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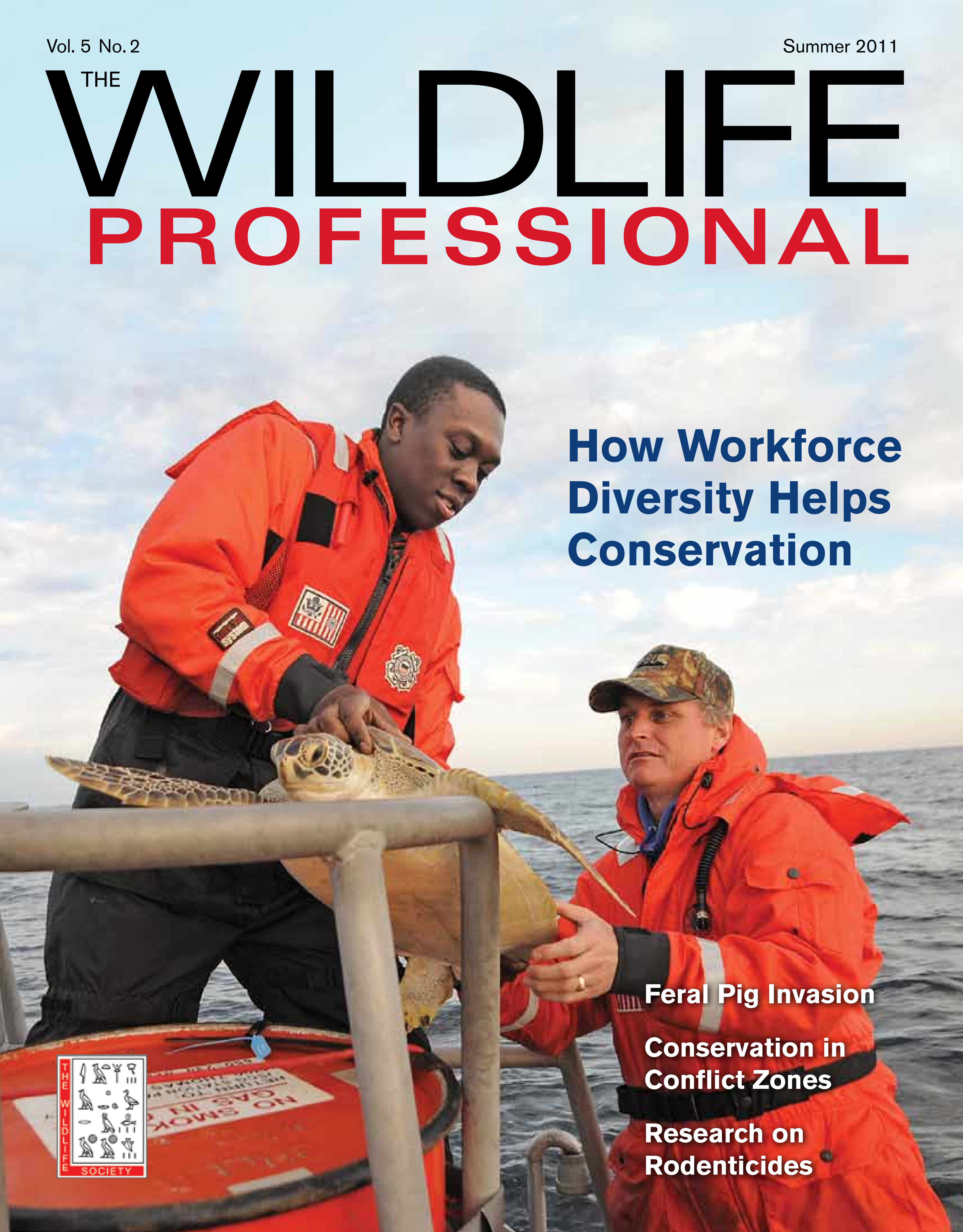

How Workforce Diversity Helps Conservation

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Conservation in Conflict Zones

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THE WILDLIFE SOCIETY

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ROTATING FEATURES

DEPARTMENTS

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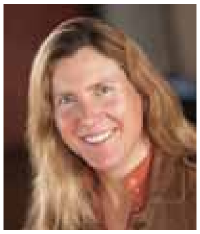
"We Can See a Deer's Ears from Here"

WILDLIFE INVENTORIES USING INFRARED AERIAL CAMERAS

By Susan Bernatas



Credit: BBSG Photography

Susan Bernatas, CWB, is President of Vision Air Research in Boise, Idaho.

Believe it or not, a deer's ears can give off a lot of energy—so much so that I can spot them from 1,500 feet above the ground. I gain this 'bionic' ability by using an infrared sensor attached to the wing of a Cessna 206 airplane. Infrared (IR) sensors, which measure the heat emitted from objects and organisms, provide useful information for a host of applications, from police surveillance to weather forecasting to, more recently, wildlife research.

Use of IR imaging for wildlife was uncommon back in the early 1990s, when we had to do tracking and population counts the hard way. During a bighorn survey in Idaho, for example, I worked with a team using helicopters to count the animals, which lived in steep, inaccessible canyons. Unfortunately, the noise of the helicopters quickly scared the animals off. I looked into alternative technologies that would avoid stressing the bighorns, including night vision goggles, ultralight planes, even balloons. Then I read about infrared. To see if infrared sensors attached to planes could identify bighorn sheep on the ground, I helped secure a contract with the Air Force for a test study. The experiments worked: We could sight bighorns clearly with infrared, while flying high enough that the animals didn't move when we passed over (Bernatas and Nelson 2004).

Credit: Vision Air Research

Posing by "R2D2," the infrared sensor attached to the wing of a Cessna plane that is used to capture images of wildlife on the ground, Art Rodgers of the Ontario Ministry of Natural Resources and author Susan Bernatas prepare to survey moose from 1,000 feet up.

Soon after that, I mortgaged all I owned to start my own IR survey company. Now my company and others have opened the door to using infrared to survey for wildlife on the ground. I've used IR sensors to study sage grouse, elephants, elk, cattle, white-tailed deer, and black bears, to name a few. Using IR may seem high-tech, but the concept is straightforward: It's simply another way to find and count animals on the landscape.

Seeing Things in a Different Light

Like a typical aerial survey, an IR survey involves a plane, a pilot, and a biologist "spotter" on board. With IR, however, that spotter is actually the sensor operator. I perform that duty, sitting directly behind the pilot, next to the left wing where the sensor is attached. The sensor is housed in a stabilizing container we call a ball or gimbal (picture R2D2 from Star Wars). I can maneuver the sensor to the angle I want using a joystick, occasionally asking the pilot to change directions to get a better view. This type of IR imaging, by which you aim and focus the sensor itself, is called forward-looking infrared or FLIR. It's also possible to mount a sensor that looks straight down from the plane—a less expensive technology. But that fixed angle reduces the versatility of imaging, and makes it hard to sight animals in areas with a lot of relief, snow, or background features such as rocks or puddles.

Everything with a temperature above absolute zero (-273°C) emits IR energy, so IR sensors can detect "heat" in the middle of a New England stream in January. However, researchers will need to choose different types of sensors depending on the survey.

For example, different sensors can collect either short (3-5 micron) or long (8-12 micron) wave energy. Short-wave sensors are a bit better for warm, humid environments—since moisture affects how IR waves are absorbed, attenuated, or reflected—but fail in extreme cold. Long-wave sensors are less likely to include "noise" from solar reflection off water, some rock types, snow, or other reflective surfaces, making them the best choice in most of North America during the winter.

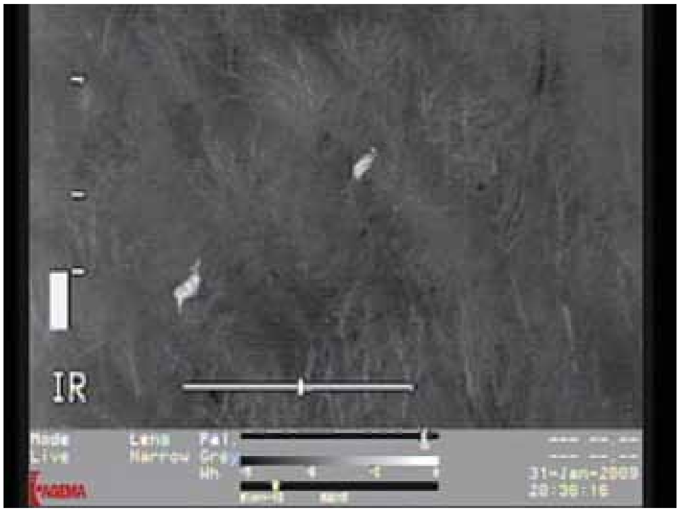
Resolution can also vary from sensor to sensor and, just as for point-and-shoot digital cameras, can make a big difference in image quality. Sensors have two types of resolution: thermal and pixel size. Thermal components are so precise that almost all sensors on the market can detect as little as a 0.1° C difference between the background and the subject, and thus work even in warm conditions. I've used FLIR to identify wild horses and burros in Yuma, Arizona, in the heat of July.

Pixel resolution is what gives us the ability to "see" precise shapes like a deer's ears. This is a key criterion for wildlife applications, since we not only want to detect the hot spot but also want to know if it's a deer, a moose, or something else. The more pixels filled by a target animal, the easier it is to distinguish body shape or morphological characteristics. With a high pixel resolution sensor, it's possible to conduct surveys on multiple species at the same time, as different species have their own unique thermal signatures. White-tailed deer appear as though their heads are detached from their bodies because of thick fur on their necks. Elk have patterning on their flanks. Bighorn sheep have hot heads. Cattle look bright hot with no real pattern until the sensor is adjusted to allow us to see their backbones, which are cooler than the rest of their bodies. Chickens are harder to detect until you find a little head dancing around the farmyard.

The Power of FLIR

In the 15 years that I've been working with FLIR for wildlife and animal applications, I've participated in a wide array of studies:

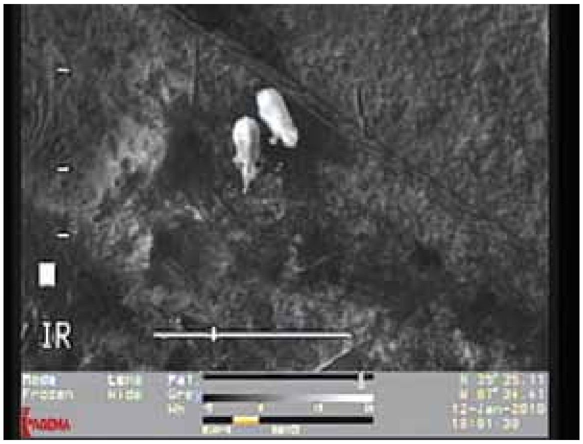
- In Delaware, I worked with the Department of Natural Resources to survey a two-by-eight-mile block in each of 17 management units across the



Credit: Susan Bernatas

Through the lens of an infrared sensor, two moose shine bright white against a backdrop of dark conifers. After adjusting the sensor to pick up fine patterning, author Susan Bernatas can distinguish male moose from female, and older from younger animals, all based on specific thermal signatures.

  state. The IR survey provided geo-referenced groups of deer and the number of deer within each group—useful information for a range of management purposes.
- During an elk survey on fenced land owned by a hunting club in northern Michigan, we learned that the elk bedded down at night under conifers rather than foraging like wild elk would, perhaps a response to living in an area with feeding stations and enclosed by a high fence.
- During a moose survey in northern Ontario, Canada, I located moose using IR and then toggled over to the color camera, which is housed in the same structure as the IR sensor, to observe enough details about the animals to verify age and sex. After locating many moose, I realized I could classify the age and sex using FLIR alone. Males have hotter, broader heads than females, among other subtle differences.
- One night while surveying deer at Brookhaven National Laboratory (BNL) on Long Island, I noticed that the deer had a ghostly appearance in IR, much fainter than the bright and strong signature given off by the deer I had just seen in an adjacent suburb. There was no evidence of atmospheric interference, such as a fog layer, because the shrubs and hard targets, such as buildings and cars, looked crisp. The BNL biologist later indicated these were rather sickly, undernourished deer. Though the pos-



During a survey at a captive elephant facility in Tennessee, the animals' distinctive shape stands out–including trunks, ears, and torso. Elephants are bigger than the typical study animal, but even similar-looking species, like elk and moose, can be distinguished from one another by their distinctive infrared emission patterns.

Credit: Vision Air Research/WWF AREAS Programme

sibility needs to be further investigated, this seems to open the door for using IR to evaluate overall body condition in wildlife.

Clearly FLIR offers a solution to many surveying challenges. IR surveys also have characteristics that set them apart from other techniques. Among the advantages:

Safety. Any aerial survey has its risks, but those risks rise as flight altitude declines. Fixed-wing aerial surveys often fly just 300 to 500 feet above the ground, and helicopter surveys also fly low, often in dangerous, steep terrain. Using a FLIR sensor, researchers can fly between 1,000 and 1,800 feet above ground, yet can still get much the same information—including age and sex data—with much less risk. In addition, by using FLIR, we can pivot the camera to the angle we want, rather than asking the pilot to make dangerous orbits of a certain spot to get a particular visual angle on an animal.

Less distress for wildlife. As with the bighorns, low-level flights create noise that can disturb animals on the ground, causing them to use valuable energy reserves and possibly abandon their normal territory. Though flying 1,000 feet over the animals is by no means silent, we've observed that animals are much less likely to change their behavior with FLIR surveys than with lower-level aerial survey techniques.

Detectability. Finding an animal is more than half the battle in wildlife surveys, and using FLIR can provide high detection rates. In our study of bighorn sheep, we used radio-collared animals as a reference and determined that the IR survey had a detection probability of 89 percent (Bernatas and Nelson 2004). In addition, some visual surveys require snow to be on the ground for animals to stand out, or find that excessive tree cover makes it harder to spot animals. FLIR reduces these concerns.

Versatility. With FLIR, we can toggle between color video and infrared, opening up a range of different possibilities to study. Sometimes color is preferable for seeing distinctive markings, such as identifying antlers to determine a male moose from a female, or distinguishing an elk from a deer. It's also possible to record both infrared and color videos simultaneously, and then go over the images later for analysis.

There are some drawbacks to IR. For one, IR and water don't mix. Rain and high humidity will degrade an IR image, and IR sensors can't detect organisms beneath the surface of a body of water. Deciduous tree leaves can also pose a challenge, as the energy of photosynthesis can cloud an IR image. In temperate areas, fall and winter are the best times to obtain suitable images of wildlife on the ground.

The bells and whistles of FLIR don't offer a substitute for detailed survey design and statistical analysis. As with any survey, a biometrician can be an important team member for larger IR surveys, helping define the population of interest, choose a survey design, and recommend a number of replicates. Beyond that, a triad of skills is needed to conduct a quality airborne infrared wildlife survey: good aviation support to select the best aircraft, an understanding of thermography to select the right sensor for the application, and familiarity with wildlife habitat use and behavior. With those elements in place, seeing a deer's ears may be just a flight away. ■

This article has been reviewed by subject-matter experts.

To watch video footage of deer from Susan Bernatas's forward-looking infrared sensor, go to this article online at *www.wildlife.org*.