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The Use of Thermal Imagery in the Aerial Survey of Panthers (and other animals) in the Florida Panther National Wildlife Refuge and the Big Cypress National Preserve

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Introduction

The use of thermal imagery has seen limited application in natural resource science due mainly to its unavailability, limited exposure, expense, and a lack of standardized methods for its use. Present methods for surveying populations of large animals or individual animals such as spotlight counts, mark-recapture, and aerial counters have inherent difficulties and have met with limited success (McCullough, 1982; McCullough and Hirth, 1988; Stoll et al., 1991; McCullough et al., 1994). Thermal imagery equipment can detect a temperature difference (delta-t) of 0.1°C of a large mammal at 1 kilometer effectively eliminating the animal's camouflage coloring and reducing the scene to a white image on a black background. By adjusting the instrument gain the background temperature can be blackened and an animal at a temperature of approximately 35°C becomes clearly illuminated. In aerial surveys of animals this method has advantages over past aerial survey procedures because a number of the variables that can affect an observer's count of an animal (sightability) and result in sample bias such as transect width, altitude, and speed can now be accounted for through thermal imaging and video tape enhancement. The present study investigates the use of thermal imagery in the 3.4 to 5 micron spectral range in the aerial survey of animals in southwest Florida.

Methods

Aerial surveys were conducted in the Florida Panther National Wildlife Refuge and the Big Cypress National Preserve from April 4 to April 6, 1995 (Figure 1). Flights were conducted using a Bell Ranger rotary winged aircraft from between 1/2 hour before sunrise to about 1 hour after sunrise on successive days. Surveys were conducted in the early morning when background temperatures were near thermal equilibrium. Direct sunlight can cause differential heating of surface features and result in confusing heat signatures. The canopy cover (mostly pine and cypress) was near

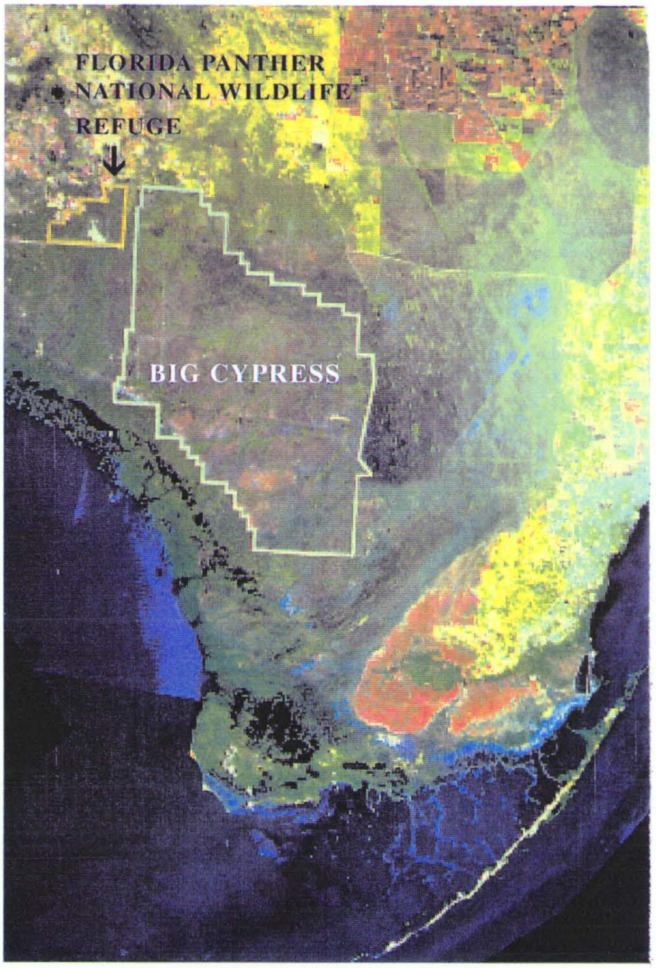

Figure 1. Research Sites: Florida Panther National Wildlife Refuge and Big Cypress National Preserve.

complete development. Flights were flown at an elevation of approximately 180 meters and a speed of between 40 and 50 knots with some identification of signals at 100 knots. An *Infracam*™ thermal imager which operates in the 3.4 to 5 micron spectral band was used to record data to an 8mm video recorder. The camera field of view is 8°x8° which results in a ground swath width of approximately 30 meters and was used to pan a 60 meter transect width. Total system weight (camera, recorder, batteries, and stabilizer) is approximately 3 lbs (Figure 2). Images recorded were displayed later for specific image identification with frame-grabber technology.

Two surveys were conducted. The first investigation used random transects to survey for animal signals and the second employed radio collared panthers as search targets. Random transects for the first investigation were flown using Global Positioning System technology over both the Fish and Wildlife Panther Preserve and the Big Cypress National Preserve on three consecutive days. The second survey used radio-collared panthers whose approximate location was determined by telemetry from a Cessna fixed-wing aircraft and then overflown with the Bell Ranger rotary-winged aircraft. When thermal signatures of large animals were located, the aircraft circled to obtain positive identification.

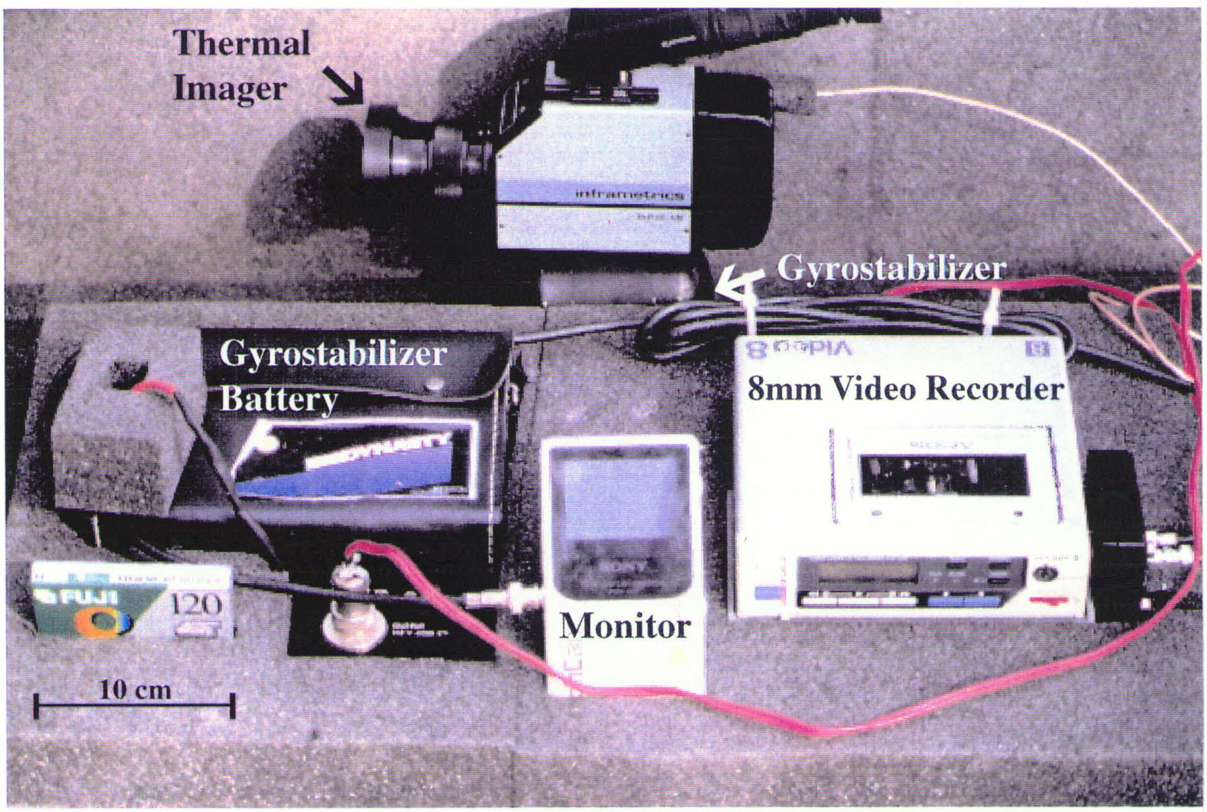

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Figure 2. Thermal Imaging System.

Results

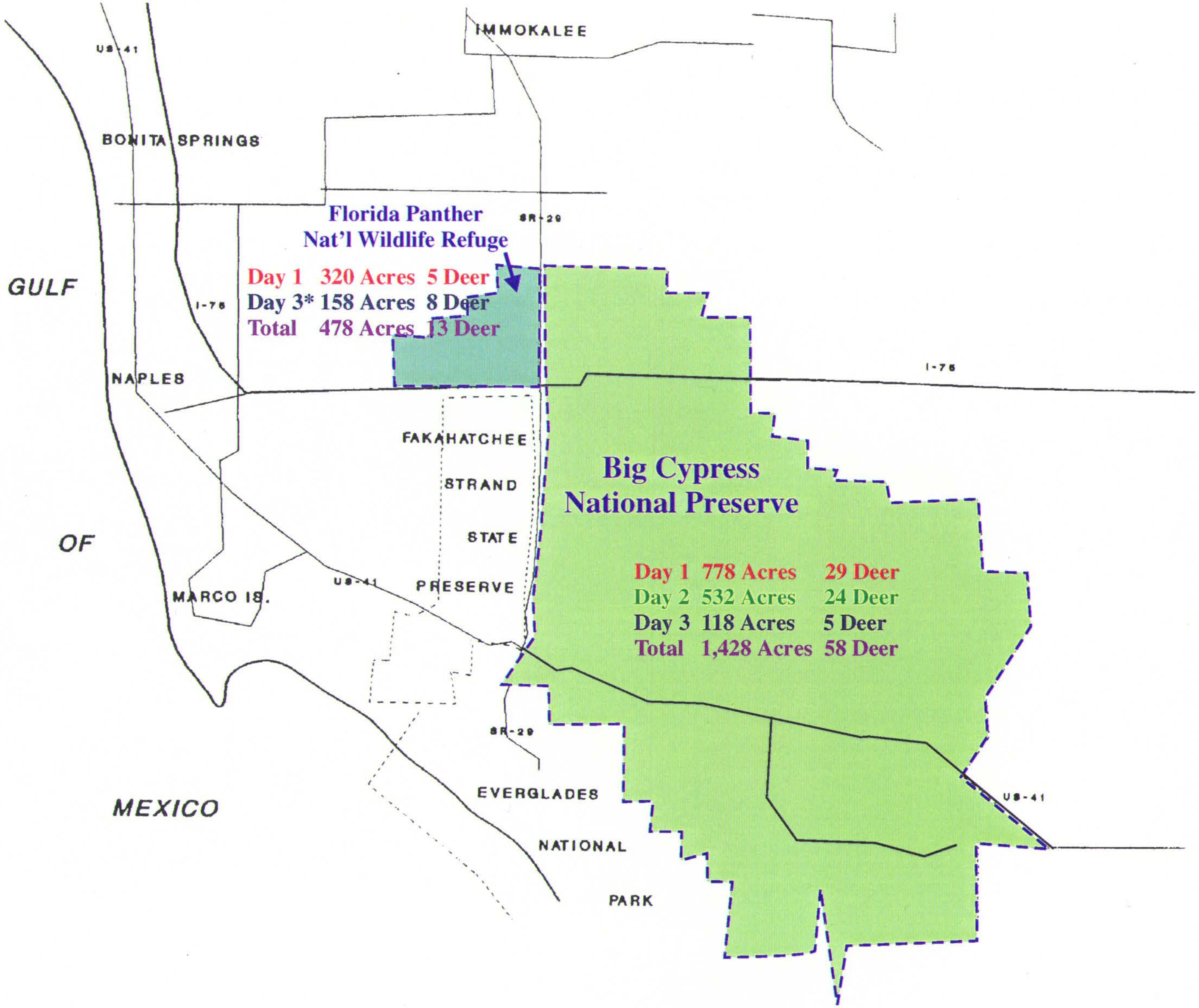
The first survey involved three consecutive days of random transect flights. The first day covered 1098 acres with a total sighting of 34 deer. The second day covered 532 acres with 24 deer. The third day covered 276 acres with 13 deer, 4 pigs, 1 bear and numerous birds. A total of 1906 acres were flown in a total surveying time of 95 minutes with 71 deer counted (Figure 3). A total of 106 thermal signatures of animals (including cows and small unidentifiable signatures and excluding birds) in their natural habitat were recorded in 100 minutes of video tape.

The second survey identified radio-collared panthers in dense tree and saw palmetto (*Serenoa repens*) cover. All three panther heat signatures were located almost immediately upon flyover, though one signature was identified only after a review of the video tape and another was only recorded for a short period before the panther moved deep into dense undergrowth and the signature was lost. Hovering time was kept at a minimum and distance to the panthers at a maximum to avoid excessive disturbance. Specific signatures of cow, bird, deer, panther, and bear were identified. Deer thermal signatures were visible in wooded areas suggesting that surveys could be conducted over wooded habitat, particularly in temperate climate zones during leaf-off.

Discussion

A number of techniques have been used in the past to survey large mammal populations and these techniques have included the use of thermal imaging. Recently, a Forward Looking Infrared (FLIR) system operating in the 8-12 micron spectral band was used to conduct a survey of white-tail deer population (Wiggers and Beckerman, 1993). This imaging system operated in a serial scanning mode (a high speed scanning mirror reflects the infrared radiation onto a four-by-four array of mercury-cadmium-telluride detectors) with a minimum resolvable temperature difference of 0.25°C and has available a wide field-of view (28 x 15°) and a narrow field-of-view (5 x 2.3° with a 5.6X magnification). In this work, the sex and age of white tail deer confined to pens were determined by flying the imager in circles around the pens and scanning at oblique angles. Wiggers and Beckerman (1993) found that the wide field-of-view would not permit the identification of species so the narrow field-of-view was used for all of their test scenes, and only scenes containing imagery that was unobstructed by tree canopies were selected for their analysis. Under these conditions they were able to identify the species, sex and age (adult or fawn, when in close proximity) for certain altitudes and aircraft speeds.

The thermal imager used in the present study employs a 256x256 platinum silicide state-of-the-art staring focal plane array operating in the 3-5 micron spectral range. This system is designed to simply stare at a scene such that the radiation emitted from different features in the scene is integrated over a longer period of time than is possible with a scanning focal plane array. In this way, it can sense very low-intensity ambient infrared radiation (minimum resolvable temperature difference is 0.05°C). Because of the staring array, the thermal sensitivity of this imager is an improvement over scanning systems operating in the 8-12 micron spectral region which are of much larger size, weight, and



*Day 3 flight into Florida Panther National Wildlife Refuge aborted due to fog.

Figure 3. Deer counts and acreage covered per day for Florida Panther National Wildlife Refuge and Big Cypress National Preserve.

power consumption. Our camera was equipped with a 50-mm lens which provided a modest field-of-view of 8x8° and was used in panning mode to increase the transect swath width. In a study of black bears in Louisiana we expanded this capability by using two identical cameras such that their fields-of-view were aligned to provide a total fixed field of view of 15.5x8°. Pojar and others (1995) discuss the need to define the exterior boundary in aerial transect surveys and that narrow (<100m) transect lines may increase observer efficiency. The exterior boundaries in this system are discretely defined by the camera field-of-view and the transect width never exceeded 60 meters.

The camera was typically handheld from a rotary-winged aircraft with a door removed so that the operator was always provided an instantaneous access of approximately 160° field-of-view. A hand-held gyroscopic stabilizer was fitted to the bottom of the camera adding another 1 lb to the unit. The stabilized unit allowed lower altitude flights at faster ground speeds without encountering high frequency pointing instabilities of the camera. In all, the increased thermal sensitivity, increased pointing stability, adjustability of gain and light level for changing ambient conditions, provides significant improvements over past efforts using thermal imaging techniques.

Using this system we have been able to identify numerous different species in the field including deer (Figure 4), bear (Figure 5), pigs, panthers, squirrels, and various species of birds. Much of this was accomplished in the presence of heavy tree canopies and heavy ground cover such as saw palmetto and included animals which were bedded down. In fact

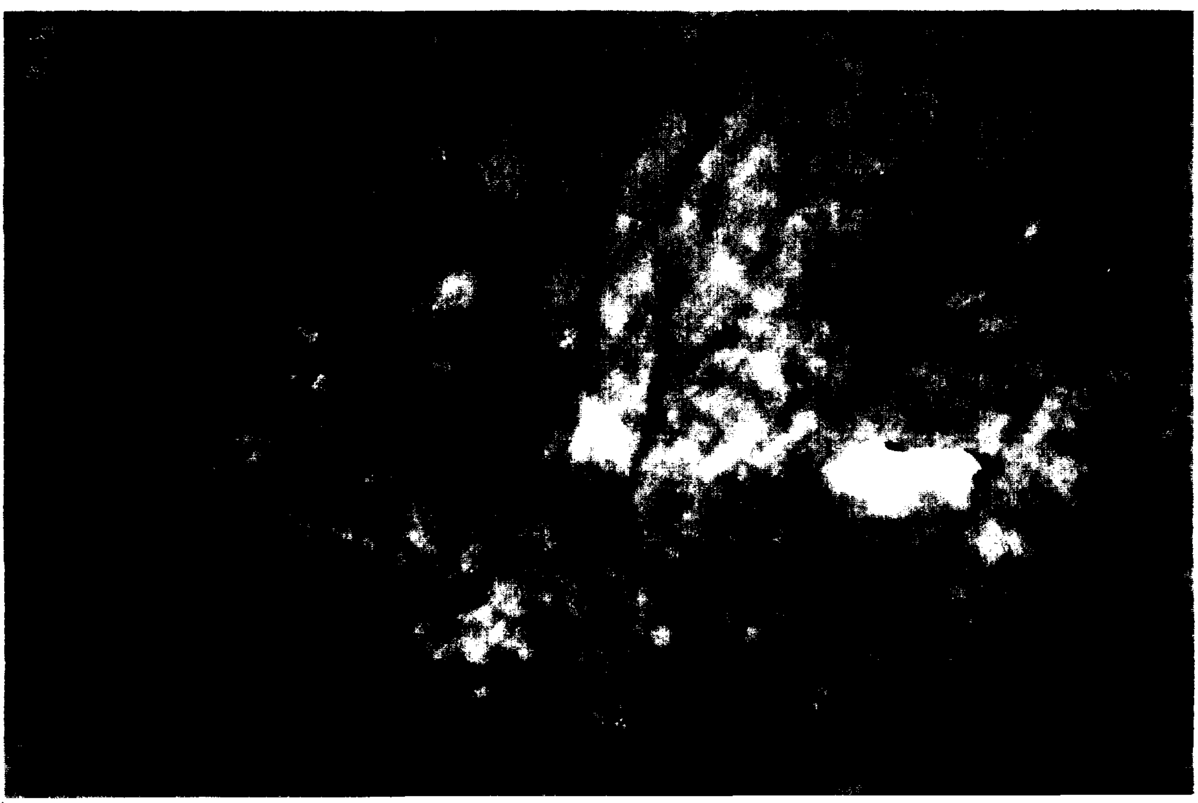


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Figure 4. Thermal image of deer.

Figure 5. Thermal image of bear.

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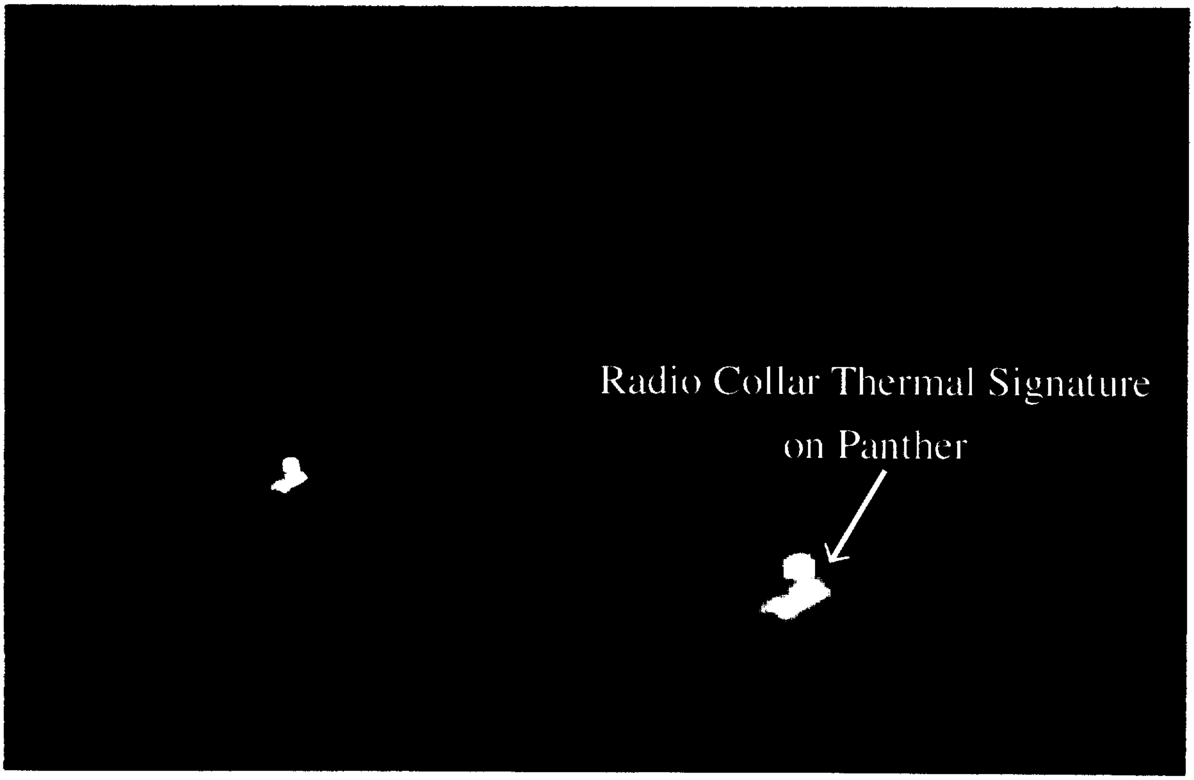
it may be possible to distinguish radio-collared individuals from non-radio-collared individuals of the same species by virtue of the distinct feature present in the thermal signature produced by the thermal shielding of the radio collar itself (Figure 6).

The use of thermal imaging in aerial observation of animals can be an accurate method for assessing roosting bird populations, deer populations, and in search and location of endangered or threatened species such as the Florida panther or the Louisiana black bear. Preliminary data from this study suggests that stratified random transect sampling using the thermal imager in an aerial survey mode could increase the accuracy of population estimates of deer, bear and panther. To determine the optimum amount of sampling without sacrificing accuracy, computer simulation modeling can be done by the Monte Carlo method. This entails total sampling of the target area and modeling the number of transects necessary to achieve approximately the same level of accuracy as total sampling. For example, the swath with of the equipment at an altitude of 600 meters is 114 meters. If our target area is 2,000 meters wide then 20 transects of distance X would be required for complete sampling. The amount of flight time and expense increases with increasing X and increasing width. It would be beneficial to achieve the same accuracy as total sampling with the least possible amount of transects. The potential number of combinations of random numbers of transects in this example is large (20! or 2.43×10^{18}), however these can be modeled from the raw data to determine the probability of accuracy for each category of random transect numbers.

Raw data will contain the number and position of "successful" transects in the total data set. For example, if 4 out of 20 transects were successful (i.e. an animal was observed) it would

Figure 6. Thermal image of radio-collared panther.



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be inaccurate to assume that only 20% of the field needs to be sampled since the probability is very low that only transects containing targeted species would be generated from random transects. It is clear that more transects would be required. Monte Carlo simulation of the total data set would model the probabilities of obtaining accurate information from categories of transects. An example of what might be found is that the 6-transect category would give "accurate" information (i.e. not significantly different from the total sampling scenario) 65% of the time and the 9-transect category would give "accurate" information 85% of the time. With this information, balancing the probability of accuracy versus cost of flight time would be possible. If funds were the limiting factor, then this model could also be used to determine the confidence level of the data which could be purchased.

Transect surveying for the Florida panther may be more difficult because of the large survey area (Big Cypress National Preserve and Florida Panther National Wildlife Refuged, combined) and the small number of panthers. However, smaller isolated areas could be surveyed for panthers or, if sign (tracks or scat) indicate that a panther is in a specific area, the thermal imager could be used to located the panther and direct capture crews to the site. Prototype development of zoom lens capability on the thermal imager is underway and will make the search and location application even more efficient. The effectiveness of thermal imaging surveys can be further enhanced by conducting search activities during the winter when the temperature difference between the background and the animal would be greatest.

Other Night Vision Equipment Applications

Studying the activity of animals during the diurnal period may limit the quality and quantity of the data. Significant differences in animal behavior or habitat use may occur between diurnal and nocturnal periods (Beyer and Haufler, 1994).

Artificial light has been shown to alter the dispersal patterns of juvenile panthers (*Felis concolor*) (Beier, 1995) making the use of night vision equipment (image intensifiers or extremely low light level cameras) well-suited for covert, non-intrusive observation of panther activity. Preliminary investigations using a night vision 24 hr monitoring station have been used to observe black bear den activity in the Atchafalaya Basin in Louisiana and to monitor game trails in the Great Dismal Swamp in Virginia. The system uses a daylight camera bore sighted with a low light level camera or image intensifier camera with a motion detector/heat sensor trigger. The entire camera system can be contained in an 8 cm x 8 cm area. The system includes a transmitter to send the video signal to a time-lapse video recorder set up in a secure location and a light level sensor to shift between daylight and nighttime viewing. The system has a solar charger and battery power supply and is equipped with an infrared light source for increased illumination during nocturnal observation periods. When the trigger is tripped the camera records a one minute segment or until the activity ceases.

This equipment has real application for monitoring panther use of highway underpasses, recording activity along game trails, and observation of denning and nursing activity.

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