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Demonstration of Satellite/GPS Telemetry for Monitoring Fine-Scale Movements of Lesser Prairie-Chickens

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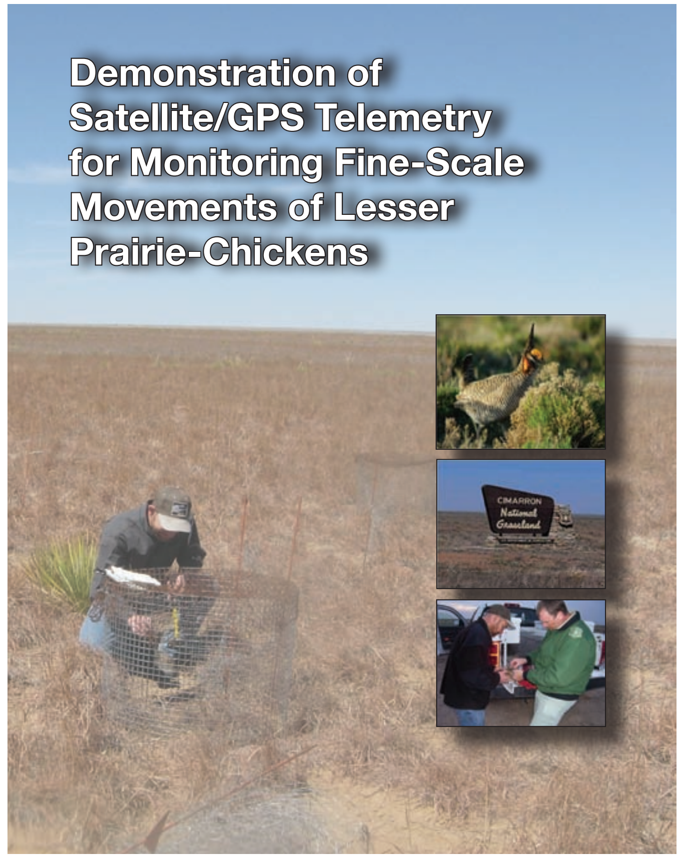

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Center

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TABLE OF CONTENTS

I. INTRODUCTION 1
A. Background 1
B. Need and Objective 2

II. WILDLIFE RADIO TRACKING TELEMETRY 3
A. VHF Tracking Telemetry 3
B. GPS Tracking Telemetry 3
C. Satellite Tracking Telemetry 4
D. GPS/Satellite Tracking Telemetry 5

III. METHODS & EQUIPMENT USED IN DEMONSTRATION DEPLOYMENT 6
A. Equipment 6
1. Argos Data Collection System 6
2. Platform Transmitter Terminals (PTTs) 7
B. Methods 8
1. Capture of LPCs 8
2. Attachment of PTTs 8

IV. RESULTS OF DEMONSTRATION DEPLOYMENT 9
A. Calendar Year 2011 9
1. Data Collected 9
2. Recovery of PTTs 10
3. LPC Movement 11
B. Calendar Year 2012 12

V. CONCLUSIONS 13
A. Performance of PTTs 13
B. Cost-effectiveness of Satellite/GPS telemetry technology 13
C. Summary 14
VI. LITERATURE CITED 15

INTRODUCTION

This project is the result of a proposal submitted by Andy Chappell of the Cimarron National Grasslands. The proposal asked the Technology and Development Program to demonstrate how satellite telemetry might be used to track the movements of the Lesser Prairie-Chicken *(Tympamuchus pallidicinctus)* throughout its lifecycle on a near 24-hour basis.

The core team members for this project were: Andy Chappell (Cimarron National Grasslands), Kraig Schultz (Kansas Department of Wildlife and Parks); Brian Bedrosian (Craighead Beringia South); and Rey Farve (San Dimas Technology and Development Center [SDTDC]).

A. Background

The Lesser Prairie-Chicken (LPC) is considered a “candidate” for listing as a threatened or endangered species by the U.S. Department of the Interior, Fish and Wildlife Service. The LPC is listed as a sensitive species by the Rocky Mountain Region (R2) of the Forest Service, an agency of the U.S. Department of Agriculture, and as a management indicator species on the Cimarron and Comanche National Grasslands.

Figure 1—Lesser Prairie-chicken (male) and its current (occupied) range (from the Natural Resources Conservation Service and Wildlife Habitat Council 1999).

LPC inhabit the sand-sagebrush-grassland communities of the Southern Great Plains of Texas, New Mexico, Oklahoma, Colorado, and Kansas. Movements of the LPC during the breeding season are poorly understood for the national grasslands. The Cimarron National Grassland (CNG) felt that information on both hen and cock movements during breeding and nesting season would greatly aid their conservation efforts for this species.

(Note: Detailed information on the life history of LPCs can be obtained from Robb and Schroeder 2005.)

Figure 2—Cimarron National Grassland.

B. Need and Objective

More detailed information on the continuous movement (throughout the year) of LPCs could help grassland mangers make more informed decisions that might lessen the impacts of the grazing program, oil and gas program, and fire and fuels projects on the LPC.

Radio-tracking telemetry technology is one of the primary tools available to biologists for tracking wildlife movements to get a better understanding of wildlife distribution and habitat use. This technology has been in use for decades, but it has recently advanced (and miniaturized) such that it is possible to track and store data on continuous movements of a wide variety of wildlife at a fine scale (using global positioning system [GPS] satellites) and have that data transmitted via satellites for download from any location. This combination of using satellites to transmit GPS data is known as "satellite/GPS tracking telemetry." (See a more detailed discussion of the various forms of Wildlife Radio Tracking Telemetry in section II.)

The Inventory and Monitoring Program (of the Technology and Development Program) felt that a demonstration of satellite/GPS telemetry would provide Forest Service units with an understanding of what the capabilities (and limitations) of the technology are and serve as a demonstration of the potential efficiency and cost effectiveness of the technology for continuous, fine-scale monitoring of wildlife movements, especially gallinaceous birds. (Gallinaceous birds are arboreal or terrestrial animals; many prefer not to fly, but instead walk and run for locomotion.) Additionally, the data generated from such a demonstration would provide the national grasslands with additional data on LPC movement that could assist in further conservation efforts of the LPC.

As such, the objective of this study was to demonstrate how satellite/GPS telemetry could be used as an efficient and cost-effective tool for monitoring continuous, fine-scale animal movements.

II. WILDLIFE RADIO TRACKING TELEMETRY

The majority of the information in this section was obtained from Mech and Barber (2002), unless otherwise cited.

Wildlife radio-tracking involves monitoring the radio signals sent from an animal-attached device to track the animal's movements. Telemetry is the process of transmitting the information through the atmosphere.

Several distinct types of radio tracking are currently in use for tracking wildlife movements: (1) VHF (very high frequency) radio-tracking; (2) GPS tracking; (3) satellite tracking using the Argos system; and (4) a combination of the advantages of GPS and the Argos satellites into a GPS/satellite telemetry method.

A. VHF Tracking Telemetry

This is the traditional (conventional) telemetry method that has been in use since the mid-1960s. This method typically requires a user to acquire the VHF transmissions from a VHF transmitter (usually in a collar attached to the animal) via a hand-held antenna (figure 3). The location of the transmitter is usually determined by acquiring the transmissions from three (or more) different locations to triangulate the location of the device.

Figure 3—Traditional VHF telemetry uses a directional, hand-held antenna to receive transmissions. (Photo by U.S. Fish & Wildlife Service.)

B. GPS Tracking Telemetry

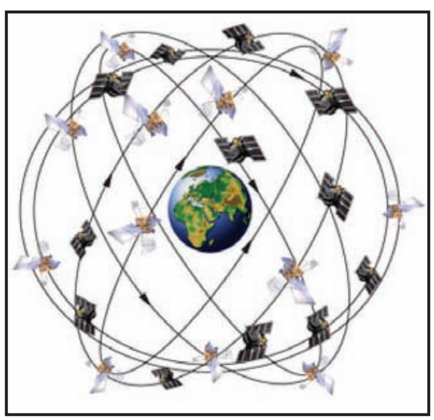

Figure 4—GPS satellite system (from gps.gov).

GPS technology involves a GPS receiver that accepts signals from several of the 24-plus GPS satellites that orbit the earth (figure 4). GPS satellites transmit low-power radio signals that are picked up by a GPS receiver on earth. A receiver that picks up signals from three satellites can locate itself in two dimensions (latitude and longitude); signals from four satellites allow the receiver to locate itself in three dimensions.

GPS tracking telemetry typically involves attaching a GPS receiver (collar) to an animal to record (track) the animal’s location over time. The GPS collar/receiver logs (stores) the location (and time) data on the device until it is retrieved either by: (1) recapturing the animal to extract GPS data stored on the collar, (2) remotely (i.e., wirelessly) downloading the GPS data stored on the collar to a separate, portable (usually handheld) receiver[1]; or (3) remotely relaying the GPS data to the Argos Satellite system. Method 3 is generally considered GPS/satellite telemetry, which is discussed in section II.D.
For a detailed discussion on the state-of-the-technology of GPS telemetry see Tomkiewicz et al. (2010).

C. Satellite Tracking Telemetry

This method has been available since the mid-1980s. Most current satellite telemetry uses the two polar-orbiting Argos satellites to receive ultra-high frequency signals from platform transmitter terminals (PTTs).

The **Argos satellite system** (figure 5) is operated under an agreement between the French Government (French Space Agency) and the United States (NOAA and NASA) exclusively for the collection and distribution of environmental and natural resource data (Argos 2008). Most (about 80 percent) of the transmitters are on drifting or moored buoys, fixed land locations, or on ships and transmit meteorological and/or oceanographic data. With the miniaturization of PTTs in the mid-1990s, more PTTs are being attached to animals to track their movements. (For a more detailed discussion on the history of satellite telemetry see Fancy et al. 1988 and Seegar et al. 1996.)

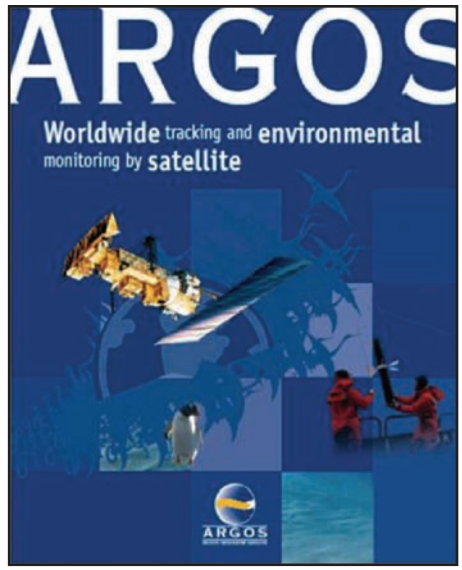

Figure 5—Argos satellite system.

[1]Space Data® can provide a communication platform that is created by a receiver attached to a weather balloon (called a high-altitude SkySite® Network) that could be used to retrieve GPS data and transmit it to users.

Also Microwave Telemetry, Inc. has recently developed (and beta tested) transmitters that utilized the GSM (Global System for Mobile Communications) network. This allows the GSM/GPS transmitter to send the GPS data to cell towers and then to Microwave Telemetry’s server for distribution to customers via e-mail attachments.

Since the two Argos satellites have a mostly polar orbit, they operate best for locations on earth greater than 60 degrees in latitude (i.e., areas not along the equator) (figure 6). For these areas (greater than 60 degrees), the satellites receive signals from PTTs during a 10–12 minute window as it passes over sites about 28 times per day. Areas around the equator (i.e., 0 to 20 degrees latitude) typically only get the two overlapping satellites about six passes per day. A network of ground and atmospheric communication links transfer the satellite data to processing centers in Toulouse, France, and Landover, Maryland, which distribute results to users worldwide (figure 7).

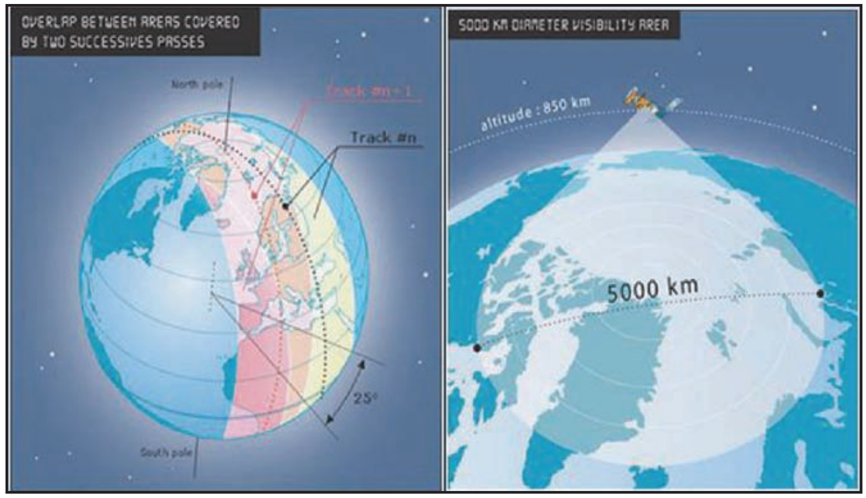

Figure 6—The two Argos satellites have a mostly polar orbit and a “visibility” of 5,000 kilometers (from Argos 2008:4).

An animal-borne PTT location is determined by calculations that rely on the Doppler Effect; that is, the perceived change in frequency that results from the movement of a transmitter and receiver. For a detailed discussion of the polar orbit of satellites and how animal locations are determined using the Doppler Effect, see Fancy et al. 1988:10 and Harris et al. 1990:3.

With satellite telemetry, the user can obtain locations of the animal-borne PTT to within 100 meters (m) to 4 kilometers (km) (330 feet to 2.5 miles). Most readings obtained by the satellite are in the middle of this range. Obviously, technology that has an error range that broad is best used only for far-ranging species.

D. GPS/Satellite Tracking Telemetry

GPS/satellite telemetry combines the technology of both the GPS receiver and satellite transmitter in one device to collect data on animals with a limited range. An animal that carries a GPS/satellite device stores its GPS location data (over time) on the device; this data is then transmitted every few days to the Argos satellite, where it can distribute the data worldwide (figure 7). This technology allows a user to collect fine-scale movement data of animals with limited ranges and have this data transmitted to any location.

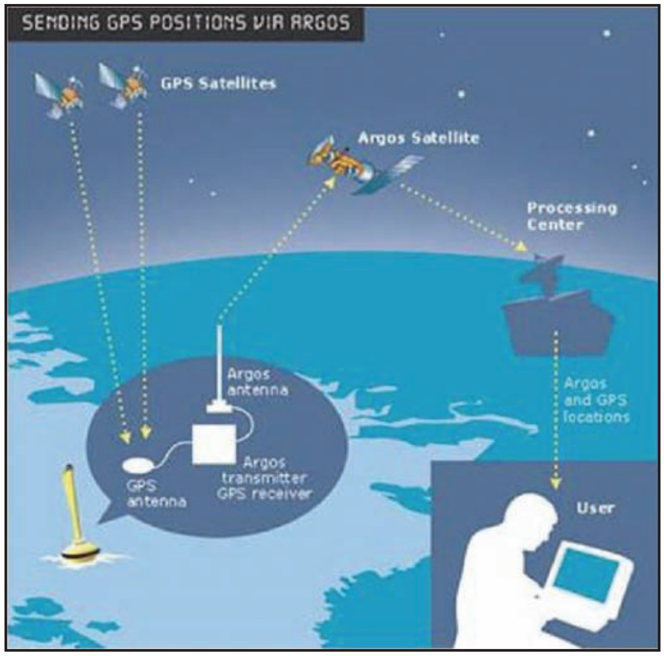

Figure 7—GPS/satellite telemetry process (from Argos 2008:11). The GPS receiver stores location data. This data is later transmitted to the Argos satellite, where it can be distributed to users worldwide.

III. METHODS AND EQUIPMENT USED IN DEMONSTRATION DEPLOYMENT

Below is a description of the equipment and methods used in the demonstration deployment.

A. Equipment

Prior to actually purchasing a platform transmitter terminal (PTT) for satellite/GPS telemetry, a user must first obtain permission to use the Argos Satellite System. Below is a description of the process for gaining use of the Argos System and the process of acquiring a PTT.

1. Argos Satellite Data Collection System

Potential users of the Argos data collections system must first complete a System Use Agreement and Technical Information Form with Argos to obtain their approval for use of the Argos System. The Argos approval process is found at:

< http://www.argos-system.org/html/userarea/quickstart_en.html>.

If the agreement is approved, Argos sends the user an ID number for each PTT that the user plans to deploy. The user ID is needed for the manufacturers of the PTT (see discussion of the PTTs below).

The subscription cost for using the Argos Satellite System depends primarily on the number of PTTs used and the amount of time (hours) that PTTs is actually transmitting data. As such, subscription cost likely will vary from month-to-month depending on a variety of factors that influence how many PTTs are actually transmitting data. The summary provided in table 1 is an average cost (in 2012 dollars) for the subscription cost for using 2–8 PTTs during the most active months that data was transmitted (typically during spring–fall) of the 2 years of the demonstration deployment. This is provided to give the potential user a general sense of what maximum subscription cost/PTT might be for a deployment of PTTs.

Table 1—Maximum monthly subscription cost (in 2012 dollars) for use of the Argos Satellite Data Collection System incurred during the demonstration deployment

# of PTTs	Average Monthly* Cost ($)	Monthly* Cost per PTT ($)
8	345.76	43.22
7	320.57	45.80
5	214.29	42.86
4	183.10	45.78
3	147.89	49.30
2	93.83	46.91
*Average of the months of highest usage—typically April–November.		

2. Platform Transmitter Terminals (PTTs)

To demonstrate satellite/GPS telemetry we purchased Solar Satellite/GPS PTTs from Microwave Telemetry, Inc. (figure 8).

Figure 8—Microwave Telemetry, Inc.

For the demonstration, we used the smallest/lightest GPS/Satellite PTT available on the market—the 22g Solar Argos/GPS PTT (figure 9) (cost in 2011 was $3,950 each). We defined the daily duty cycle for obtaining GPS fixes as: 0400 hours to 2200 hours every other hour. Also, the PTTs were manufactured to upload all GPS locations to the Argos satellite once every 3 days.

Figure 9—Microwave Telemetry's 22g Solar Argos/GPS PTT.

This 22-gram (g) device added less than 3 percent to an average LPC's body weight (as reported for LPCs [table 2]), per the oft-cited 3–5 percent "rule-of-thumb" for animal-born devices. (More detailed discussion on 3–5 percent "rule" is at: Mech and Barber [2002:30] and Wilson and McMahon [2006].)

Table 2—Average body weight of adult LPC (from "Birds of North America Online")

LPC	Average Weight (g)	3% of Weight (g)
Male	790	23.7
Female	740	22.2

Note: During the course of the demonstration deployment we were able to capture seven male LPCs; these birds had an average weight of 824g (actual weights: 790g; 750g; 850g; 900g; 820g; 860g; 800g).

B. Methods

Since SDTDC expected there to be a significant "learning curve" for us to negotiate as we demonstrate this technology, we acquired the services of Brian Bedrosian of the Craighead Beringia South to assist in the demonstration. Brian has extensive experience in using satellite/GPS telemetry to track the fine-scale movements of greater sage-grouse in Wyoming (Bedrosian 2009).

1. Capture of LPCs

During the spring of 2011 (early April to early May), we used walk-in traps on the leks and were able to capture three males and fit them with PTTs.

In the spring of 2012 Craighead Beringia South provided the team with rocket-launched nets (the Coda net launcher and modified portable rocket-net system [see Grubb 1991]), and we were able to capture four male birds and fit them with PTTs.

PTTs were retrieved only after they become dislodged from birds. (See discussion in section IV.2, on PTT recovery.)

2. Attachment of PTTs

Bedrosian made harnesses for the team to use in mounting the PTTs on the rumps of LPCs and instructed the team of the rump-mount technique. (See figure 10)(For more details on the rump-mount, see Bedrosian and Craighead 2007 and Bedrosian 2009.)

Figure 10. Kraig Schultz (Kansas Department of Wildlife & Parks) prepares to release a LPC with rump-mounted PTT.

IV. RESULTS OF DEMONSTRATION DEPLOYMENT

A. Calender Year 2011

As mentioned previously, we were able to capture three male LPCs on the Cimarron National Grasslands (Lek 4) and fitted them with PTTs. One bird each was captured on April 7, 13, and 29. The trapping effort was discontinued on May 9.

1. Data collected

The Solar Satellite/GPS PTTs functioned as advertised by Microwave Telemetry, Inc. The PTTs collected and stored approximately 10 GPS locations onto the device for 3 days and then uploaded the data to the Argos satellite. Argos stores the data for 9 days, so every 9th day we downloaded the GPS locations from the Argos Web site. As such, we had no real time access to location data.

The data that is downloaded from the Argos Web site is in a raw form (text file) and consist of a hodgepodge of information on: latitude, longitude, date, time, temperature, speed, battery voltage, and satellite ID. (Note: Argos provides satellite/GPS data based on the universal Greenwich Mean Time. Dates and times must be converted to local time.)

Microwave Telemetry, Inc. provides parsing software that arranges Argos data into more manageable text file folders. These parsed files can then be imported into Excel spreadsheets.

Table 3 is a spreadsheet that can be generated from the GPS location data.

Table 3—GPS location (latitude and longitude) by date and time of a male Lesser Prairie-Chicken (PPT # 100861) during June 10–12, 2011

GMT[1] date	GMT time	Central[2] Date	Central Daylight Time[3]	Latitude	Longitude
6/10/2011	11:00	6/10/2011	4	37.1275	-101.736
6/10/2011	13:00	6/10/2011	6	37.125	-101.743
6/10/2011	15:00	6/10/2011	8	37.12767	-101.741
6/10/2011	17:00	6/10/2011	10	37.12733	-101.74
6/10/2011	19:00	6/10/2011	12	37.1275	-101.74
6/10/2011	21:00	6/10/2011	14	37.1275	-101.74
6/10/2011	23:00	6/10/2011	16	37.1275	-101.74
6/11/2011	1:00	6/10/2011	18	37.12733	-101.74
6/11/2011	3:00	6/10/2011	20	37.118	-101.736
6/11/2011	5:00	6/10/2011	22	37.118	-101.736
6/11/2011	11:00	6/11/2011	4	37.1205	-101.733
6/11/2011	13:00	6/11/2011	6	37.12433	-101.732
6/11/2011	15:00	6/11/2011	8	37.12467	-101.738
6/11/2011	17:00	6/11/2011	10	37.1245	-101.738
6/11/2011	19:00	6/11/2011	12	37.12433	-101.738
6/11/2011	21:00	6/11/2011	14	37.12433	-101.738

Table 3—con't.

6/11/2011	23:00	6/11/2011	16	37.1245	-101.738
6/12/2011	1:00	6/11/2011	18	37.1235	-101.727
6/12/2011	3:00	6/11/2011	20	37.12717	-101.737
6/12/2011	5:00	6/11/2011	22	37.12717	-101.737
6/12/2011	11:00	6/12/2011	4	37.12717	-101.738
6/12/2011	13:00	6/12/2011	6	37.1265	-101.737
6/12/2011	15:00	6/12/2011	8	37.12683	-101.737
6/12/2011	17:00	6/12/2011	10	37.12567	-101.739
6/12/2011	19:00	6/12/2011	12	37.12767	-101.738
6/12/2011	21:00	6/12/2011	14	37.12767	-101.738
6/12/2011	23:00	6/12/2011	16	37.12767	-101.738
6/13/2011	1:00	6/12/2011	18	37.12667	-101.736
6/13/2011	3:00	6/12/2011	20	37.12533	-101.734
6/13/2011	5:00	6/12/2011	22	37.1255	-101.734

[1]GMT = Greenwich Mean Time. [2]Central = Central Time Zone.

[3]Time is in military (24-hour) time.

As with any GPS device, on occasion a GPS fix was not made; also on a rare occasion the voltage of the solar battery became drained and the device was incapacitated until it recharged. These were very rare occurrences.

2. Recovery of PTTs

PTTs were retrieved only after they became detached from birds. We routinely monitored LPC-movement data to determine if the PTTs had not moved for a day (or two). A stationary PTT would indicate that it was no longer attached to a bird or that the bird was dead.

In mid-July 2011, we observed that one of the PTTs (#100858) was no longer moving and that its battery was drained. Andy Chappell (CNG) used a Trimble Geo XT to visit the last reported location (latitude/longitude) and found the PTT within 20 feet of the location. No bird body parts were near the PTT. Parts of the harness were still on the PTT, and the harness appeared to be cut or chewed.

In late October 2011, we observed that another PTT (#100861) was not moving. After several searches at the last reported location of the PTT (even with the assistance of a metal detector), we failed to recover this PTT during 2011. This PTT was eventually recovered in August 2012 (see table 4)[2].

So, by early November 2011, only one PTT (#100860) (of the three deployed in the previous spring) remained active. Below is a summary of the fate of PTTs in 2011.

[2]It should be noted that during the course of this demonstration deployment, all PTTs were recovered; all were eventually found within 20–30 feet of their last reported locations.

Table 4—Fate of PTTs during 2011

PTT #	Date deployed	Date transmissions stopped	Days of deployment (in 2011)
100858	not deployed	n/a[1]	n/a
100859	4/29/2011	7/18/2011[1]	80
100860	4/13/2011	Still active	262[2]
100861	4/7/2011	10/9/2011[3]	185

[1] PTTs 100858 and 100859 were eventually deactivated and stored for reuse in spring 2012.
[2] Also see table 5
[3] This PTT was presumed permanently lost during 2011 until eventually located in August 2012.

3. LPC Movement Data

We used ArcGIS Online (free ESRI software) to plot LPC movement and to demonstrate a simple, inexpensive means of graphically presenting and sharing location data of birds.

Figure 11 shows locations/movements on the Cimarron National Grassland of each of the three male LPCs in the spring of 2011.

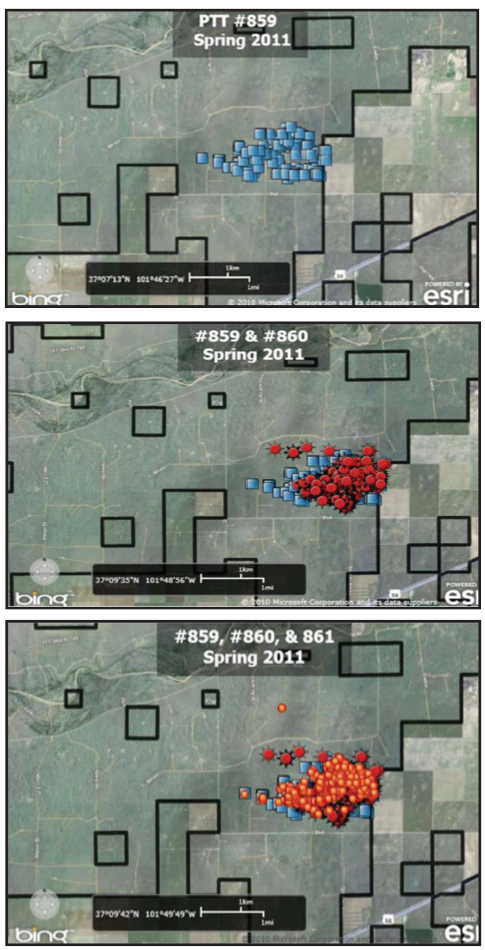

Figure 11—Movements of (male) LPC's (PTT nos. 859, 860, and 861) during spring 2011 on Cimarron National Grasslands. Each point is a GPS location of the bird taken every other hour (between 0400 and 2200) of the day during spring.

See links below for the more detailed presentation of movements (locations) during spring, summer, and fall of 2011 using ArcGIS Online.

Spring 2011 → http://explorer.arcgis.com/?present=225466045cb14592bc0c19789b424e7b

Summer 2011 → http://explorer.arcgis.com/?present=82a5fbe619154cc69a4627950ef0f89a

Fall 2011 → http://explorer.arcgis.com/?present=e6c4de0f38644d618560aa0e45615198

B. Calender Year 2012

During 2012, the team continued the second year of the demonstration deployment. Prior to spring 2012, SDTDC purchased two additional PTTs for the demonstration. Also, Chaparral Oil Company donated funds that enabled us to purchase two additional PTTs for the demonstration.

During April to May 2012, we were able to capture and attach PTTs to four male LPCs. The bird with PTT 100860 (attached in April 2011) was still alive and continued to transmit data during FY 2012. Throughout 2012, the PTTs collected data and perform as they had the previous year (see table 5).

Table 5—Fate of PTTs from April 2012 to Oct 1, 2012.

PTT #	Date deployed	Date transmissions stopped	Days of deployment (as of 10/1/2012)
100858	4/3/2012	---	181
100859	4/4/2012	4/29/2012 (found: 6/5/2012)	25
100860	4/13/2011[1]	---	537[2]
100861	not deployed	n/a	n/a
100862	4/7/2012	----	177
100863	not deployed	n/a	n/a
112784	not deployed	n/a	n/a
112785	4/5/2012	---	179

[1]Note: PTT #100860 was deployed in 2011.
[2]Total days, including days during 2011.

Beginning Oct. 1, 2012 (start of FY 2013), SDTDC turned all aspects of the project over to the Cimarron National Grasslands for their continued funding and management.

V. CONCLUSIONS

A. Performance of PTTs

The 22g Solar Argos/GPS PTT (manufactured by Microwave Telemetry, Inc.) performed as advertised. PTTs continuously (daily) recorded data at our prescribed duty cycle (i.e., every other hour from 0400 to 2200) and stored data for later transmission to the Argo Satellite every third day. The devices remained operational for as long the device's photovoltaic cells could recharge the batteries. It is noteworthy that one device has remained attached to the same bird for nearly 2 years (over 530 days of October 1, 2012) with the device still functioning normally.

No devices malfunctioned during the deployment. All PTT devices that eventually became detached from birds were eventually recovered within 20–30 feet of their last reported location.

In the deployment, we were able to demonstrate that—as long as the devices remained attached and/or the animal is alive and moving (so that photovoltaic cells can recharge the device's battery)— animal movement data can be obtained over a very long period.

B. Cost-effectiveness of Satellite/GPS telemetry technology

Whether (or not) satellite/GPS telemetry technology is cost effective depends largely on whether or not the user has a need to obtain large amounts of fine-scaled location (movement) data of an animal. The cost of PTTs is expensive at about $4,000 each, and the monthly subscription to use the Argos Satellite System can be as much as $42 to $50 a month per PTT. (While we did not lose any devices during our deployment, potential users of this technology should assume that the device is at risk of not being recovered once the animal is released.)

If the user needs large amounts of fine-scale location (movement) data of wildlife, no other telemetry method is practical. Obviously, satellite/GPS telemetry technology provides the user with the ability to be able to download data from the transmitter (through the Argos Satellite System) via the Internet; this saves many person-days of field time that would be necessary to receive transmissions from a traditional VHF device. Also, this technology allows users to acquire multiple, daily locations that is not practical (or realistically possible) using VHF telemetry. The advantage of this telemetry over traditional GPS telemetry is that the user can retrieve data via satellite transmission and not incur costs necessary to physically recapture the animal to extract location data.

C. Summary

SDTDC partnered with the Cimarron National Grassland to demonstrate the efficacy and cost-effectiveness of using satellite/GPS tracking devices (platform transmitter terminals) for continuous, long-term monitoring of fine-scale movements of Lesser Prairie-Chickens during 2011–2012.

We attached lightweight PTTs to birds and were able to acquire fine-scale bird movement data successfully throughout the 2-year period of the demonstration. We used the Argos Satellite Data Collections System to remotely retrieve data from the PTTs via the Internet.

This technology is best suited for investigators with a need to remotely track fine-scale wildlife movements over very long periods. Given that need, this technology is probably the only practical, cost-effective means of collecting that kind of data.

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