A practical method for measuring horizontal cover

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Abstract: We propose a new cover cylinder as a useful tool for a single observer to measure horizontal cover in the field. We compared it with 4 other methods for measuring horizontal cover at brown bear (*Ursus arctos*) beds, with all measurements taken 10 m from beds in the 4 cardinal directions. We also compared cylinder cover values from a fixed distance with an index of cover, namely a sighting distance, *D*, the minimum distance at which the cylinder could no longer be seen; we also compared measurements from a random direction and from the 4 cardinal directions. The cylinder provided measurements comparable to other devices, including a cardboard profile of a bedded bear, and was the most practical to use in the field. Measuring *D* was scarcely more time consuming than measuring cover from the fixed 10-m distance, and *D* is better for statistical analysis. We recommend the cylinder, and using the index of cover, *D*, taken from the 4 cardinal directions, when assessing horizontal cover for bears or other medium and large terrestrial vertebrates.

Key words: bears, cover cylinder, horizontal cover, sighting distance, Sweden, *Ursus arctos*

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Cover, a habitat element that conceals, shelters, or protects, is important for animals; it can protect against weather and lower the risk of predation (Mysterud and Østbye 1999, Ratikainen et al. 2007). Horizontal cover (hereafter, cover) may be an important factor affecting habitat choice, so proper measures of cover in the field are relevant to understanding habitat selection. However, methods to measure cover tend to be inefficient or subject to considerable bias (Collins and Becker 2001). We compared the efficacy of 5 devices used by 1 person to measure cover in the field. Three of these devices were described previously: the table board (Nudds 1977), cover pole (Robel et al. 1970, Griffith and Youtie 1988, Toledo et al. 2008), and cover board (Mysterud 1996). We also tested a cardboard profile of a bedded bear and a new, light, self-supporting, collapsible, easily carried cover cylinder that we designed (Fig. 1). We compared (a) the practicality of these 5 devices for measuring cover at brown bear (*Ursus arctos*) resting sites, (b) cover measurements obtained from the cylinder when standing 10 m from the resting site, versus an index of cover (the sighting distance *D*), the minimum distance at which the cylinder was completely blocked from view, which provides a continuous variable for statistical analysis (Mysterud and Østbye 1999), and (c) results from the cylinder when taking measurements from the 4 cardinal directions versus from 1 random direction. We sought the most effective device and method to quantify horizontal cover that could be applied by a single observer in the field.

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Methods

Study area

The study took place in 2007 in Sweden, near the southernmost distribution of the Scandinavian brown bear population (61°N, 15°E). The area was 80% covered with highly managed forest, mainly composed of Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), and birch (*Betula* spp.). The understory vegetation was dominated by heathers (*Calluna vulgaris*), grasses, and berries (*Vaccinium*

Fig. 1. The 700-g, collapsible cover cylinder developed to measure horizontal cover in the field measures 60 cm high x 30 cm diameter. The 30-cm upper section is red and the lower section is white (left photograph).

myrtillus, *V. vitis-idaea* and *Empetrum hermaphroditum*). For further details on the study area, see Elfström et al. (2008).

Comparison of methods

We compared techniques to assess cover in an ongoing study on the effect of human disturbance on brown bear resting site selection. To find resting sites, we used data from 22 bears equipped with global positioning system (GPS)-global system for mobile communication (GSM) collars (Vectronic Aerospace GmBh, Berlin, Germany). For details on bear capturing and marking see Arnemo et al. (2006) and Arnemo and Fahlman (2007). We defined a bed as a resting site (hereafter, bed) only if it contained bear hairs.

We used the following devices to measure the cover of beds:

1. Table board (Nudds 1977): originally 1.5 m high, 30 cm wide, divided into 3 50-cm sections. To compare it with other devices, we only used the lower 2 sections (upper red, lower white; hence, it was only 1.0 m high for this study).
2. Cover pole (Griffith and Youtie 1988): 1 m high, 2.5 cm wide; 10 alternating black and white 10-cm bands.
3. Cover board (Mysterud 1996): 30 cm high, 40 cm wide; 40 black and white grid cells, 6 x 5 cm each.
4. Cardboard profile of a bedded bear (modified from a bear profile published by the Swedish Association for Hunters and Wildlife Management): 40 cm high, 120 cm long.
5. Cover cylinder (designed by us): 60 cm high, 30 cm in diameter, with 2 30-cm sections, upper red and lower white, collapsible and made of steel spring wire and light cloth (Fig. 1).

We placed all devices consecutively inside the bed and estimated how much of each device was visible. The same observer took all the measurements at each bed to avoid individual bias and to standardize the same height from which all the measurements were taken. For the table board, the cover pole, and the cover cylinder, we obtained separate values for upper and lower sections. We divided the cover pole into an upper and lower section with 5 bands each. We gave a score to all the devices and sections, except the cover board, according to the percentage that was visible: 1 if $<25\%$; 2 if 26–50%; 3 if 51–75%; and 4 if $>75\%$ visible. For the cover board, we counted the number of squares totally visible (Mysterud 1996). To compare devices, we took all measurements at 10 m from 43 bear beds, from the 4 cardinal directions (Nudds 1977, Griffith and Youtie 1988). Secondly, using the cover cylinder we measured D, the minimum distance at which the device could no longer be seen, at 439 beds from 1 random and the 4 cardinal directions. That is, D

Table 1. Linear regression with the cardboard bear, i.e. the device that most accurately represented the shape of a resting bear, as response variable, and the alternate methods as predictors (cover board, cover cylinder, cover pole, and table board).

Model	β	SE	*t*	*P*
Cover board (R^2 = 0.77)				
Intercept	0.336	0.031	10.805	<0.001
Cover board	0.906	0.092	9.845	<0.001
Cover cylinder (R^2 = 0.74)				
Intercept	0.044	0.062	0.71	0.484
Cover cylinder	0.794	0.087	9.094	<0.001
Cover pole (R^2 = 0.53)				
Intercept	0.148	0.08	1.835	0.077
Cover pole	0.660	0.116	5.701	<0.001
Table board (R^2 = 0.49)				
Intercept	0.106	0.094	1.124	0.27
Table board	0.671	0.127	5.271	<0.001

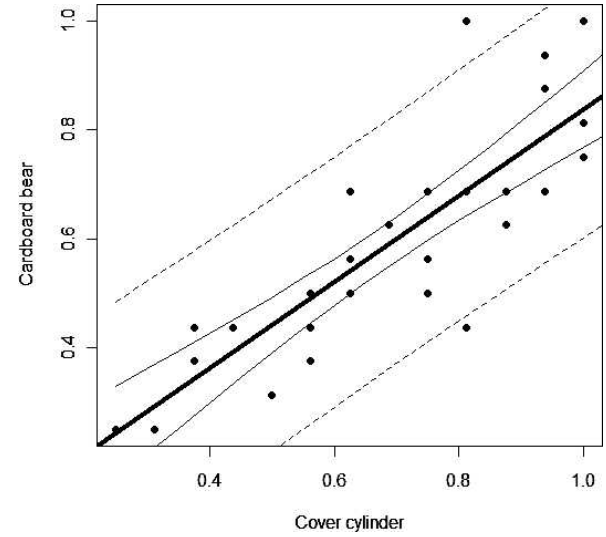

Fig. 2. The linear relationship (thick line) between the measurements of cover obtained with the cover cylinder and the cardboard bear (R^2 = 0.74). Dashed lines represent the 95% prediction intervals and solid lines the 95% confidence intervals.

readings reflected the distance at which the cylinder was completely covered.

To obtain a cover value for each device and bed, we added the values from the 4 cardinal directions and calculated the observed percent of the maximum possible value (i.e., the value that would be obtainable without any cover). To compare the measurements obtained with different devices, we used linear regression models with the cardboard bear as the response variable, given that this was the most accurate representation of the shape of a resting bear, and the alternate methods as the predictor variable. To compare the 10-m fixed distance vs. *D*, we correlated the average value obtained from the 4 cardinal directions at 10 m and *D*. Finally, we compared (paired *t*-test) *D* from a random direction and from the average value of the 4 cardinal directions. We used the statistical package R 2.8.1 (R Development Core Team 2008) in all statistical analyses

Results

The upper sections of the table board, the cover pole, and the cover cylinder were on average 19% more visible at the 10-m distance than their respective lower sections (16% for the table board, 20% for the pole and the cylinder). From the results of a linear regression analysis, the visibility of the cover board and the cover cylinder showed the highest correlation (R^2 = 0.77 and R^2 = 0.74 respectively) with the cardboard bear (Table 1; Fig. 2).

Because of the ease of use of the cover cylinder (see Discussion), we used it for further comparisons in 439 beds. The measurements ranged from 0% (the devices fully covered by vegetation) to 100% (the devices fully visible). The lower section was fully covered more often than the upper section (7.7% versus 2.5%); thus, for comparative purposes we only show results from the upper sections. The correlation coefficient between cover values at 10 m and *D* was 0.75 when using the average *D* of the 4 cardinal directions, and 0.48 when using *D* from a random direction. The average *D* was similar (paired *t*-test: $t = -0.36$, $n = 439$, $P = 0.72$) from a random direction (21.4 m, SD = 13.8 m) and from the 4 cardinal directions (21.2 m, SD = 10.8 m), and the correlation coefficient between them was 0.51.

Discussion

A single observer had problems using 3 of the 5 devices. The table board was heavy (5 kg), and had to be held in the vertical position. The cover pole was lighter (1 kg) and easier to carry, but did not stand by itself on hard substrates and often required help from a second person. The cardboard bear was impractical to put up, required a second person to hold it, and frequently did not fit well inside the

beds. In addition, it broke quickly with daily use under outdoor conditions. The cover board required time to count the squares and a second person to hold it. The cylinder and the cover pole were circular, allowing observation from different directions without turning the device, which was necessary for the other devices. The cover pole may require interchangeable spikes to stand by itself on different substrates (Toledo et al. 2008), a disadvantage compared with the light (700 g), self-supporting cylinder, which was the easiest to transport and use. The high and similar relationship between the cover board or the cylinder and the cardboard bear (Table 1) suggested that device selection was more constrained by practical reasons than by measuring accuracy. Given the cylinder's practicality, we consider the cylinder as the best option to measure horizontal cover.

The average D was 21.2 m (SD = 10.8 m), which was only twice the 10-m fixed distance. In practice, measuring D was not much more time consuming and provides a continuous variable for more rigorous statistical analysis (Mysterud and Østbye 1999). This also avoided the use of more subjective categorical values that must be given to the observed portion of the device from a fixed distance. In addition, the fixed distance should be changed depending on the study area or vegetation types (Nudds 1977, Collins and Becker 2001), which causes difficulties in comparing results from different study areas or vegetation types. Averaging 4 directions gave a better concealment description than using only 1 direction, maybe because beds were often close to a tree or large rocks. This is probably reflected by the higher correlation between measures at 10 m and average D of 4 directions (r = 0.75) than 10 m versus a random D (r = 0.48). Although the average D value was similar from a random direction (21.4 m, SD = 13.8 m) and from the 4 cardinal directions (21.2 m, SD = 10.8 m), the relatively low correlation coefficient (r = 0.51) may indicate that 4 readings provided more accurate information than only 1. Readings from 4 cardinal directions are frequently used (Griffith and Youtie 1988), but using only 1 random direction is also advised (Mysterud 1996, Mysterud and Østbye 1999). Directional values are useful when describing specific characteristics of cover, such as testing whether the animal had more cover in the direction of prevailing winds or better vision in open habitats (Mysterud and Østbye 1999). Depending on study areas characteristics, measuring D from 4 cardinal directions or from a random direction is a trade-off among accuracy, effort, and objectives.

Management implications

Measuring cover quickly and reliably in the field is important, because projects normally have cost and time constraints. We recommend the cover cylinder as a practical device that is useful for a single observer. Other methods, including the improved design of the cover pole described by Toledo et al. (2008), are not self-supporting on bedrock or other impenetrable surfaces, thus requiring 2 people to take measurements. Device size depends on species and study area (Nudds 1977, Toledo et al. 2008), but the proposed 60 cm high x 30 cm in diameter cylinder may be practical for studies of many medium to large terrestrial vertebrates, including all bear species. Also, the cylinder is very quick to use, because it opens and folds quickly due to its steel spring wire structure.

Interpretation and comparison of data collected can be confounded by inconsistent design and measurement criteria. It is advisable to ensure taking measurements from the same height if several observers participate, or if comparisons are to be made among studies carried out by different researchers (e.g. Toledo et al. 2008).

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