INTRODUCTION

The overall aim of my research is to investigate the relationship that is formed when tourism, red deer and rare moths all share a small Hebridean island, Ulva.  Here, I report on a field season in which I attempted to introduce new methods to investigate how the daily influx of tourists on Ulva affects the routines of the resident red deer.  The island can be defined as being composed of two main areas: namely the 'hill' area, and the 'in-bye' (**Figure 1**).  These areas are separated by a deer fence.
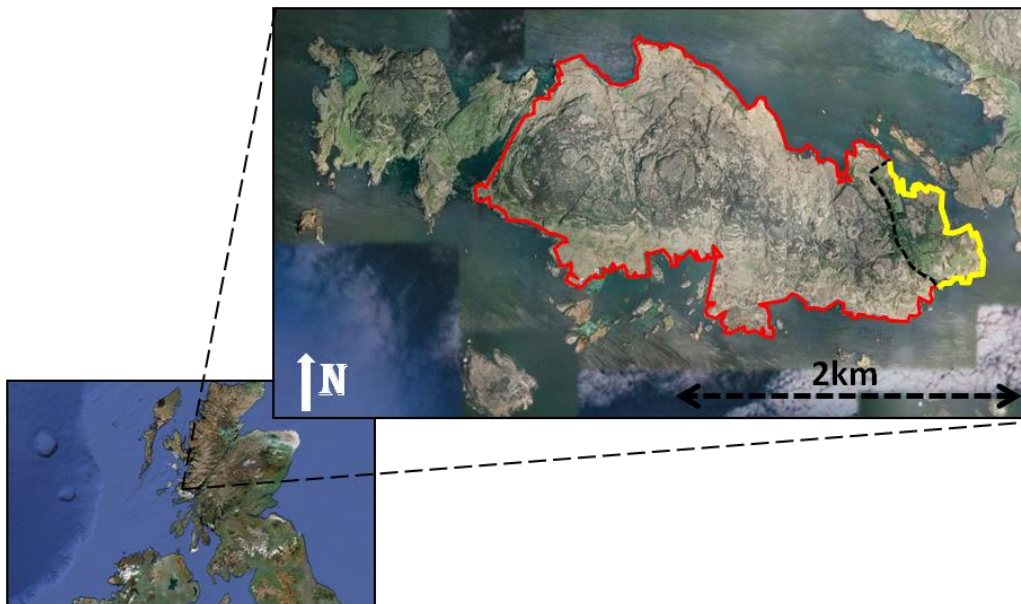


**Figure 1:** The Isle of Ulva: shown is the relative position of the island relative to Scotland, and in its entirety. The area outlined in red and yellow represent the 'Hill' and 'In-Bye', respectfully.  The black dotted line represents the separation of these two areas by a deer fence. [*Image © Google Earth*].

This division represents on-going land management on the island; the in-bye features comparatively extensive farming practices and associated infrastructure whereas the hill is largely excluded from land management practices.  The island is a privately owned estate, but it is managed as a tourist attraction, and public access is allowed throughout most of the island. Visitor access to the island is conducted by a ferry which crosses from Mull and terminates at a small slipway in the in-bye.  A network of paths exists on Ulva, which facilitate movement for tourists throughout the island.

As the in-bye has a much smaller area than the hill and acts as the main entry point for tourists, it is assumed that the tourist density in this area is higher than the hill.

My objective was to investigate the temporal overlap of path use between red deer and tourists in both the hill and the in-bye, in order to identify if the disturbance regimes particular to each site inform the degree and timing of path use by red deer. To investigate the patterns of path use, camera traps were used to quantify the degree of tourist and deer activity at different sections of the path.

On Ulva, the majority of tourist access is dictated by the ferry crossing service, of which the first and last crossings operate at 0900hrs and 1700hrs GMT, respectively. Therefore, it is expected that the majority of tourist path-use would occur within that timeframe and decrease strongly afterwards. It is anticipated that, in general, deer will be observed to use the paths outside of those hours. Specifically, given that deer are most active at dawn and dusk, deer path use will peak at both these times. This pattern of overlap may vary between the hill and the in-bye. The in-bye features many obstructions in the form of dry-stone walling, fencing and housing that are not present in the hill, and as such it is expected that red deer will exhibit a stronger degree of path use in the in-bye in order to bypass these barriers. However, as the in-bye features comparatively frequent tourist-related disturbance, it is anticipated that the in-bye will feature less temporal overlap in path use between deer and tourists.

METHODS

To quantify tourist and deer traffic on the different paths, 6 Reconyx Hyperfire trail cameras were positioned at 14 locations throughout the path system from the 10th June 2015 to the 13h July 2015. A rotation scheme was maintained to ensure that the traffic at each location received similar amounts of coverage over the course of the data recording period. All cameras were placed at approximately 3 feet from ground level on purpose-built wooden posts.

Photographs of tourists and deer were each converted into a dataset that represented a random sample of a probability distribution; this describes the probability of either tourists or deer being photographed at a given time throughout the 24 hour cycle (**Figures 2 and 3**). The temporal overlap

of path-use patterns between red deer and tourists were analysed for inter-site differences (hill and in-bye).
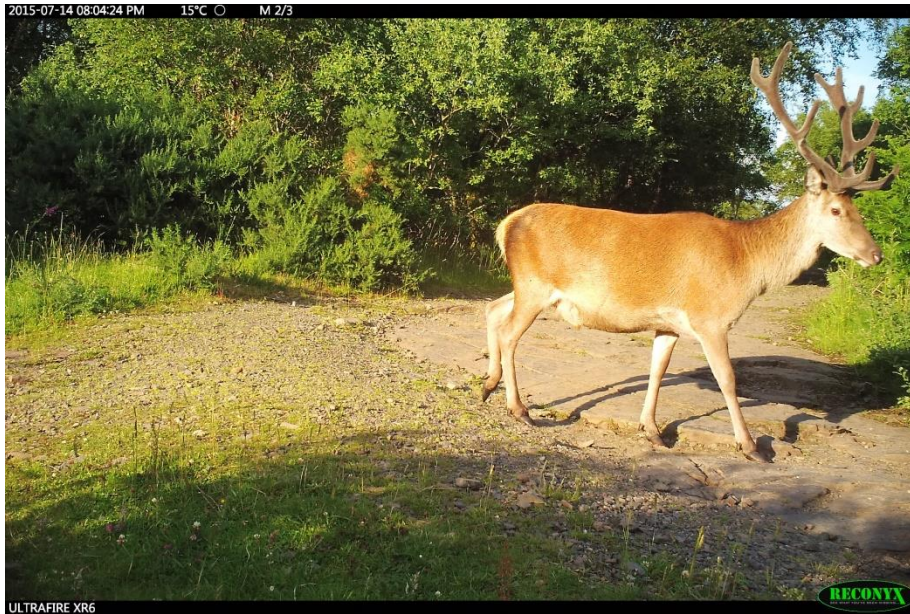


**Figure 2:** Diurnal photograph taken by a camera trap of a stag using a path in the in-bye area.



**Figure 3:** Nocturnal photograph taken by a camera trap in the hill area showing two hinds walking along a path.

RESULTS

The patterns of overlap on paths are visualized in **Figure 4**. In both sites, tourist path use peaked sharply slightly after midday, and was defined by the first and last timings of the ferry crossing (hill: 77% of observations were between 09:00 and 17:00; in-bye: 84% of observations were between 09:00 and 17:00). A less notable peak of tourist path use occurred slightly after 18:00, which was more obvious in the hill than the in-bye (hill: 12% of observations between 17:00 and 19:00; in-bye = 9% of observations between 17:00 and 19:00). In both sites, deer exhibited a bimodal pattern of path use, being photographed mostly at night/dawn, and again to a lesser extent at dusk (hill: 53% of observations between 01:00 and 07:00, and 36% of observation between 18:00 and 00:00; in-bye: 63% of observations between 01:00 and 07:00, and 39% of observation between 18:00 and 00:00).
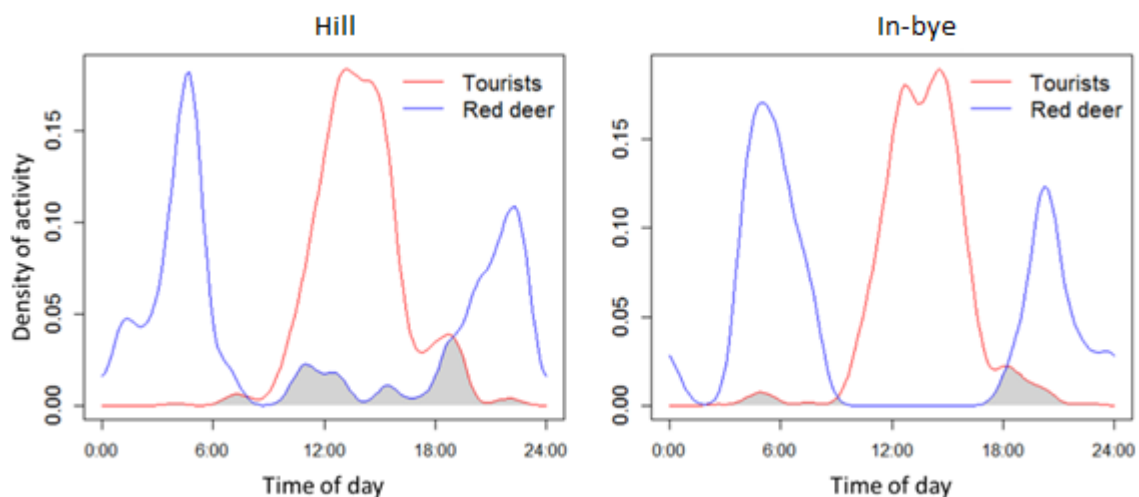


**Figure 4.** Estimates of the daily patterns of tourist and red deer path use in the hill (left) and the in-bye (right). Lines in red are the activity patterns for tourists, and lines in blue are the activity patterns for red deer, derived from photograph times. The overlap in patterns of activity between tourists and deer is represented by the grey area in each plot. Average time of sunrise was 0410 hours, and average time of sunset was 2120 hours during the study.

DISCUSSION

The study assessed explicit path-use behaviour as opposed to overall activity, and in doing so presents the first study to quantify the temporal patterns of path-use in red deer, and furthermore, to assess the degree of overlap in these patterns with that of human path-use. These results provide a temporal perspective on the use of path systems by wildlife and tourists.

The results showed a clear contrast between deer use and human use of the path at all sites. Unsurprisingly, a majority of human path-use in all sites was between 0900hrs and 1700hrs, given that those times represent the first and last ferry crossing, respectively. All sites feature a secondary peak of human path-use, which occurred slightly after 1800hrs. This was almost entirely comprised of routine activities carried out by the local residents of Ulva, such as dog-walking and farming necessities. Deer were observed to use the path with mutual exclusivity to the temporal pattern of human path-use in both the hill and the in-bye, but a stronger degree of overlap in path-use was found in the hill than the in-bye. This is a small difference, and is potentially a product of the in-bye being a much smaller site and closer to the ferry access point, allowing deer to more accurately predict when tourist activity ceases for the day. Of the two sites, the hill area is the furthest point from the ferry access studied, and receives fewer tourists, so it would be harder for deer to predict the cessation of tourist activity.

For both sites, deer presence peaked at approximately 0500hrs and again at 2100hrs. These timings correlate with the crepuscular nature of deer activity. Path-use may facilitate the daily altitudinal shifts in habitat use characteristic to the species i.e. descending from high altitudes in the evening, and returning to higher ground the following morning. The same patterns of path use were found for the in-bye, but since this site features little altitudinal variation, it is likely the paths are used as travel corridors through otherwise relatively harsh woodland.