ESTIMATION OF NEST SUCCESS
Trends in males on sage-grouse leks in Wyoming and eastern Nevada

Western WY

\[ y = 4.723 - 0.1364x + 0.002x^3 \]

Eastern NV

\[ y = 3.242 - 0.070x + 0.0011x^2 \]
Traditional approaches to estimating nest success simply divided the number of nests that hatched by the total number of nests found.

This calculation requires a specific assumption that is unlikely to be true in many studies.
One must assume that all nests are found, or that nests that already failed have the same probability of being found as active nests. If this assumption is not met, nest success will be overestimated.

An additional issue is that nests that are found near hatching have already survived most of the period during which they could fail. Thus, such nests will hatch with a higher probability than nests found during egg laying.
Your text provides an example. If all nests in the sample have a probability of 0.99 of surviving each day, a nest found at the beginning of egg laying must survive the entire egg laying and incubation periods. Assume these require 30 days total. Nests found at the beginning of egg laying will survive with probability $0.99^{30} = 0.74$. Nests found two days before hatching will survive with probability $0.99^2 = 0.98$. 
We demonstrated that apparent nest success can be biased high and may lead to erroneous interpretations of productivity. The apparent nest-success rate of 0.46 is higher than any of our seasonal estimates for average habitat and observed precipitation conditions, which ranged from 0.24 to 0.32 for early nests and 0.32 to 0.42 for late nests. Of greater concern, the positive bias in estimates of apparent nest survival was variable, ranging from 8% to 91%.

Howard Mayfield (1961, 1975) was the first to recognize the potential for bias in estimates of nest success using traditional methods. Mayfield calculated daily survival rate as:

\[
\hat{S} = 1 - \left( \frac{\text{Number of failures}}{\sum L (n_{LS} + 0.5n_{LF})} \right)
\]

\(L\) = interval between visits
\(n_{LS}\) = number of nests surviving interval
\(n_{LF}\) = number of nests failing during interval

The 0.5 multiplier in the denominator reflects the assumption that nests failed at the mid-point of intervals.


More formal methods of estimating daily survival rate for nests have been developed by Johnson (1979), Bart and Robson (1982), Hensler and Nichols (1981). These methods allow nests to be visited at a variety of intervals, \( l = 1, \ldots, L \) days. Let \( n_l \), the total number of observed intervals of length \( l \) for which nest fate was determined.

\[
n_l = n_{ls} + n_{lf}
\]

The probability model for the modern Mayfield can be written:

\[
f(n_{ls} | n_l, S) = \prod_{l=1}^{L} \frac{n_l!}{n_{ls}! n_{lf}!} (S^l)^{n_{ls}} (1 - S^l)^{n_{lf}}
\]
Program SURVIV can be used to estimate parameters for these models.

Assumptions:
1. Fates of all nests are known at each visit;
2. Survival rates are constant over the study;
3. All visits are recorded;
4. Survival probability is not influenced by the observer;
5. Probability of a visit is independent of probability of survival.
We can address some of the assumptions directly. The assumption of constant survival can be addressed by stratifying survival estimates based on the time in the cycle they correspond to. For example, we might estimate daily survival rate separately for nests during egg laying, early incubation and late incubation. Program Mark also allows for the incorporation of covariates into survival analyses so we can examine the impact of an additional variable, say nest initiation date, on daily nest survival rate. We often use a logistic function for such relationships:

\[ S = \frac{e^{(\beta_0 + \beta_1 x)}}{1 + e^{(\beta_0 + \beta_1 x)}} \]

where \( \beta_0 \) is an intercept term and \( \beta_1 \) is a slope parameter.
### Survival Data for Moring Doves

<table>
<thead>
<tr>
<th>Interval Between Visits</th>
<th>No. Nests Sampled with This Interval</th>
<th>No. Nests Surviving</th>
<th>No. Nests with Mortality</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>12</td>
<td>0</td>
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<tr>
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<tr>
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<td>18</td>
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<td>26</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>31</td>
<td>2</td>
</tr>
</tbody>
</table>

Data from Bart and Robson 1982
## Survival Data for Moring Doves

<table>
<thead>
<tr>
<th>INTERVAL BETWEEN VISITS</th>
<th>NO. NESTS SAMPLED WITH THIS INTERVAL</th>
<th>NO. NESTS SURVIVING</th>
<th>NO. NESTS WITH MORTALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
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<td>0</td>
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</table>

\[
\hat{S} = 1 - \left( \frac{9}{1 \cdot 12 + 2 \cdot (7 + 0.5) + 3 \cdot (12 + 1.5) + 4 \cdot (17 + 0.5) + 5 \cdot (24 + 1) + 6 \cdot (31 + 1)} \right)
\]

\[
= 1 - \left( \frac{9}{12 + 15 + 40.5 + 70 + 125 + 192} \right)
\]

\[
= 1 - (0.0198)
\]

\[
= 0.9802
\]
\[
\hat{S} = 1 - \left( \frac{9}{1 \cdot (12) + 2 \cdot (7 + 0.5) + 3 \cdot (12 + 1.5) + 4 \cdot (17 + 0.5) + 5 \cdot (24 + 1) + 6 \cdot (31 + 1)} \right)
\]
\[
= 1 - \left( \frac{9}{12 + 15 + 40.5 + 70 + 125 + 192} \right)
\]
\[
= 1 - (0.0198)
\]
\[
= 0.9802
\]

If mourning doves require 30 days to produce a clutch, incubate it and fledge the young then expected survival of the average nest would be:

\[
\hat{S}^{30} = 0.549
\]
The graph illustrates the daily survival rates of various nest age groups. The x-axis represents the nest age in days, ranging from 0 to 40. The y-axis represents the daily survival rate, ranging from 0.90 to 1.00.

Three different lines represent different OSC levels: 6%, 20%, and 34%. Each line shows a decreasing trend in daily survival rate as the nest age increases. The error bars indicate the variability in the survival rates across different nest age groups.

- The 6% OSC line starts at a higher survival rate and shows a slight decrease over time.
- The 20% OSC line is slightly below the 6% line, indicating a higher variability in survival rates.
- The 34% OSC line is the lowest among the three, with the most variability in survival rates, especially at older nest ages.

The graph effectively demonstrates how different OSC levels affect daily survival rates over the course of nest age.