Joint analysis of survival and reproduction over 10 years in perennial *Echinacea* plants from seven populations

Stuart Wagenius[1], Ruth Shaw[2], Charles Geyer[2]

[1]Chicago Botanic Garden
[2]University of Minnesota

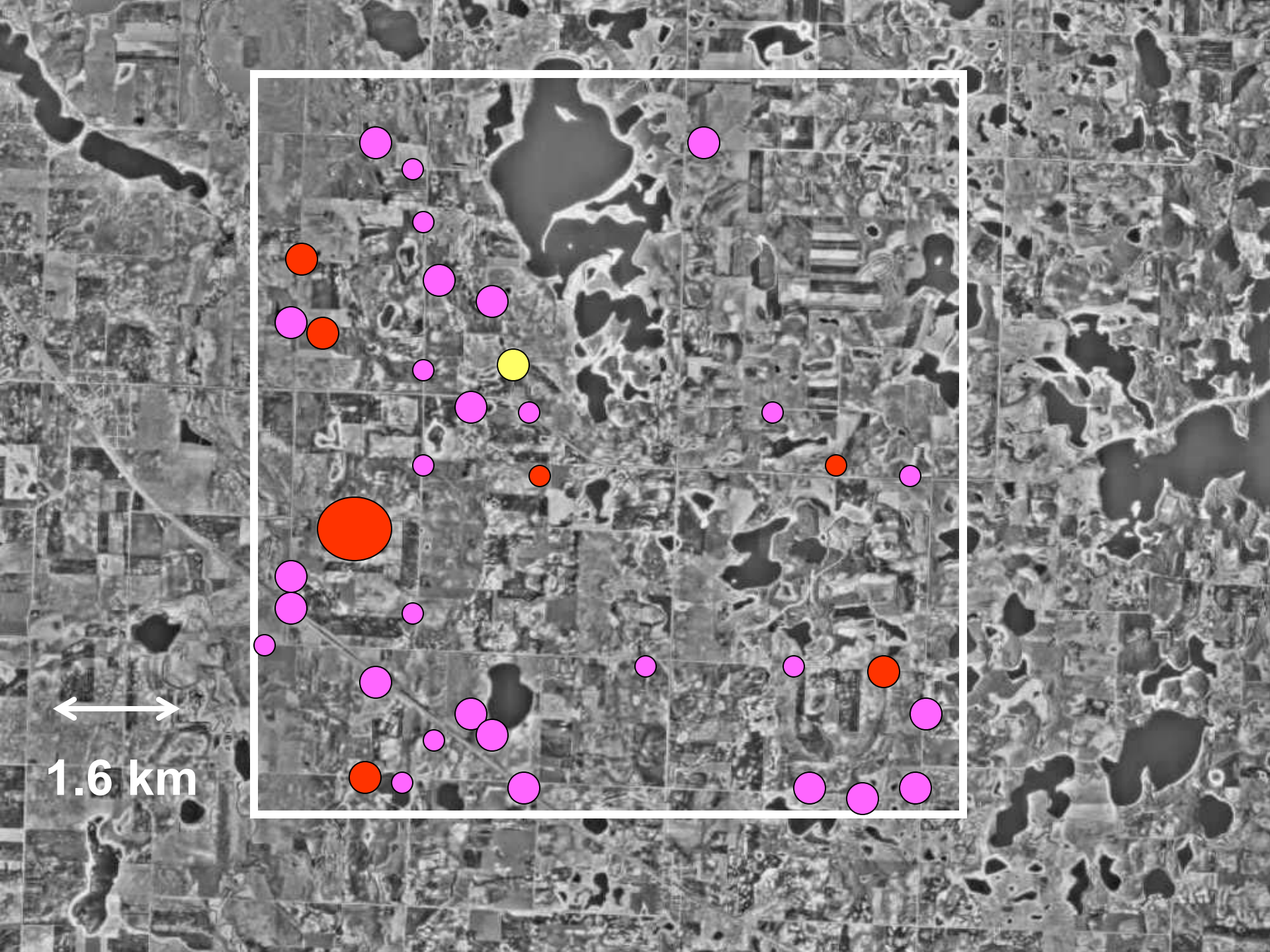
http://www.stat.umn.edu/geyer/aster/
http://echinacea.umn.edu/

S. Wagenius

STOP
H. Hangelbroek

Echinacea: Model prairie species

- Asteraceae
- Herbaceous
- Long-lived
  - juvenile
  - adult
- Reproduces by seed


1.6 km

Common Garden

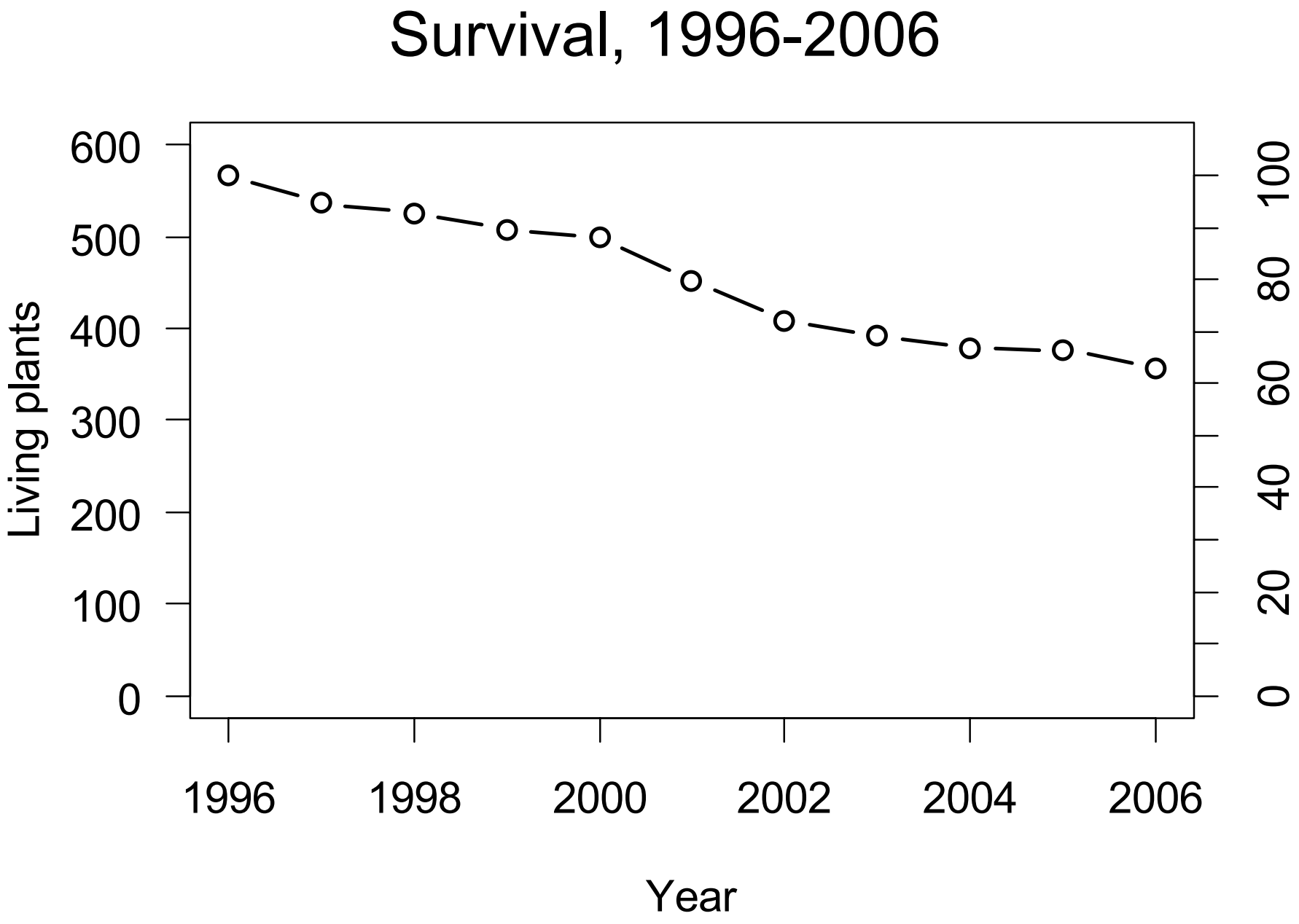
571 plugs planted in 1996.

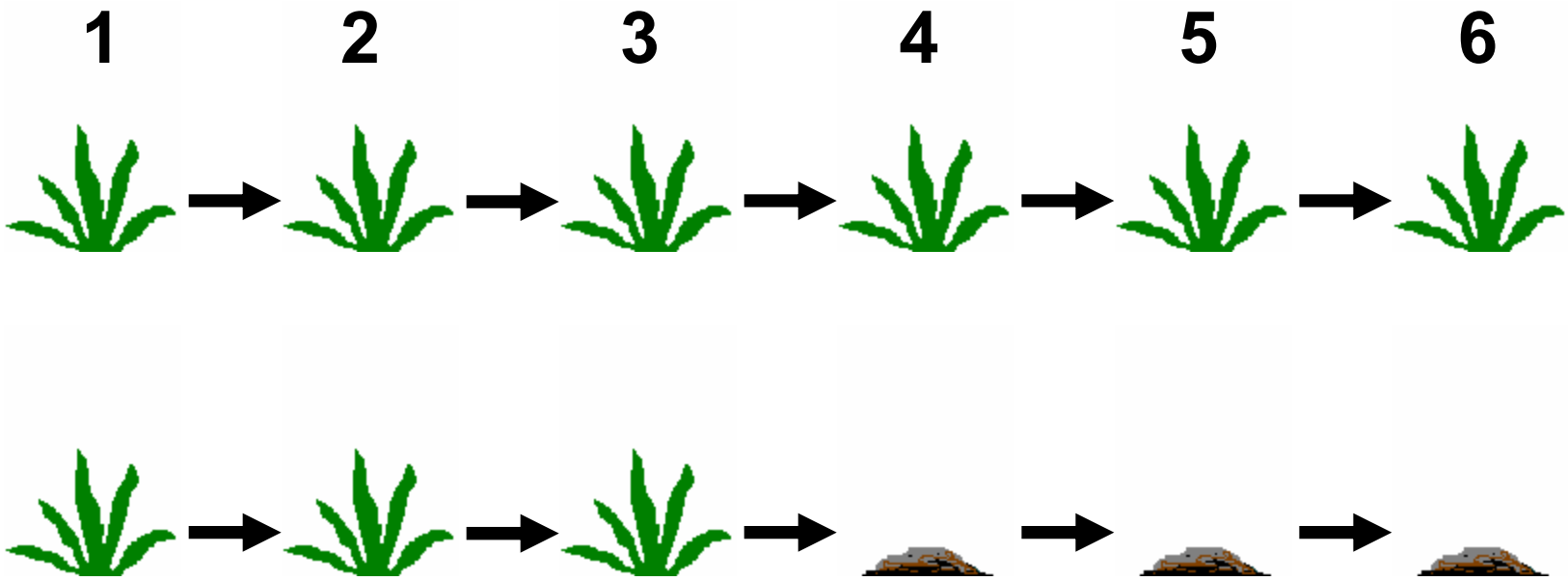
Randomized positions on 1m x 1m grid.

Old field with competition.

Biennial spring burns.

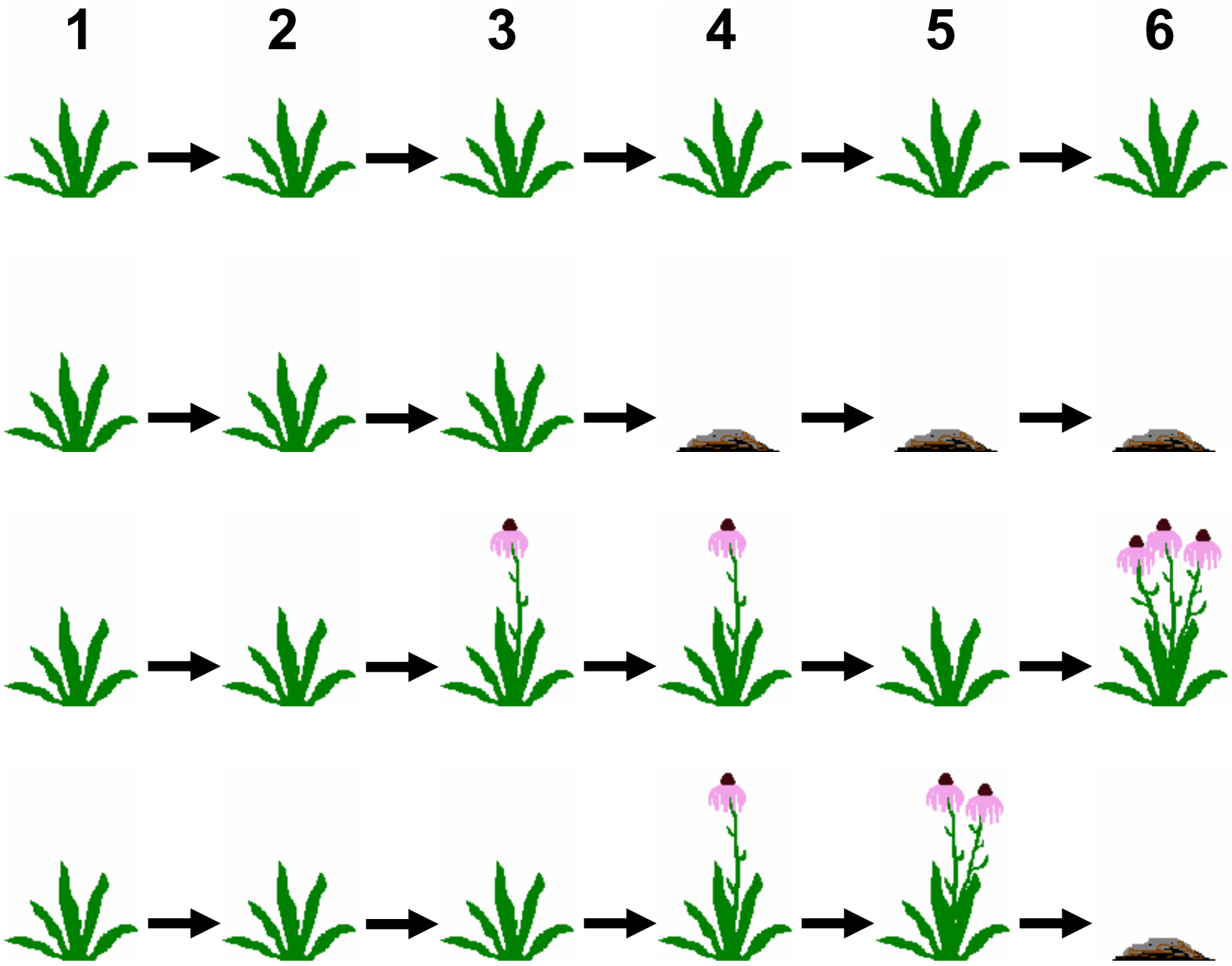
Annual measurements & harvests.

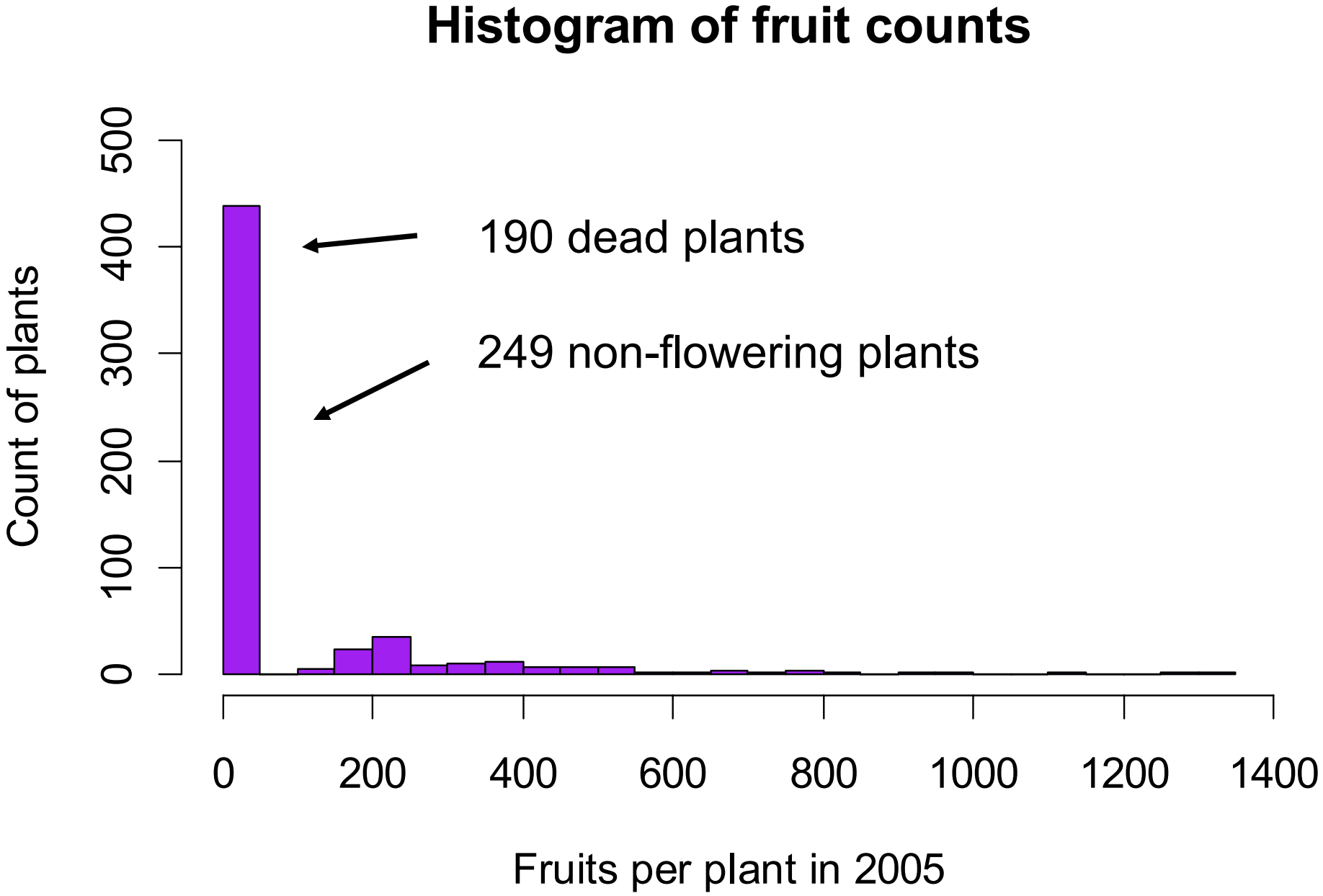

Survival, 1996-2006
Living plants
600
500
400
300
200
100
0
100
80
60
40
20
0
1996
1998
2000
2002
2004
2006
Year


1
2
3
4
5
6

Problems measuring fitness

1. Each fitness component for a given individual is conditional on the individual's state for an earlier component of fitness.


1
2
3
4
5
6

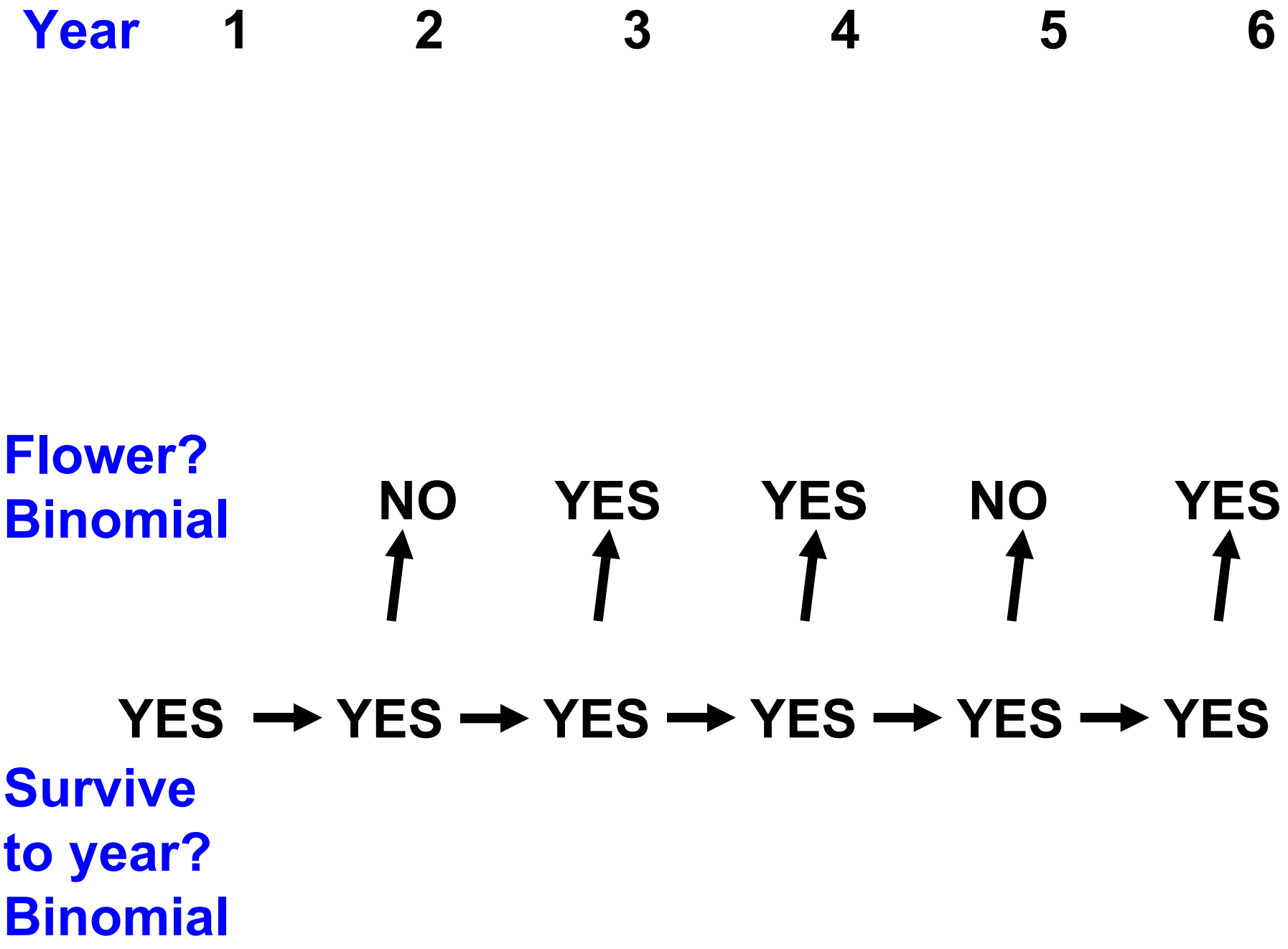

Histogram of fruit counts
Count of plants
0
100
200
300
400
500
190 dead plants
249 non-flowering plants
0
200
400
600
800
1000
1200
1400
Fruits per plant in 2005

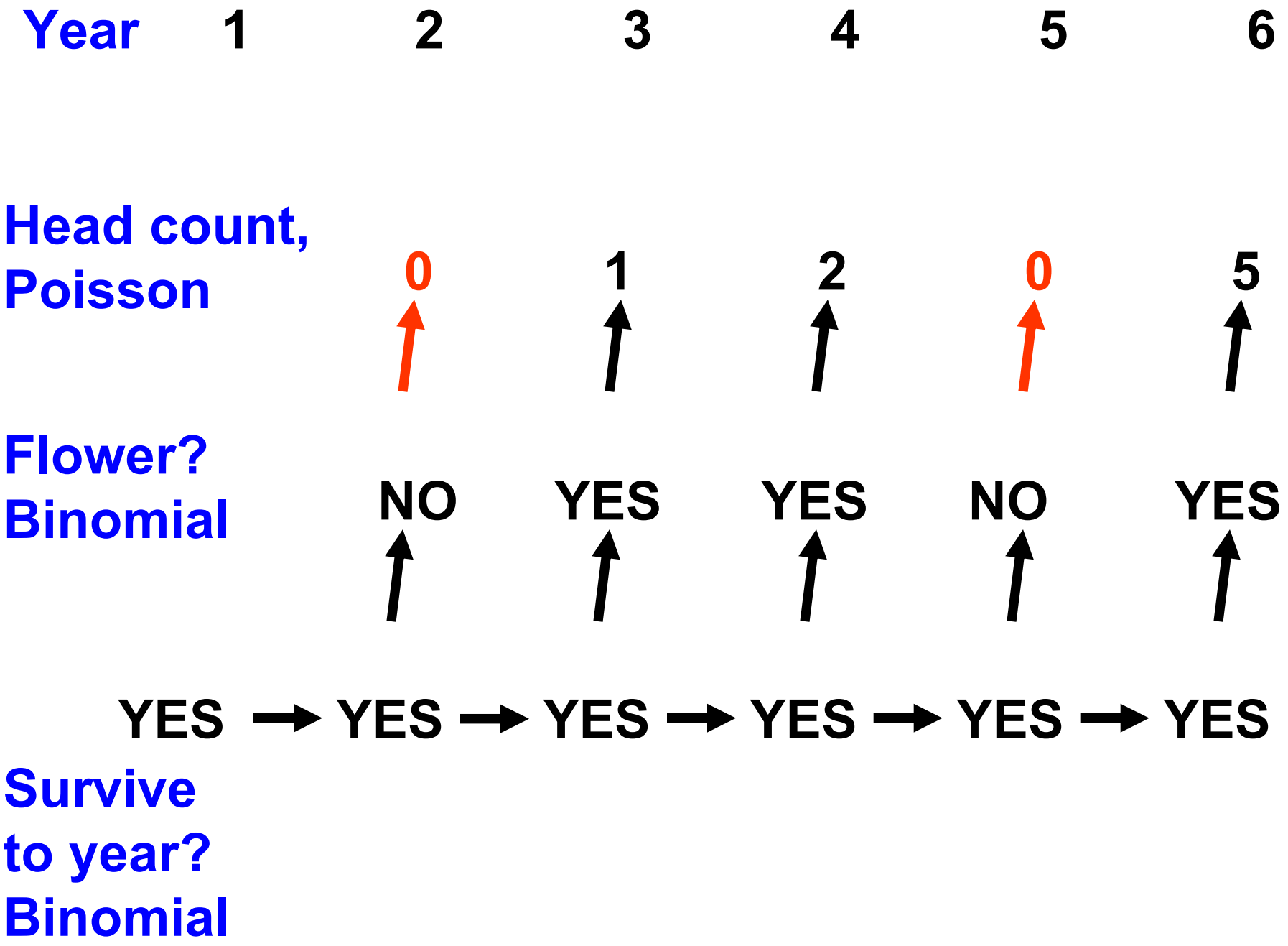
Problems measuring fitness

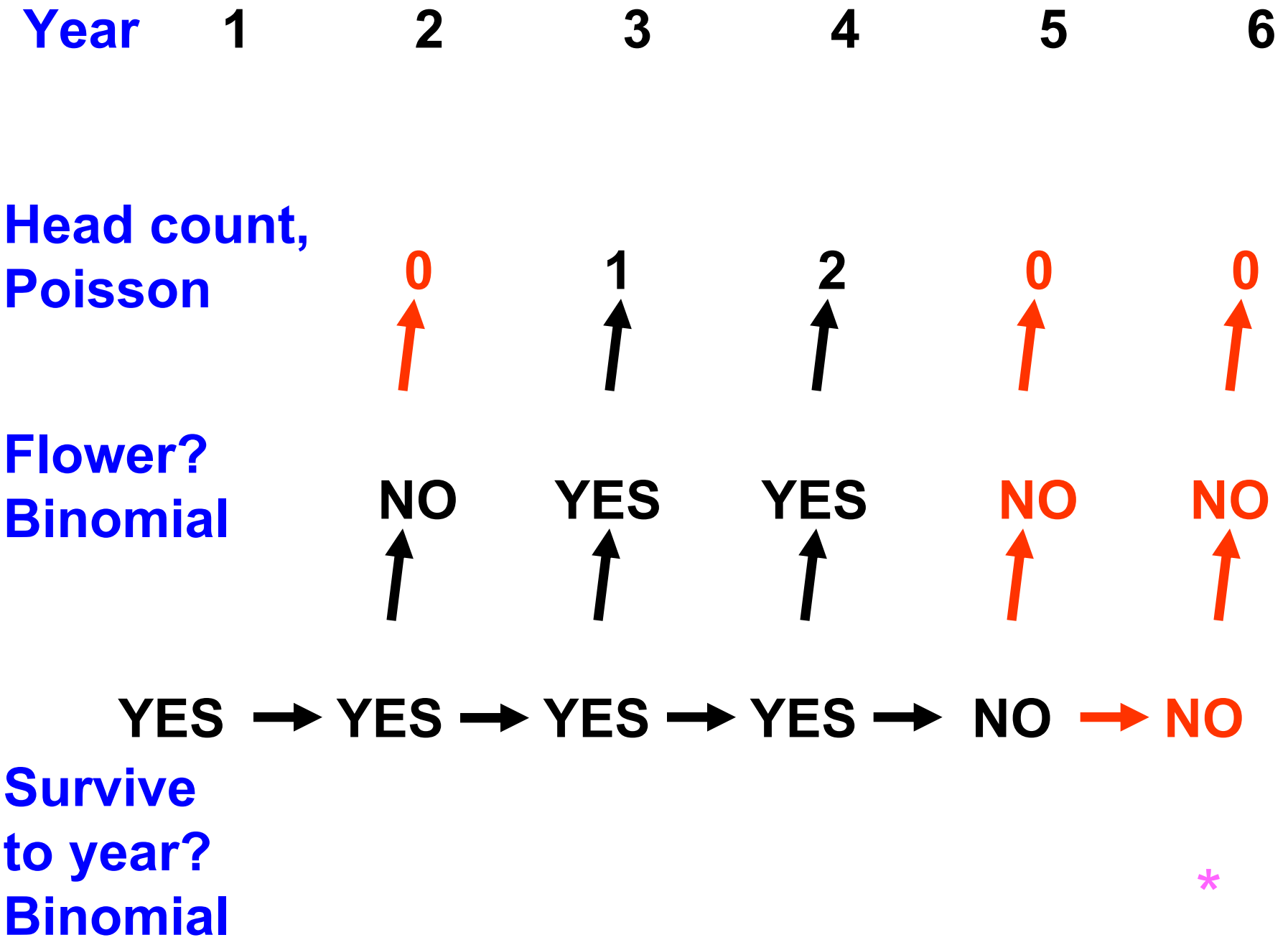
1. Each fitness component for a given individual is conditional on the individual's state for an earlier component of fitness.

2. No single probability distribution is suitable for modeling all components of fitness.

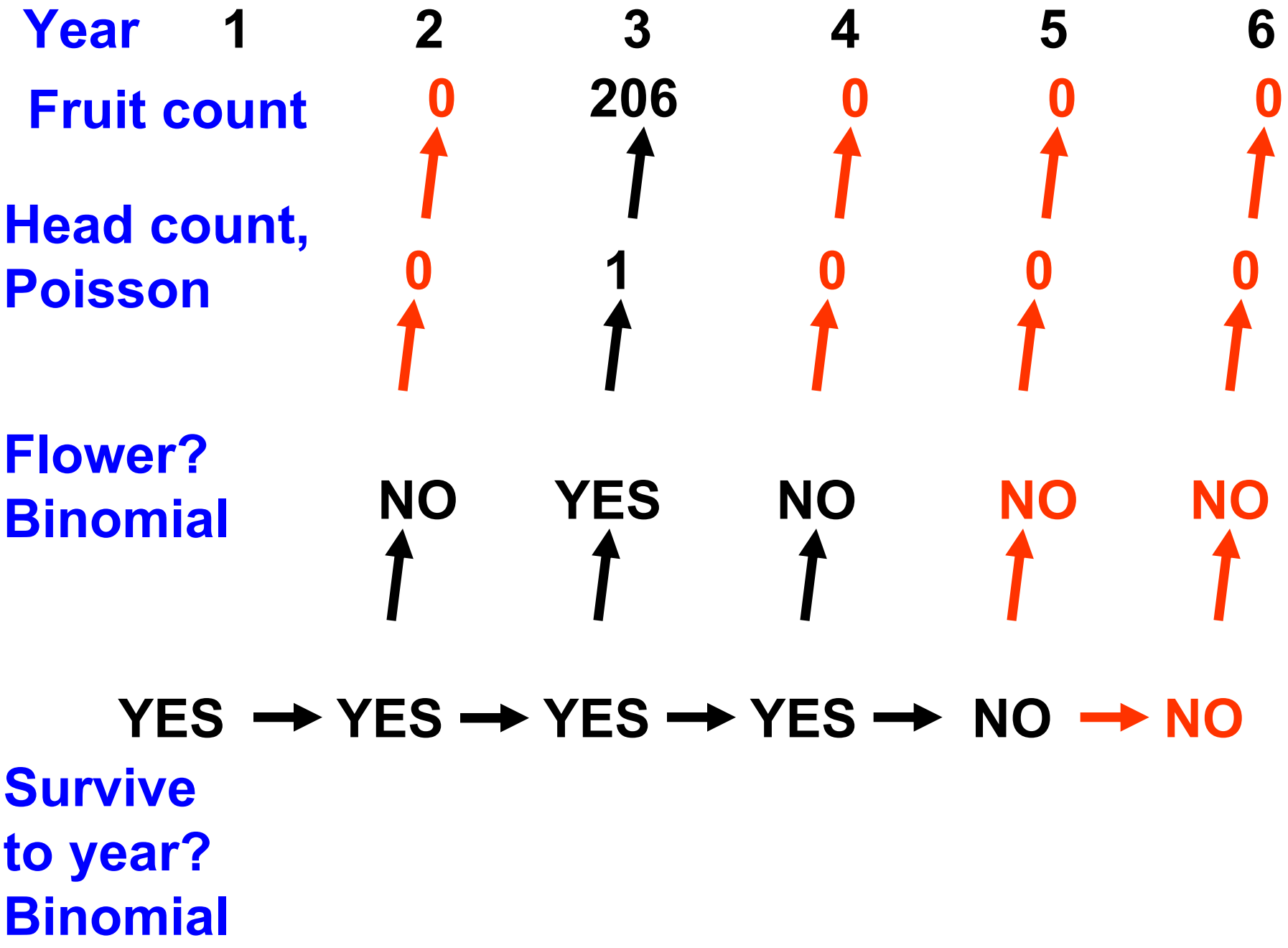
Year	1	2	3	4	5	6
Survive to year?	YES →	YES →	YES →	YES →	YES →	YES
Binomial						


Year
1
2
3
4
5
6
Flower?
Binomial
NO
YES
YES
NO
YES
YES
YES
YES
YES
YES
YES
YES
Survive
to year?
Binomial


Year
1
2
3
4
5
6
Head count, Poisson
0
1
2
0
5
Flower? Binomial
NO
YES
YES
NO
YES
YES → YES → YES → YES → YES → YES
Survive to year? Binomial

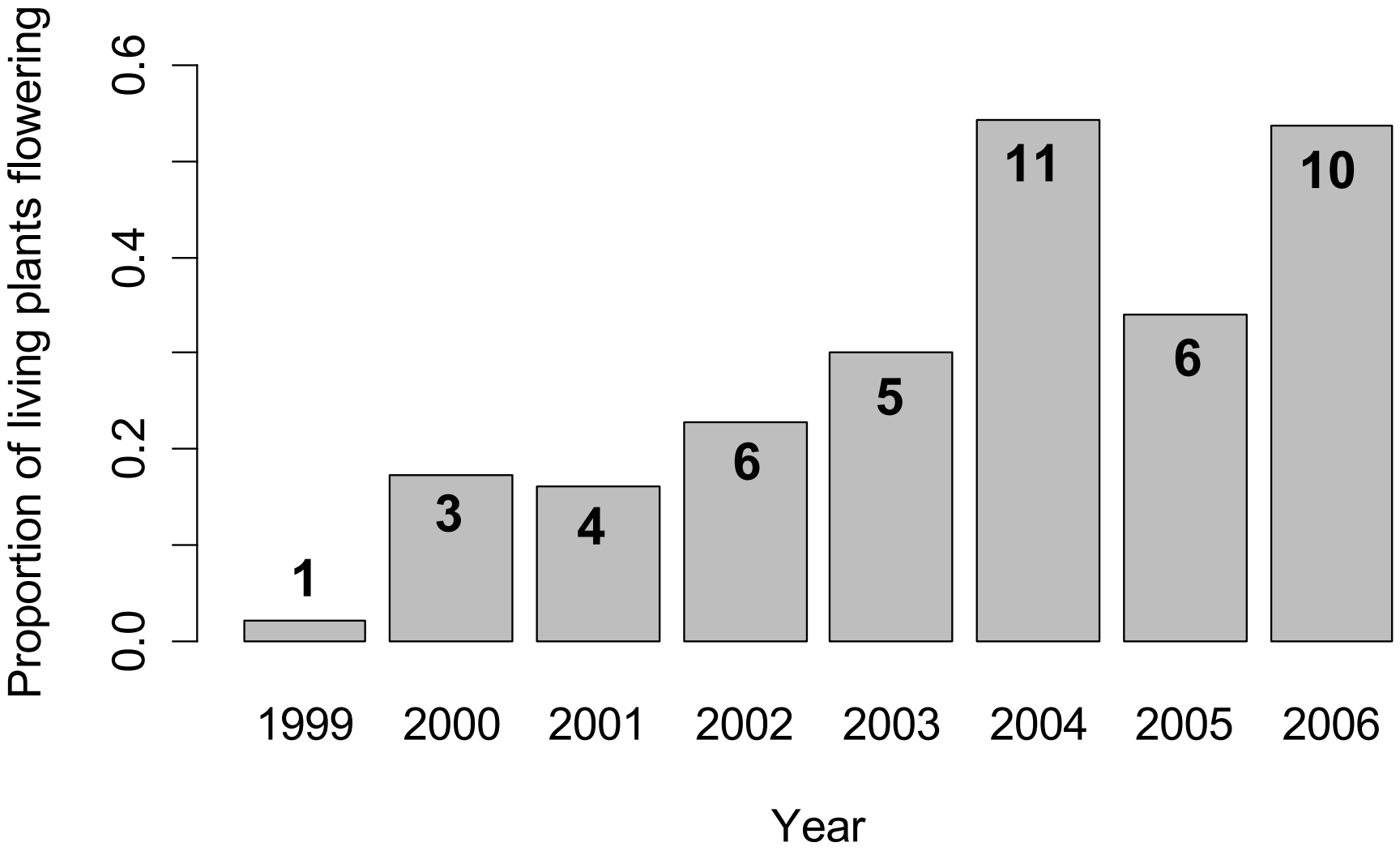

Year
1
2
3
4
5
6
Head count, Poisson
0
1
2
0
0
Flower? Binomial
NO
YES
YES
NO
NO
YES → YES → YES → YES → NO → NO
Survive to year? Binomial
*

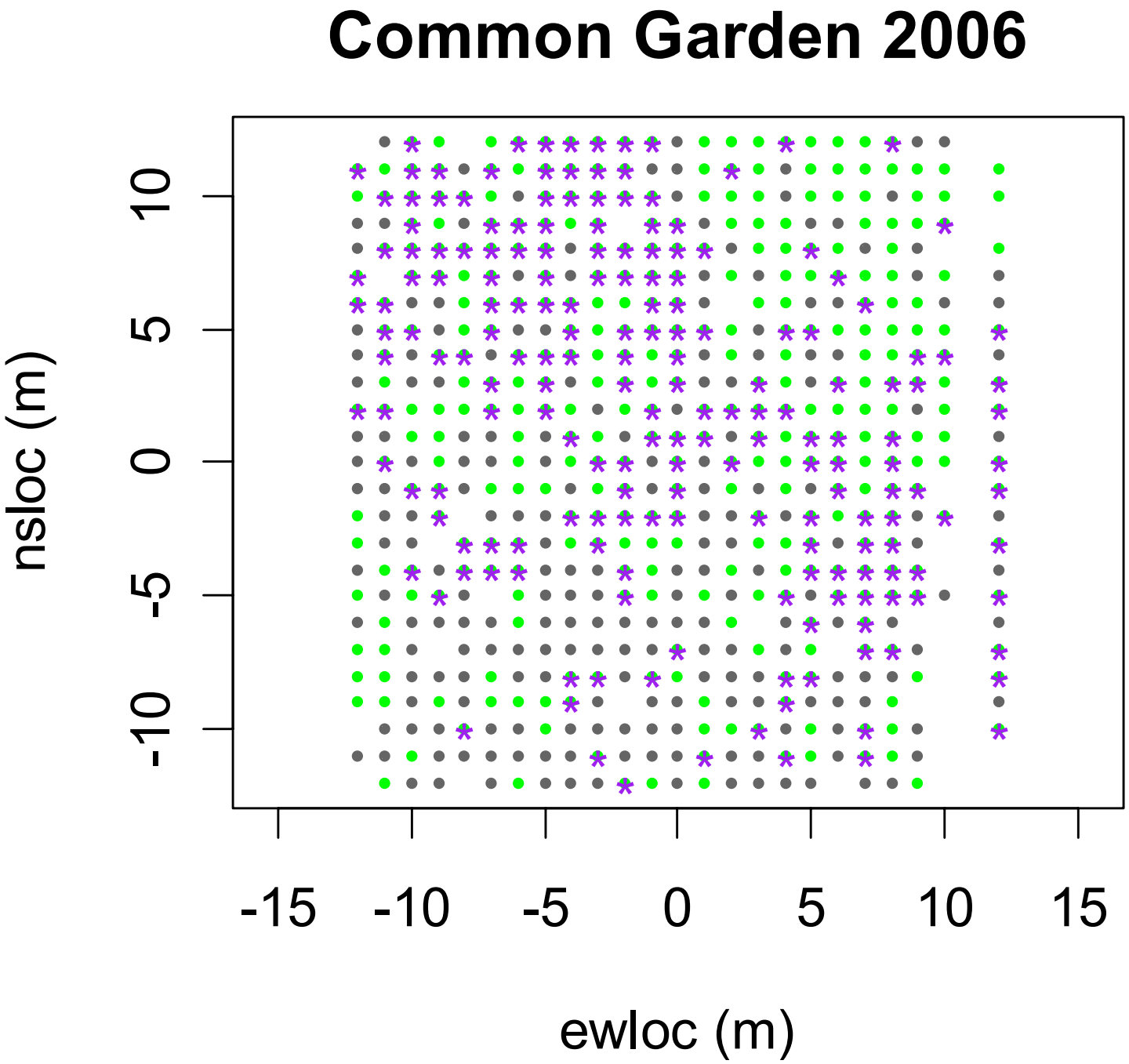
problem	solution
Measuring	*Echinacea* project echinacea.umn.edu
Modeling	aster life history analysis www.stat.umn.edu/geyer/aster/
Implementing	R statistical software www.r-project.org


Year
1
2
3
4
5
6
Fruit count
0
206
0
0
0
Head count, Poisson
0
1
0
0
0
Flower? Binomial
NO
YES
NO
NO
NO
YES → YES → YES → YES → NO → NO
Survive to year? Binomial

Proportion of plants flowering

(& most heads per plant each year)




Common Garden 2006
nsloc (m)
10
5
0
-5
-10
-15
-10
-5
0
5
10
15
ewloc (m)

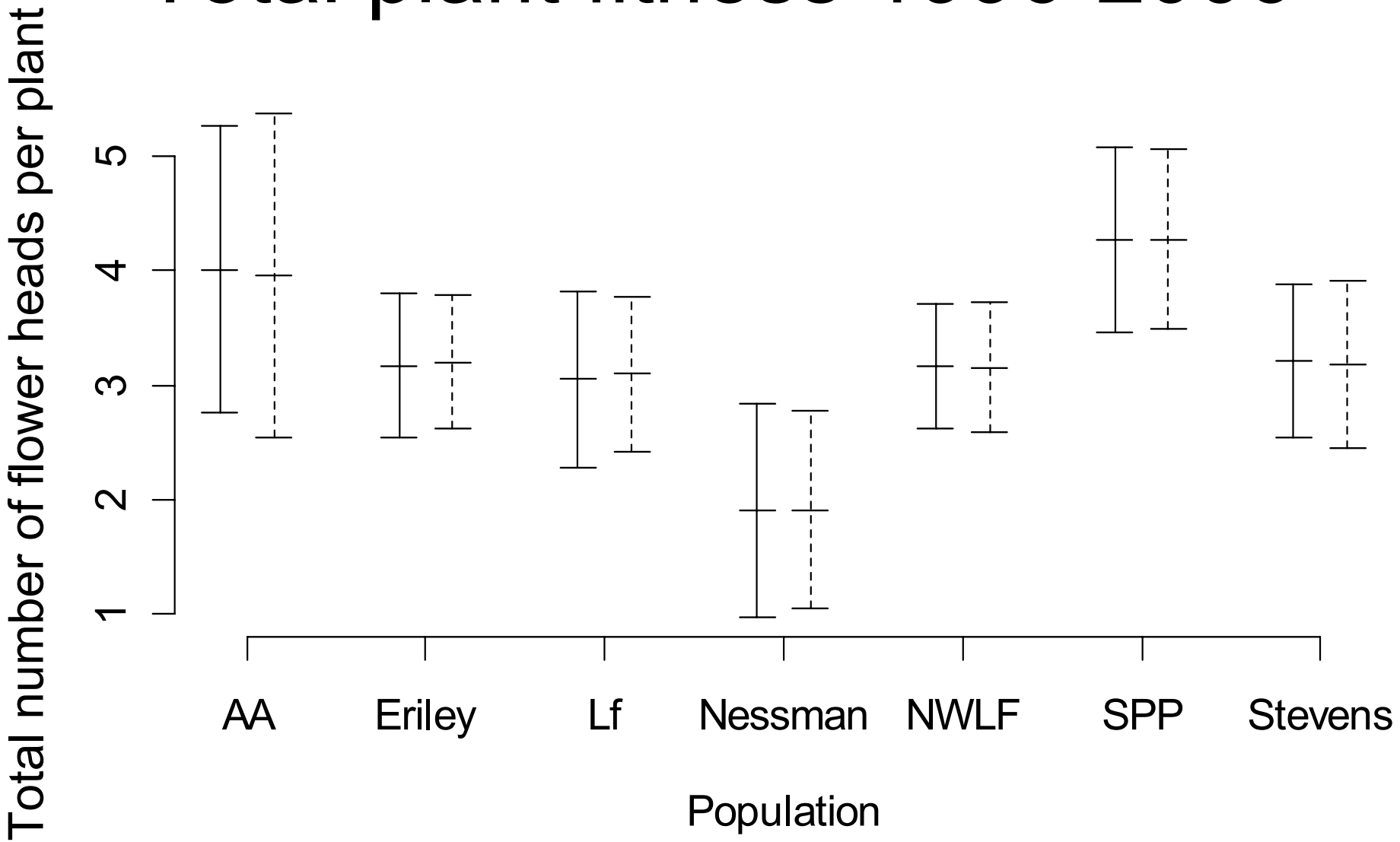
Model Comparisons

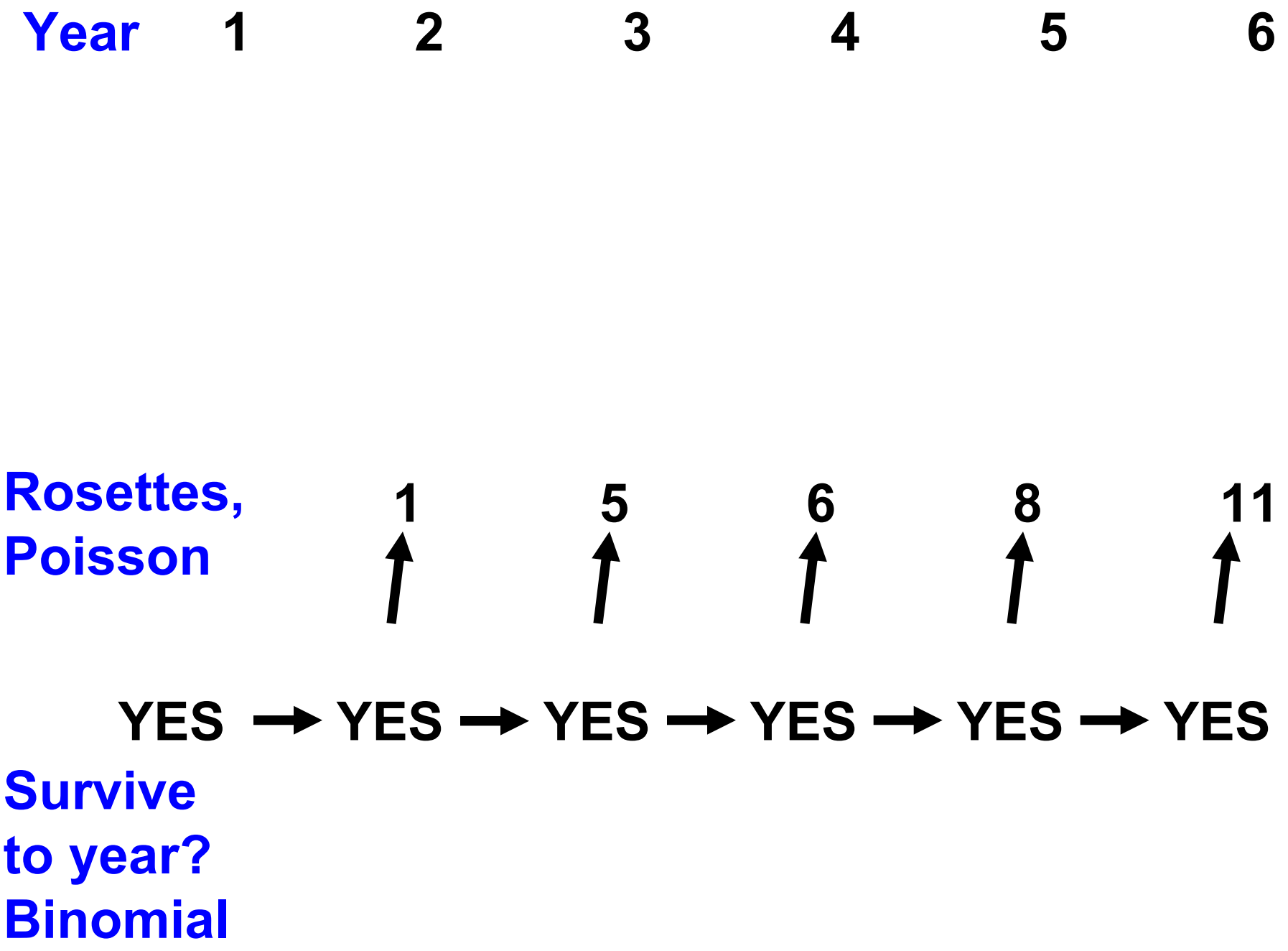
Analysis of Deviance Table

Model 1: resp ~ varb + level:(nsloc + ewloc)
Model 2: resp ~ varb + level:(nsloc + ewloc) + hdct * pop - pop
Model 3: resp ~ varb + level:(nsloc + ewloc) + hdct * pop
Model 4: resp ~ varb + level:(nsloc + ewloc) + level * pop

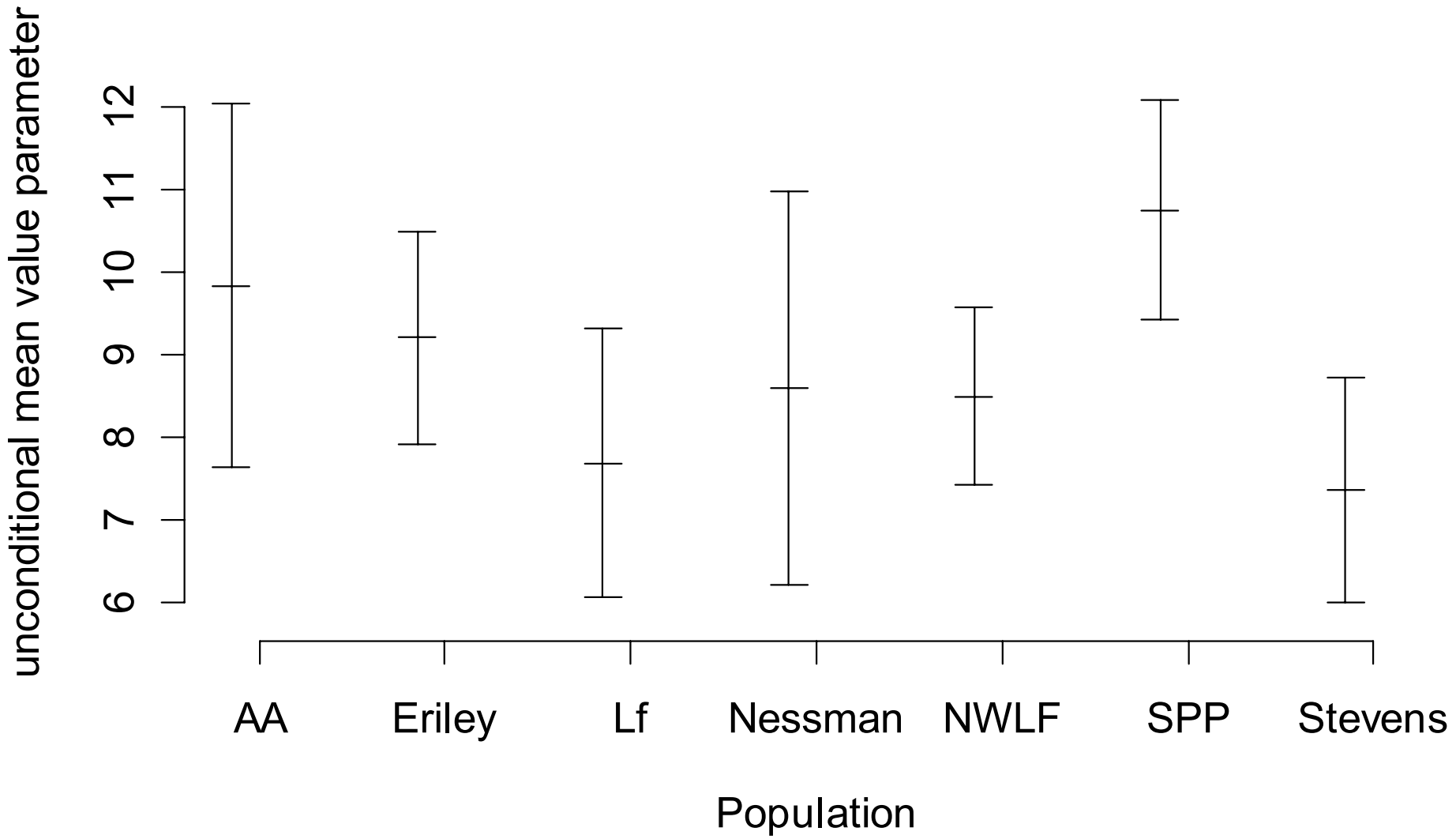
Model No.	Model d.f.	Model Deviance	Test d.f.	Test Deviance	Test *p*-value
1	31	5308.1			
2	37	5293.8	6	14.3	0.026
3	43	5266.9	6	26.9	0.00015
4	49	5255.7	6	11.1	0.1

Total plant fitness 1996-2006




Year
1
2
3
4
5
6
Rosettes,
Poisson
1
5
6
8
11
YES
YES
YES
YES
YES
YES
Survive
to year?
Binomial

Rosettes per plant, 2003-2006



Conclusions

Population differences in head count (fitness).

Population differences in rosette count (biomass).

The new statistical model "aster" jointly models composite sequential responses with predictors in a single analysis.

Further study with Echinacea

Fruit counts

179490 & counting

More pops & pop characteristics

common garden & remnants

Experimental inbreeding

A big plant

Other aster applications

Selection experiments in annuals

Herbivory on inbred plants

Aphid population growth from life tables

What data do you have?

http://www.stat.umn.edu/geyer/aster/

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echinacea.umn.edu

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R project

www.r-project.org