A Comparison of Traditional Counts and Distance Sampling Methods for Estimating the Abundance of Ute Ladies'-tresses (*Spiranthes diluvialis*)

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2005

US Fish and Wildlife Service
Chubbock Office
Order No. 1448-14420-03-M323A

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Annual monitoring for Ute ladies'-tresses traditionally consists of "complete" counts by several observers of all the detected individuals in a population. We tested the efficacy of distance sampling methodology as an alternative to traditional counts. The theory allows for some objects to go undetected and for detectability to decrease with increasing distance from the transect line. Population estimates using distance sampling cluster methods were generally similar to traditional counts, and better models than the distance sampling individual method ($P>0.05$). We concluded traditional "complete" counts are most appropriate for small populations (<100) with distribution patterns that are linear (e.g., 4x100 m) or in small patches. Alternatively, distance sampling is more appropriate in evenly distributed large populations (>250) in homogenous blocks. In addition, distance sampling is replicable and generates a mean population estimate with 95% confidence intervals that facilitate tests for statistical significance among populations and years. Distance sampling provides a more valid and powerful estimate of population trends regardless of observer experience. We recommend establishing permanent distance sampling transects at 25-m intervals within contiguous populations of Ute ladies'-tresses to facilitate evaluating population trend significance.

Ute ladies'-tresses (*Spiranthes diluvialis*) was designated a threatened species under the Endangered Species Act in 1992. The plant was discovered in Idaho in 1996. Populations of Ute ladies'-tresses and its habitat were monitored annually at known occurrences on the South Fork of the Snake River, Idaho by the Idaho Department of Fish and Game (IDFG), Idaho Conservation Data Center (IDCDC), Bureau of Land Management (BLM), and Caribou-Targhee National Forest (C-TNF). Traditional monitoring techniques consisted of "complete" counts of all the observable flowering individuals by several observers while noting threats and general habitat conditions at each occurrence, and measuring biological conditions at permanent habitat transects.

Phenology of flowering by Ute ladies'-tresses is variable among years, and plants in fruit are readily concealed by other vegetation (e.g., sedges). As a result, unknown error associated with environmental variability and observer bias associated with traditional monitoring techniques may be inadequate for determining accurate long-term population estimates and trends. Moreover, error associated with traditional counts is positively related to the actual size of the population. For example, relatively few plants in small, discreet patches are counted more accurately than many plants in large evenly distributed populations. In Idaho, populations of >200 plants occur on the South Fork of the Snake River at Annis Island (EO 006), Warm Springs Bottom (EO 003), Lufkin Bottom (EO 011), Black Canyon (EO 022), and Pine Creek #3 and #4 (EO 016). At these sites, Ute ladies'-tresses tend to occur as evenly distributed individuals in relatively large (>0.2 ha) patches of habitat, clearly delineated by unsuitable habitat.

As an alternative to traditional counts, we tested the efficacy of distance sampling methodology (also called line transects and variable circular plots). The advantages of distance sampling are (1) estimates density without estimating both abundance and area; (2) produces confidence intervals associated with density estimates that facilitate statistical analyses not possible with traditional counts; (3) facilitates direct comparison among areas and between years; and (4) minimizes observer bias. Distance sampling methods are related to mark-recapture techniques for incomplete counts that employ the concept of capture probability. However, because distance sampling does not require physical capture and remarking it is referred to as a detection probability.

Distance sampling asks the question: Given the detection of *N* objects, how many objects are estimated to occur within the sampled area? In practice, a set of randomly placed transect lines are established and the perpendicular distances measured from the line to the objects detected by an observer moving along the transect. The theory allows for some objects to go undetected and for detectability to decrease with increasing distance from the transect line.

We appreciate the financial support provided by the US Fish and Wildlife Service, Chubbuck Office. Rex Sallabanks of IDFG helped with the experimental design and analysis. Wendy Velman and Tessa Bowen of the US BLM, Upper Snake River Field Office and Rose Lehman of the US Forest Service, C-TNF assisted with logistics and provided the traditional count data. Chris Murphy of IDCDC gave us much needed advice.

METHODS

We compared the methods of estimating the abundance of Ute ladies'-tresses using traditional complete counts and distance sampling at Warm Springs Bottom, Lufkin Bottom, and Pine Creek #3 (Figure 1). We measured both individual and 1.0-m cluster distances at Lufkin Bottom (300 m^2) and Pine Creek (868 m^2), and individual and 0.5-m cluster distances at Warm Springs Bottom (2846 m^2). Distance sampling methods were assessed in part on how similar results were to comparable traditional counts conducted on the same day. We also assumed a positive relationship between objects measured (i.e., individual plant or cluster) and the time required to conduct the survey. Last, we directly compared 0.5-m and 1.0-m cluster distances on a subset of data from Warm Springs Bottom (640 m^2).

We used Distance Version 4.1 Release 2 to generate density estimates (Thomas et al. 2003). The distribution of plants at Pine Creek was influenced by a ditch, so data for that site were truncated to include observations up to 90% of the maximum detection distance. Akaike's Information Criterion (AIC) was used to select a model with 1 parameter (Buckland et al. 1993). The final detection function model was based on half-normal cosine parameters and no distance truncation.

RESULTS

Distance sampling compared to traditional counts

Warm Springs Bottom-The 0.5-m cluster method predicted a 95% confidence interval (450-743) that included (P>0.05) the estimate (486) based on the traditional count (Table 1). However, the individual method prediction (495-697) exceeded (P<0.05) the traditional estimate. Likewise, AIC (665.8) and examination of the detection function for the 0.5-m cluster method indicated a better model fit and greater stability than the individual method (1352.8; Figure 2).

Lufkin Bottom-The 1.0-m cluster method predicted a range (75-462) that included (*P*>0.05) the traditional estimate (88), although the individual method (196-317) yielded results greater (*P*<0.05) than the traditional count (Table 1). The AIC value for the 1.0-m cluster method (55.6) was much lower than for the individual method (206.2), even though the detection functions indicate the individual model was better (Figure 3).

Pine Creek #3-The 1.0-m cluster method (82-227) and individual method (115-208) both underestimated (*P*<0.05) the traditional count (267; Table 1). The AIC for the 1.0-m cluster (101.2) was considerably lower than for the individual method (479.6). Examination of the detection functions (Figure 4) supported the conclusion that the non-normal distribution pattern was due to the ditch.

0.5-m compared to 1.0-m clusters

Abundance estimates using the 0.5-m and 1.0-m cluster methods were similar (*P*>0.05) on a subset of data for Warm Springs Bottom (Table 1). However, the 0.5-m cluster method predicted a 95% confidence interval (29-170) lower and narrower than the 1.0-m method (62-259). The AIC value for the 0.5-m method (55.3) was approximately one-half that for the 1.0-m method (100.7). There was no comparable complete count for this area, but the 0.5-m method took less time to conduct, based on the need to measure fewer observations (*N*=12) compared to the 1.0-m method (21). Last, the detection function the 1.0-m model appeared to be the best fit (Figure 5).

DISCUSSION AND RECOMMENDATIONS

Distance sampling methods for Ute ladies'-tresses was relatively easy and robust. In general, cluster methods generated similar estimates to traditional counts and better models than the individual method. Truncating rarely improved model fit, but might be useful in limited circumstances such as Pine Creek. Assuming an inverse relationship between the frequency of observations and sampling efficiency, it takes less time to conduct 0.5-m cluster sampling than 1.0-m and individual, respectively.

In conclusion, traditional "complete" counts are most appropriate when estimating the abundance of Ute ladies'-tresses in small populations (<100) or when distribution patterns are linear (e.g., 4x100 m) or in small patches. Alternatively, distance sampling is more appropriate in evenly distributed large populations (>250) in homogenous blocks. In addition, distance sampling is replicable and generates a mean population estimate with 95% confidence intervals that facilitate tests for statistical significance among populations and years. Distance sampling provides a more valid and powerful estimate of population trends regardless of observer experience.

Although more testing is needed to identify the most appropriate use of distance sampling for monitoring Ute ladies'-tresses, we recommend establishing permanent transects at 25-m intervals within a block of a contiguous population (e.g., 6 transects in 50x150-m area in the middle of the Warm Springs Bottom population). Confidence intervals produced using distance sampling can be used to determine statistical significance associated with population monitoring of Ute ladies'-tresses. Distance sampling may be applicable for monitoring population trends for other plants.

LITERATURE CITED

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Table 1. Estimated abundance of Ute ladies'-tresses using distance sampling methods and traditional counts on the South Fork of the Snake River, Idaho.

Study site	Sampling method	*N*[1]	AIC[2]	ESW[3]	95% LCL[4]	95% UCL[5]	Comparable traditional count
Warm Springs Bottom	0.5-m cluster	125	665.8	8.9	450	743	486
	Individual	240	1352.8	11.2	495	697	486[88]
Lufkin Bottom	1.0-m cluster	19	55.6	2.6	75	462	88
	Individual	92	206.2	1.9	196	317	88[88]
Pine Creek	1.0-m cluster[6]	36	101.2	2.5	72	190	267[88]
	Individual[7]	180	479.6	2.8	174	282	267
Warm Springs Bottom subset	0.5-m cluster	12	55.3	9.2	29	170	-
	1.0-m cluster	21	100.7	9.8	62	259	-

[88]significant difference ($P<0.05$) between the distance sampling method and comparable traditional count method.
[1]*N*=number of observations.
[2]AIC=Akaike's Information Criterion.
[3]ESW=effective strip width.
[4]LCL=lower confidence limit.
[5]UCL=upper confidence limit.
[6]right truncated 5.5 m.
[7]left truncated 1.5 m.

Figure 1. Ute ladies'-tresses study sites on the South Fork of the Snake River, Idaho.

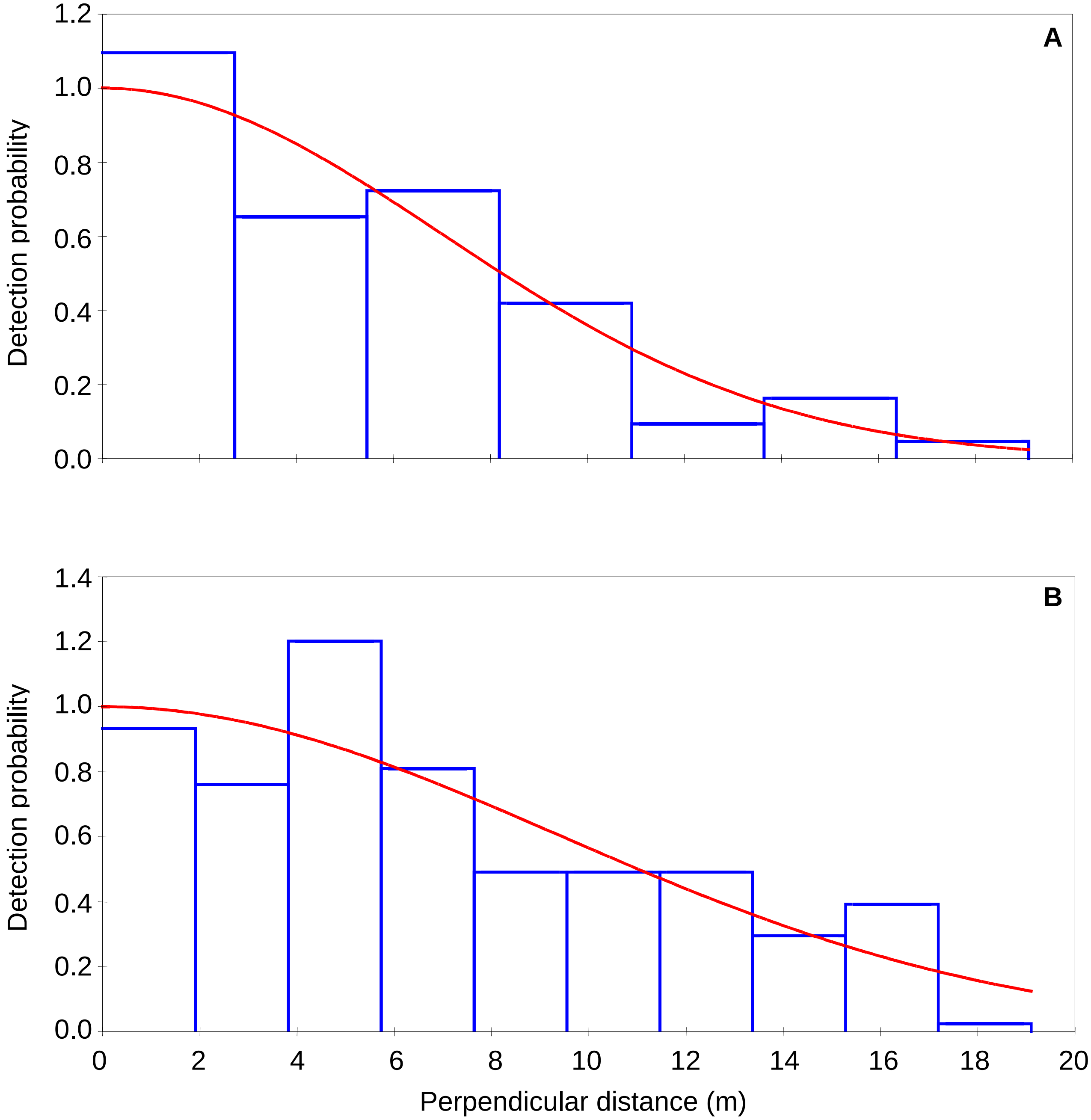

Figure 2. Probability of detecting Ute ladies'-tresses at Warm Springs Bottom at increasing distances from the line transect using the 0.5-m cluster (A) and individual (B) distance sampling methods. The detection function model was based on half-normal cosine parameters and no distance truncation.

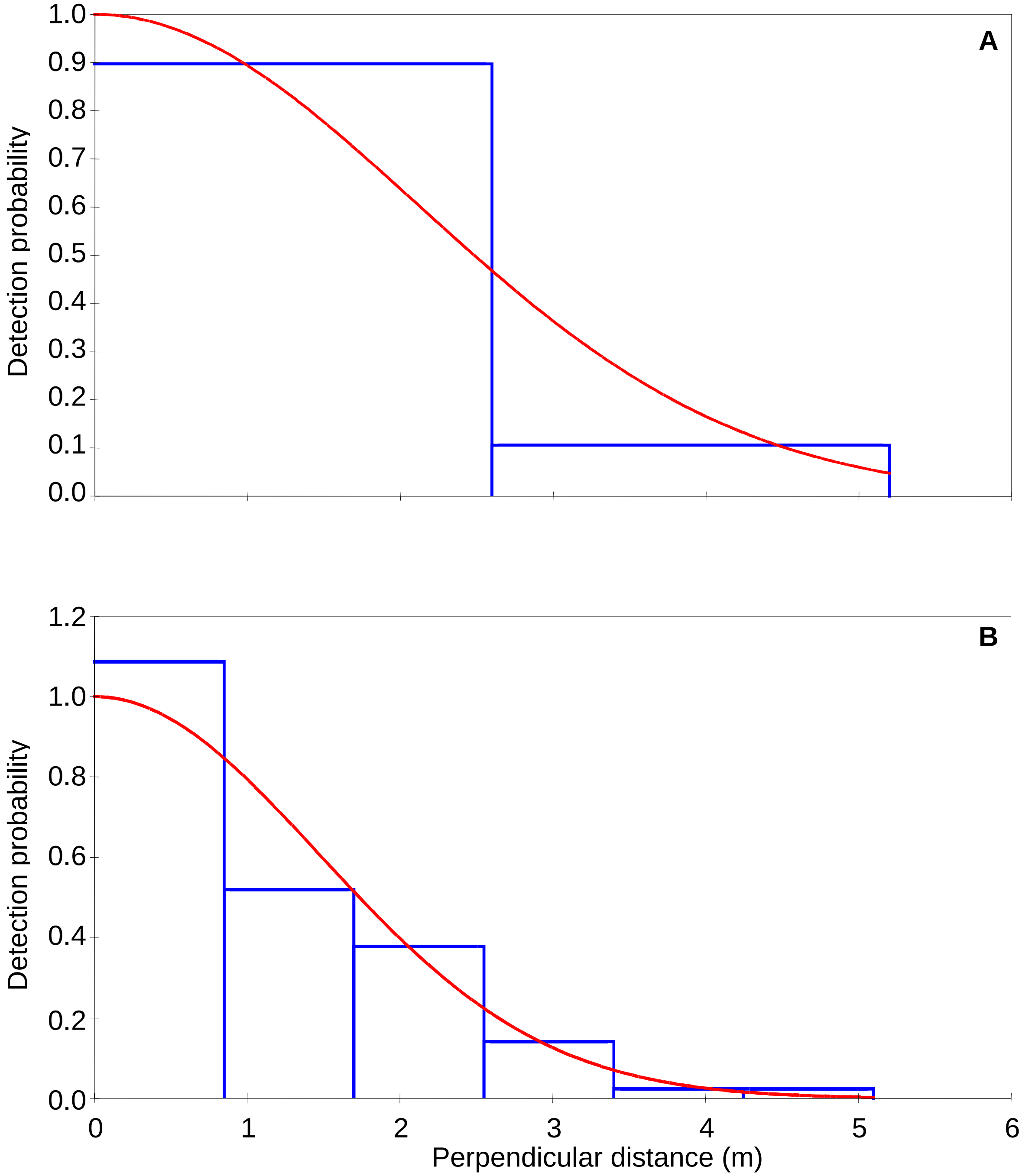

Figure 3. Probability of detecting Ute ladies'-tresses at Lufkin Bottom at increasing distances from the line transect using the 1.0-m cluster (A) and individual (B) distance sampling methods. The detection function model was based on half-normal cosine parameters and no distance truncation.

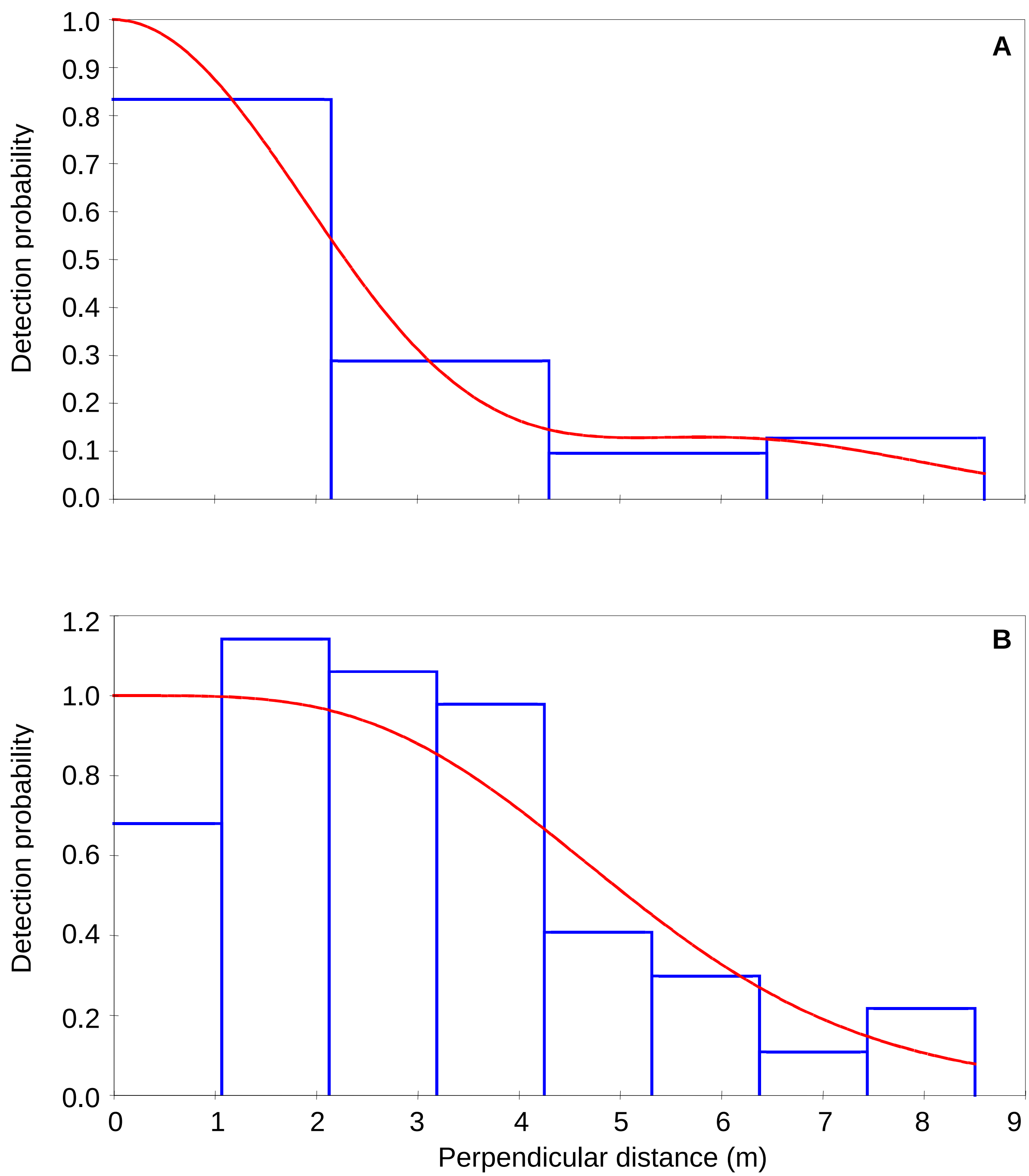

Figure 4. Probability of detecting Ute ladies'-tresses at Pine Creek #3 at increasing distances from the line transect using the 1.0-m cluster (A) and individual (B) distance sampling methods. The detection function model was based on half-normal cosine parameters and no distance truncation.

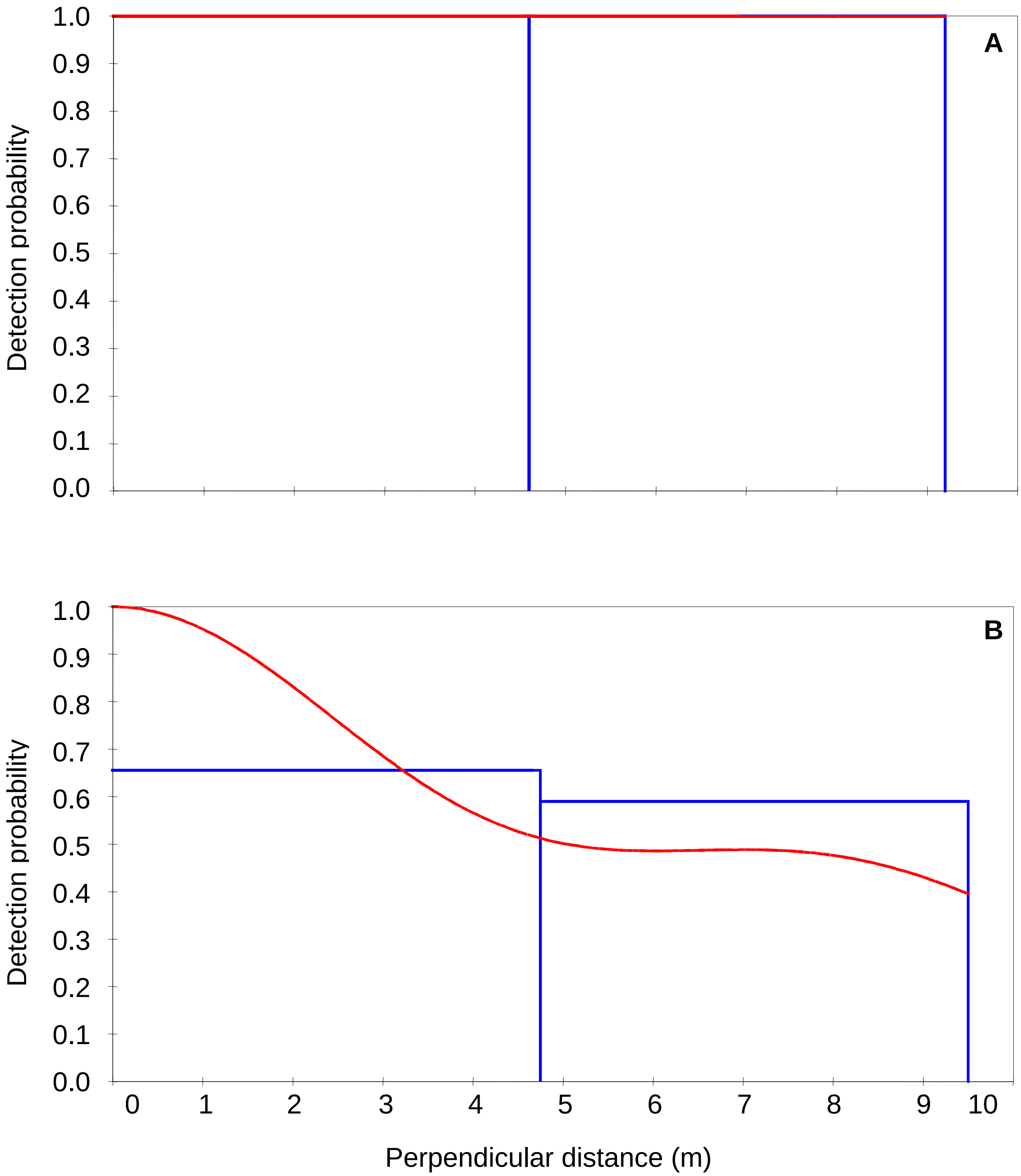

Figure 5. Probability of detecting Ute ladies'-tresses at a subset of Warm Springs Bottom at increasing distances from the line transect using the 1.0-m cluster (A) and 0.5-m cluster (B) distance sampling methods. The detection function model was based on half-normal cosine parameters and no distance truncation.