

Multiple covariate distance sampling (MCDS) - Complications

- Aim:
 - Discuss some complications that arise with MCDS analyses
 - Give some analysis guidelines

Complications 1. Clustered populations

There are two approaches to estimating number of individuals when objects are in clusters:

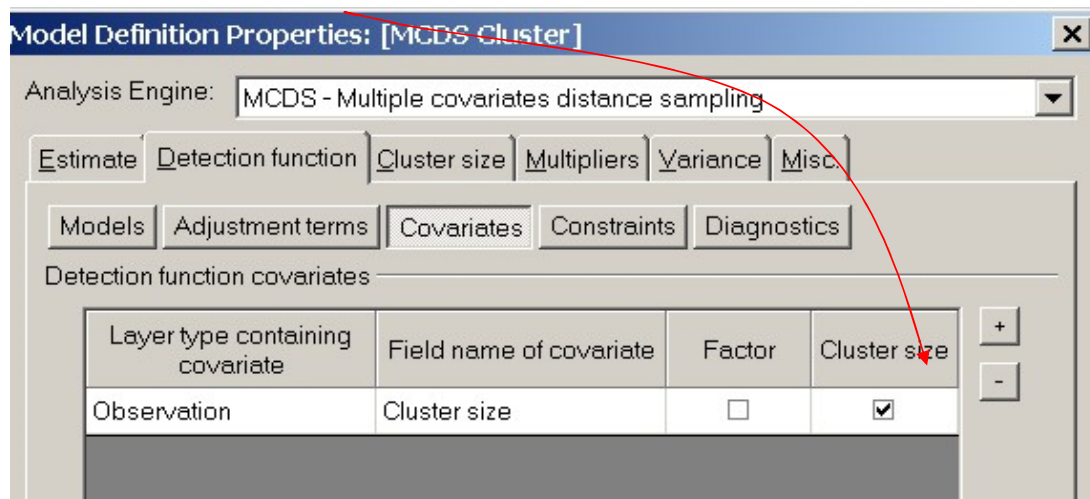
$$(1) \quad \hat{N} = \sum_{i=1}^n \frac{1}{\Pr[\textit{group included}]} \hat{E}[s] \\ = \frac{A}{2L} \hat{E}(s) \sum_{i=1}^n \hat{f}(0 | z_i)$$

$$(2) \quad \hat{N} = \sum_{i=1}^n \frac{\textit{group size}}{\Pr[\textit{group included}]} \\ = \frac{A}{2L} \sum_{i=1}^n s_i \hat{f}(0 | z_i)$$

When cluster size is *not* a covariate, we use (1); when it is a covariate, we use (2)

Clustered populations (contd.)

To tell Distance that a covariate represents cluster size, tick the box:



When cluster size is a covariate:

- Distance does not estimate variance using analytic methods: the bootstrap must be used (Reflected in the Variance tab)
- There is no need for size bias regression methods (Cluster size tab changes)
- No stratification allowed (Estimate tab)

Complications 2. Adjustment terms

With adjustments:
$$g(x, z) = k(x, z) \left[1 + \sum_{j=1}^m a_j p_j(x_s) \right] / c$$

Adjustment terms use *scaled* distances, x_s

- cosine adjustment of order 2: $\cos(2\pi x_s)$
- simple polynomial of order 4: x_s^4

Why scale?

- Avoid numerical problems
- Limits cosine adjustment to a small number of ‘wiggles’

How to scale?

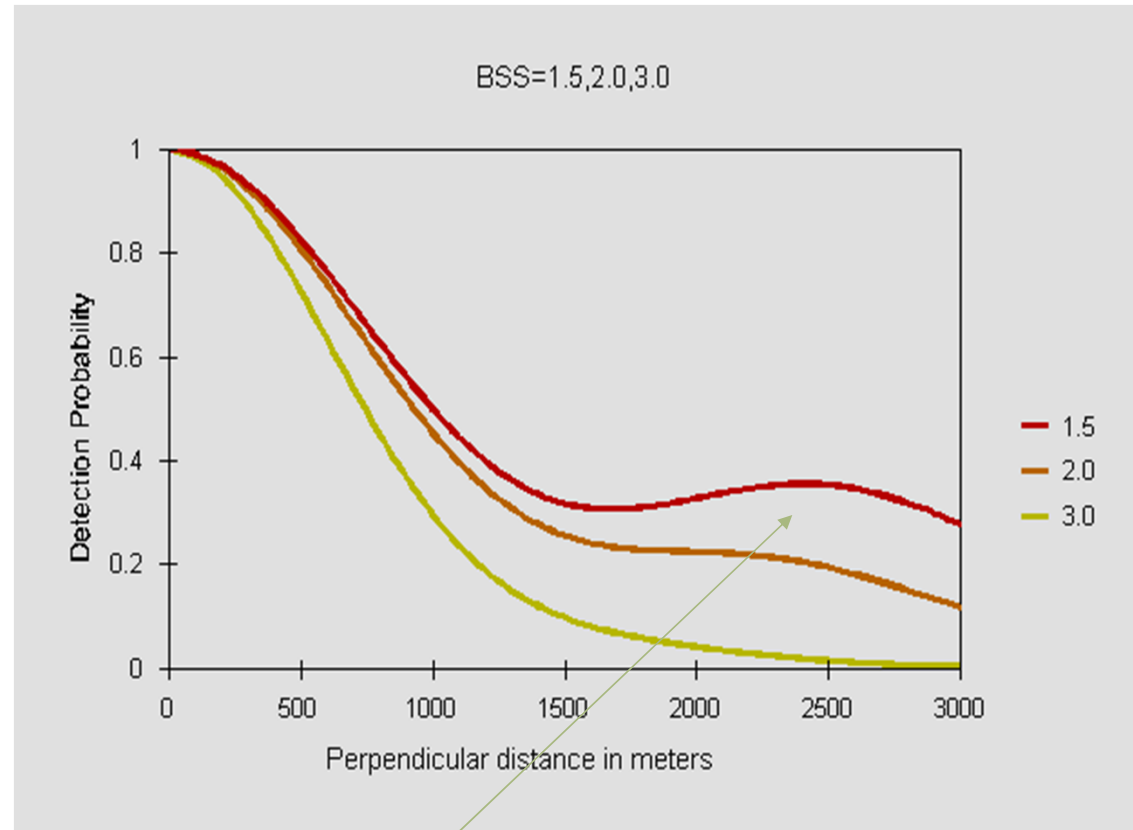
Adjustment terms (contd.)

Scenario 1: Scale distances by w , the right truncation distance $x_s = x/w$

Then covariates affect the scale of the key function, but adjustment terms are unaffected by covariates, so the overall shape varies with covariate value:

e.g., half-normal with 1 cosine adjustment of order 2

$$g(x | \mathbf{z}) \propto \exp\left(\frac{-x^2}{2\sigma(\mathbf{z})^2}\right) \left[1 + a_2 \cos\left(\frac{2\pi x}{w}\right)\right]$$



Note: no monotonicity constraint

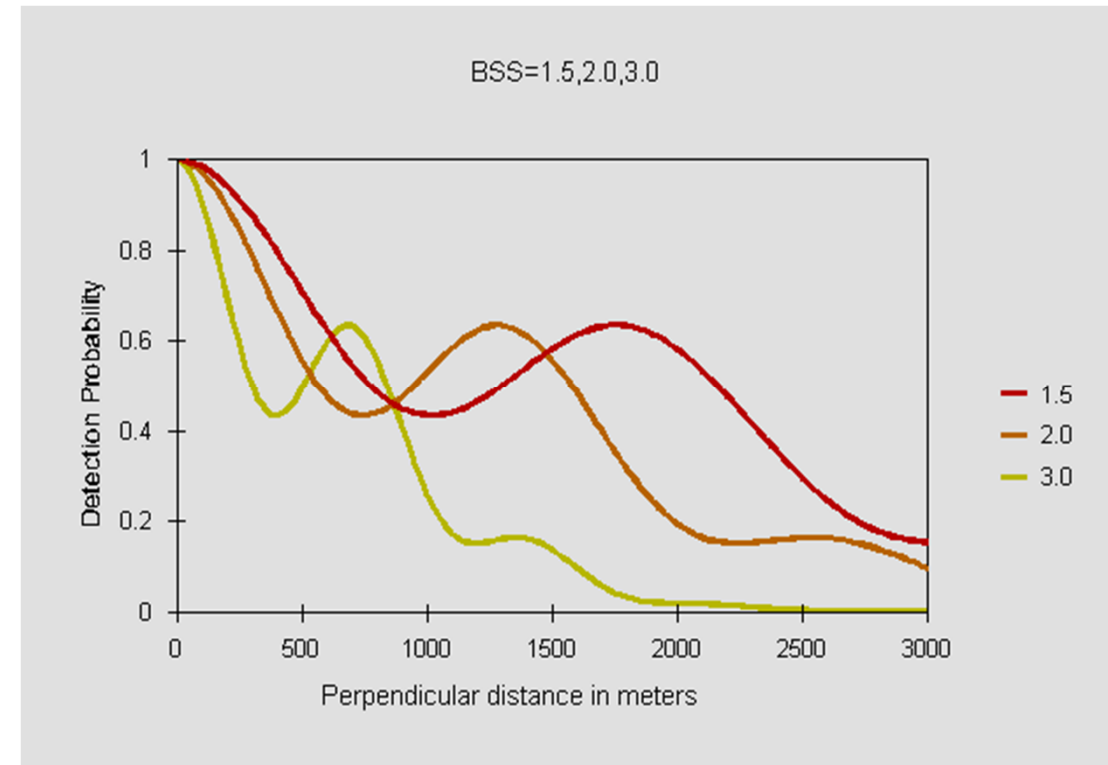
Adjustment terms (contd.)

Scenario 2: Scale distances by $\sigma(z)$, the estimated scale parameter $x_s = x/\sigma(z)$

Then covariates affect the scale of the key function, and the scale of the adjustment terms, so only the scale and not the shape of the overall function is affected:

e.g., half-normal with 1 cosine adjustment of order 2

$$g(x|z) \propto \exp\left(\frac{-x^2}{2\sigma(z)^2}\right) \left[1 + a_2 \cos\left(\frac{2\pi x}{\sigma(z)}\right)\right]$$



Adjustment terms (contd.)

- The previous was an extreme example, to illustrate the difference between scaling factors.
- Generally:
 - start with no adjustment terms and introduce covariate terms one by one
 - check the fit with adjustments looks reasonable
 - consider whether to scale by w or σ
- you may need fewer adjustment terms with MCDS than CDS analyses

Model Definition Properties: [HN MCDS Obs by strat]

Analysis Engine: MCDS - Multiple covariates distance sampling

Estimate Detection function Cluster size Multipliers Variance Misc.

Models Adjustment terms Covariates Constraints Diagnostics

Selection of adjustment terms

☒ Automated selection

Selection method: Sequential Look-ahead: 1

Selection criterion: AIC Significance level: 0.15

Maximum terms: 5

☐ Manual selection

Model	Num adj. parameters	Order of adjustment parameters (optional)
1	0	

☐ Manually select starting values

Model	Num parameters
1	0

Scaling of distances

Scale distances by: W (right truncation distance)

Defaults Name: HN MCDS Obs by strat OK Cancel

Complications 3. Stratification

If we want stratum-level estimates of density/abundance we can fit the detection function with covariates globally, and estimate $f(0|z)$ by stratum:

Model Definition Properties: [MCDS both]

Analysis Engine: MCDS - Multiple covariates distance sampling

Estimate | Detection function | Cluster size | Multipliers | Variance | Misc.

Stratum definition

☐ No stratification Layer type: Field name:

☒ Use layer type: Stratum

☐ Post-stratify, using: Stratum Area

Sample definition (for encounter rate)

Use layer type: Sample

Quantities to estimate and level of resolution

	Level of resolution of estimates		
	Global	Stratum	Sample
Density	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Encounter rate	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Detection function	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Cluster size (if required)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Global density estimate is Mean of stratum estimates

weighted by Stratum area

Defaults Name: MCDS both OK Cancel

Tick both boxes

- Note: Global variance estimate for density/abundance must be calculated via the bootstrap

MCDS analysis guidelines

Choose covariates that are:

- independent of distance
- not strongly correlated with each other

Specifying the model:

- factor covariates generally harder to fit
- avoid or limit automatic selection of adjustment terms
- if using adjustments, consider whether to scale by w or σ
- check convergence and monotonicity
- add only one covariate at a time
- where necessary, use starting values and bounds for parameters
- consider reducing the truncation distance, w , if more than 5% of the $P_a(z_i)$ are <0.2 , or if any are less than 0.1