Daily rhythmic behaviour of water buffalo and its effect on their spatial distribution

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Abstract: Water buffalo (*Bubalus bubalis*), like the majority of animals, have evolved daily rhythms in their behaviour, allowing them to acquire resources safely and efficiently. However, water buffalo have since been introduced to Northern Australia, where they are responsible for significant environmental damage, and substantial effort is dedicated to their control. Understanding their daily behaviours therefore has direct conservation applications by determining optimal times to conduct management operations, and by informing accurate predictions of their distribution.

To understand the temporal evolution of buffalo's behaviour, we fitted step selection analysis (SSA) models to GPS-tracking data of 17 water buffalo. SSA models jointly estimate movement and habitat selection parameters, and the inclusion of harmonic terms allows for temporally varying parameters to be estimated. Using these parameters we generated dynamic predictions of expected buffalo distribution, both with an analytic approximation approach that considers the animal's movement dynamics, and a simulation-based approach that is equivalent to simulating biased correlated random walks. The simulation-based approach also allowed us to assess connectivity, short-term predictions, as well as identify potential movement corridors for unsampled areas.
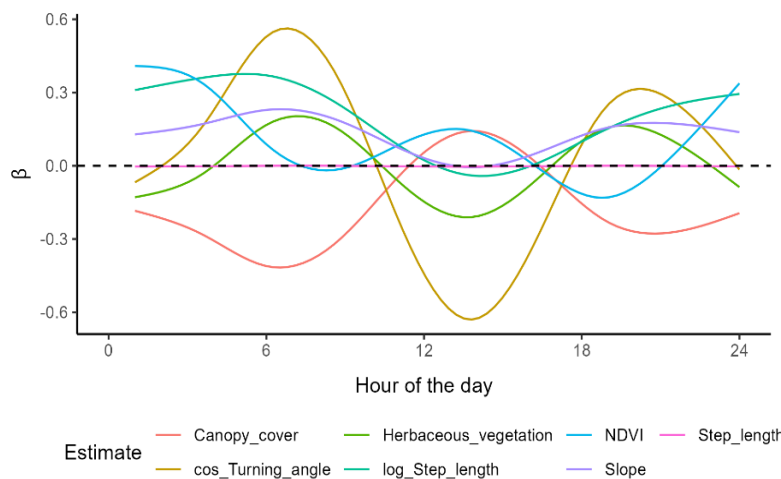

Figure 1. Temporally varying coefficients resulting from fitting the step selection analysis model to a single female buffalo for January of 2019. Values above 0 indicate a positive selection given what was available to the animal, and negative values indicate avoidance. At dawn and dusk, this buffalo selected vegetation that was less productive with a more open canopy, had a stronger preference for herbaceous vegetation (rather than woody vegetation), and had faster, more directed movements. These patterns led to differing distribution patterns throughout the day.

Buffalo showed a crepuscular pattern, with much higher movement activity around dawn and dusk, with little preference for any particular habitat during these periods, whilst habitat selection differed between day and night. Incorporating this information affected their predicted distribution over longer time-scales than when the daily rhythms were not considered, and ultimately resulted in more accurate predictions. We argue that daily rhythms should be considered when prediction distributions for species that show rhythmic behaviour, even when predictions over longer time-scales are of interest.

Keywords: *Water buffalo, temporal dynamics, daily rhythms, step-selection analyses, simulation-based predictions*