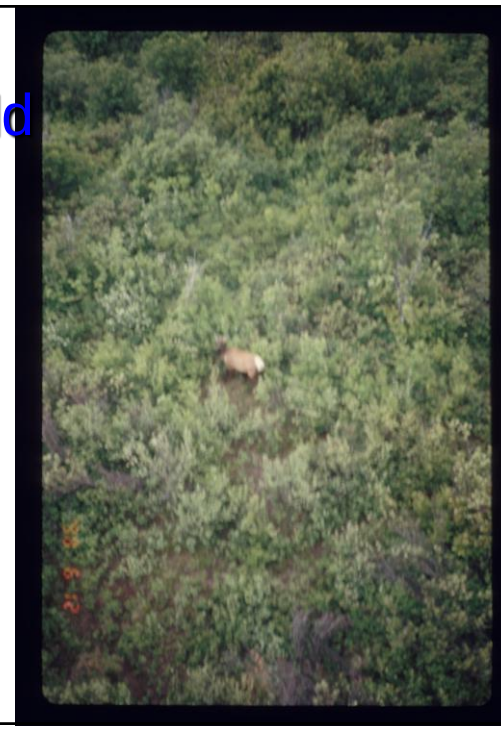
Estimating Abundance: Sightability Models

Visibility Bias

- Virtually all counts from the air or ground are undercounts because can't see all the animals due to vegetation cover or topographic irregularity
- Solutions utilize mark-resight methods, distance estimation (line transects), a correction factor or a sightability model

Elk in Brushfield

How many?



Elk in Light Timber


Medium Timber


Heavy Timber

Sightability Model

- Attempts to remove visibility bias by estimating a correction factor for each group of animals seen.
- Adaptable to a variety of conditions.
- Cost efficient, especially once model built
- Only works if model is applicable and if visibility averages at least 33%.

Developing a Sightability (or Visibility Bias) Model

- Mark elk (deer, sheep, etc.) groups with radio-collars or have observers on ground keep track of individual groups when helicopter/plane passes over.
- Fly aerial survey over the geographic area where the marked groups occur.
- Determine which individual groups were seen and which groups were missed.

Developing Sightability Models

- Identify which factors such as group size, tree and shrub cover, snow cover, weather, observers, type of helicopter, etc. influenced whether a group was seen or missed.
- Important: factors must be ones that will have the same effect each time a survey is conducted

Developing Sightability Models

- Keep some factors constant such as type of helicopter or fixed-wing, experience of observers, speed of flight, height above ground, etc.
- Estimate the effects of the other important factors we can't control such as group size, vegetation cover, etc. using logistic regression.

So how many seen of known total for each variable of interest?

Samuels et al (1987)

Table 1. Elk sightability survey results by independent variable from 4 study areas in northcentral Idaho, 1982–85.

Variable	No. of groups		Visibility[a]
	Missed	Seen	
Study areas[b]			
SRB	1	18	0.95
FCD	10	27	0.73
HR	19	10	0.34
DC	17	9	0.35
Group size			
1	18	5	0.22
2	7	6	0.46
3	5	5	0.50
4	4	6	0.60
5	4	9	0.69
6	6	4	0.40
7–15	3	14	0.82
16–30	0	10	1.00
30+	0	5	1.00
Vegetation cover class (%)			
0–12	3	26	0.90
13–27	1	9	0.90
28–42	0	2	1.00
43–57	6	12	0.66
58–72	5	5	0.50
73–87	13	8	0.38
88–100	19	2	0.10
Behavior			
Bedded	10	4	0.29
Standing	27	34	0.56
Moving	10	26	0.72
% snow cover			
0–19	1	9	0.90
20–50	4	5	0.56
51–99	4	5	0.56
100	38	45	0.54
Observers[c]			
MWS	10	34	0.77
LXK	17	14	0.45
GNP	20	16	0.44
Search rate (min/km²)			
2.00–4.99	10	8	0.44
5.00–6.19	9	11	0.55
6.20–7.39	2	15	0.88
7.40–9.89	8	14	0.64
9.90–12.39	11	10	0.48
12.40+	7	6	0.46

[a] Visibility = (no. of groups seen) ÷ (no. of groups seen + no. of groups missed).
[b] SRB = Salmon River Breaks, FCD = Fish Creek Drainage, HR = Hungry Ridge, and DC = Deadman Creek.
[c] Initials of primary observers.

Sightability Model:Analysis

- Logistic regression is one of a number of statistical models that can be used to analyze the observations of groups seen and groups missed.

$$\text{logit}(p_i) = \log\left[\frac{p_i}{1-p_i}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots$$

- Where p_i is the probability of seeing a group
- e.g. X_1 = group size, X_2 = veg. cover

Table 2. Final logistic regression results (N = 111) from elk sightability surveys on 4 study areas in northcentral Idaho, 1982–85. Minimum level of significance for inclusion of variables set at P = 0.10.

Variable	Level of significance[a]	Final coefficient[b]	Coefficient ÷ SE[c]
Constant		1.22	1.81
Group size	0.0000	1.55	4.14
% vegetation cover	0.0000	−0.05	−4.90
Observers[d]	0.1081		
Study areas[d]	0.1891		
Behavior[d]	0.4387		
% snow cover[d]	0.7554		
Search rate[d]	0.8960		

[a] Probability that variable has no significant influence on sightability.
[b] Regression coefficients for sightability model.
[c] Coefficient divided by SE is equivalent to a t-test for the coefficient = 0.0.
[d] Variables not included in final logistic regression model.

$$u = 1.22 + 1.55\ \ln(\text{group size}) - 0.05\%\ \text{vegetation cover}.$$

Samuels et al (1987)

Probability of Seeing Elk

How does sightability of elk change with group size and veg cover?

626 VISIBILITY BIAS IN ELK SURVEYS • *Samuel et al.* J. Wildl. Manage. 51(3):1987

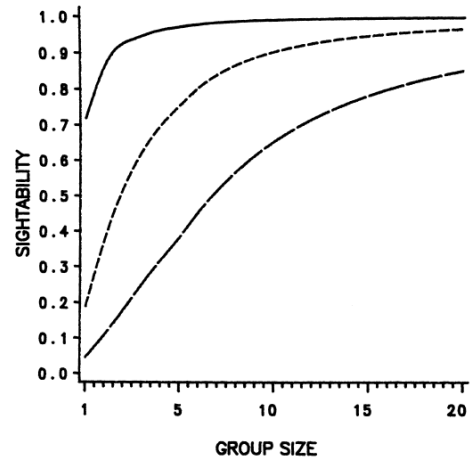


Fig. 1. Predicted sightability by group size for 0–12 (——), 43–57 (– – –), and 73–87 (— — —)% vegetation cover (Model II), based on 111 elk groups observed during helicopter surveys in northcentral Idaho, 1982–85.

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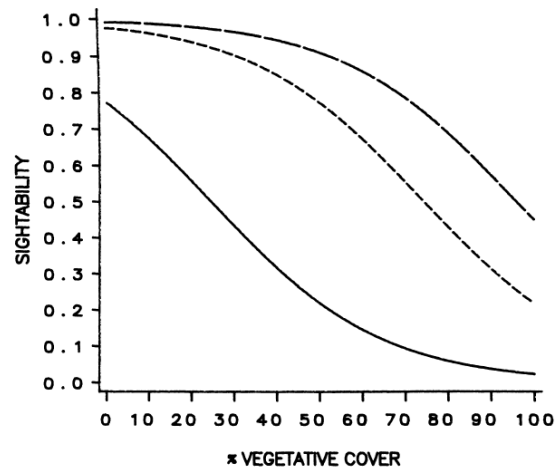


Fig. 2. Predicted sightability by percent vegetative cover for groups of 1 (——), 5 (– – –), and 10 (— — —) elk (Model I), based on 111 elk groups observed during helicopter surveys in northcentral Idaho, 1982–85.

Factors Affecting Elk Sightability

- Size of group
- Percent vegetation cover around group
- Percent snow cover
- Secondary factors also statistically signif.:
  - Activity (moving vs. still)
  - Observer experience
  - Composition (Bull groups vs. others)
  - Type of helicopter or fixed-wing

Sightability Model

- Use the logistic regression model to calculate the probability that each group is seen.

Simple Application

- Suppose we see a group of 3 elk in an open forest with 40% cover of obscuring vegetation.
- If our logistic regression model estimates that only ½ of groups of 3 in 40% cover are seen (p=0.5), then if we saw this one group of 3 animals, there was probably another group of 3 that we missed.

Simple Application

- So if we saw 3 there were actually 6 in the area.
- How? Probability of detection = 0.5
- True N = N_{obs} /Prob. of det. = 3 / 0.5 = 6

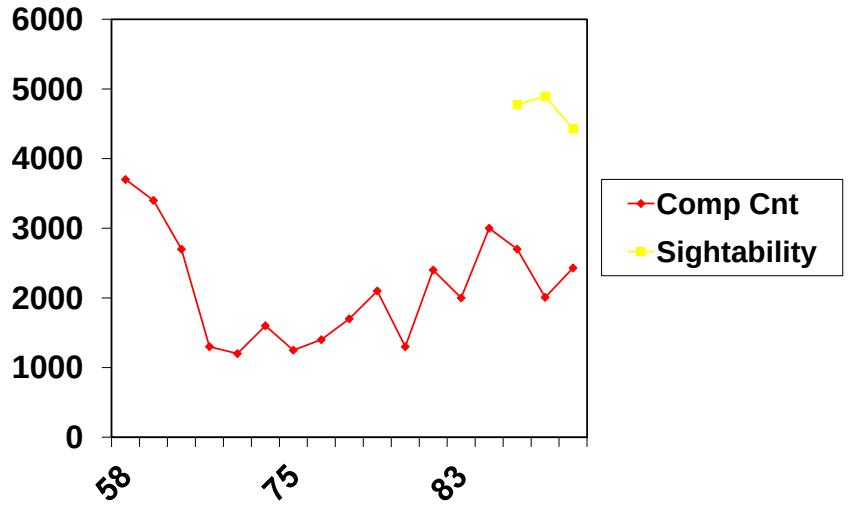
Simple Application

- If the next group we saw was a group of 2 animals in 80% cover and the model said that we only have a 20% chance of detecting such a group (p=0.2)
- We would correct this group of 2 to represent 2/0.2 or 10 animals in the population.

Lochsa River Elk Herd

- This sightability model was applied to the elk herd wintering on the Lochsa River in 1985.
- Half of the winter range was flown obtaining a raw count of 2718 elk.
- When the sightability model corrections were applied to the counts the corrected estimate was 4775 with 90% bound of 458.

Lochsa Elk Herd



Can be applied to similar areas/ conditions, or new sightability models created

Gilbert & Moeller (2008) – elk in central Cascades (WA)

TABLE 1. Complete model set including c-statistic, AICc, AICc difference, AICc weights for logistic regression models of elk sightability in the Packwood Area in the Cowlitz River drainage, Washington. Response variable was probability of sighting an elk group. All models based on a sample size of 57 elk groups.

Model	C	AICc	AICc Diff	AICc Wts	Sum of Wts
Group size, vegetation cover	0.908	49.905	0.000	0.759	0.759
Group size, vegetation cover, vegetation class	0.904	53.704	3.799	0.114	0.873
Group size, vegetation cover, activity	0.908	54.178	4.273	0.090	0.962
Vegetation cover	0.847	57.940	8.035	0.014	0.976
Group size, vegetation cover, vegetation class, activity	0.904	58.062	8.157	0.013	0.989
Group size	0.814	60.240	10.335	0.004	0.993
Vegetation cover, activity	0.855	61.149	11.244	0.003	0.996
Vegetation cover, vegetation class	0.848	61.566	11.661	0.002	0.999
Group size, activity	0.818	63.550	13.645	0.001	1.000
Group size, vegetation class	0.812	64.499	14.594	0.001	1.000
Vegetation cover, vegetation class, activity	0.855	65.059	15.154	0.000	1.000
Group size, vegetation class, activity	0.814	67.952	18.047	0.000	1.000
Vegetation class	0.591	83.172	33.267	0.000	1.000
Activity	0.527	83.393	33.488	0.000	1.000
Vegetation class, activity	0.617	85.490	35.585	0.000	1.000

Results w parameters for 2 best models

TABLE 2. Summary of results of logistic regressions investigating the probability of sighting elk groups from a helicopter in aerial surveys in the Packwood Area of the Cowlitz River drainage in west-central Washington in 2004 and 2006. Included models are from the 90% confidence set as established by AICc model selection.

Model		Group Size			Vegetation Cover			Vegetation Class		
Rank	Constant	β	SE	P	β	SE	P	β	SE	P
1	0.835	0.217	0.096	0.025	-0.047	0.015	0.002			
2	0.893	0.227	0.101	0.026	-0.050	0.016	0.002	0.442[c]	0.600	0.462
								-0.256[h]	0.757	0.735

c = conifer cover class, h = hardwood cover class

Describe how sightability changes in each model

Raw and adjusted counts by various classes.

Does using sightability model to adjust make a difference?

TABLE 3. Summary of aerial survey results for the Packwood area of the Cowlitz River drainage in west-central Washington during late winter (early 2006).

	Original Unit designations		Adjusted Unit designations	
	Estimate	90% CI Bound	Estimate	90% CI Bound
Total elk	662	81	968	229
Cows	409	50	607	143
Bulls	67	11	88	19
Branched antler bulls	24	9	27	11
Calves	178	25	262	74
Spikes	43	7	61	15
Raghorns	19	7	21	10
Adult bulls	5	2	6	3
Bulls:100 cows	16	8	15	3
Calves:100 cows	43	1	43	12
Spikes:100 bulls	63	18	69	46
Raghorns:100 bulls	28	35	24	32
Adult bulls:100 bulls	8	4	7	3
Branched bulls:100 bulls	36	52	31	35