



# Lecture 8

## Survival estimation

WILD3810 (Spring 2020)

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# Readings

Powell & Gale 103-122; 123-138

# Life tables

If detection probability is

- will be biased low
- All other life table statistics will be biased as well
  - Survival biased low, mortality biased high



# Survival estimation

# Survival estimation

Methods used to estimate plant and animal survival generally fall into three categories:

- 1) Known fate
- 2) Capture-mark-recapture
- 3) Recovery models

# Known fate

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# Known fate

Data

Individual	Capture history	Probability
Indv 1	111	
Indv 2	110	
Indv 3	100	

# Known fate

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# Known fate

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## Individual 2

- Captured on occasion 1
- Resighted **alive** on occasion 2

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# Known fate

## Data

Individual	Capture history	Probability
Indv 1	111	
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## Individual 2

- Captured on occasion 1
- Resighted **alive** on occasion 2

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# Known fate

## Data

Individual	Capture history	Probability
Indv 1	111	
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## Individual 3

- Captured on occasion 1
- Resighted **dead** on occasion 2

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# Known fate

Kaplan-Meier model

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- : Number of individuals at risk of dying during interval
- : Number of individuals that died during interval

# Known fate

Kaplan-Meier model

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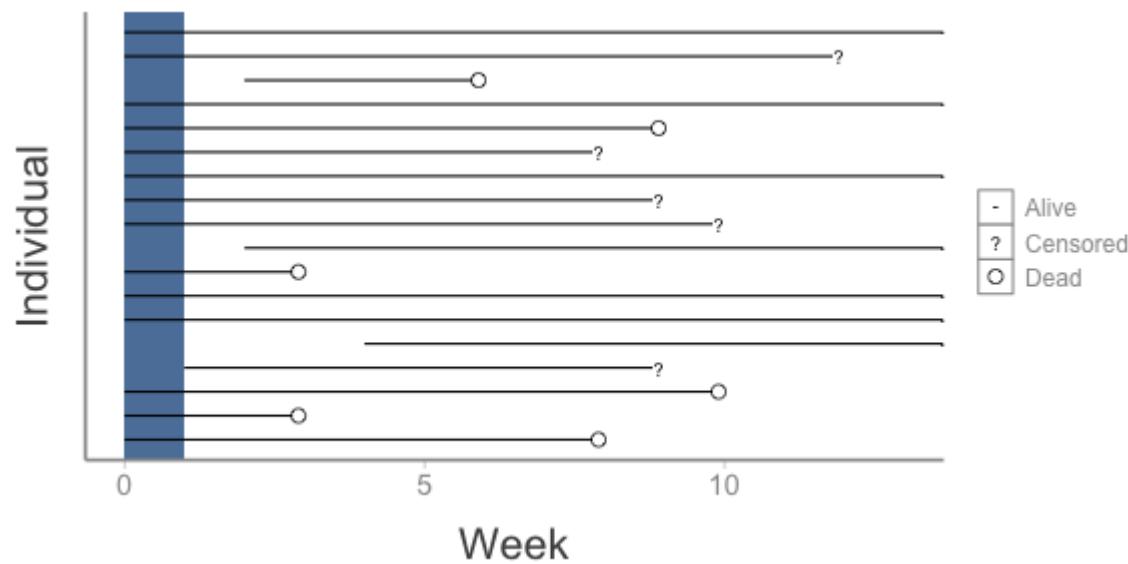
Who is at risk of dying?

- Individuals who are **known** alive at the beginning of the interval
  - Does not include individuals not yet marked (*staggered entry*)
  - Does not include individuals whose fates are unknown (*censoring*)

# Known fate

Estimating survival

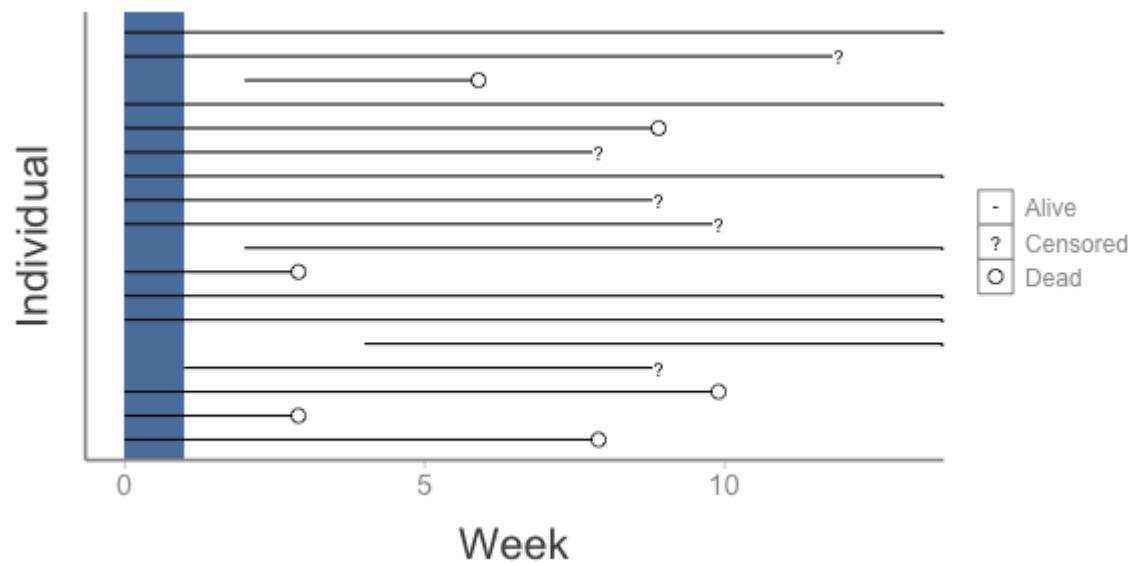
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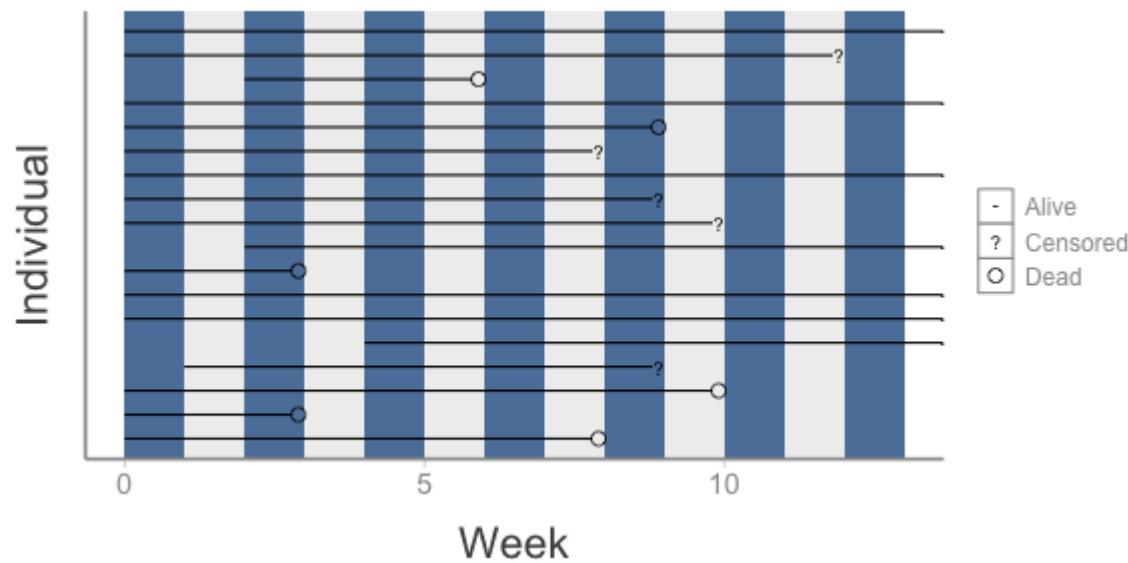
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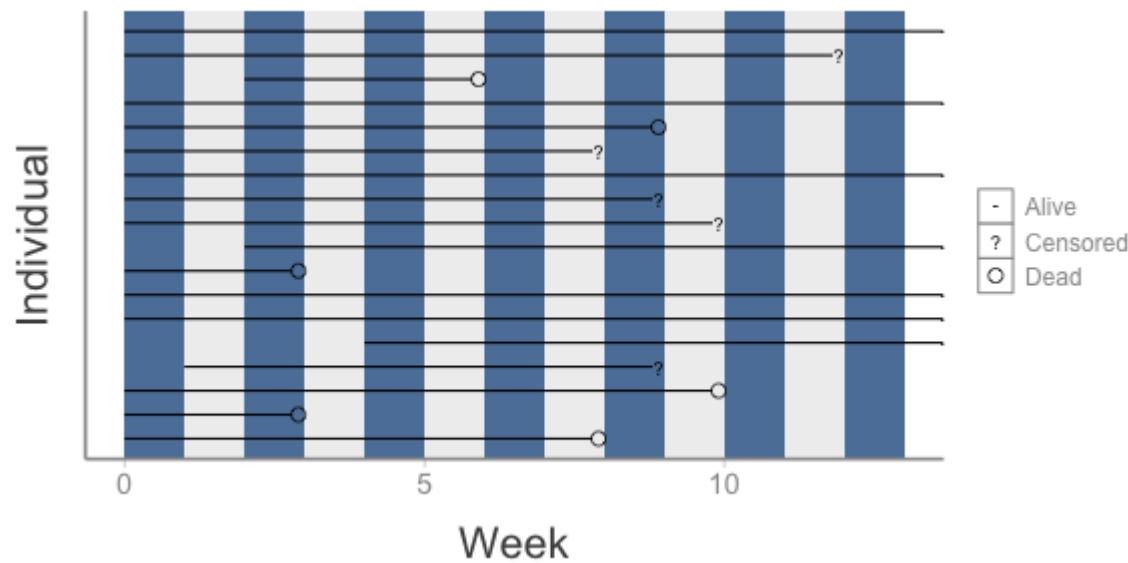
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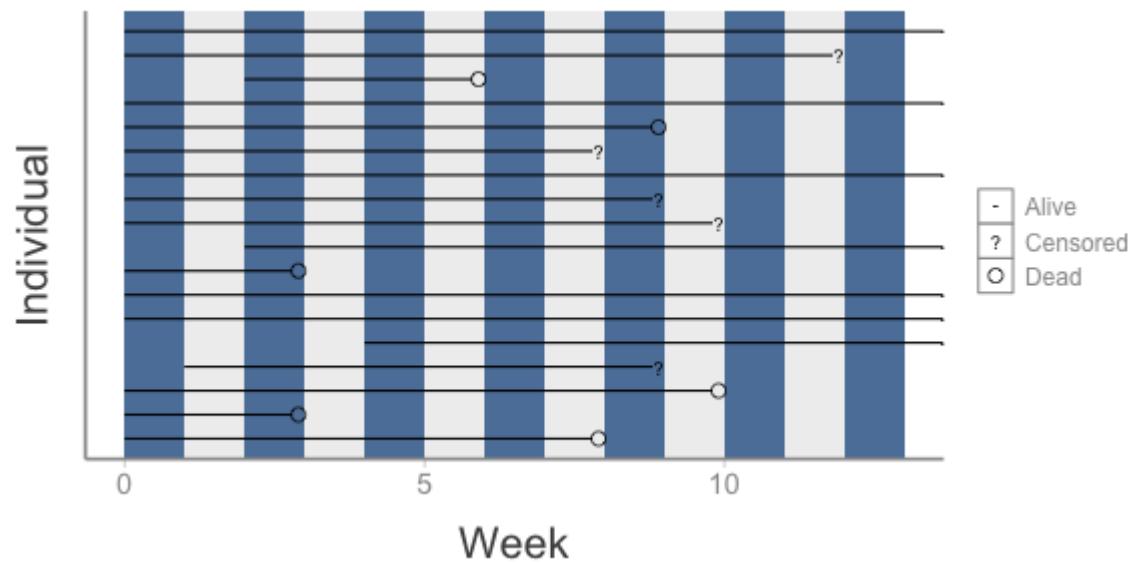
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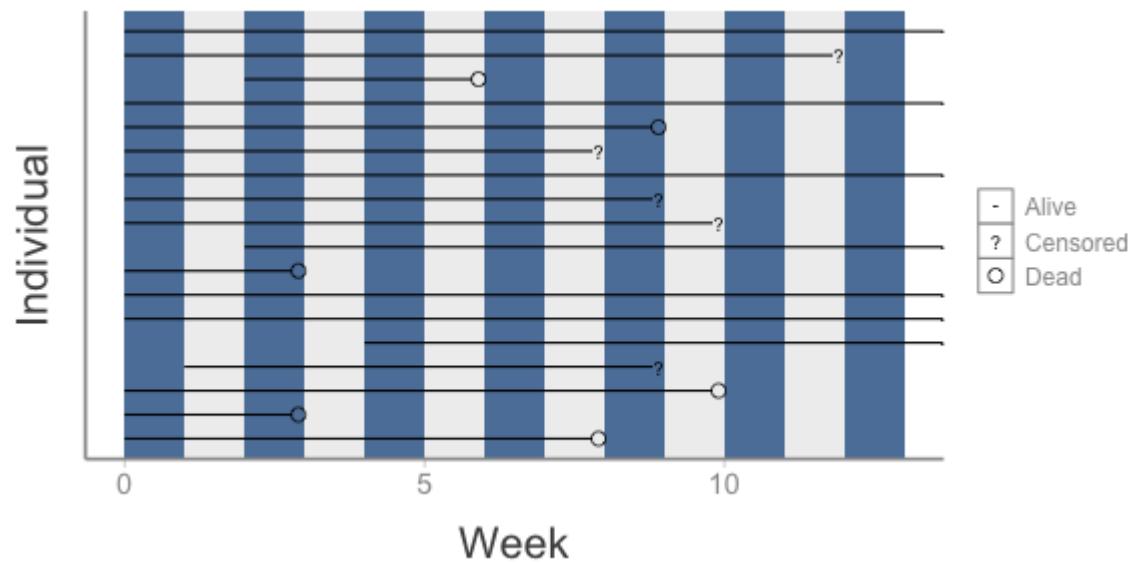
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# Known fate

Estimating survival

Who is at risk of dying?



# Known fate

Week (t)	# at risk	# deaths	# censored	# added	s(t)	S(t)
1	14	0	0	1	1.0000	1.0000
2	15	0	0	2	1.0000	1.0000
3	17	2	0	0	0.8824	0.8824
4	15	0	0	1	1.0000	0.8824
5	16	0	0	0	1.0000	0.8824
6	16	1	0	0	0.9375	0.8272
7	15	0	0	0	1.0000	0.8272
8	15	1	1	0	0.9286	0.7681
9	13	1	2	0	0.9091	0.6983
10	10	1	1	0	0.8889	0.6207

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When using mark-recapture,

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**Open population** models relax this assumption

During each sampling occasion

- individuals are captured

# Capture-recapture

On the occasion after release, 4 possible scenarios:

- 1) Individual survives and is re-captured (capture history = **11**)
- 2) Individual survives but is not recaptured (capture history = **10**)
- 3) Individual dies and is **not available** for recapture (capture history = **10**)
- 4) Individual survives but leaves the study area and is **not available** for recapture (capture history = **10**)

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Not possible to distinguish between scenarios 3 & 4 without additional data

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## Cormack-Jolly-Seber model

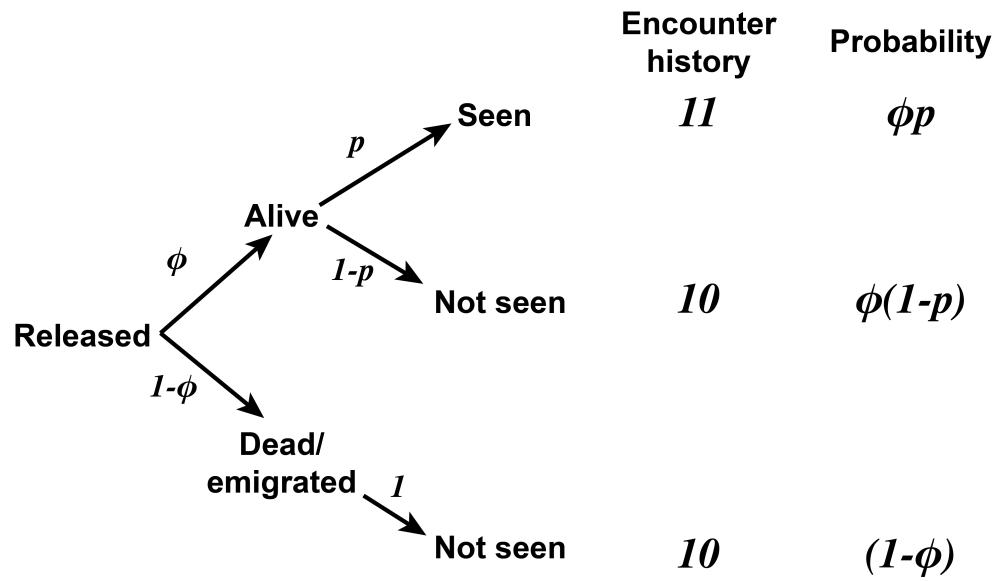
### Parameters

- $\psi$ : Apparent survival probability
- $\phi$ : Recapture probability

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- survived interval 1      , recaptured on occasion 2      , survived  
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### Individual 2

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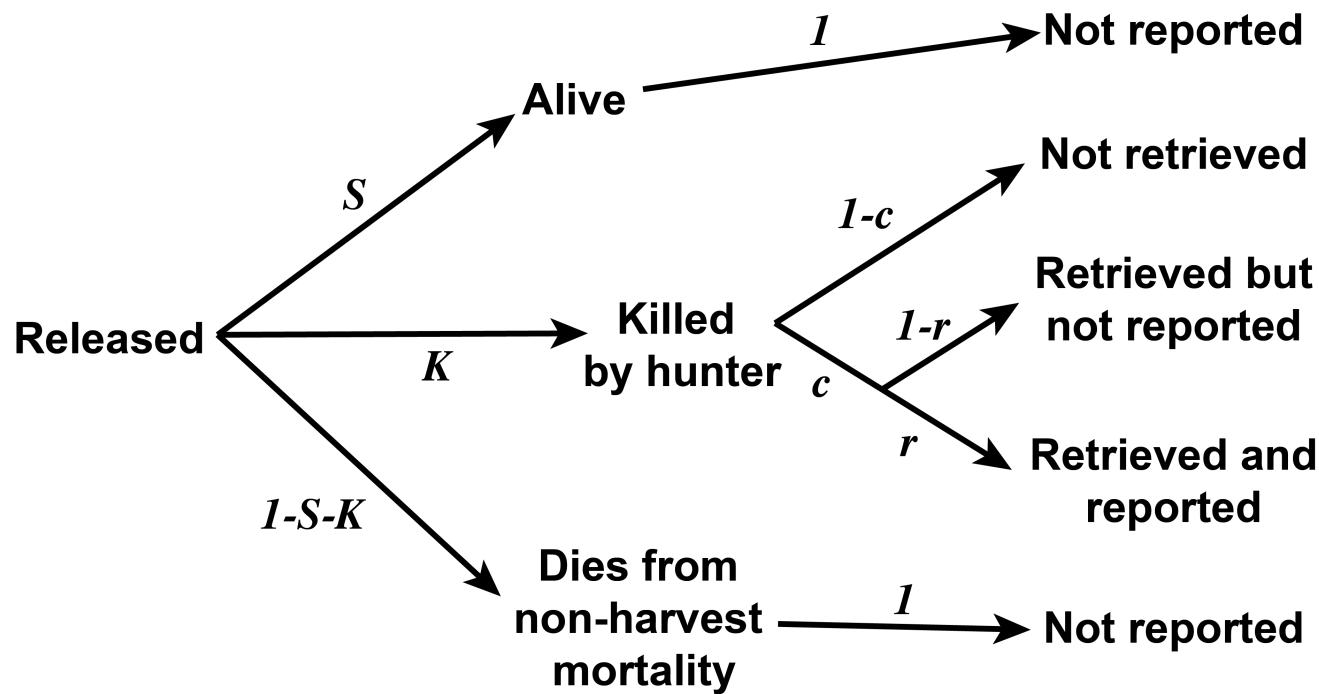
# Recovery models

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In some cases, marked individuals may be recovered dead



# Recovery models



# Life tables

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# Life tables

- Ages-specific estimates of  $\mu_x$  or  $\bar{m}_x$  are equivalent to

0					0.7

1					0.86
2					0.67

3					0
4					

# Life tables

- With unbiased estimates of  $\mu_x$ ,  $\lambda_x$ , can obtain unbiased estimates of  $\mu_{x+1}$  and  $\lambda_{x+1}$
- $\mu_x = \lambda_x e^{-\lambda_x}$ ,
- $\lambda_{x+1} = \mu_x / (1 - \mu_x)$

0		1.0	0.7	0.3	
1		0.7	0.86	0.14	
2		0.6	0.67	0.33	