for illumination and Spectralon® panel for reference. These spectra were converted to absolute reflectance using a NIST traceable spectralon reflectance spectrum. The ASD spectrometer has 5-nm spectral resolution from 0.35–1.0 microns and 11-nm spectral resolution from 1.0–2.5 microns. Snakes were measured while they were held within the beam of the tungsten lamp about 1 m distant from the light source. The ASD fiber optic probe was held perpendicular to the skin surface and 10 six-second spectra were collected at each location on the snake's body. These ten spectra were co-averaged and converted to absolute reflectance for comparison of skin absorption features. Snake spectra were plotted against reference spectra for woody and leafy vegetation and examined for wavelengths of marked contrast (Fig. 2).

Ideally, we hoped to identify one or more wavelengths at which Brown Treesnakes exhibit a peak of reflectance with respect to other objects in their environment (primarily woody and leafy vegetation). Spectra were also recorded from a Common House Gecko (Hemidactylus frenatus) and a Mangrove Monitor (Varanus indicus) as these species may also be encountered during Brown Treesnake surveys. Additionally, we took this opportunity to determine whether diagnostic absorption features existed for a Brown Treesnake (Boiga irregularis) from Indonesia, a closely-related Mangrove Snake (Boiga dendrophila), a Western Hognose Snake (Heterodon nasicus), and a Massasauga (Sistrurus catenatus). This methodology provides a high-resolution spectrum profile for the entire range of wavelengths investigated. It is not proposed as a field application for snake detection, but rather to identify a small subset of wavelengths which could be selectively filtered or amplified with equipment designed for field detection.

Results and Discussion.—Sample spectra from the ventral, lateral, and dorsal surfaces of a single Brown Treesnake specimen are plotted against reference spectra from woody and leafy vegetation in Fig. 2, while the range of all spectra from three surfaces of six Brown Treesnakes are depicted in Fig. 3. The only range within which Brown Treesnake reflectance exceeds the reflectance of vegetation is the ventral surface of the snake across the visible range of the spectrum. High reflectance across the visible spectrum is seen as white. This will be no surprise to experienced Brown Treesnake surveyors whose search image is typically triggered by the white to whitish-yellow underbelly of snakes perched in arboreal activity. The low reflectance of blues, moderate reflectance of greens and higher reflectance of reds in all body surfaces are perceived as the olive-brown color characteristic of Brown Treesnakes, increasing in darkness from as or less reflective than vegetation, requiring observers to rely upon the snake shape aspects of their search image.

While there is a large contrast between lateral and ventral surfaces of Brown Treesnakes and green vegetation in the red range (~0.7 microns), this is also true of woody vegetation. Selective filtering of non-reds or amplification of reds may help to decrease the brightness of green vegetation, but do little to distinguish snakes from the branches and vines which they also resemble in shape.

Within the span of UV wavelengths, the ventral surface of the Brown Treesnake is brighter than dorsal and lateral surfaces of the snake and the vegetation spectra; however, the magnitude of the difference is not much greater than the difference throughout the visible portion of the spectrum and overall UV reflectance is low, indicating that selective enhancement of UV wavelengths is not likely to be worth the additional technological effort required to do so.

Within the infrared domain, all three Brown Treesnake surfaces show a reflectance peak at 1.1 microns (Fig. 2); however, the chlorophyll in leafy vegetation is known to have remarkably high reflectance within the near-infrared, which overwhelms the peaks of Brown Treesnake reflectance and negates any visibility advantages these peaks might have conferred. Nowhere throughout the Brown Treesnake spectra are the hoped-for diagnostic absorptions that would have indicated promising features for selective amplification leading to the desired high-contrast search image and increased detection probability. Using a computerized algorithm exploiting the "shoulderness" of the snake's spectrum as it slopes downward from 1.1 to 1.6 microns, combined with the green peak and chlorophyll absorptions of green vegetation, one could effectively differentiate snakes from dry vegetation (which has "small shoulderness"—flat or shallow slope—from 1.1 to 1.6 microns) and green vegetation (with "large shoulderness," or steep slope) compared to intermediate shoulderness or slope of the snakes' spectra. This assumes that the spatial resolution of the image is fine enough that single pixels would land entirely on the snake. The presence of a chlorophyll band would eliminate the green vegetation while a low shoulderness would eliminate dry vegetation (branches, etc.). Collecting such spectral data at night would pose a challenge, considering the amount of light needed to get a workable signal-to-noise ratio on the detectors. While this may technically be possible, the prospects for cost-effectively implementing such sophisticated technology in a manner practical for use by a field worker are not promising.

The reference vegetation spectra were obtained in North America rather than Guam; however, given the lack of distinctive spectral features in the snake spectrum profiles, there is little reason to believe that Guam's vegetation would be different in any meaningful manner. The results of our lab experiment have indicated that a more expensive effort in Guam is not likely to be worth the investment of resources.

In comparison to the sympatric gecko and monitor species, as well as the four additional snake species tested, all spectra were similar in the UV and IR ranges of the spectrum. Given the taxonomic breadth of species examined here, it is not promising that such features may be observed in other reptile species of invasion concern, such as the Burmese Python (Python molurus bivittatus) and other large-bodied boids devastating the native fauna of the Florida Everglades (Dorcas et al. 2012; Dove et al. 2011). All living organisms—including vegetation—exhibit the negative spectral features, or light absorption bands, indicated at ~0.97, 1.20, 1.45, and 1.95 microns which result from absorption by water and/or the carbon-hydrogen and nitrogen-hydrogen bonds of organic compounds (Fig. 2). The ubiquity of these features in biotic organisms negates their utility as characters to discern them from other life forms. All noteworthy differences between Brown Treesnake and other reptile spectra assessed here lie within the visible portion of the spectrum, manifesting in differences in color that are obvious to the unaided eye.

As predators that rely on stealthy foraging or ambush to obtain prey, it is not surprising that the coloration of the Brown Treesnake is difficult to visually distinguish from its surroundings. The results of spectroscopy reflect little potential for simple filtering or single-feature amplification techniques. While there may be some potential for multi-wavelength computer algorithms to enhance snake features while "backing out" characteristic features of vegetation, such technologies are not likely to be cost-effective or practical for field applications in the short term. The apparent lack of significant results reported here is extremely important, in that this small-scale validation of a novel concept has forestalled a hasty investment of scarce resources in a more comprehensive research and development program, and provides important information for others considering similar approaches.

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