3.1.1. Distance sampling on transects with thermographic cameras or spotlighting, and point transect

Objective

By observing individuals / groups along transects and, if the distance sampling is used to analyse data (see below), recording the distances to which they have made such observations. The objective is to obtain a detectability function with which to estimate the local density of the wild ungulate population.

Measure estimated

Population density and population structure

Applicability

Potentially all ungulates with restrictions due to visibility and/or detectability of species (e.g., wild boar) or habitats (closed).

Methodology

Transect methods include different techniques to detect animals and to estimate population density. The method requires that the observer travelling along a transect records the perpendicular distances (or the sighting distance and sighting angle) of all animals visible from the transect. In other cases, i.e., line transects, there is no assumption that all animals are detected, but the final density estimation uses a detectability function calculated from the distribution of observation distances (i.e., perpendicular distance of the animals from the line of the transect) (Buckland et al. 1993, Buckland et al. 2001, Morellet et al. 2011).

Transects can be carried out on foot, but it may be demanding in terms of sampling effort, and it is difficult to apply at spatial scales of several hundred km^2 (typical scale of deer management units). Depending on the accessibility of the territory, alternatively, transects may be carried out by using a vehicle to monitor large areas (e.g., Pellerin et al. 2017 - See pictures in this section). The animals can be detected by using point transect also. In this case, the observations of individuals / groups take place from fixed points (e.g., from hide-outs or high seats) and, using distance sampling, by recording the distances from the observer to the animals.

Transect methods can be implemented during the day, in general during crepuscular hours, by using binoculars, or during the nightlight by using spotlights to detect the individuals (e.g., Garel et al. 2010, Corlatti et al. 2016). The presence of a reflecting *tapetum lucidum* increase the probability to detect individuals during nocturnal spotlight counts (by car). The absence of a reflecting *tapetum lucidum* in wild boar makes nocturnal spotlight counts (by car) more difficult as compared to cervids. Spotlight counts are only useful for deer species but do not really work in wild boar (even as distance sampling) (Gräber et al. 2015). The problem of low visibility of wild boar during spotlight counts was solved successfully in Italy (Focardi et al. 2002, Franzetti et al. 2012) and in GB (Gill & Ferryman 2015) using distance sampling on transects with thermographic cameras (thermographic imaging TI; Buckland et al. 2004). The use of thermal imaging allows the detection of animals by detecting the long-wave energy radiated by warm-bodied. This technique enhances the probability of detecting animals before being perceived, thus reducing disturbance due to the observers (Gill et al. 1997; Ward et al. 2004; La Morgia et al. 2015). Even if the method works well when applying a high effort, in low densities and in habitats with dense understory (Gill et al. 1997, Franzetti et al. 2012, Focardi et al. 2013, Wäber and Dolman 2015), it can fail in other situations (e.g., Gill & Brandt 2010). Evaluation of this method can be seen in Table 1. The price of new-generation infrared cameras is now more attainable and present better performance, which can increase the cost-effectiveness and applicability of this method once it is fine-tuned.

Evaluation

· Pro: large areas observed with low disturbance, very accurate in high densities for local areas, low cost-effectiveness (currently no for thermographic camera).

· Con: need for assumptions using distance sampling, in study sites with low densities, dense understory, and high hunting pressure a very high sampling effort is needed, need for thermographic camera => expensive, mainly in winter.

· Accuracy: high.

· Habitat: open to mixed, less useful in pure forest.

Recommendations to improve comparability and accuracy

• Previous studies/knowledge are needed to prepare the study (transects) design, as well as basic biological information about the animal (activity rhythms).

• In the design of the study, attention should be paid to the fact that the population to be estimated does not have any type of correlation with the transect line in its distribution.

• Sampling design and data analysis must consider the type of habitat.

• The centre line of each transect must be clearly marked: the observer can determine their position at each moment.

• A minimum number of transects must be sampled depending on the distribution of the target species in the study area.

• Using distance sampling, all animals in the centre of the transect line are viewed with probability equal to one.

• The width of the transect should be the maximum possible. The points that are considered external must be eliminated during the analysis.

• Three basic measurements: perpendicular distance, observation distance and observation angle.

• All the measurements of angles and distances must be accurate.

• The measurements must be saved separately for each segment of the total length of the transect.

• The data collection must be carried out by competent, motivated, and trained staff.

• Point transects requires areas of good visibility

• At least 40 objects (individuals or groups), preferably 60-80 objects, should be recorded.

[2] See definition at section 2.1