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RECOMMENDATIONS FOR FINDING PTTS ON THE GROUND WITHOUT VHF TELEMETRY.

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Abstract: From 1999 through 2003 we recovered 18 30-g Microwave PTT-100 transmitters that had been deployed on Prairie Falcons (*Falco mexicanus*) as part of a study of long-range movements and survival. Falcons had shed six of the recovered transmitters, and 12 were associated with dead birds. We used satellite-received data from ARGOS to determine that PTTs were no longer attached to live birds, to identify the general locations of PTTs, and to predict transmission periods. We located PTTs from the ground in 9 states using a Radio Shack Pro-70 Scanner and ARGOS RMD01 and RMD02 Receivers, manufactured by SERPE-IESM. The technique for finding PTTs on the ground relies on signal strength, which varies with distance and the orientation of the receiver antenna and the transmitter antenna. We used the Radio Shack scanner for long-range (usually up to 4 km) signal detection, and the RMD receiver for closer ranges (usually < 2 km). In this paper, we describe specific techniques for locating PTTs based on our field case histories. The ability to find small PTTs on the ground has numerous benefits. Microwave Telemetry was able to refurbish the 12 PTTs that we had recovered as of December 2001, and we subsequently deployed them successfully on new birds, at a considerable savings. The data we obtained by recovering PTTs was important in confirming mortalities and identifying specific habitats used by Prairie Falcons.

INTRODUCTION

Radio telemetry has become a common technique for biologists to study animal survival and mortality (Norman et al. 2001, Thirgood et al. 2002). Analytical methods have been developed specifically for estimating survival from telemetry data (Heisey and Fuller

1985, Pollock et al. 1989, Kenward 2001, Winterstein et al. 2001). Many avian studies have been conducted with vhf telemetry (e.g., 164-MHz band), and the location estimates and status (dead or alive) of the animals are usually monitored from the ground or aircraft. If a biologist suspects a radio-marked animal has died, attempts to confirm death, determine cause of mortality, and recover the transmitter usually are accomplished by radio tracking on the ground and homing to the transmitter (Samuel and Fuller 1994). If animals occur in remote areas or are wide ranging or rapid moving, the use of conventional vhf telemetry can be limited by logistics or cost. The use of Platform Transmitter Terminals (PTTs) and the Argos satellite system can provide an alternative technique to study survival and mortality in some circumstances that preclude other methods.

We used the Argos satellite system to study the annual movements and survival of Prairie Falcons (*Falco mexicanus*) that nest in the Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho, USA. We developed this research to help understand the population dynamics of this nesting population that has been monitored since 1974 (Steenhof et al. 1999). Little was known about the survival of the Prairie Falcons, and banding (ringing) recovery data revealed that individuals from the NCA moved in several directions up to 2,170 km from their nesting areas (Steenhof et al. 1984). Satellite telemetry was the most efficient method to track their movements and obtain data on when and where they died. We tried to confirm mortality in as many cases as possible. The usefulness of data is greatly diminished if it is not clear whether a transmitter has become detached from a live animal or if the animal is dead; in some cases the animal must be "censored" from the study, thus reducing the sample size. Consequently, it is very important to be able to find the transmitter after mortality is

suspected, and confirm whether the animal has died or if the transmitter is off the animal, which might be dead or alive.

We marked 40 adult female Prairie Falcons during 4 breeding seasons in the NCA. Because the PTTs were approximately 4% of a female Prairie Falcon's mass and USFWS guidelines recommend transmitter weights less than 5 % of body mass, we could not incorporate a small vhf transmitter in or on the PTT. Consequently, we could use only the infrequent (approximately one signal every 70 seconds during "on" cycles) 401.65-MHz PTT transmissions when searching for a PTT we suspected to be on a dead bird or to have fallen from the bird. We encountered a variety of circumstances in which we wanted to confirm the status of the PTT and the radio-marked falcon. The purpose of this paper is to describe some general methods for finding PTTs on the ground, and to emphasize that many factors affect the search effort and must be considered on a case-by-case basis.

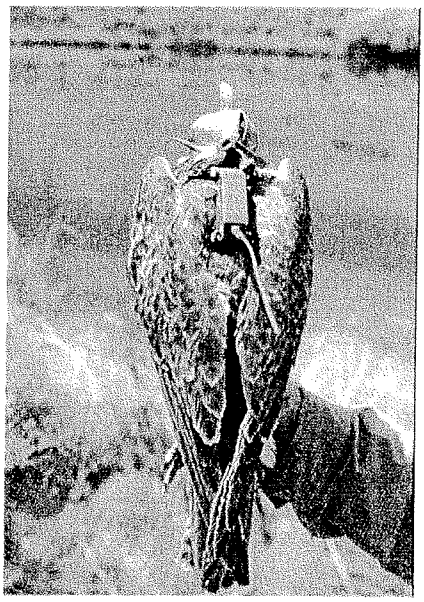

Fig. 1. Adult female prairie falcon (*Falco mexicanus*) with 30-g Microwave PTT-100 unit, just prior to release.

METHODS OVERVIEW

We deployed 40 30-g Microwave PTT-100 units on female Prairie Falcons from 1999 through 2002 (Fig. 1) to study long-range movements and to confirm when and where mortalities occurred. We instrumented 10 birds each year. From 1999 through 2003 we recovered 18 PTTs in 9 states (Fig. 2). Six of the transmitters we found had been shed by falcons, and 12 were associated with dead birds. Falcons shed these 6 PTTs the first year, after which we changed the attachment method. Early attempts to find shed PTTs in the Snake River Canyon sometimes involved more than one search day, but as our methods improved, we were later able to locate PTTs on a single visit. We also had some success in training other individuals to use the technique by themselves: cooperators found 2 of the 18 PTTs in New Mexico and Kansas when we could not be present. We, or our cooperators, searched for but failed to find 2 PTTs (1 in Texas and 1 in Montana) that were still transmitting. In one of these cases we heard signals from the ground, and in the other we did not. Both cases involved a failure to predict transmission timing accurately (see below) from a few receptions spread over several duty cycles, and in both cases we had limited time and resources to reach and re-visit remote sites.

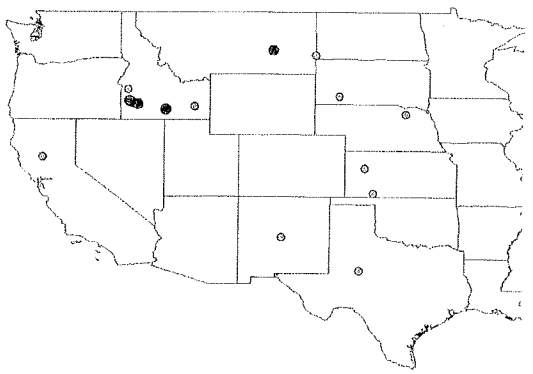

Fig. 2. Locations where we recovered PTTs, 1999-2003. Rose circles represent shed transmitters, and blue circles represent dead falcons.

The following information and recommendations are based largely on our experience with recovery efforts. Please note that the one overriding generality we can convey is that each case has one or more unique circumstances and the following serve as guidelines, not inflexible directions.

DETERMINING WHEN A PTT IS DOWN

We determined that a PTT was no longer attached to a live bird when ARGOS data showed minimal or no activity changes and temperature readings that fluctuated with ambient temperatures. A lack of activity change by itself does not necessarily indicate that a transmitter is down. If the satellites receive transmissions from quiescent roosting birds on successive duty cycles, the activity sensor may not change. We were careful to check whether receptions were in daylight or nighttime hours whenever the activity sensor showed no or minimal changes. Temperature readings < 8 degrees Centigrade, during the cooler months, are usually a sign of trouble. For example, we estimated that the falcon carrying PTT #34205 (Table 1) shed the PTT or died between 12 and 16 January 2003 because the activity sensor stopped changing and temperatures dropped drastically to < 8 degrees Centigrade. In this case, the bird had died and the quality of the locations deteriorated soon thereafter because the PTT was upside down and the tip of the antenna was touching the soil. In some cases, particularly when ambient temperatures are cold, the voltage level also drops after the PTT is on the ground. Voltage decreases with lower temperatures, hence the power decreases slightly, but the PTT's position on the ground is a bigger factor in the deterioration of the location quality (P. Howey, pers. comm.).

Table 1. An example of Argos data, showing values used to determine a PTT was down. Note the change in temperature values between 12 and 16 January as well as the lack of activity sensor changes and lowered quality of location estimates after 16 January.

PTT id	date	time (GMT)	activity	LC	temp C
34205	1/2/03	18:45:09	26	1	30.59
34205	1/2/03	16:54:14	22	0	27.95
34205	1/2/03	16:39:34	22	2	25.64
34205	1/2/03	12:55:45	17	2	30.59
34205	1/7/03	14:44:36	02	1	31.25
34205	1/7/03	14:09:48	02	2	31.58
34205	1/7/03	10:39:00	3D	1	29.93
34205	1/7/03	08:55:53	3D	1	30.59
34205	1/12/03	09:42:43	2E	2	33.23
34205	1/12/03	05:47:37	2A	0	32.57
34205	1/12/03	04:10:48	1E	0	30.92
34205	1/16/03	23:38:40	30	A	6.83
34205	1/16/03	20:26:44	30	Z	8.81
34205	1/17/03	01:24:32	30	Z	5.18
34205	1/21/03	09:41:26	30	Z	4.19
34205	1/26/03	01:44:22	31	B	11.12
34205	1/26/03	01:10:03	31	Z	11.45
34205	1/30/03	15:44:20	31	B	8.48
34205	1/30/03	13:17:15	31	Z	8.15
34205	2/4/03	05:35:26	32	A	3.2
34205	2/4/03	01:32:27	32	Z	2.21
34205	2/4/03	00:59:06	32	Z	4.19
34205	2/8/03	15:34:52	33	1	-0.43

PREDICTING TIMING

After we concluded that a particular PTT was "down," we reviewed the timing of its duty cycle and attempted to predict future transmission periods. The Microwave PTT-100 units we recovered (manufactured from 1999-2002) were programmed to have similar on and off periods. Duty cycles varied slightly among PTTs, and the duration of each on and off period was influenced by ambient temperature: cold weather shortened the

cycle; hot weather prolonged it. The influence of temperature on timing was more noticeable when the PTT was not attached to a live bird. To predict future on-times we noted the first and last receptions of recent duty cycles. We also estimated the beginning and ending times of recent transmissions using Microwave's information frame: "current hour of present ON part of the duty cycle." We predicted on times for several future duty cycles and selected a date with a transmission period that would give us the most daylight time to search for the PTT. The time available for searching is determined by the PTT duty cycle: in our case 8 hours of transmission once every 3-7 days.

The technique that we describe below has worked best on PTTs that are still being received by the satellites. When satellites stop receiving data, it is not known whether the PTT has stopped transmitting or if the PTT is in an area where the transmission is being blocked. To determine if the PTT is still transmitting, the key is to be able to identify a search area based on a high density of recent receptions (preferably received after a PTT is down; see below) and then to time searches so that transmissions can be received from the ground. In at least one case, we were able to estimate the timing of a PTT that the satellites had stopped receiving. The case involved a PTT in a river canyon with steep walls where satellite reception was limited. We provided the Radio Shack scanner to a local resident and asked him to keep the unit on and within hearing range for an entire duty cycle (approximately 80 hours) and to report the first and last signals he heard from the scanner. The information he provided allowed us to schedule a search in which we successfully recovered the transmitter.

Fig. 3. The Radio Shack Pro-70 Scanner and Argos RMD 02 Receiver used to locate PTTs.

BASIC EQUIPMENT

We used a Radio Shack Pro-70 Scanner (programmed for 401.65 MHz) with a 158-mm omni antenna and ARGOS RMD01 and RMD02 Receivers with 84-mm omni antennae to locate PTTs (Fig. 3). The RMD receivers are manufactured by SERPE-IESM of France. The RMD02 receiver is a newer, updated, version of the RMD01. We used the Radio Shack scanner for initial and long-range (usually up to 4 km) reception of the PTT transmissions and the RMD receiver for closer ranges (usually <2 km). The scanner and the RMD emit an audible signal that there has been a reception of a PTT transmission, and the RMD also displays digital information. In some situations we also used a 3-element Yagi antenna designed to receive 401.65-MHz radio transmissions with the RMD receiver. The technique for locating PTTs on the ground relies mainly on transmission signal strength, which varies with distance as well as the orientation of the receiver antenna and the transmitter antenna. Environmental factors such as

topography affect PTT transmissions and receptions similar to the ways they affect the more commonly used frequencies (e.g., 164-MHz band) in wildlife telemetry (Samuel and Fuller 1994, Kenward 2001). The Radio Shack scanner emits slightly different audible signals that reflect signal strength. The ARGOS RMD02 receiver displays signal strength as a numeric value ranging from 1 (weakest) to 99 (strongest). Our RMD02 receiver also displays PTT identification numbers, but only for the 20-bit PTTs and not the newer 28-bit transmitters. Our total cost for receiving equipment was about $1,925 - $2,125: Radio Shack scanner, $100; RMD receiver, $1,700 – $1,900, Yagi antenna, $125. We also were able to rent an RMD receiver. To purchase or rent equipment to detect PTTs, contact Service Argos for a list of potential suppliers or visit their website: (http://www.argosinc.com).

RECOMMENDED STEPS FOR LOCATING PTTS

Below, we outline recommendations for finding a PTT after determining that the PTT is no longer on a live animal and after selecting a day for searching.

BEFORE THE FIELD SEARCH BEGINS

Use all receptions after the PTT is down to refine the predictions of duty cycle timing. Use all location estimates (mainly Class A and better) after the PTT is down to identify the geographic locale where you will try to receive PTT transmissions. In some cases, location estimates obtained when the bird was alive can be helpful. To obtain more accurate location estimates, modify the ARGOS altitude setting for the PTT by telnetting into your Argos account to match the elevation of the downed PTT if it differs by >200 meters from the latest Argos altitude setting. For example, to set the elevation at 15 00 m for subsequent location estimate calculations, the command would be: "/ MOD 22111 / ALT=1500" (where 22111 = the PTT id number).

Before traveling to the general search area, contact local biologists and wardens who are familiar with the area to maximize your efficiency in the field. Enlist their help in identifying and contacting landowners and ask them to accompany you on the search. Assemble a complete set of appropriate field equipment for the PTT recovery attempt (Table 2). If possible, become familiar with the road network and meet the landowners before you begin your searches (e.g., the afternoon before a PTT is scheduled to transmit).

Table 2. Field Equipment Checklist for PTT searches

Argos RMD Receiver
Radio Shack Scanner, or similar type, tuned to frequency 401. 65 MHz
Banding/Salvage Permits (Federal and State)
Maps (several copies at several scales:
some with locations; extras for plotting)
List of past locations, quality by date
Past and predicted timing of transmissions
Extra batteries – 9-volt and AA
Small Phillips Screw Driver to change batteries in RMD Receiver
Binoculars
Camera + Extra Film
Steno Pad & Pencil
Magnet and Electrical tape to turn off PTT when recovered
GPS Receiver
Compass
Cell Phone
Plastic Bags
Calculator
Flagging
Headlamp / Flashlight

DURING THE RECOVERY ATTEMPT

Use whatever road or trail network is available to drive and delineate the perimeter of the area to be searched. Turn the Radio Shack scanner "on" and place it on your dashboard when you are within 7-10 km of your general search area; i.e., before you

reach the actual cluster of locations received from ARGOS. The PTTs we used transmitted approximately every 65-75 seconds (or roughly 50 transmissions per hour). If possible, stop at crests along the road to listen for a signal on the scanner. Standing on the vehicle roof or hiking to a high point with the scanner can be useful for increasing the chance of reception. Initial receptions might occur when you are >4 km from the PTT if there are no obstructions between you and the transmitter, or you might be within only a hundred meters of it if the terrain is steep or if there are boulders or heavy vegetation between you and the PTT. Always be aware of the surroundings and potential features that might influence reception of a PTT transmission.

The Radio Shack scanner with omni antenna usually was effective for initial signal detection and worked best to begin delineating a rough perimeter area around the PTT. We did not use the Yagi antenna for initial signal detection because the scanner body is not shielded; it receives transmissions directly through the external casing, which confounds determining directionality.

Cover as much ground as possible from the road system. Make note of where the Radio Shack scanner first receives the transmission and where you lose reception. Record on a map or in a notebook, the positions from where you receive transmissions while establishing a perimeter around the PTT. Loss of signals on the Radio Shack scanner usually indicates that you have moved out of range or are no longer in line of sight. Remain at the place where you lost the signal and try to obtain one more reception to confirm you have moved beyond reception range. Then move back toward the area from which you last received transmissions.

When the Radio Shack scanner is receiving strong and regular transmissions, turn on the RMD receiver. This might occur before you define the perimeter around the PTT. Turn off the Radio Shack scanner when the RMD receiver is turned on, because we experienced interference during some situations when both were on simultaneously. Use the RMD receiver with the omni antenna and hold the receiver vertically for the initial search. Standardize the receiver height and vertical orientation and where you hold it in relation to your body, and continue using that position to listen for subsequent signals. To help you anticipate the next transmission, watch the RMD receiver; it displays the seconds since the last reception. After you have established the perimeter from roads, you should begin walking to further reduce the search area.

The key to finding PTTs is consistency and patience! After a reception, walk about 50 – 70 meters in one direction with the RMD antenna in a consistent vertical orientation until decreasing signal strength is indicated. Then walk in the opposite direction to find the point of greatest signal strength along that line. Do the same along a perpendicular line, starting at the point with the greatest signal strength. Repeat this process on an increasingly localized scale. Beware: this is a time-consuming process. We found it useful to record signal strength values at the receiver location on a map of the search site and in a notebook. Also, it can be helpful to flag shrubs or fence posts where you received transmissions during this procedure, and to record signal strength values on the flagging with a permanent marker. Color-coded wire flags or survey tape also could be useful. Occasionally the RMD receiver will miss a PTT transmission. When this occurs, attempt a second reception from the same location. If you still do not receive a transmission you are either out of range due to distance or a topographic feature. It is also possible that the PTT has stopped transmitting, or the receiver battery voltage is low. We found that RMD receivers deplete alkaline batteries at a rapid rate when

receiving transmissions (i.e., < 2hrs). Check the battery voltage levels every 30 minutes and replace the 9-volt battery if voltage readings are below approximately 7.5 volts. To ascertain if the PTT has stopped transmitting, go back to a previous strong reception area and attempt to receive a transmission. If this fails, turn off the RMD receiver and use the Radio Shack scanner to attempt reception from strong reception areas.

In situations where the RMD receiver is giving inconsistent or consistently low signal strengths, using a Yagi antenna attached to the RMD receiver can be helpful to obtain values from several directions to determine the direction of the PTT. However, beware that the Yagi is less helpful than the omni antenna at defining a perimeter of the search area using the methods described. The Yagi is a more efficient antenna than the omni. You might obtain the same relatively strong signal from opposite directions. In this case lower the Yagi and use your body to "shield" the antenna from transmissions from one of the two directions, then compare signal strength from the different directions. Next, move in the direction of the strongest signal and repeat direction finding with the Yagi. Remember, the Yagi also is more sensitive to bounced (reflected) transmissions (Samuel and Fuller 1994, Kenward 2001). Also, when you are close to the PTT the Yagi will be "over-powered" by the transmissions and you must revert to the omni antenna on the RMD receiver.

Every search is site-specific and is influenced by the topography and the position of the PTT. Be aware that in some situations you might receive a lower signal strength value when you are moving closer to the PTT due to site-specific topography. If you get a dramatic change in signal strength, look for features that could affect the reception, such as a rock, a nearby rise, or a hill that is now between you and the potential location of the transmissions toward which you were moving. Use the terrain to your advantage, to

block or receive a transmission and thus get clues about the PTT's location. Be aware of potential transmission bounce. For every transmission received or missed, always ask yourself why you are receiving it or not in relation to the receiver location and in comparison to previous signal strength values and receiver locations. Keep in mind that the (as yet) unknown orientation of the transmitter's antenna is also affecting the signal strength values.

Once signal strength values are approximately 70-80, change the orientation of the RMD receiver to horizontal (Fig. 4). Holding the receiver horizontally will decrease sensitivity, thus signal strength values will drop. Do not attempt to compare your horizontal values with values from the vertical position! Standardize the horizontal position of the omni antenna by picking a distant point on the horizon or a specific cardinal direction. Aim the tip of the antenna in this same direction for all subsequent receptions. Resume approaching the location of the strongest signal. When values reach 99 consistently from a horizontal position, remove the omni antenna to further attenuate the receiver sensitivity, but continue orienting the receiver toward the horizon feature or chosen cardinal direction.

Fig. 4. Mark Fuller orients the RMD receiver horizontally near Emmett, Idaho after getting consistently high signal strengths with the receiver in a vertical position.

When you receive very high signal strength values without the omni antenna and the RMD receiver in a horizontal position, you are probably within a few meters of the PTT. It helps to have a second person involved in the search to look for inconspicuous PTTs. We have found PTTs under snow, in dense grass, in stands of tumbleweeds, along riverbanks, and in cryptic situations.

SUCCESSFUL CASE HISTORIES

PTT #5723

After PTT #5723 went down, we used location estimates from the ARGOS system to narrow the search area to a 40-km^2 area in Mitchell County, Texas (Fig. 5). In this example, we had only Class 1 and Class 0 locations to guide us. We received the signal on the Radio Shack scanner while driving south on Highway 163. The signal became audible just after we descended from the Beals Mountain ridge (Fig. 5). We turned on the RMD receiver as we continued driving south. When signal strength (SS) values dropped (B), we turned around and headed north. We took advantage of a knoll (C) and compared SS west of the knoll and east of the knoll. Because SS values with the omni antenna in a vertical position were much higher west of the knoll, we were fairly certain, the PTT was west of the highway.

After obtaining permission from the landowner via cell phone, we headed west (Fig. 5A) on an unimproved road, where we received SS values in the 40s. We continued west until SS started dropping; we then headed south and then east—the road network allowed us to circle the basin outlined in Fig. 5 while using the RMD receiver. We got a SS value of 60 from the ridge at Point E with the omni antenna in a vertical position. Walking throughout the Basin yielded lower SS values so we returned to point E (which

we had flagged) and replaced the omni with the Yagi. Signal strength was significantly higher with the Yagi antenna pointed northwest, so we drove back along the road system to Point F. From Point F we used the Yagi and then the omni to home toward the PTT. We found the PTT near the centroid of the Argos receptions, approximately 1 km from the nearest "1" location and 1.5 km from the nearest "0" location.

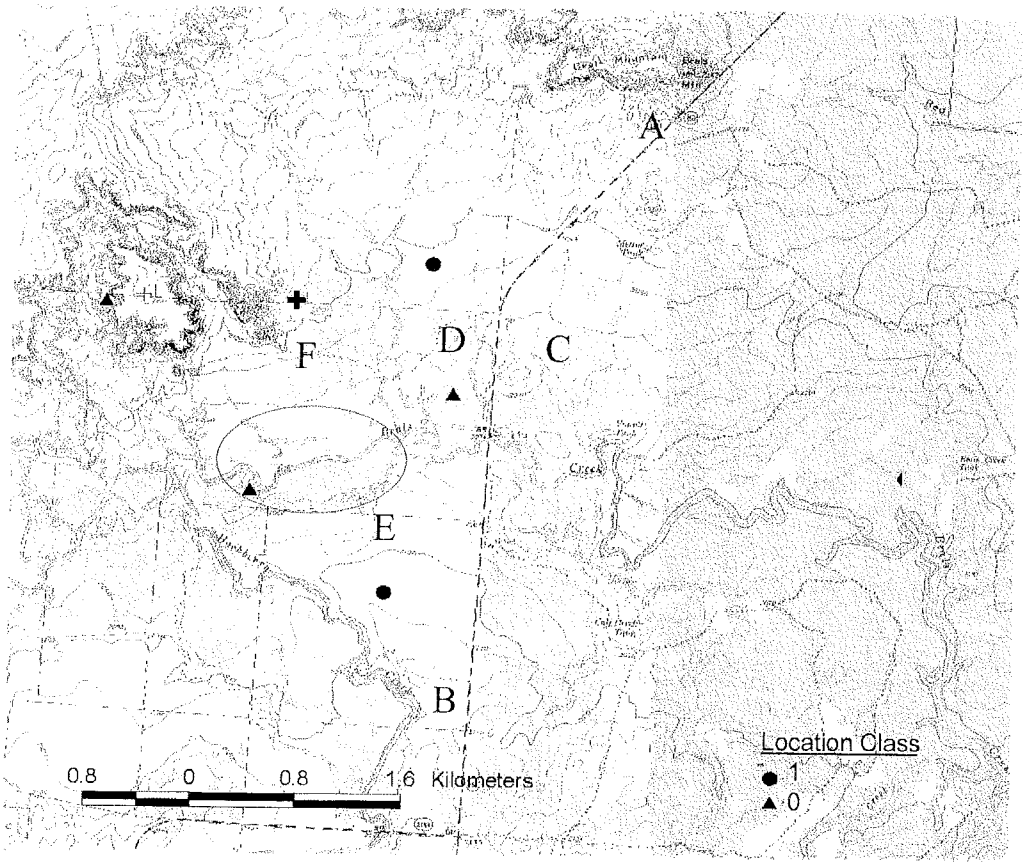

Fig. 5. PTT #5723 search area in Mitchell County, Texas. Red circles indicate Argos Location Class (LC) 1 estimates and red triangles indicate LC 0 estimates. The black cross shows the PTT recovery location.

PTT #34204

The ARGOS location estimates for PTT #34204, after it went down, helped us to delineate a 20-km^2 search area in Caribou County, Idaho (Fig. 6). While driving from the northwest, we turned on the Radio Shack Scanner several kilometers before entering the general vicinity of location estimates.

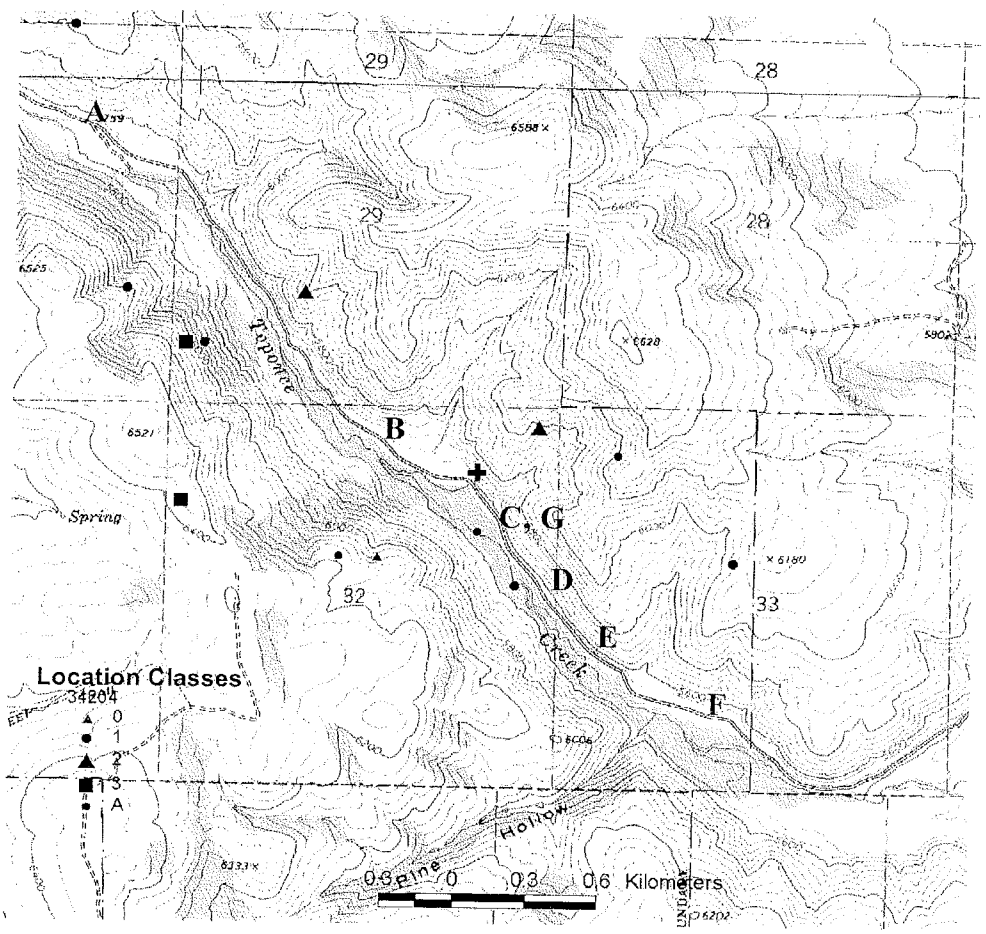

Fig. 6. PTT # 34204 search area in Caribou County, Idaho. Black squares indicate Argos Location Class (LC) 3 estimates. Large and small black triangles indicate LC 2 and LC 0 estimates, respectively. Large and small black circles indicate LC 1 and LC A estimates, respectively. The black cross shows the PTT recovery location.

A) We first detected the PTT transmission with the Radio Shack Scanner. We turned on the RMD Receiver and it displayed a signal strength (SS) value of 26 (RMD Receiver in vertical position with omni antenna).

We continued driving southeast on the road with the RMD Receiver omni antenna in the vertical position. Overall the SS gradually increased and decreased as follows:

B) SS value of 69

C) SS value of 82

D) SS value of 53

E) SS value of 47

F) SS value of 33

G) We drove back to point "C" where SS of 82 was received, and began the recovery attempt using the Yagi antenna. While moving around in this general area we took SS readings with the Yagi pointed in several directions. SS values suggested PTT location was probably somewhere on southwest-facing slope. However, using the Yagi antenna, SS values were now in the mid to high 90's from this slope area.

To reduce receiver sensitivity, we removed the Yagi and began using the omni antenna again, but this time with the RMD receiver and omni in the horizontal position oriented in one specific direction for all subsequent SS readings. The first SS value received with this orientation was 71. We proceeded to move approximately 20-30 meters for each subsequent SS reading, sometimes backtracking if SS values started to drop. Eventually when SS values were in the mid-high 90's, we located the prairie falcon carcass with the PTT.

Discussion and Conclusions

We found that the combination of methods we describe with the use of Radio Shack scanner and RMD receivers was an effective way to find and retrieve PTTs on the ground. There are other methods for finding PTTs on the ground. M. Vekasy (pers. comm.) has been successful recovering PTTs without a scanner, relying on a Yagi antenna with RMD receiver for initial signal detection and direction. His technique requires discrimination between back-bearings and true bearings and emphasizes using structures or high topographic features. However, once he gets close to a PTT, he switches back to the omni antenna because the Yagi is too sensitive.

Howey (2000 a, b) provided some guidance for using a Radio Shack Pro-75 scanner and field procedures to find PTTs, and he noted that a "Gonio" receiver can be used to determine directionality. The Gonio, manufactured by SERPE-IESM (http://www.serpe-iesm.com), is another receiver for detecting PTT transmissions. Although this receiver has the advantage over the RMD receivers in that it indicates direction to the PTT, it is much larger and costs approximately $8,000-$8,500 versus $1,700-$1,900 for the RMD (depending on exchange rates). H. Schulz (pers. comm., schulz.wildlife@t-online.de) used the direction-indicating IESM-GONIO 400 P Argos Ground Receiver (http://www.serpe-iesm.com) to find PTTs on dead White Storks (*Ciconia ciconia*), and he has used it to track from the ground to approach and observe migrants. We, too, have observed live birds on several occasions after homing with the equipment and methods we described above. M. Domeier (pers. comm., domeierml@cs.com) used the Gonio 400 to find PTT popup tags floating in the ocean after they had detached from fish. S. Brodeur (pers. comm., serge.brodeur@pc.gc.ca) used the Gonio 400 from a helicopter to localize 2 downed PTTs in the snow, and Nelson et al. (these proceedings) placed a Gonio on a tripod to find PTTs in forest vegetation.

Some investigators have had success with other Radio Shack products. G. Huschle (pers. comm.; Gary_Huschle@FWS.gov) used a AOR 8000 receiver to find 2 live and three dead Bitterns. Huschle used the receiver and its standard antenna tuned to a 401-MHz frequency to receive the transmissions from a distance (up to 2 miles). A Yagi antenna designed for the 164-MHz band with the receiver tuned to 160.662 MHz (second harmonic of the 401-MHz band) was used at close range (< 50 m) to obtain directionality and home to the PTT. P. Boveng and J. Bengtson (pers.comm., peter.boveng@noaa.gov) used a Radio Shack scanner set at 401.65 MHz and an aluminum foil cone around the scanner omni antenna to find a PTT in a packing crate.

As noted above when PTT data are no longer received through the Argos satellite system, it does not necessarily mean the PTT has stopped transmitting. We recovered two PTTs by searching the general area of the last Argos location estimates, obtaining receptions there with the scanner and RMD02 receiver, and then homing to the PTT. H. Schulz (pers. comm., schulz.wildlife@t-online.de) also has done this with a Gonio receiver, first detecting signals 5 – 10 km from the PTT.

Northstar Science and Technology (http://www.northstarst.com) and Telonics (http://www.telonics.com) sell other equipment that is useful for receiving PTT signals. Microwave Telemetry (http://www.microwavetelemetry.com) has introduced the Ground Track GT system in which a 0.5-g UHF frequency transmitter is incorporated in the PTT, and can be tracked from the ground with their receiver – antenna combination. With such equipment, searchers can apply our general procedures and develop additional equipment-specific field techniques. B.-U. Meyburg (pers. comm.) reminds us of the utility of having a return address label on the PTT so local persons who discover a PTT might return it to you! A private citizen found one of our dead Prairie Falcons, and using information on the band (ring), the PTT eventually was mailed to us.

PTT finding procedures can be time consuming, and the searcher must be flexible and innovative in applying them in each situation. However, recovery can be worthwhile because it can provide important information about the status of the animal. It can facilitate finding and observing live birds or retrieving information from data loggers. It also can be cost effective to recover PTTs. For example, our objective was to instrument 10 falcons each year for 4 years. Because we successfully recovered PTTs 12 times during the first 3 years of the study (9 different PTTs, 3 recovered twice each) we needed to purchase only 28 PTTs to attain our sample size of 40 PTT marked falcons. Assuming that new PTTs cost $2900 and that refurbishments cost an average of $200, this represents a savings of $32,400. This savings does not reflect costs of finding the PTTs (salary and travel), but we had budgeted for these costs because finding carcasses was one of our original study objectives. We turned over the 6 PTTs that we recovered in the final year of the study to a colleague who will have them refurbished and collaborate with us on a complementary new study of falcon movements in a different part of the continent.

By following the guidelines we have outlined, investigators should be able to locate a high percentage of PTTs. We recommend that biologists practice with these guidelines and their equipment before they deploy PTTs, using the transmitters that will be used to mark animals, in field conditions similar to those that will be encountered during the actual study.

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