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Combining near infrared spectra of feces and geostatistics to generate forage nutritional quality maps across landscapes

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An important asset for the management of wild ungulates is the ability to recognize the spatial distribution of forage quality across heterogeneous landscapes. To do so typically requires knowledge of which plant species are eaten, in what abundance they are eaten, and what their nutritional quality might be. Acquiring such data may be, however, difficult and time consuming. Here, we are proposing a rapid and cost-effective forage quality monitoring tool that combines near infrared (NIR) spectra of fecal samples and easily obtained data on plant community composition. Our approach rests on the premise that NIR spectra of fecal samples collected within low population density exclosures reflect the optimal forage quality of a given landscape. Forage quality can thus be based on the Mahalanobis distance of fecal spectral scans across the landscape relative to fecal spectral scans inside exclosures (referred to as DISTEX). The Gi* spatial autocorrelation statistic can then be applied among neighbouring DISTEX values to detect and map "hot-spots" and "cold-spots" of nutritional quality over the landscape. We tested our approach in a heterogeneous boreal landscape on Anticosti Island (Québec, Canada), where white-tailed deer (*Odocoileus virginianus*) populations over the landscape range from 20 to 50 individuals km^{-2}. Our results suggest that hot-spots of forage quality occur when 300 ha neighbourhoods comprise > 40% old growth balsam fir stands, whereas cold-spots occur in laggs (i.e., transition zones from forest to peatland). In terms of ground level indicator plant species, Canada bunchberry (*Cornus canadensis*) was highly correlated with hot-spots whereas tamarack (*Larix laricina*) was highly correlated with cold-spots. Mean DISTEX values were positively and significantly correlated with the neutral detergent fiber and acid detergent lignin contents of feces. Our approach is a promising tool for the advancement of fundamental and applied ecology of large herbivores.