Additional Issues in Distance Sampling

We can apply distance approaches to the typical point counts used to index abundance of bird populations.
Point counts are the most widely used method of monitoring birds and are the method used in the North American Breeding Bird Survey.

Point count data have numerous problems, however, because they require the assumption that detection rates are constant across time and habitats. For example, a trend in numbers through time could result either from a real trend or a change in detection probability, possibly associated with habitat change.

“We cannot recommend using point counts for inferential monitoring...because of substantial problems associated with incomplete and unequal catchability”

Thompson, White and Gowan 1998
If we collect additional distance data we can apply distance methods to point count data.

$r_i$ represent distances from the sampling point to each detected individual.
The logic is the same as that for line transect; we expect that detection of individuals further from the sampling point is less likely than for those nearer the sampling point.
For point counts, unlike line transects, data are circular. For $k$ replicate points a natural estimate of density if detection is 100% is:

$$\hat{D} = \frac{n}{A} = \frac{n}{k\pi w^2}$$

where $w$ is the radius of the area sampled.
As for the case of line transects, however, not all individuals are detected and detection likely declines with distance from the sampling point. Correcting for detection probability,

\[
\hat{D} = \left( \frac{n}{k \pi w^2} \right) / P_a
\]
Detection probability moving from the center to the edge of a point count area. (Half of area shown.)
If individuals are distributed randomly with respect to the sampling point, the probability of detecting individuals that are present will decline as a function of distance from the sampling point. The area sampled will increase because of increasing area at larger radii.

\[ \text{Area in the outer annulus is larger.} \]
We define two probability distributions that are subtly different from each other.

\[ f_1(r) = \frac{2\pi r}{\pi w^2} \]

\[ f(r) = \frac{rg(r)}{\int_0^w r g(r) dr} \]

\(f_1(r)\) is the distribution of radial distances, while \(f(r)\) is the probability density of observations within a distance \(w\) from the sample point.
Note the similarity between $f(r)$ for point samples and $f(x)$ for line transects.

\[
f(r) = \frac{rg(r)}{\int_0^w rg(r)dr}
\]

\[
f(x) = \frac{g(x)}{\int_0^w g(x)dx}
\]
Probability density function for detections:

\[ f(r) = \frac{rg(r)}{\int_0^w r g(r) dr} \]

The number of individuals in an annulus of width \( dr \) is given by \( N f_1(r) dr \), detected with probability \( g(r) \).
Total detected within the sampling area is given by the integral of number detected within $dr$ across $r$:

$$E(n) = \int_{0}^{w} Ng(r) f_1(r) dr$$

$$= N \tilde{P}_a$$

where, $P_a$ is the average detection probability averaged over $f_1(r)$.

$$P_a = \int_{0}^{w} g(r) f_1(r) dr$$
\[ f_1(r) = \frac{2r}{w^2} \]

Substituting into the equation for \( P_a \)

\[ P_a = \int_0^w g(r) \left[ \frac{2r}{w^2} \right] dr \]

\[ = \frac{2}{w^2} \int_0^w r g(r) dr \]
The density estimator becomes

\[ \tilde{D} = \left( \frac{n}{A} \right) \frac{1}{P_a} \]

\[ = \frac{n}{2k\pi \int_0^w r g(r) dr} \]

Evaluating \( f'(0) \), we can show that:

\[ \hat{D} = nf'(0) / 2k\pi \]

Where \( f''(0) \) is estimated from the data.
As for line transects, it is essential that sampling points be random with respect to the location of animals. Otherwise, estimates of the detection function will be biased because we assume that declines in detection are not a function of changes in density.