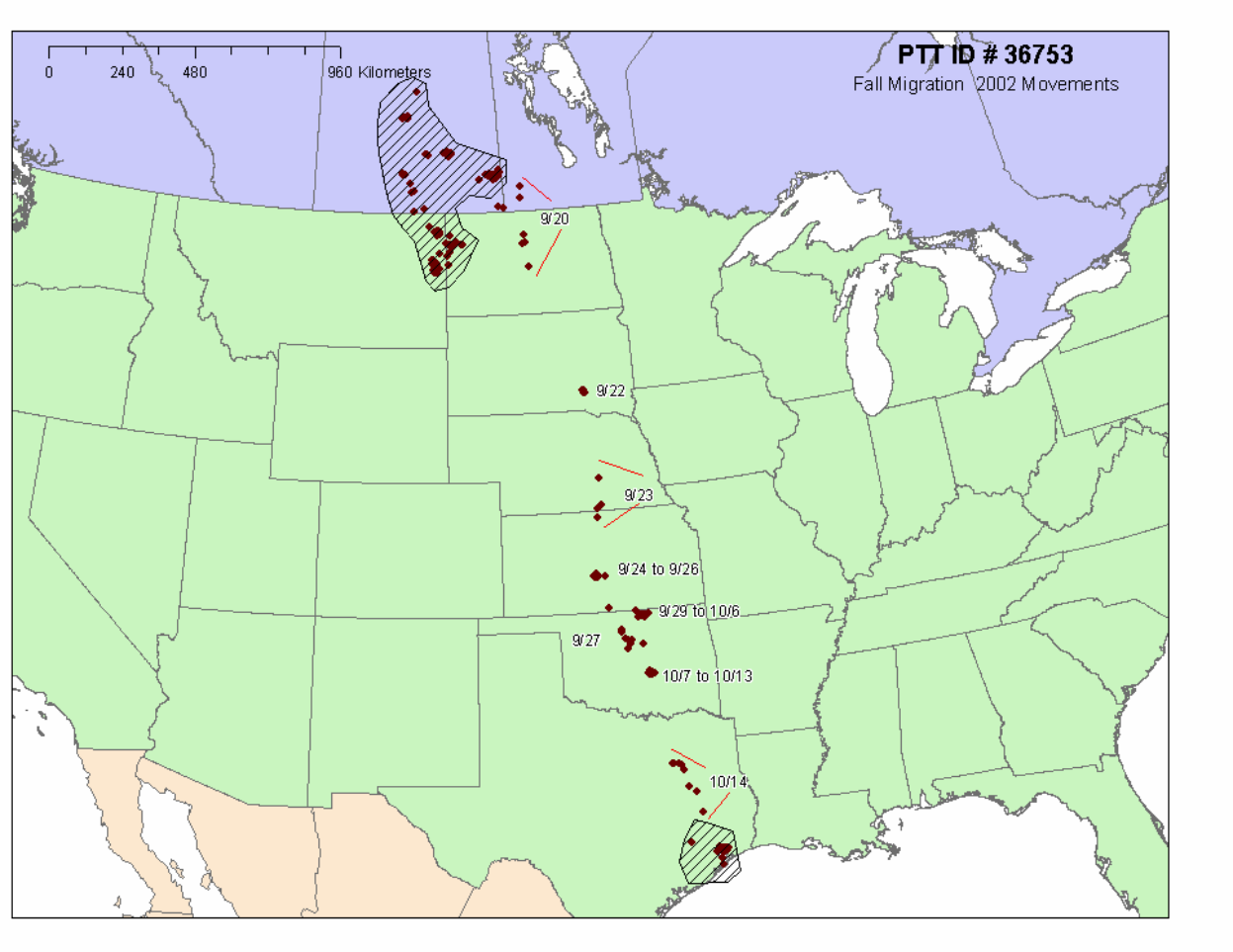


Figure 5. Autumn migration route of American white pelican 36753 during 2002.

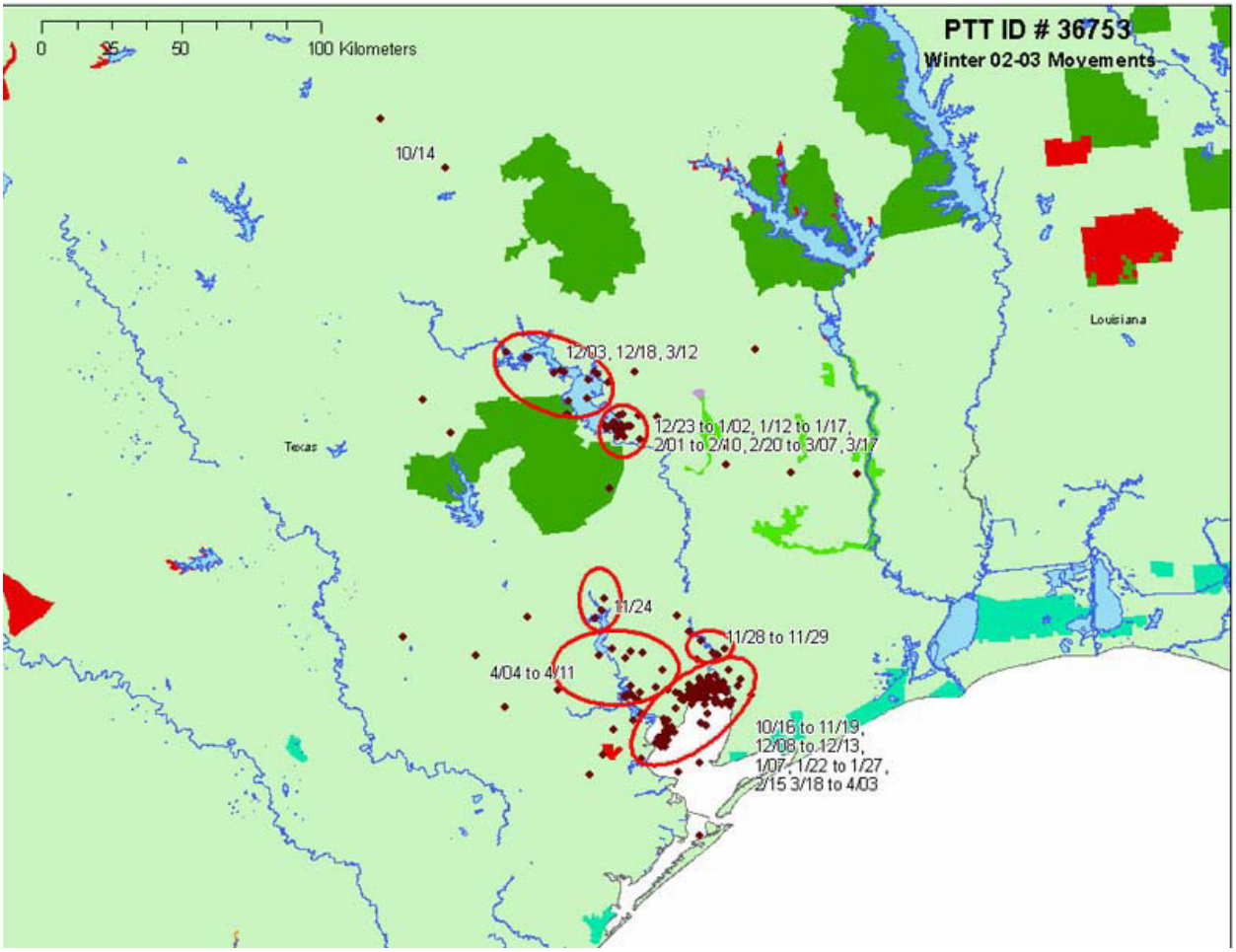


Figure 6. Movements of American white pelican 36753 in Texas during winter 2002-2003.

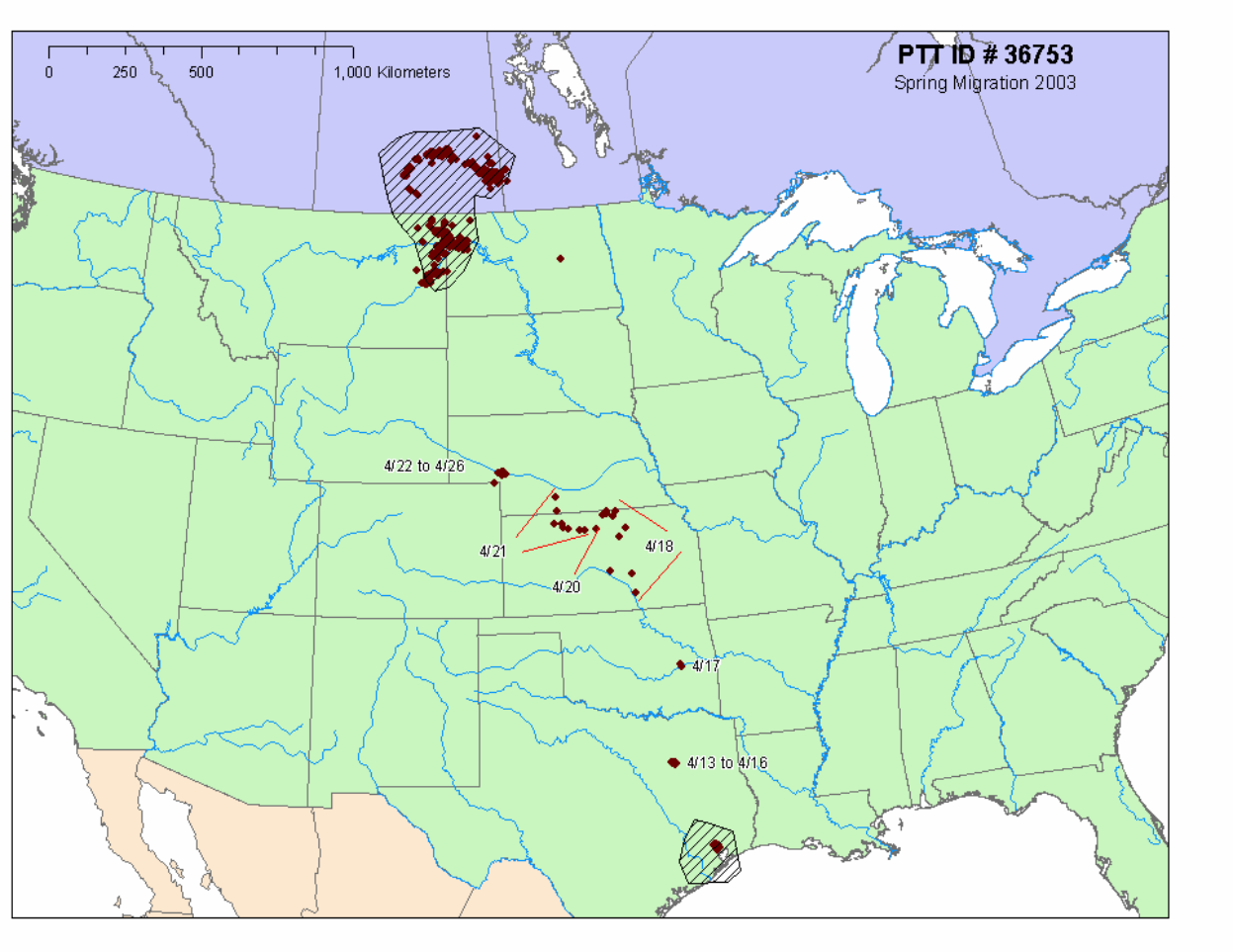


Figure 7. Spring migration route of American white pelican 36753 during 2003.

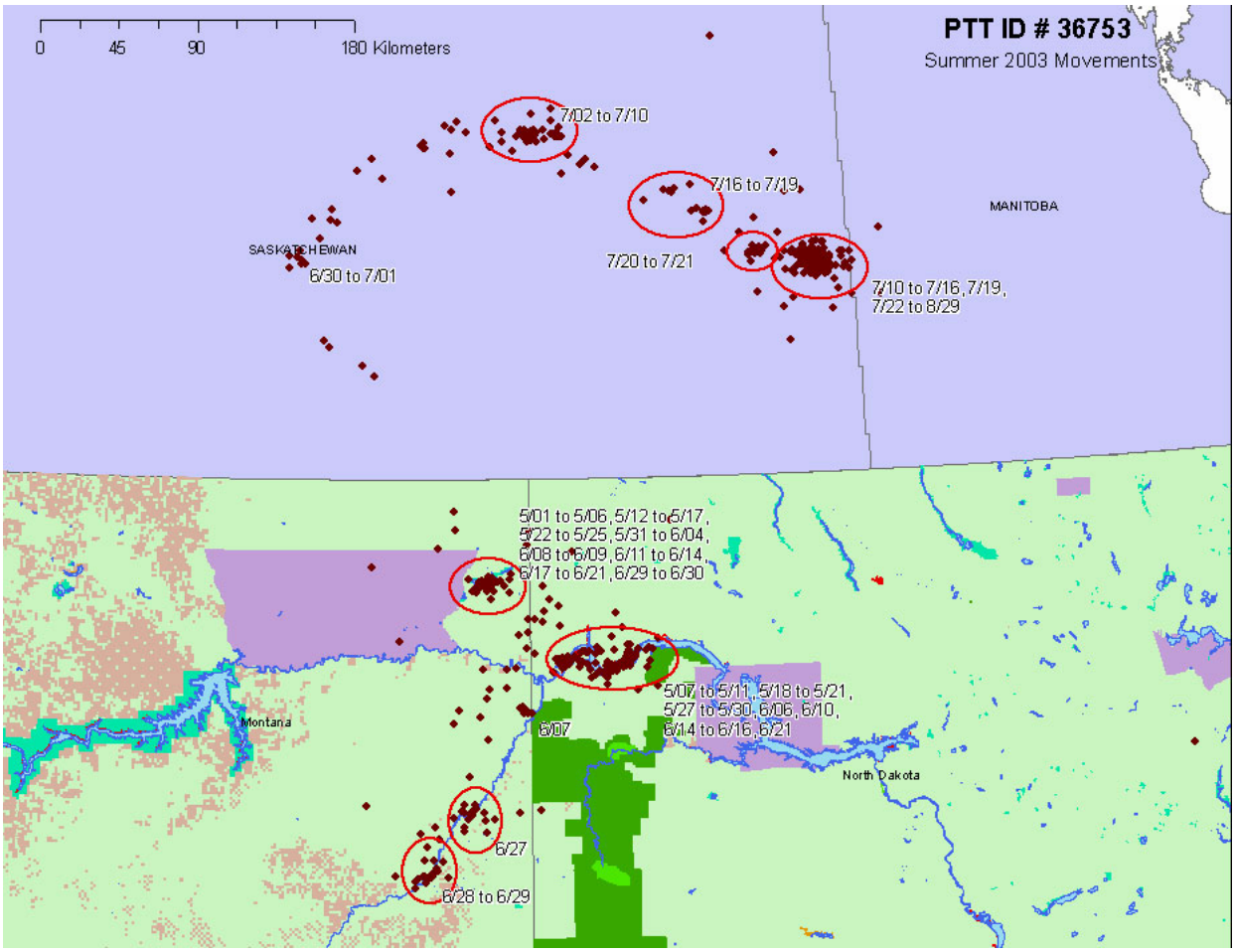


Figure 8. Movements of American white pelican 36753 in the northern Great Plains during summer 2003.

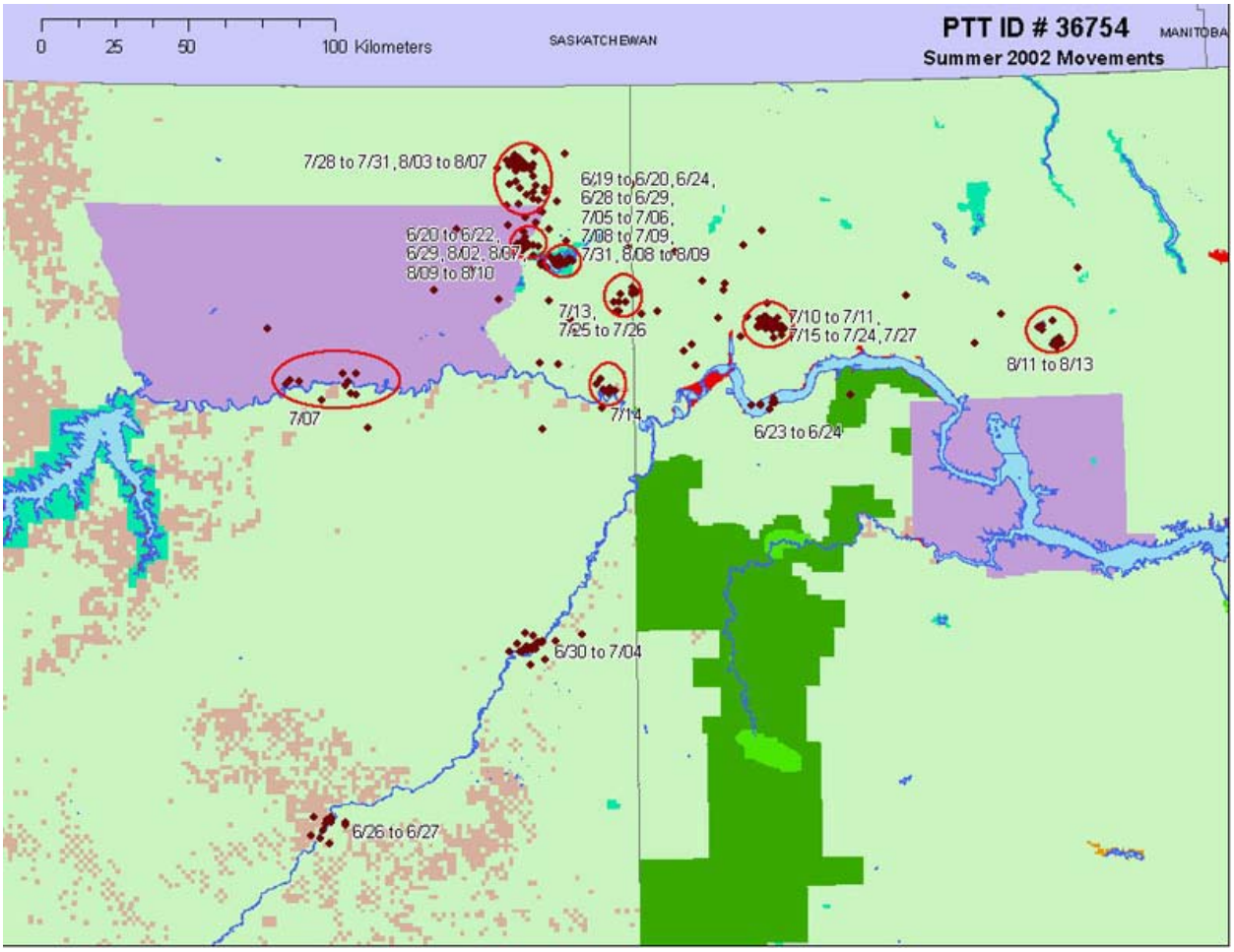


Figure 9. Movements of American white pelican 36754 in Montana and North Dakota during summer 2002.

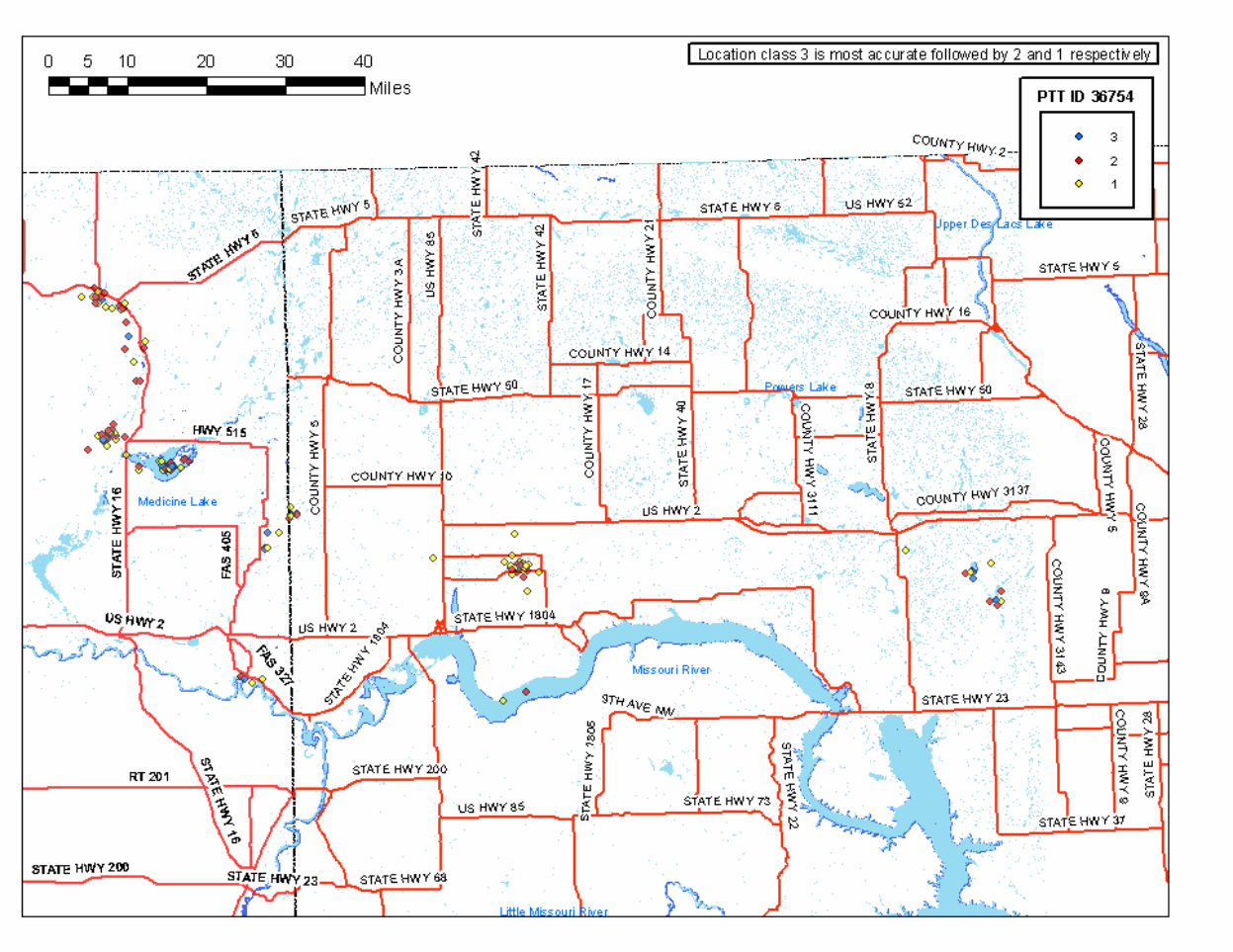


Figure 10. Movements of American white pelican 36754 in northeastern Montana and northwestern North Dakota during summer 2002.

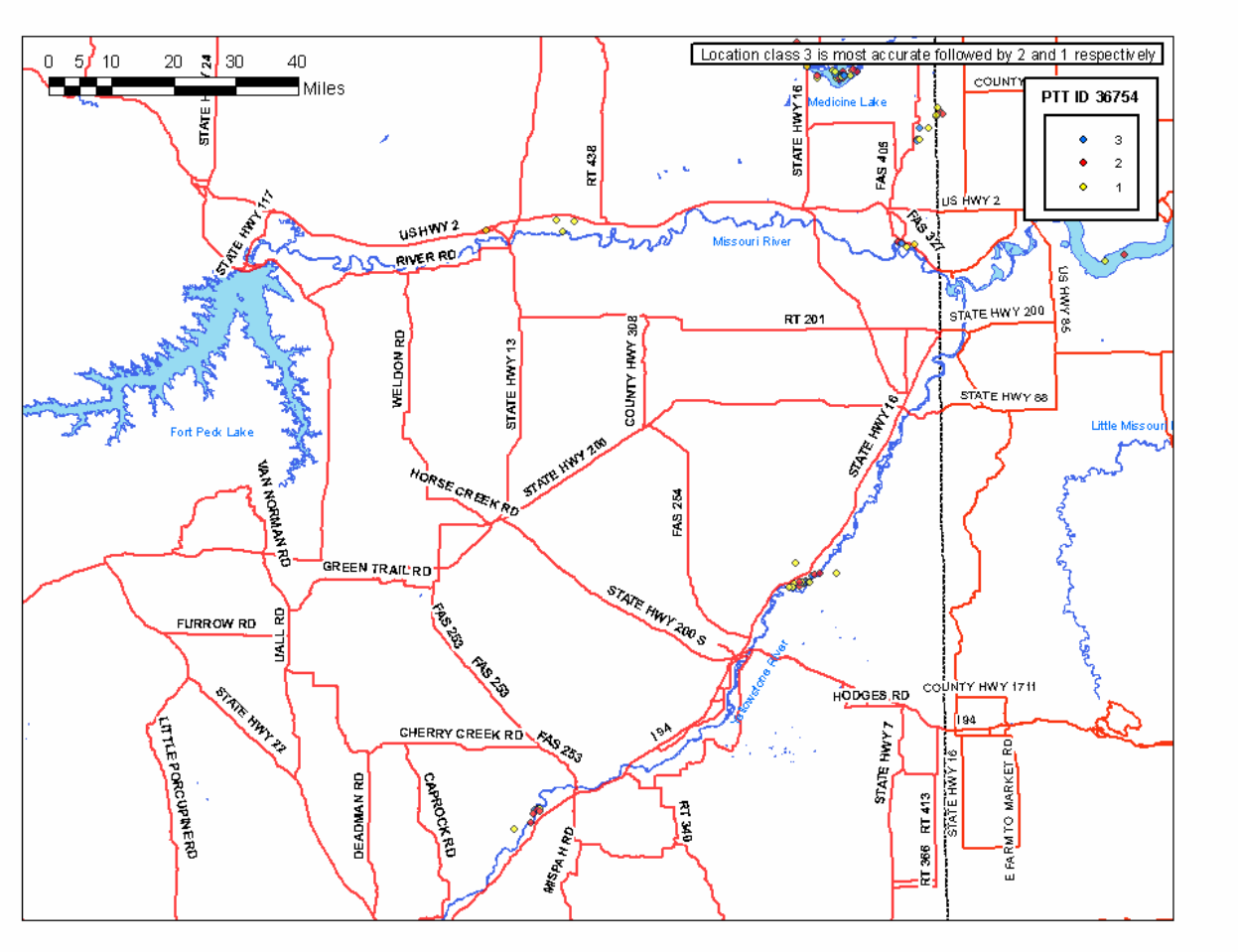


Figure 11. Movements of American white pelican 36754 in eastern Montana during summer 2002.

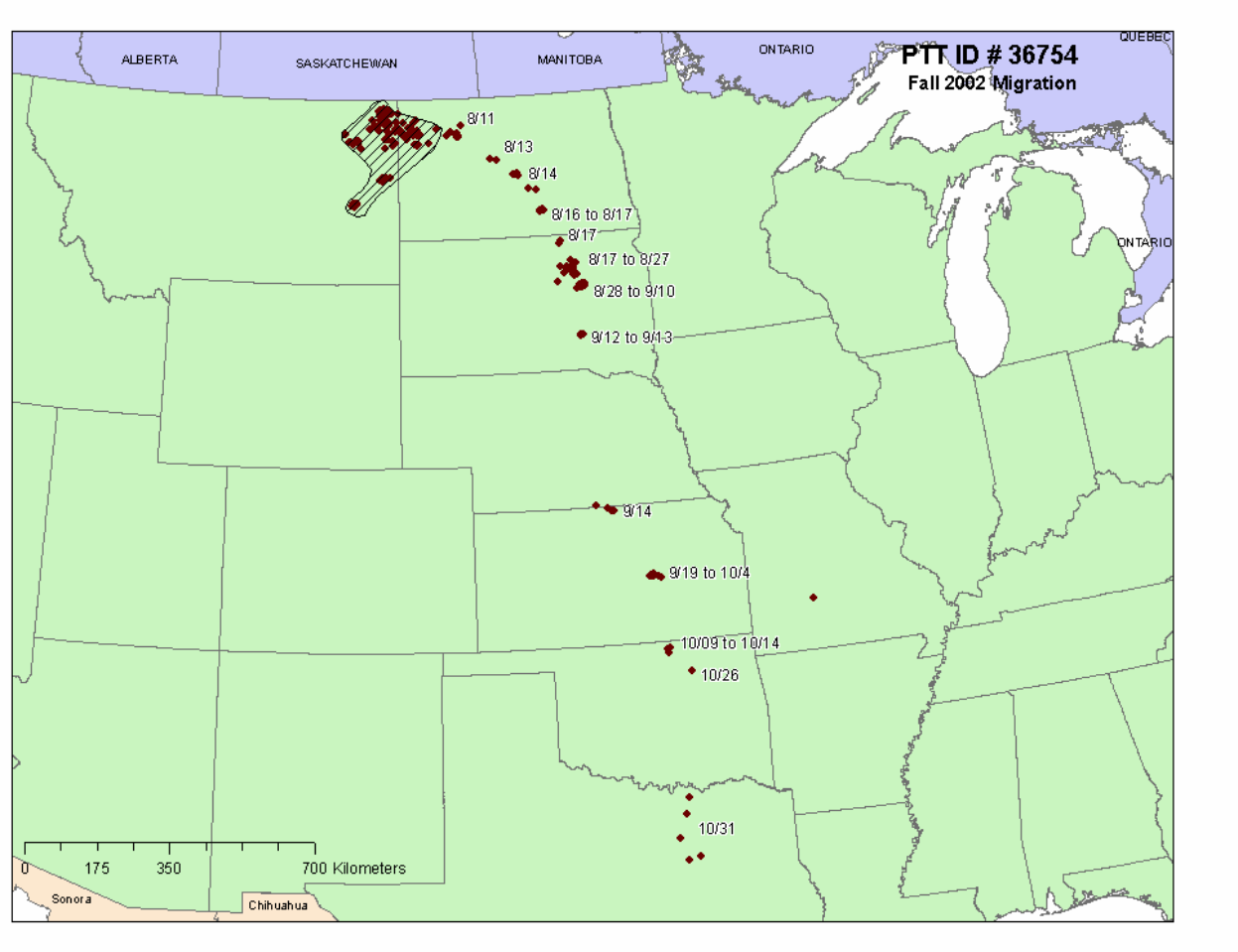


Figure 12. Autumn migration route (partial) of American white pelican 36754 during 2002.

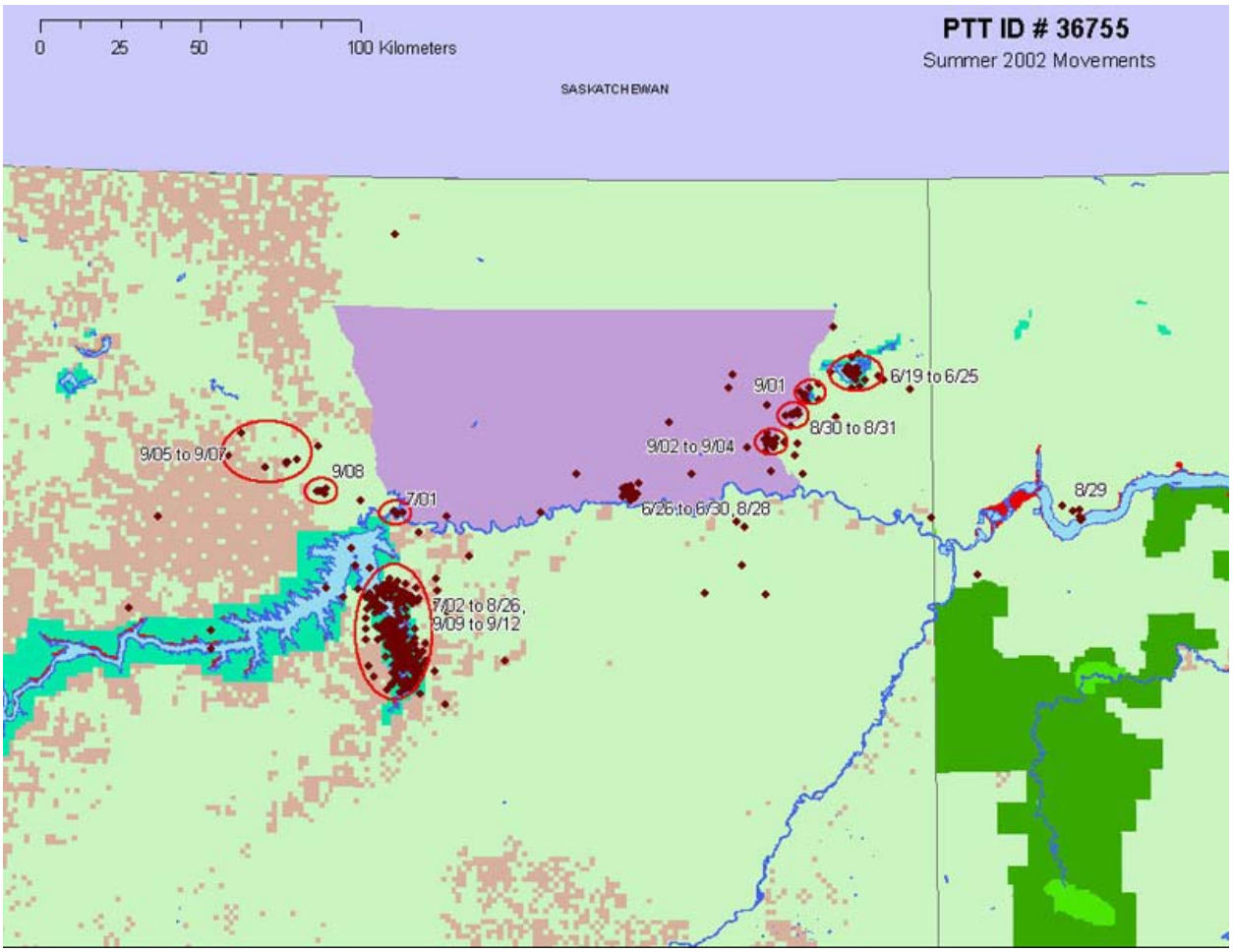


Figure 13. Movements of American white pelican 36755 in northeastern Montana and northwestern North Dakota during summer 2002.

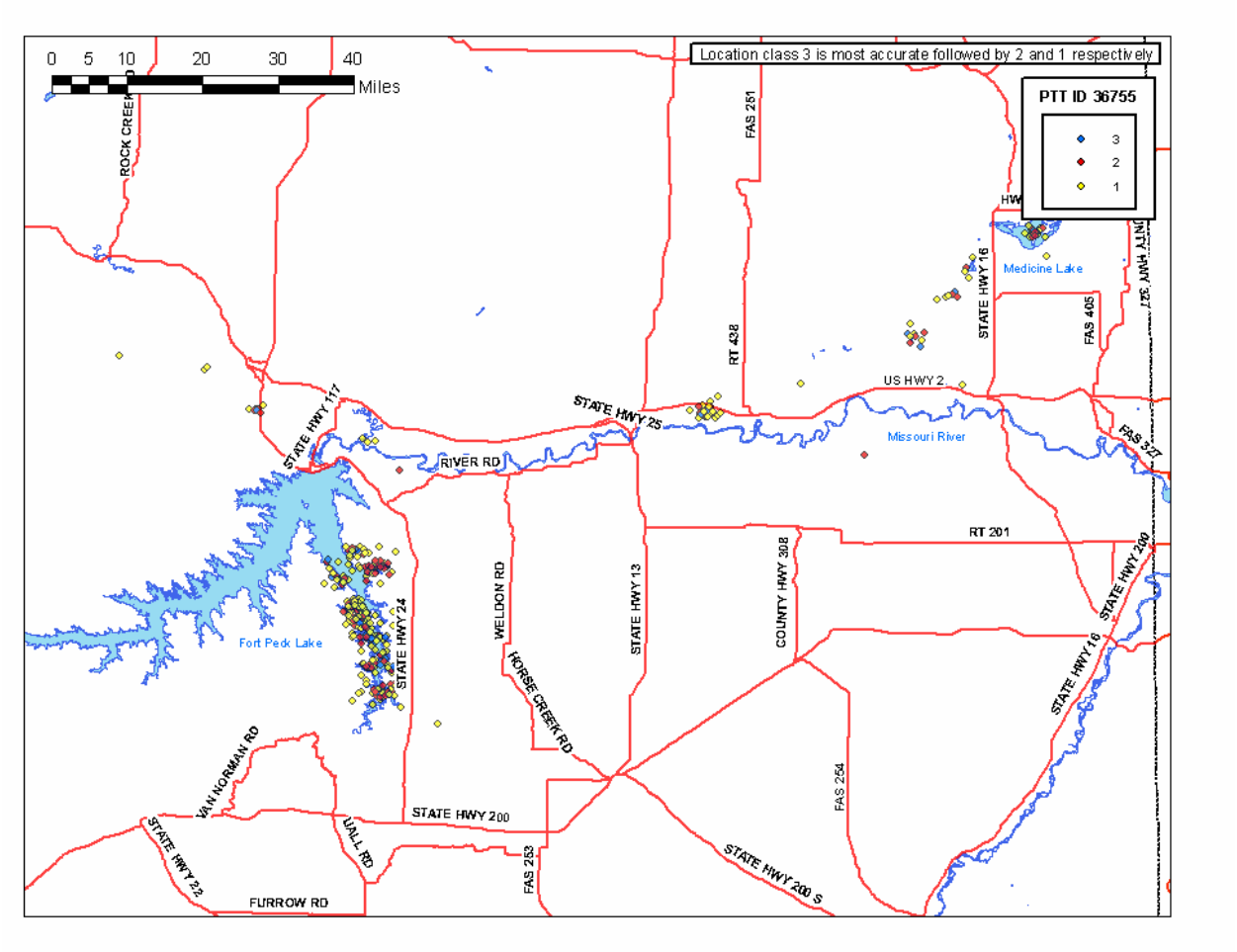


Figure 14. Movements of American white pelican 36755 in northeastern Montana during summer 2002.

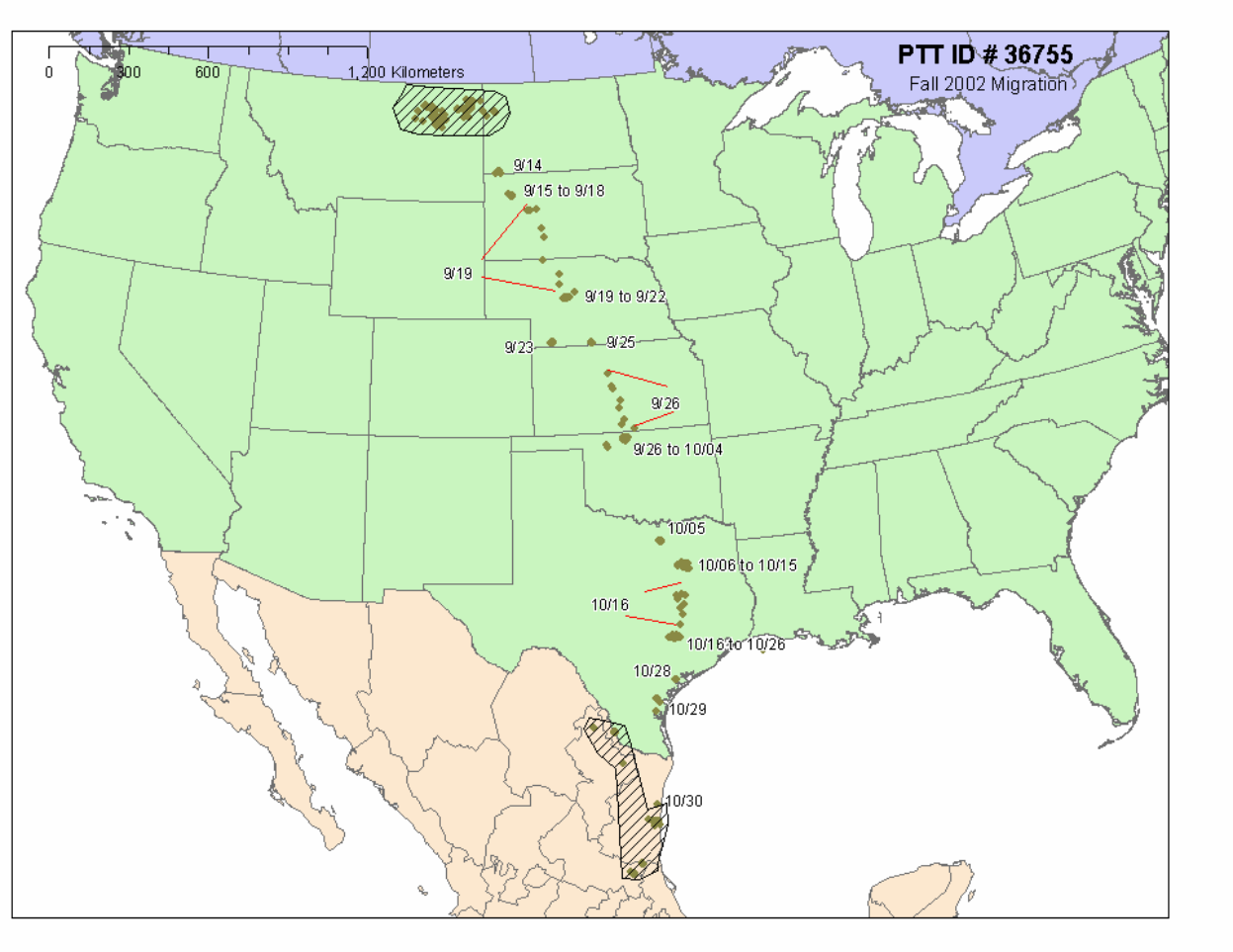


Figure 15. Autumn migration route of American white pelican 36755 during 2002.

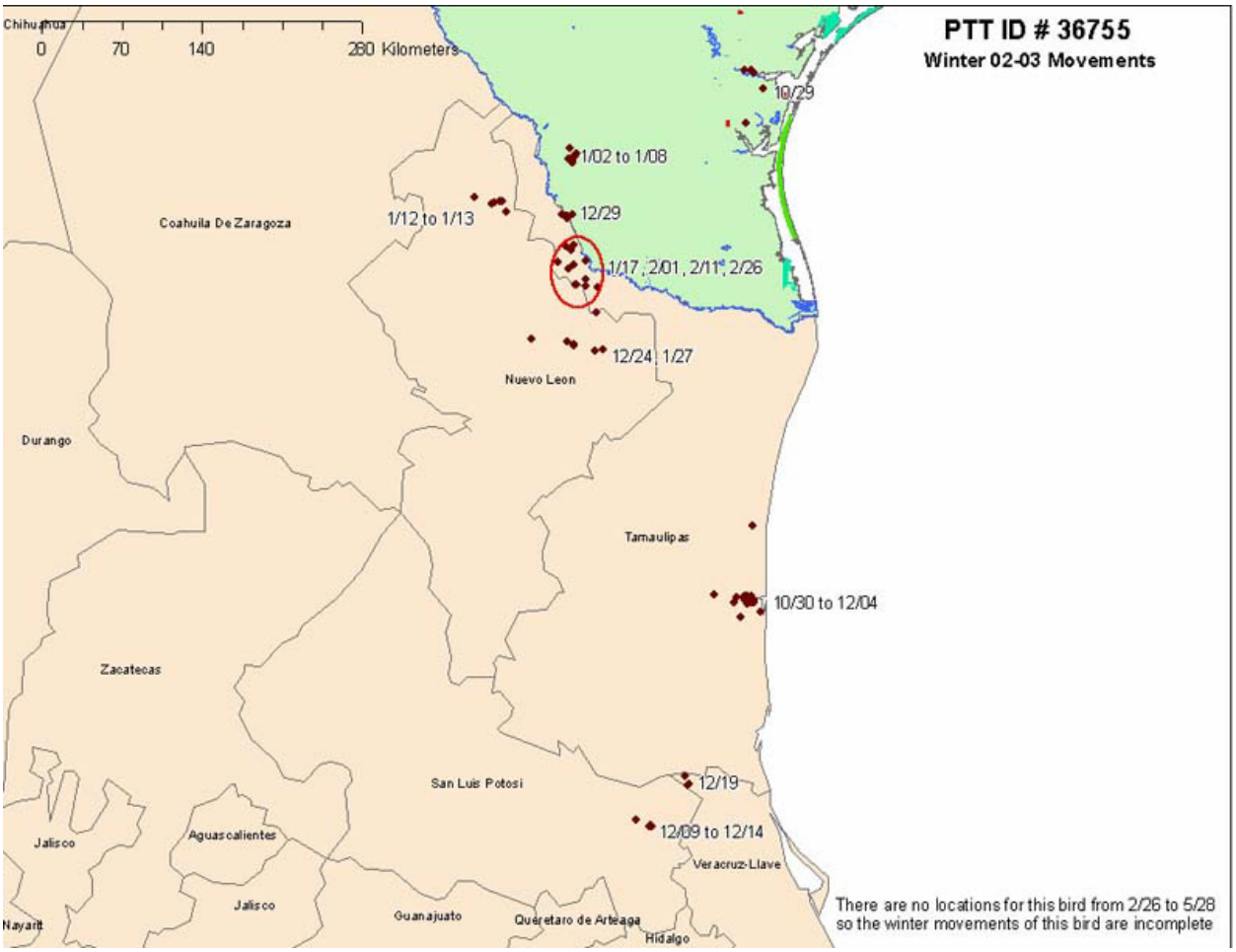


Figure 16. Movements of American white pelican 36755 in northern Mexico and southern Texas during winter 2002-2003.

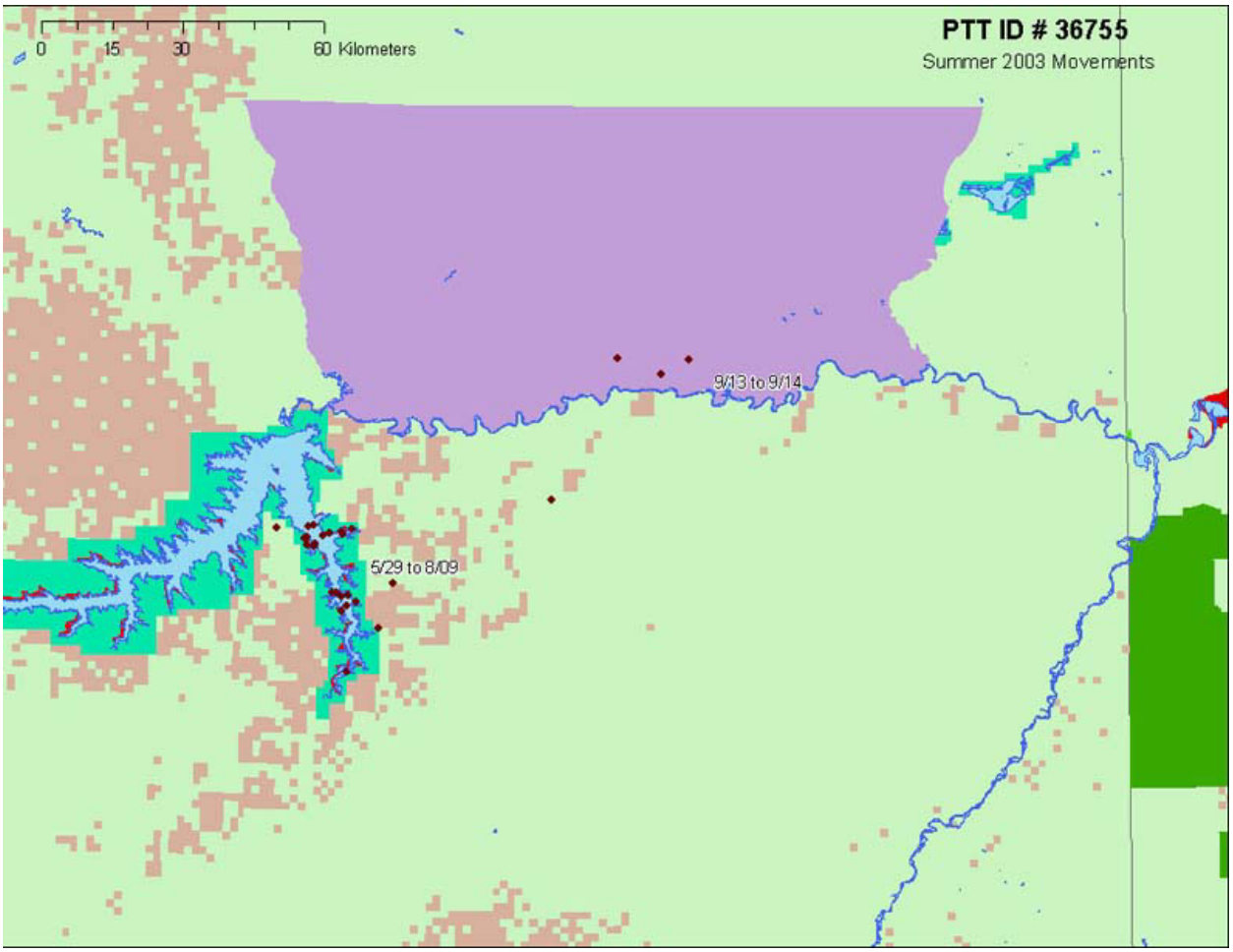


Figure 17. Movements of American white pelican 36755 in northeastern Montana during summer 2003.

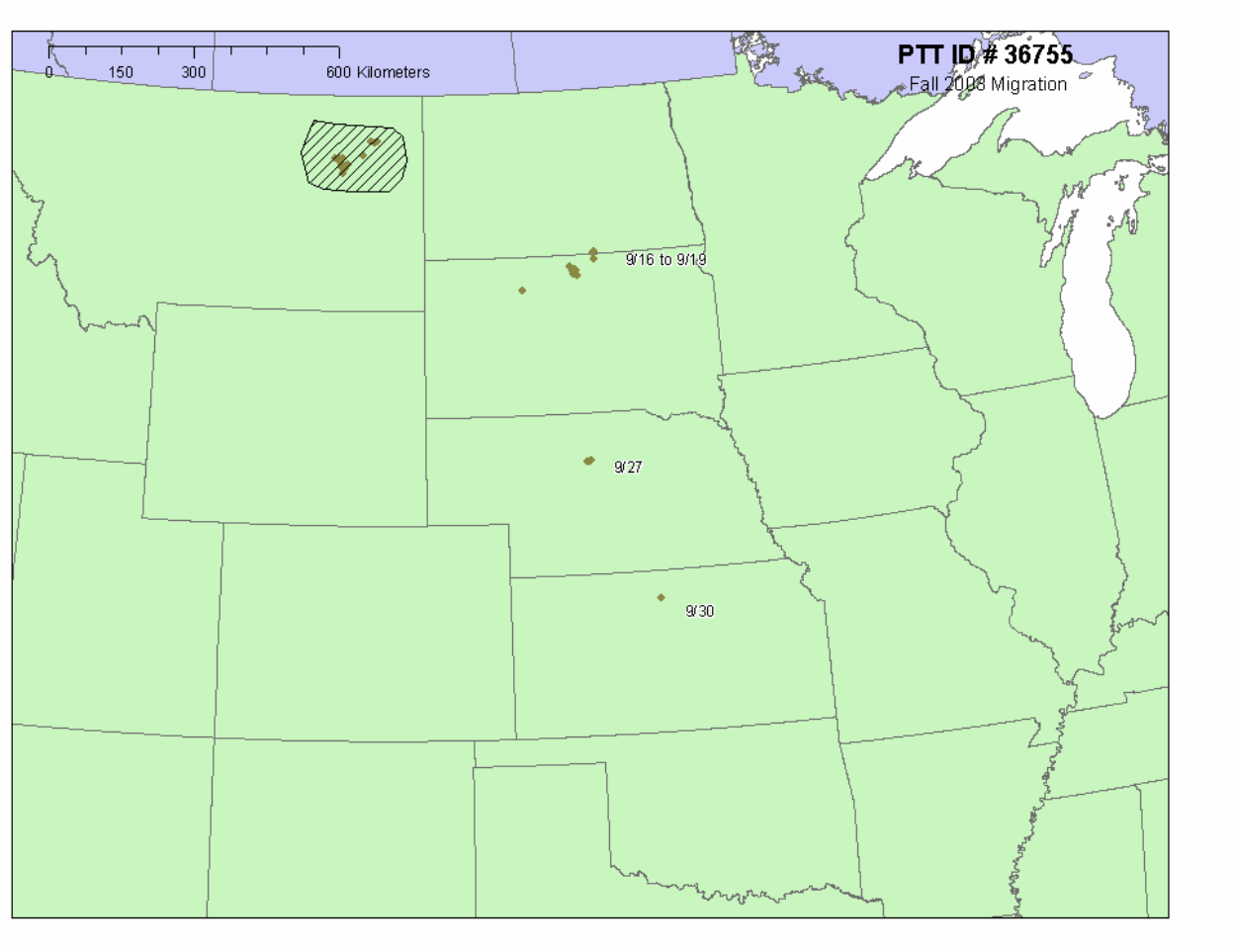


Figure 18. Autumn migration route (partial) of American white pelican 36755 during 2003.

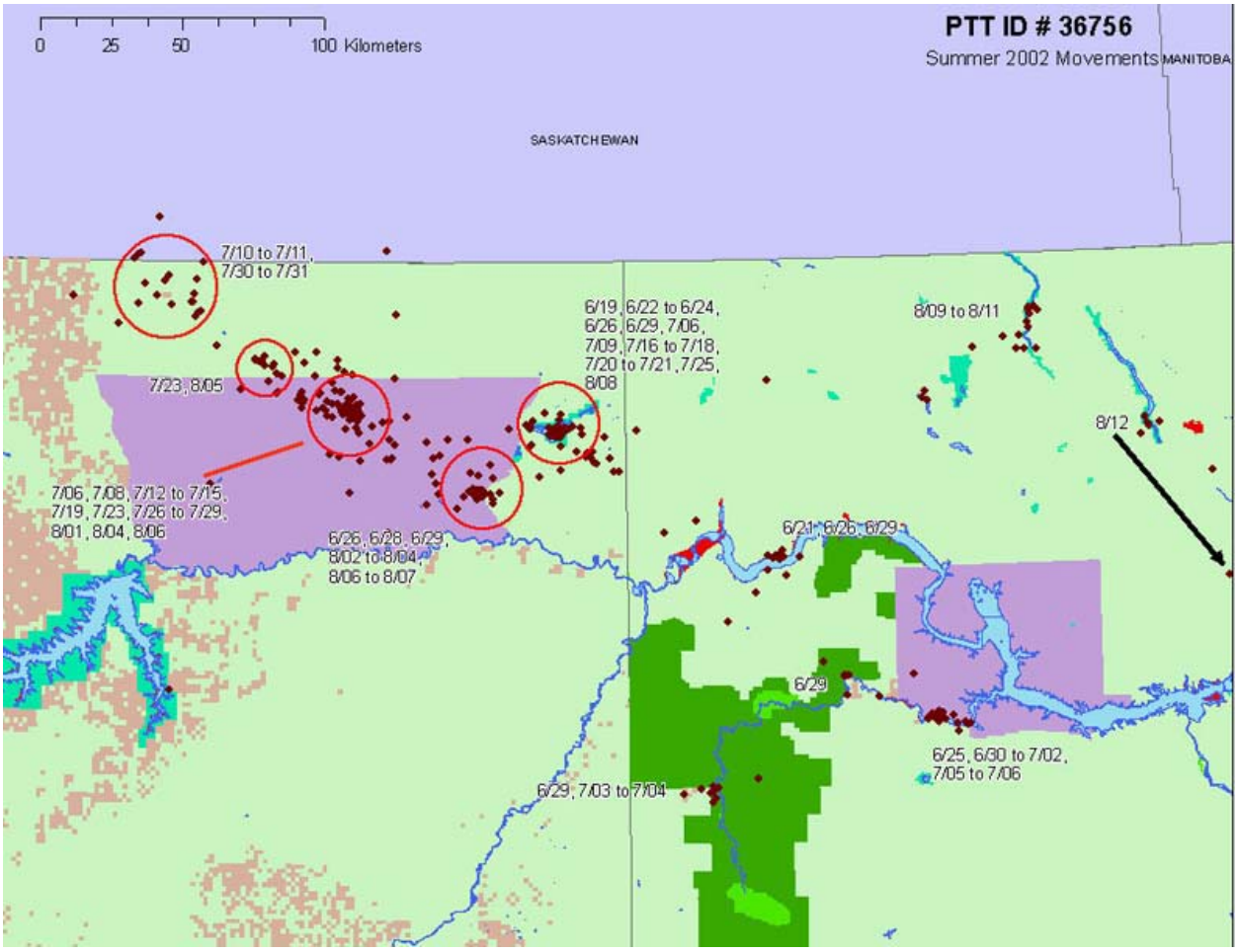


Figure 19. Movements of American white pelican 36756 in the northern Great Plains during summer 2002.

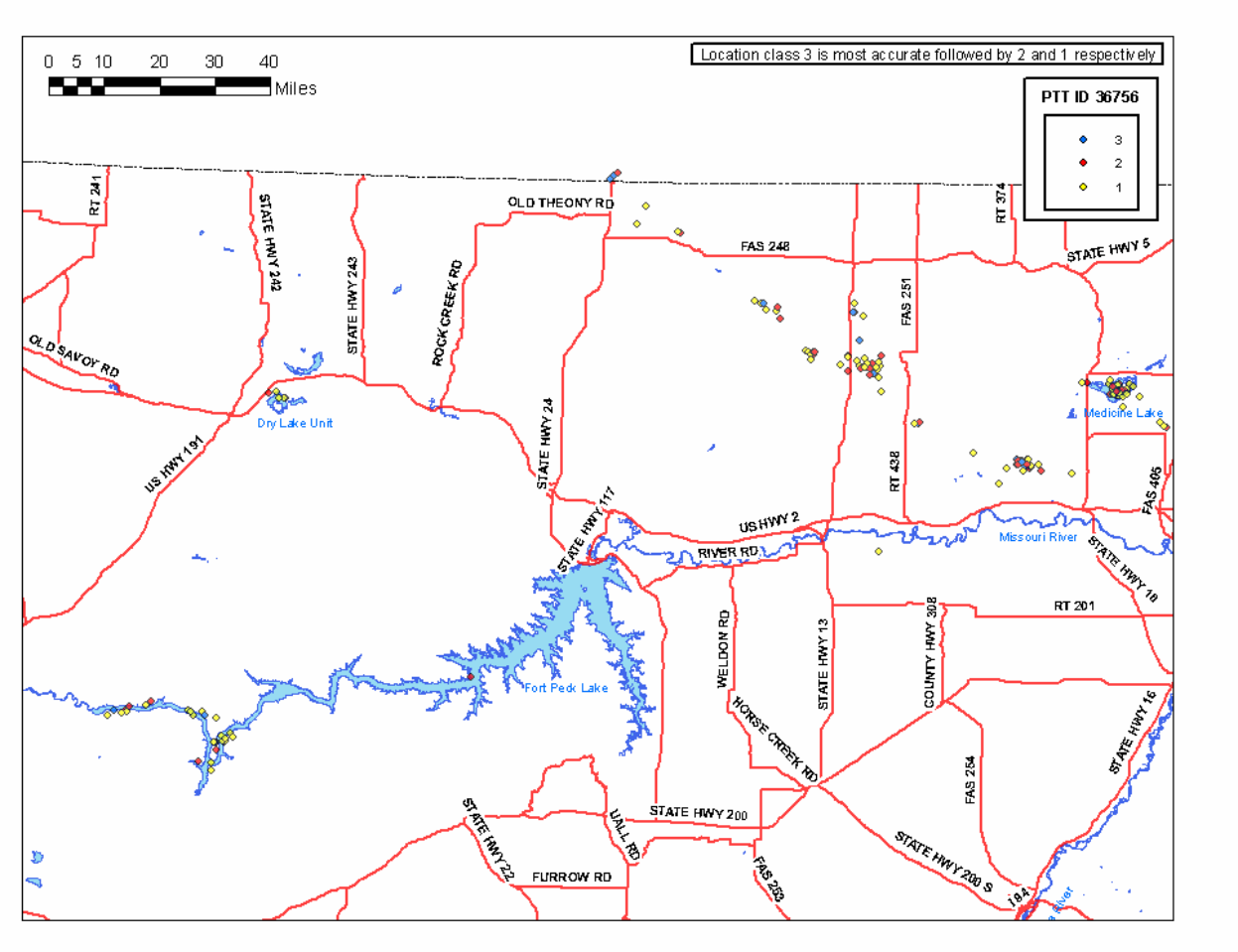


Figure 20. Movements of American white pelican 36756 in eastern Montana during summer 2002.

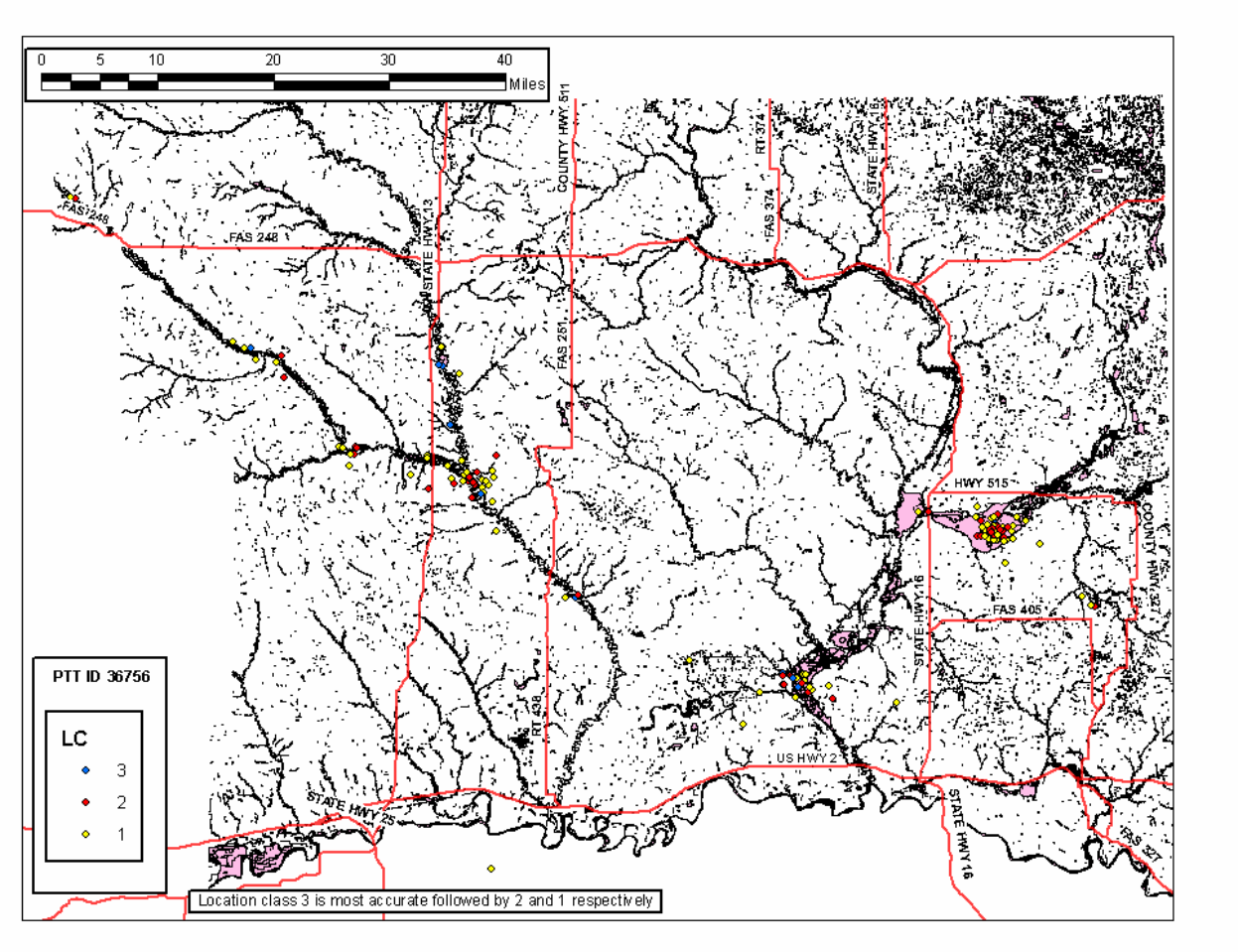


Figure 21. Movements of American white pelican 36756 in northeastern Montana during summer 2002.

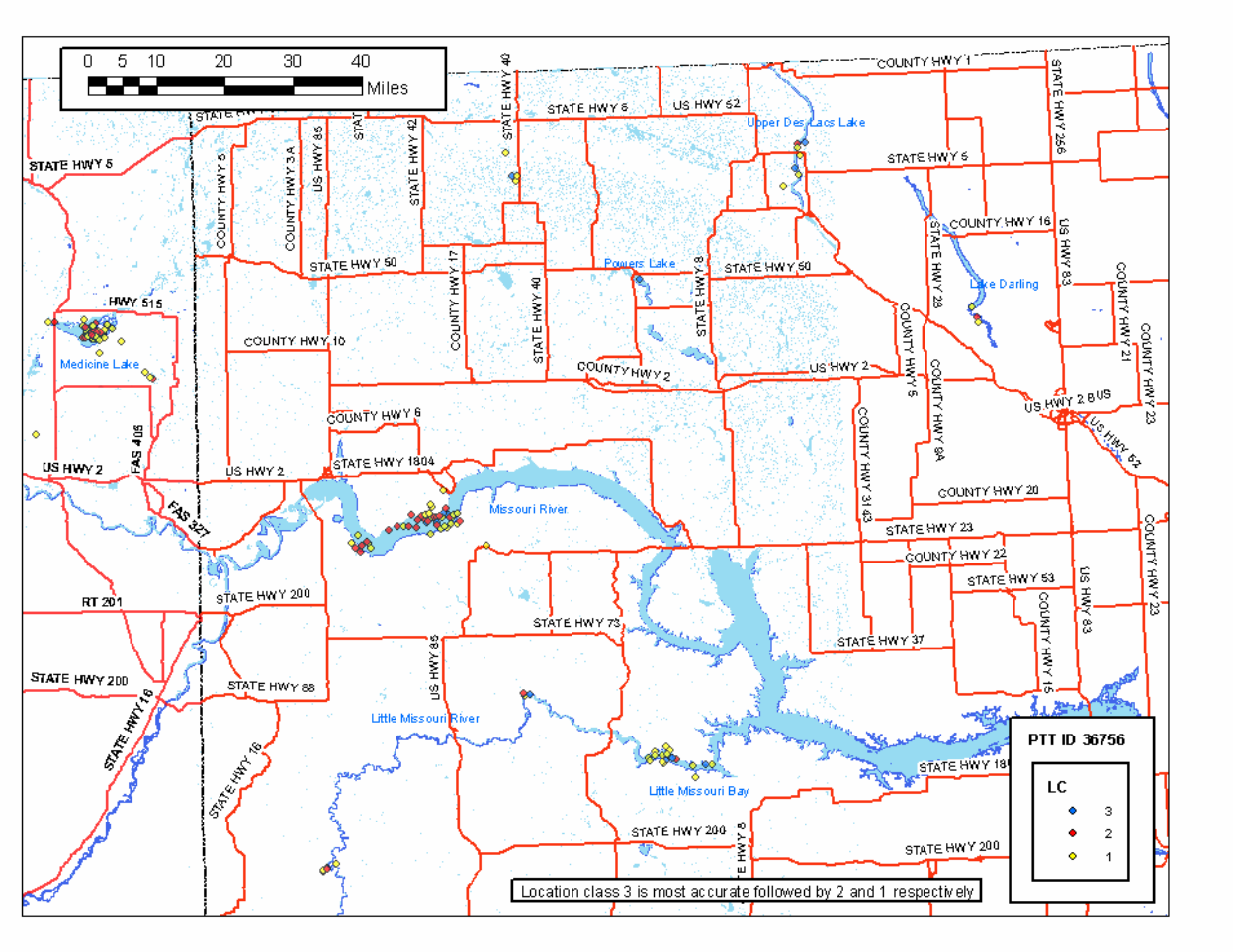


Figure 22. Movements of American white pelican 36756 in northwestern North Dakota during summer 2002.

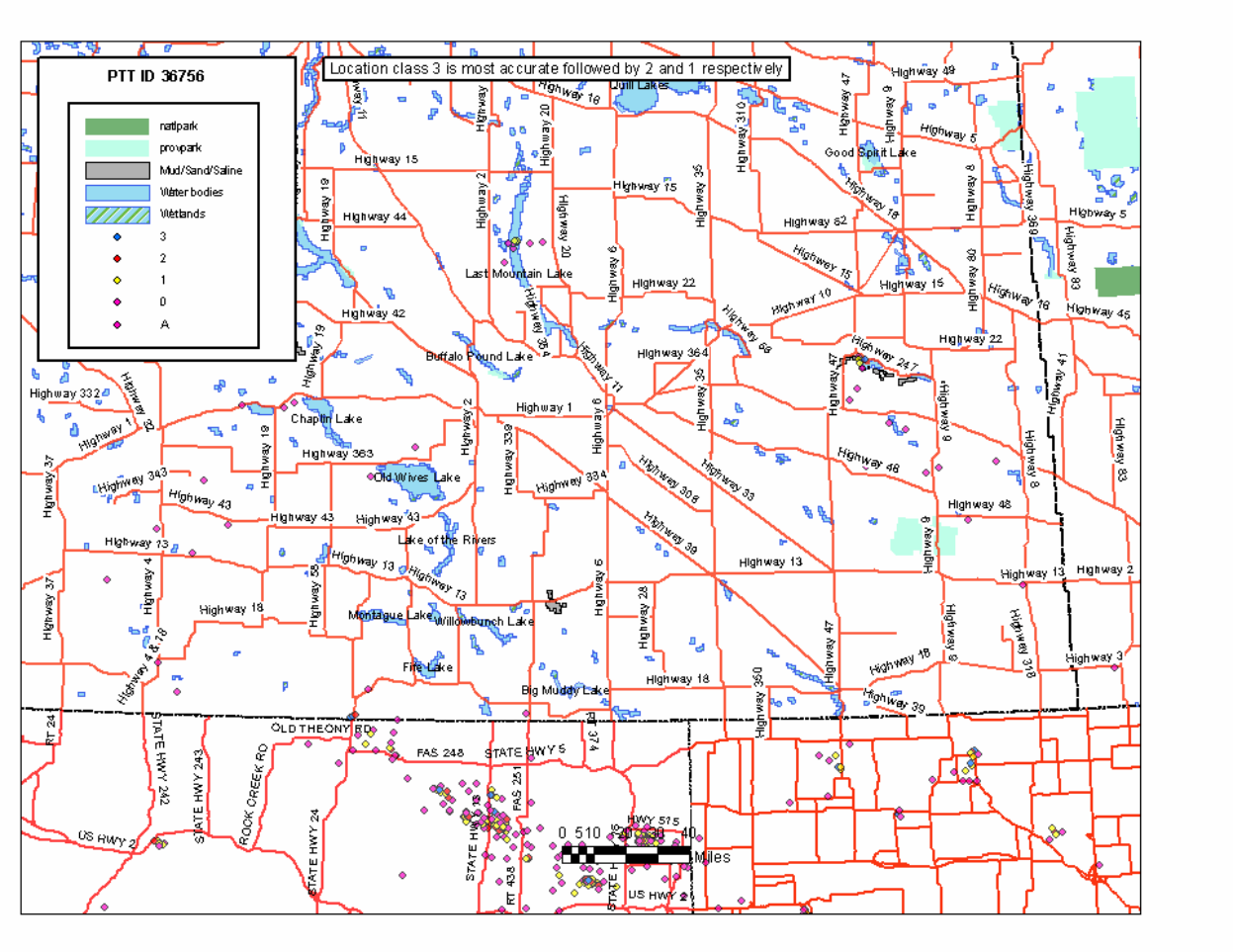


Figure 23. Movements of American white pelican 36756 in northeastern Montana and southern Saskatchewan during summer 2002.

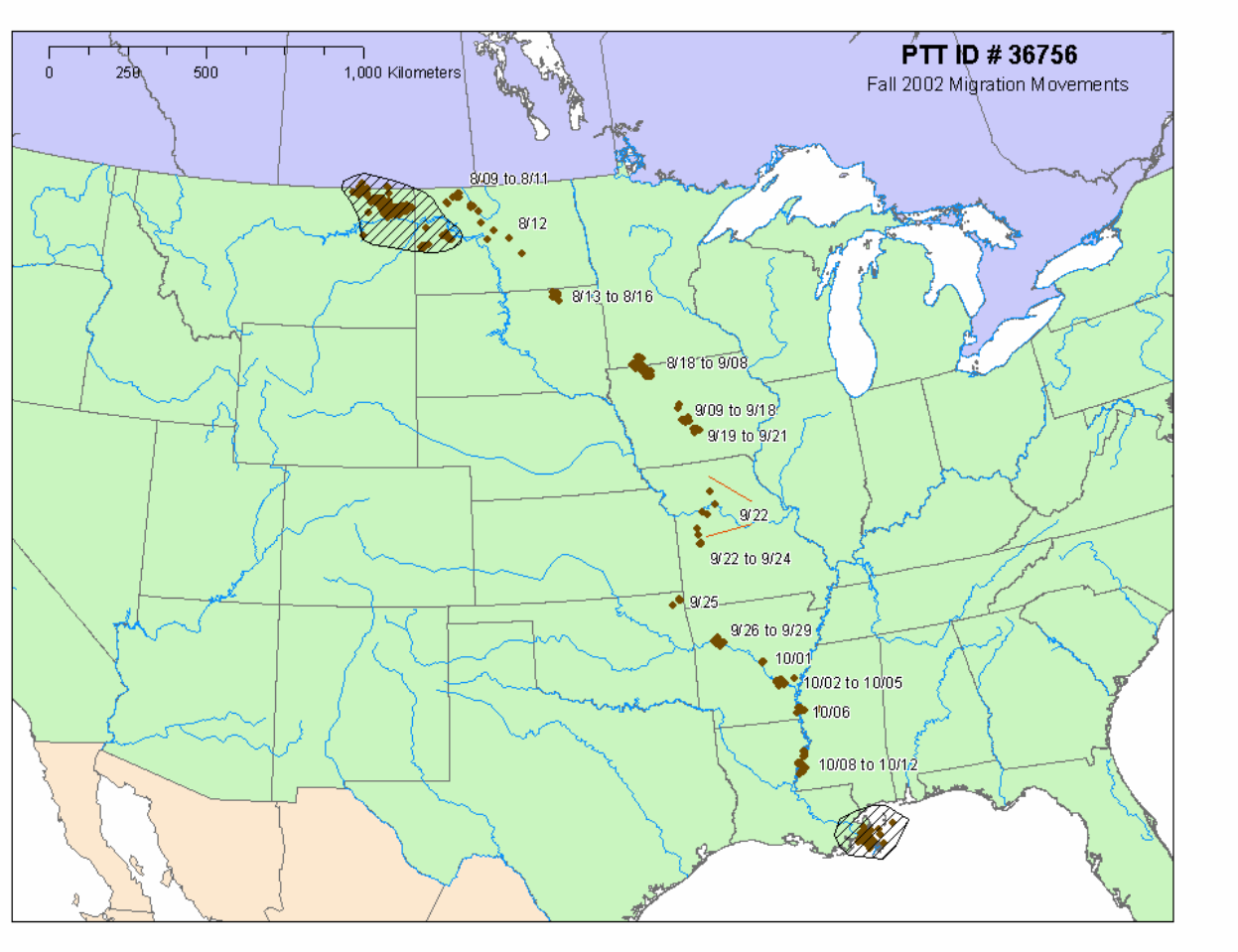


Figure 24. Autumn migration route of American white pelican 36756 during 2002.

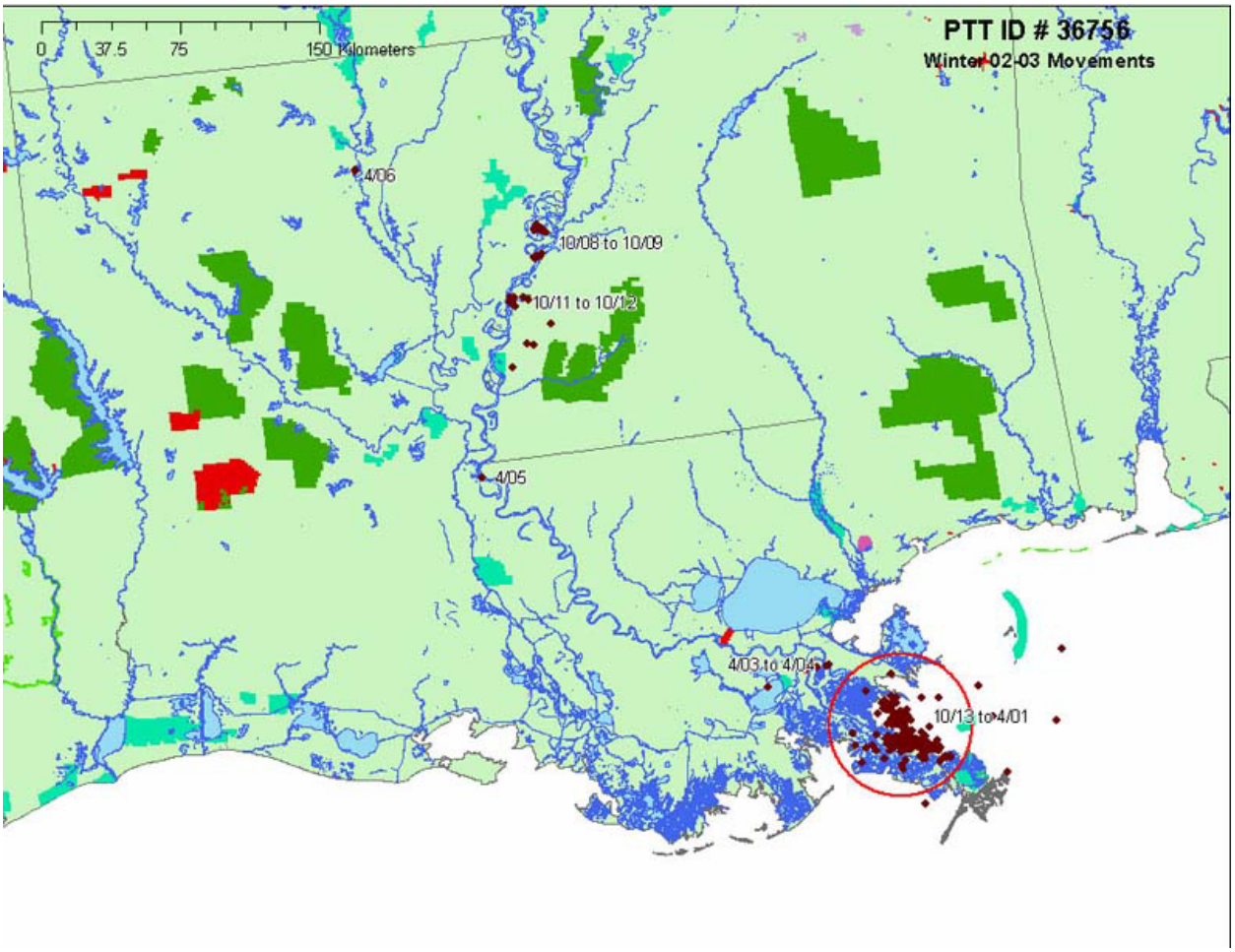


Figure 25. Movements of American white pelican 36756 in southern Louisiana during winter 2002-2003.

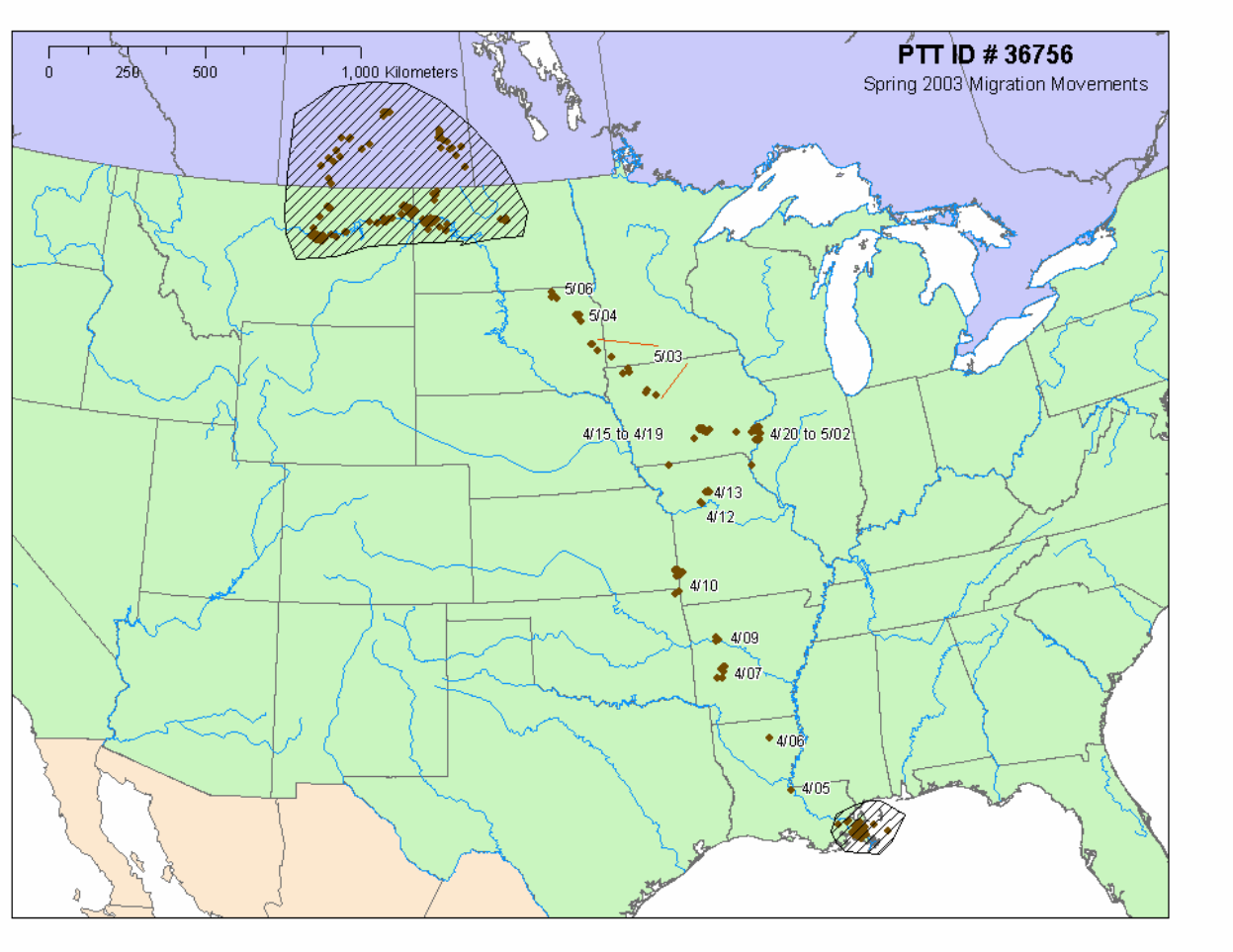


Figure 26. Spring migration route of American white pelican 36756 during 2003.

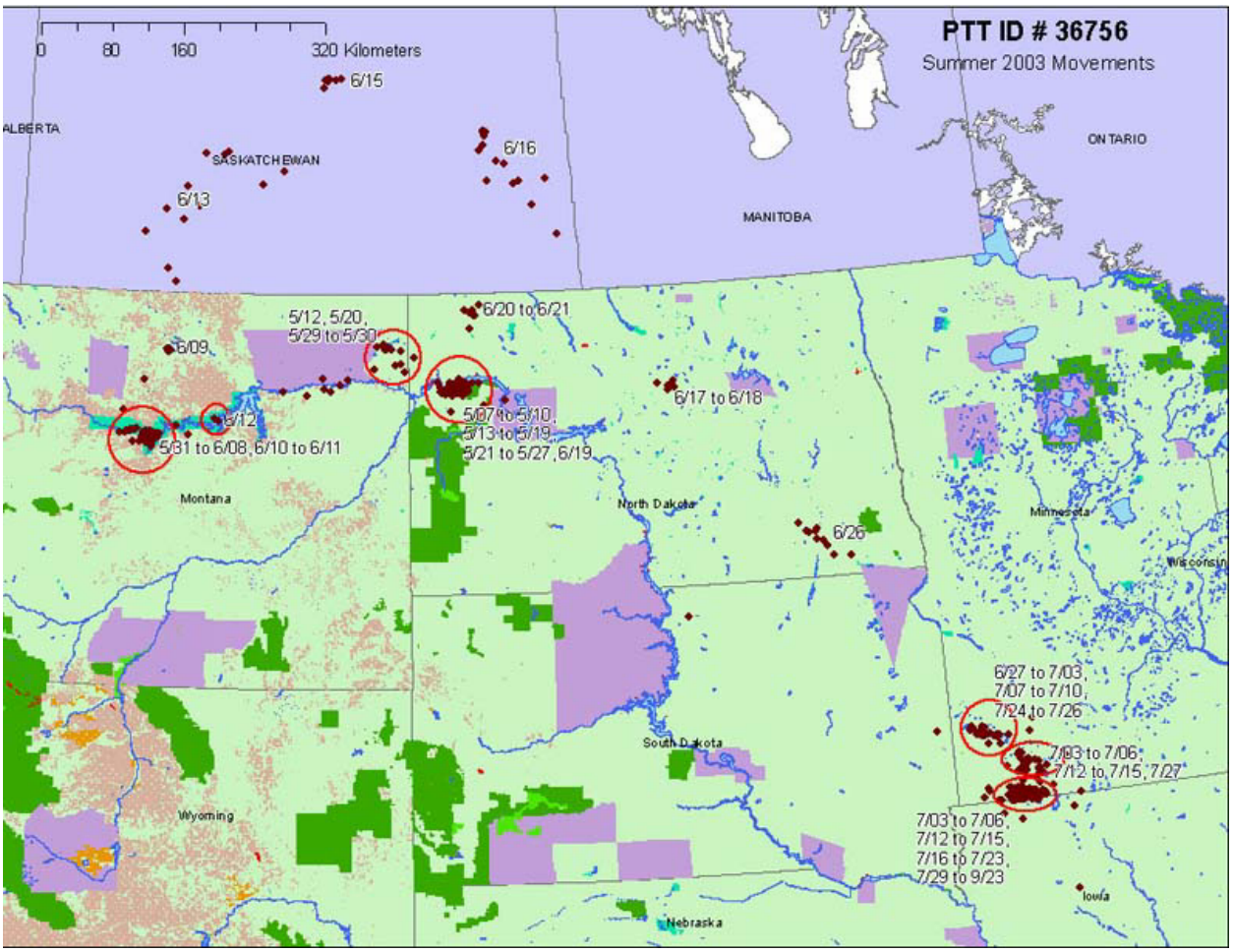


Figure 27. Movements of American white pelican 36756 in the northern Great Plains during summer 2003.

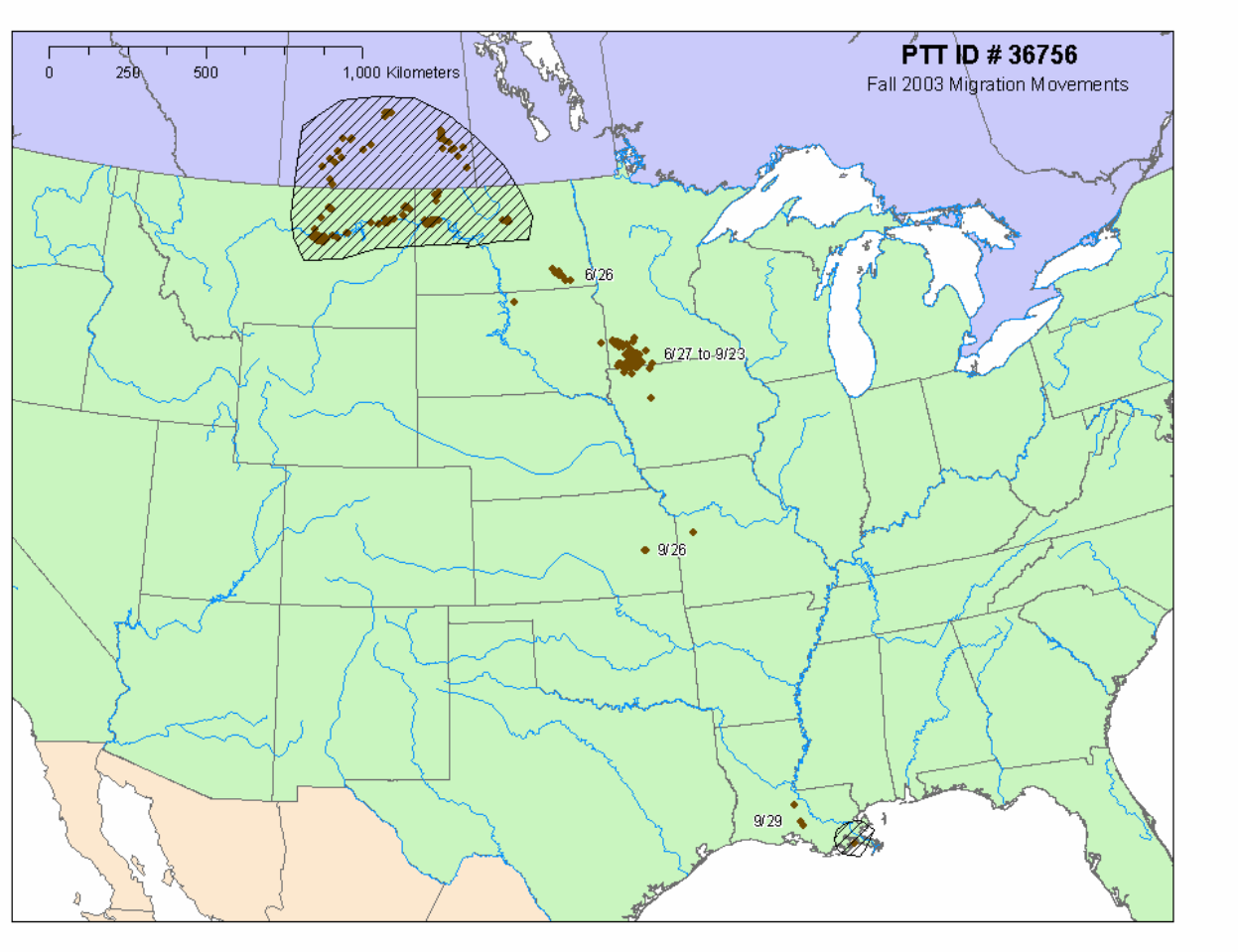
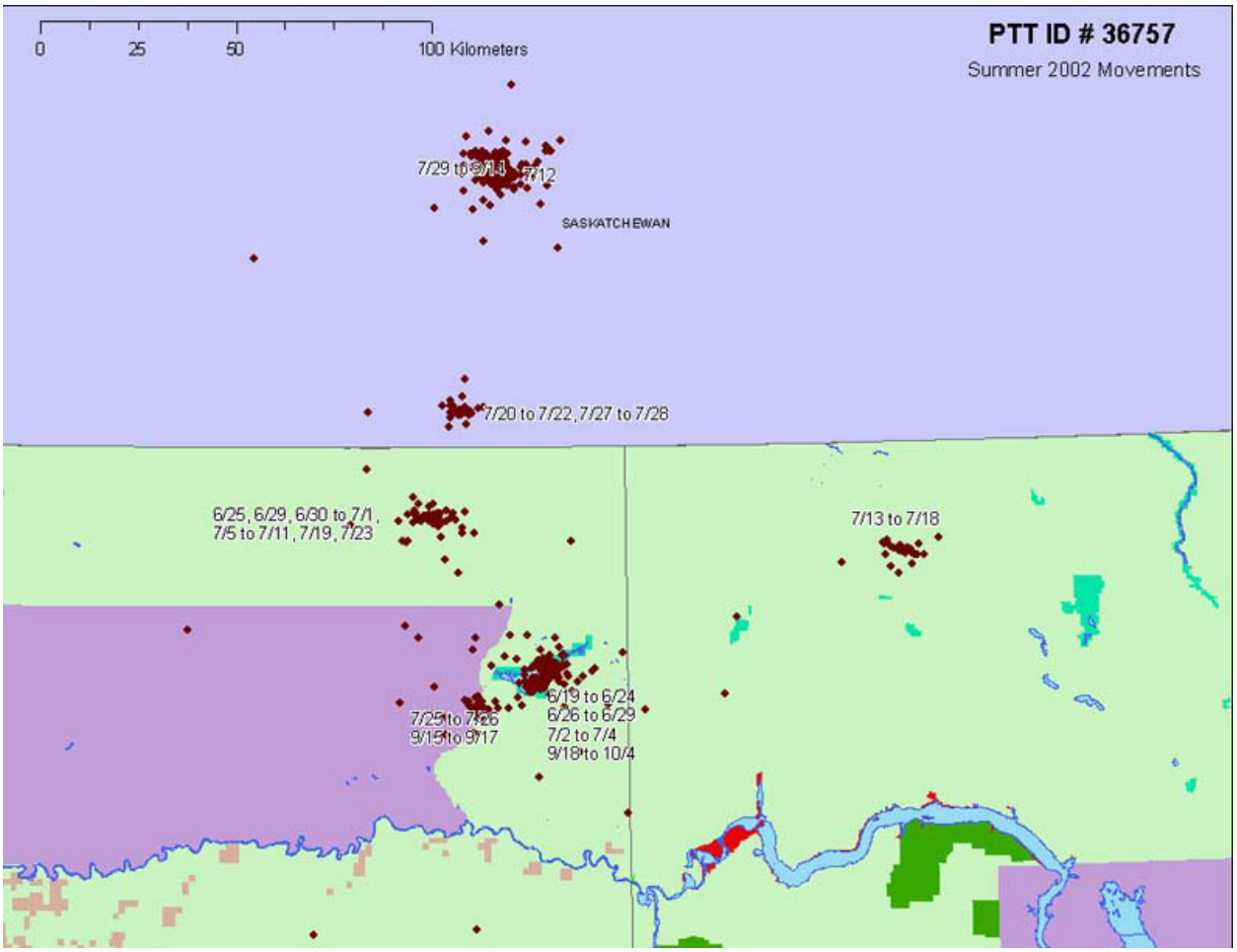


Figure 28. Autumn migration route of American white pelican 36756 during 2003.



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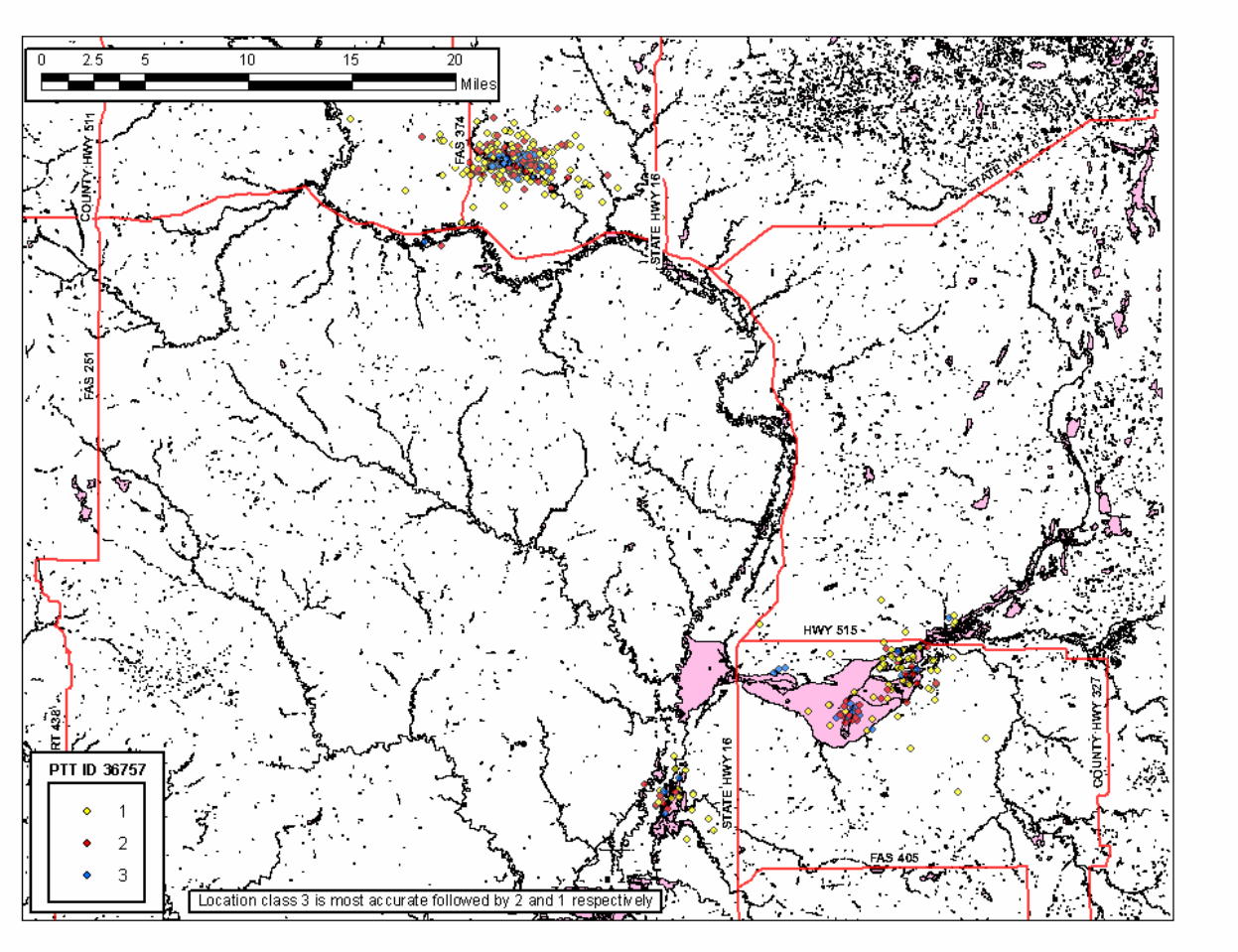

Figure 30. Movements of American white pelican in northeastern Montana during summer 2002.

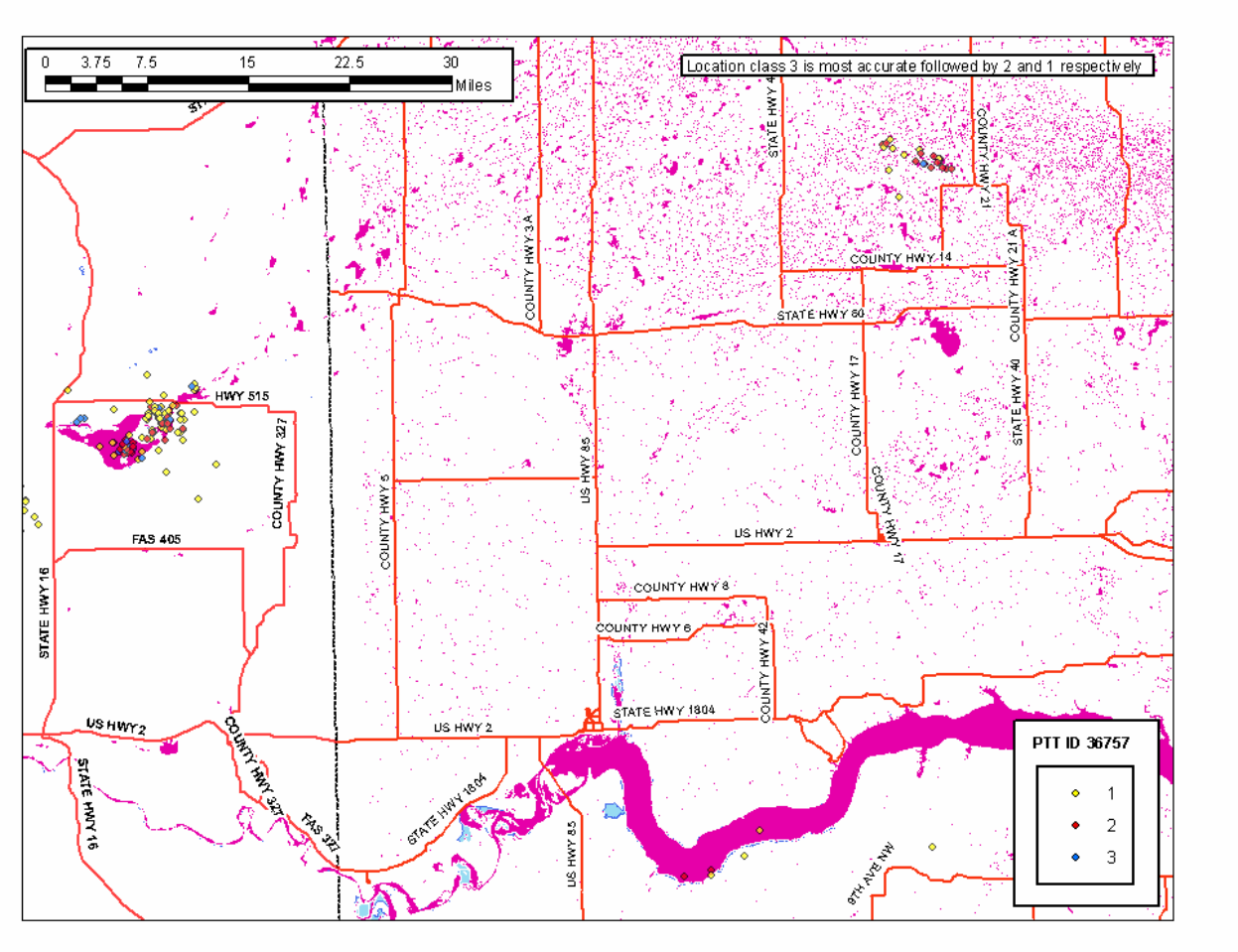

Figure 31. Movements of American white pelican 36757 in northeastern Montana and northwestern North Dakota during summer 2002.

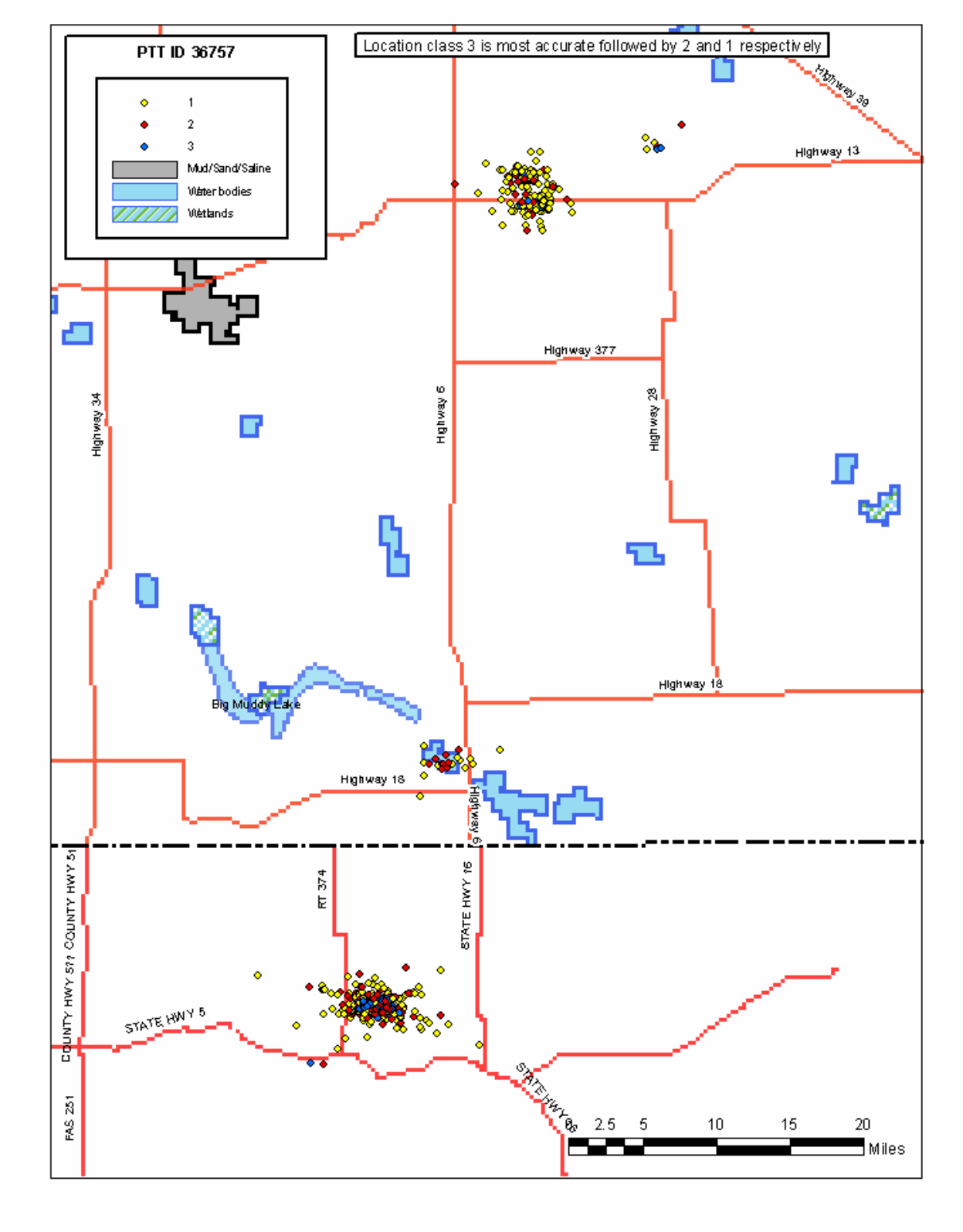

Figure 32. Movements of American white pelican 36757 in southern Saskatchewan during summer 2002.

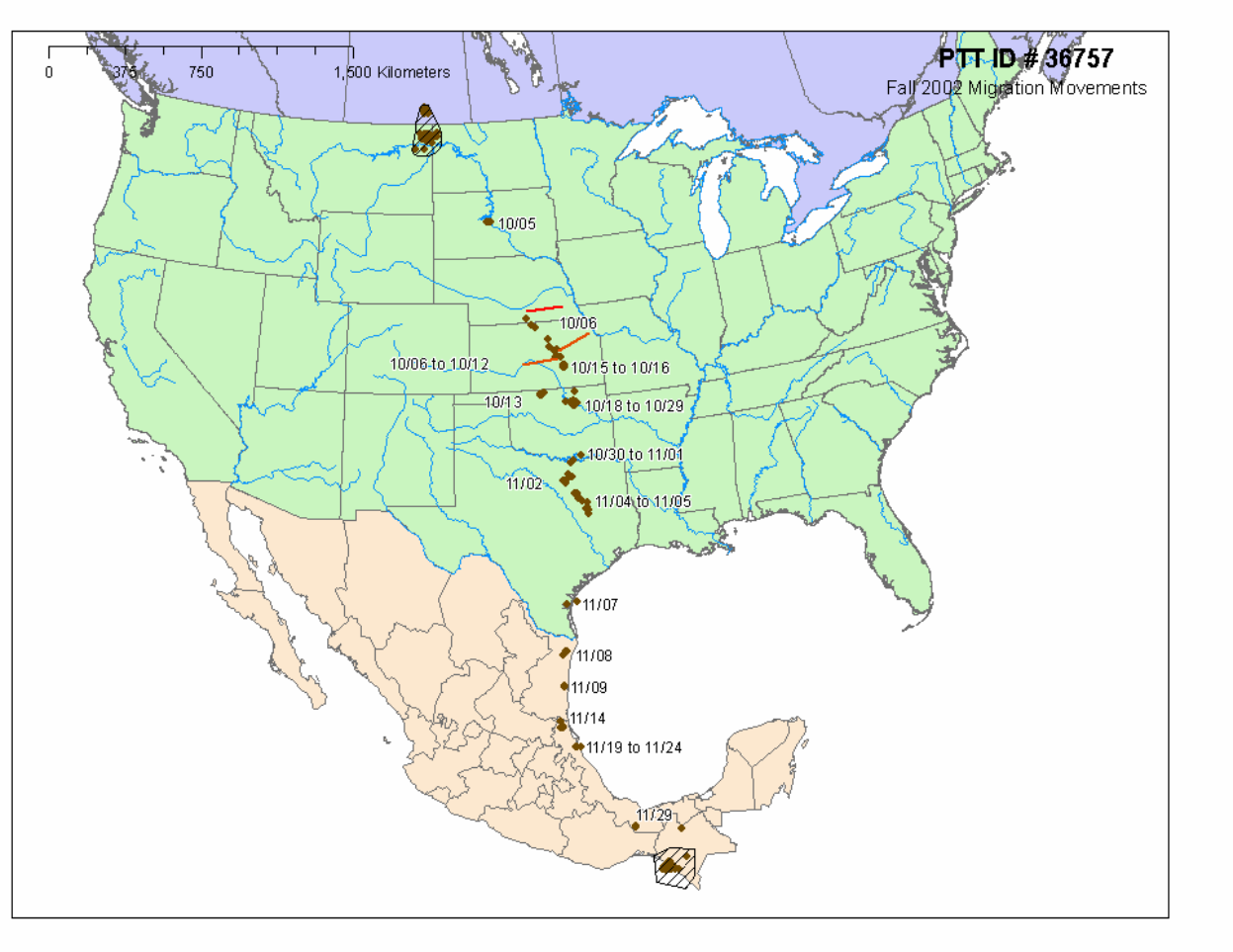

Figure 33. Autumn migration route of American white pelican 36757 during 2002.

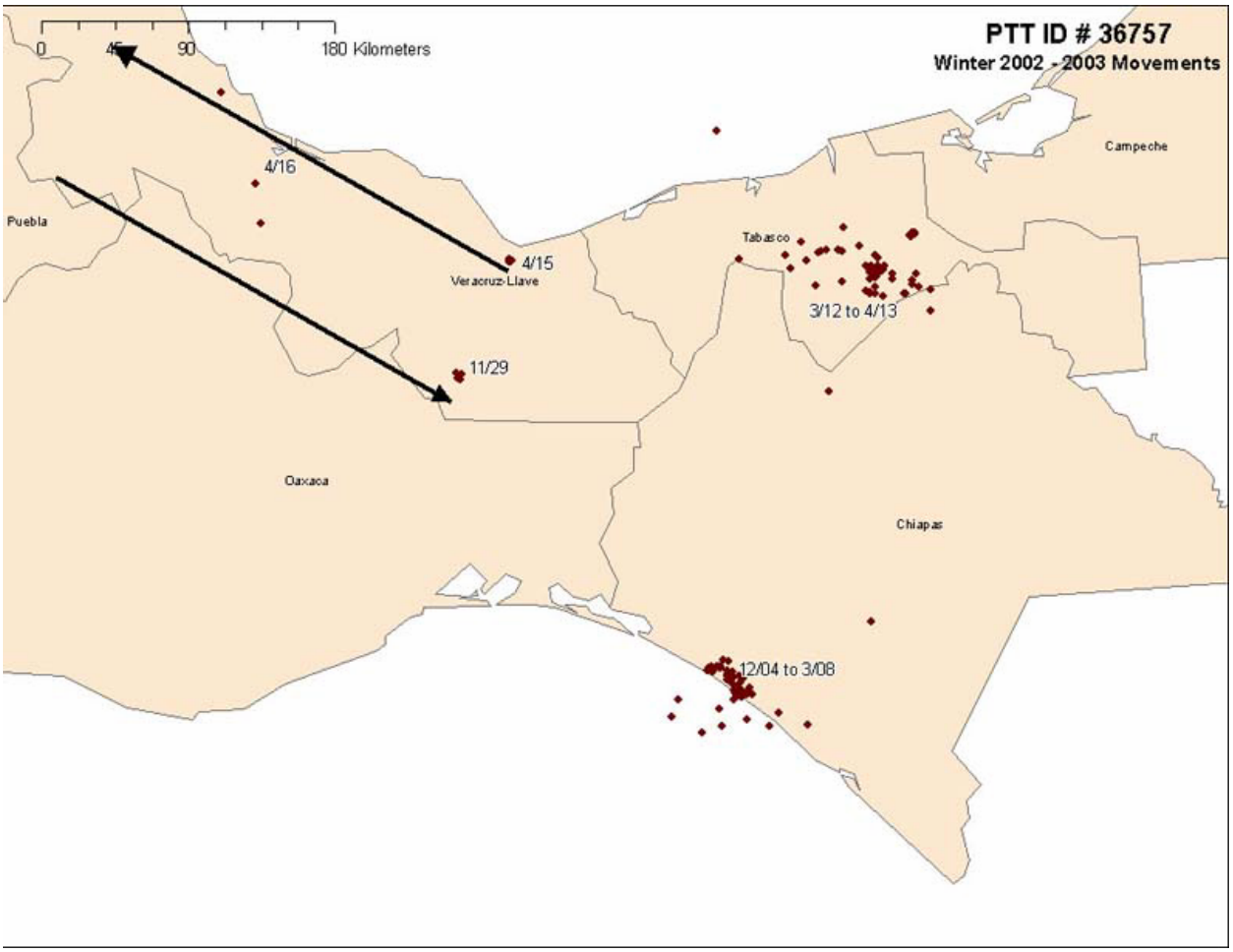

Figure 34. Movements of American white pelican 36757 in southern Mexico during winter 2002-2003.

Figure 35. Spring migration route of American white pelican 36757 during 2003.

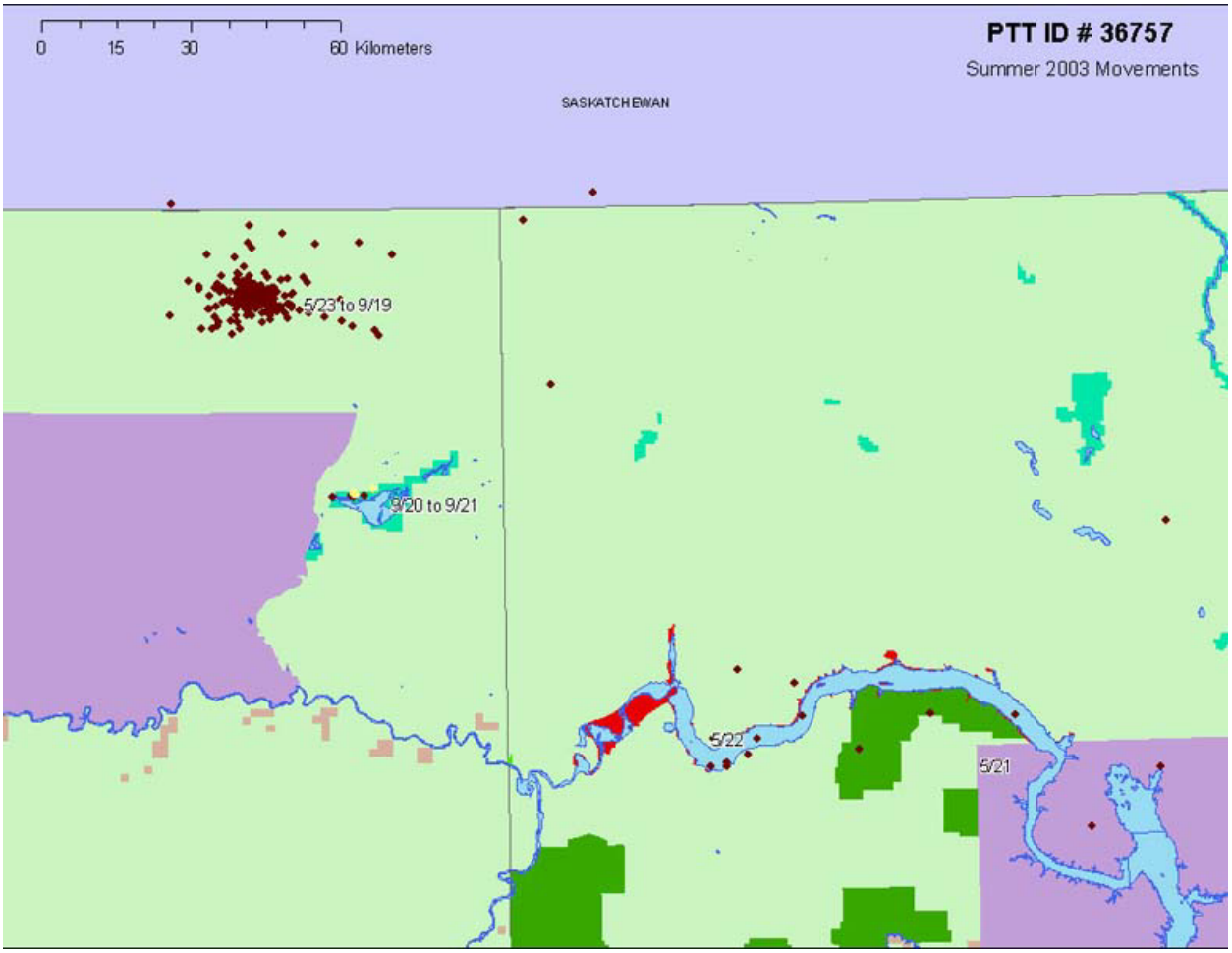

Figure 36. Movements of American white pelican 36757 in the northeastern Montana and northwestern North Dakota during summer 2003.

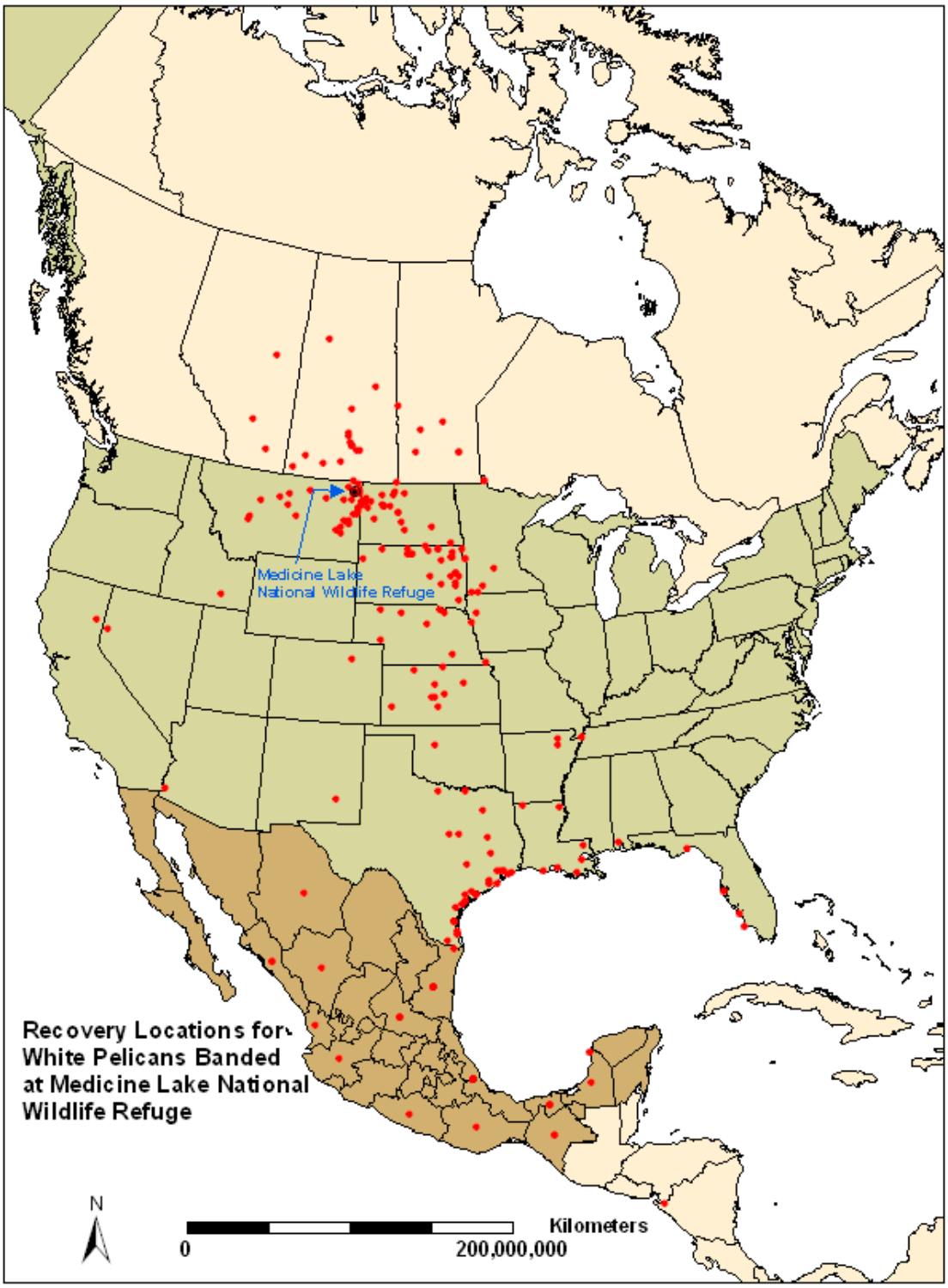

Figure 37. Recovery locations of American white pelicans banded as nestlings at Medicine Lake National Wildlife Refuge, Montana, 1957-1968.