

Joint analysis of series of life history traits
and its application to
multiyear records of *Echinacea angustifolia*

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#Chicago Botanic Garden

FITNESS

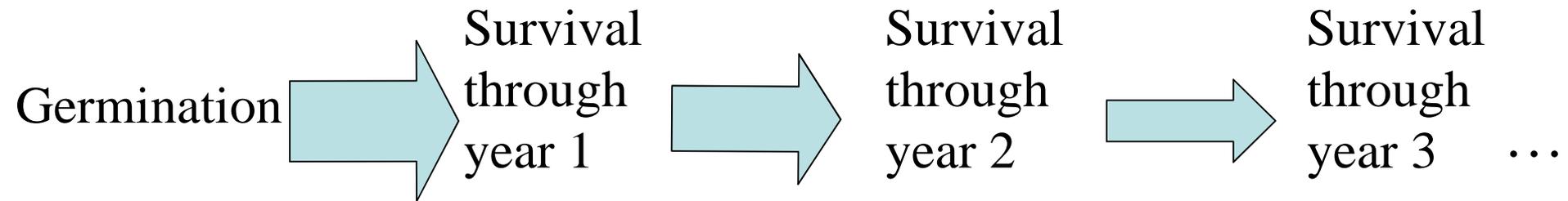
W

Composite of outcomes at several stages of the life cycle,

“components of fitness”,

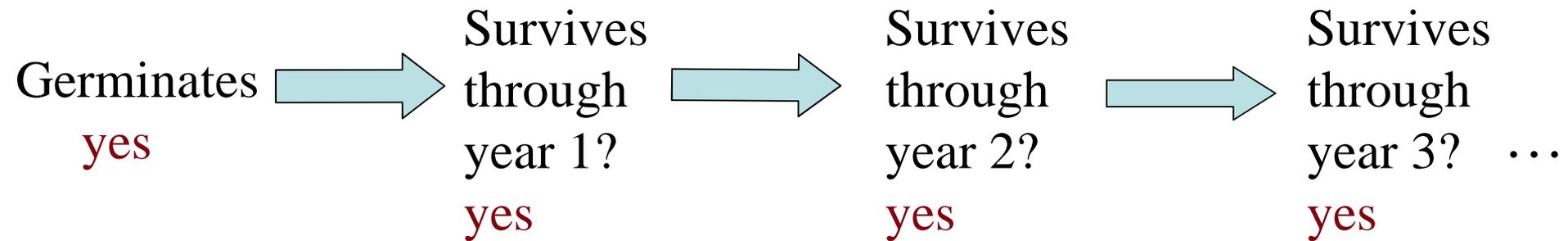
expressed sequentially

For example, for a perennial plant:



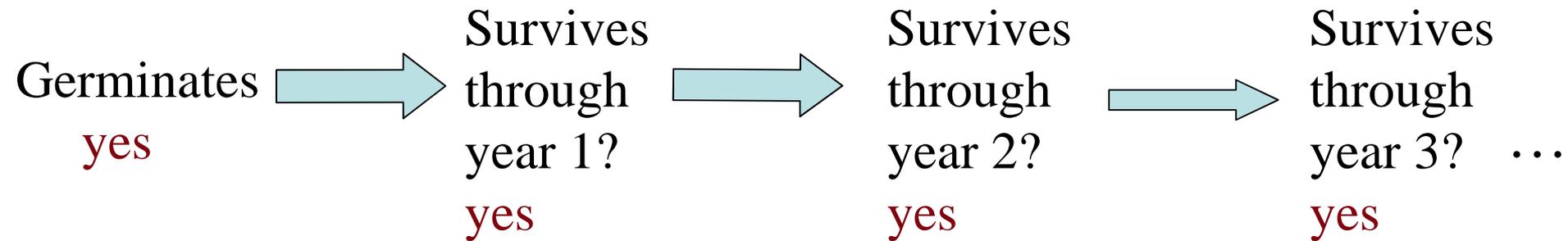
Example records for individuals:

1.

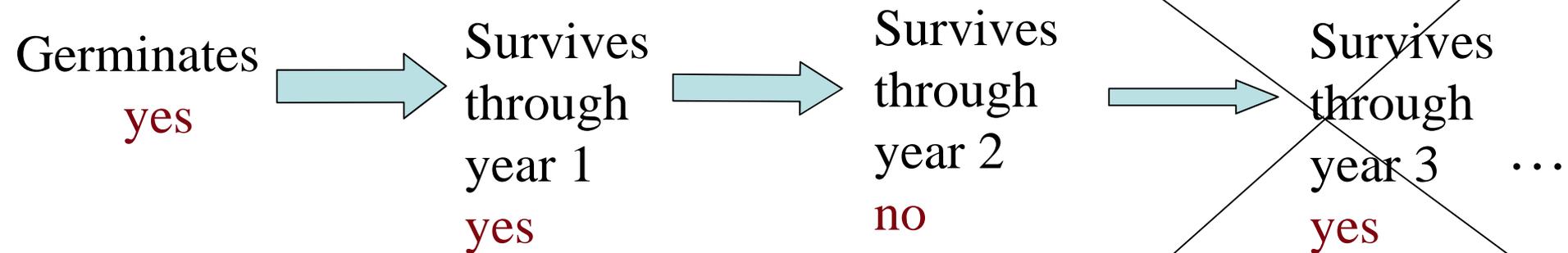


Example records for individuals:

1.



2.

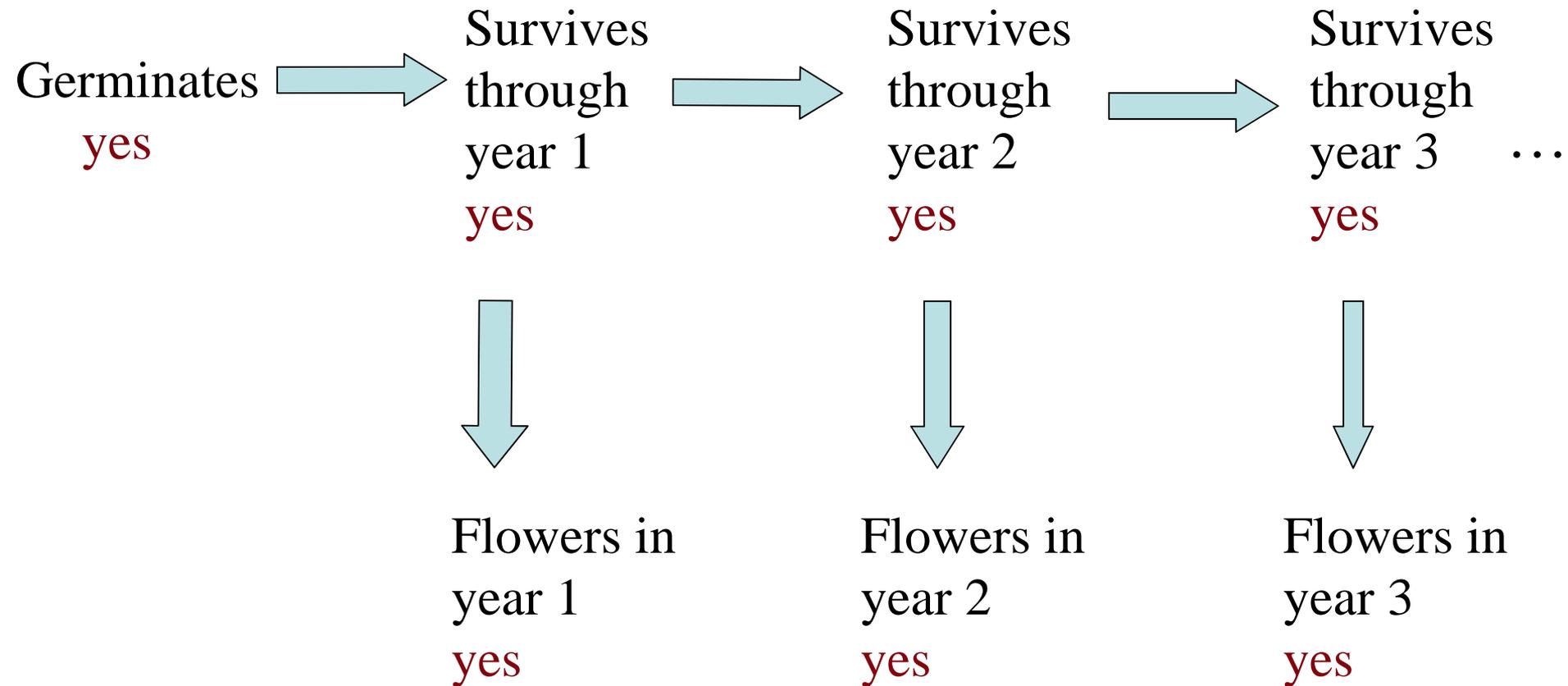


A problem:

- Observation of each fitness component for a given individual is conditional on the individual's state for an earlier component of fitness.

Extending the example of a perennial plant:

1.



Extending the example of a perennial plant:

2.

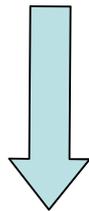
Germinates
yes



Survives
through
year 1
yes



Survives
through
year 2
no



Flowers in
year 1
no

Extending the example of a perennial plant:

2.

Germinates
yes



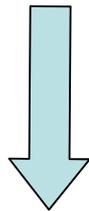
Survives
through
year 1
yes



Survives
through
year 2
no



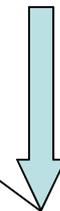
Survives
through
year 3 ...
--



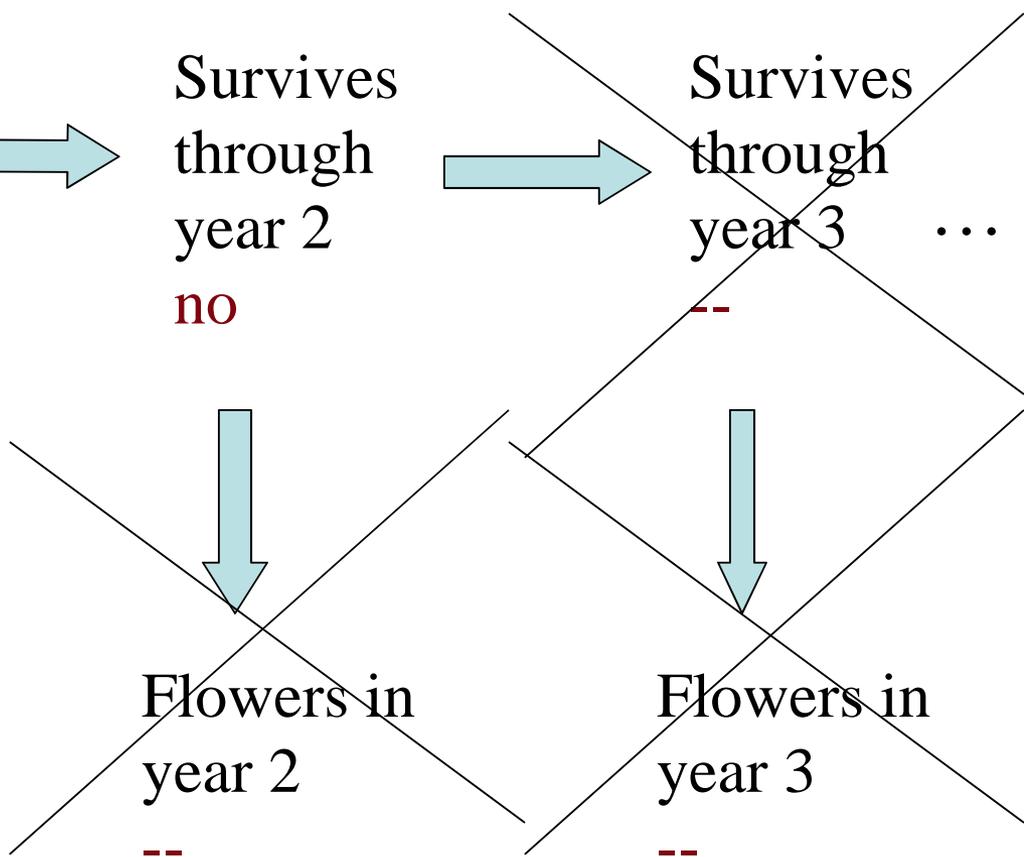
Flowers in
year 1
no



Flowers in
year 2
--



Flowers in
year 3
--

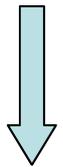


Further extending the example of a perennial plant:

1.

Germinates

1



Survives through year i



1



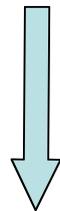
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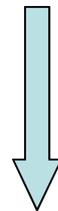
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...

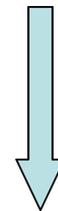
Flowers in year i



1

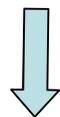


1

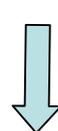


1

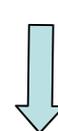
Number of flower heads



1



1



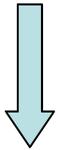
3

Further extending the example of a perennial plant:

2.

Germinates

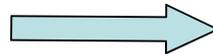
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Survives through year i



1



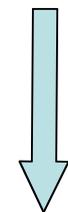
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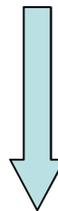
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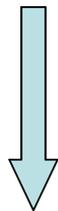
Flowers in year i



0

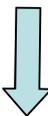


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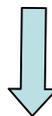


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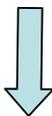
Number of flower heads



-



-



-

Problems:

- Observation of each fitness component for a given individual is conditional on the individual's state for an earlier component of fitness.
- No single probability distribution is suitable for modeling all components of fitness.

Fitness: a multivariate response unsuited to analysis by standard multivariate methods

Solution

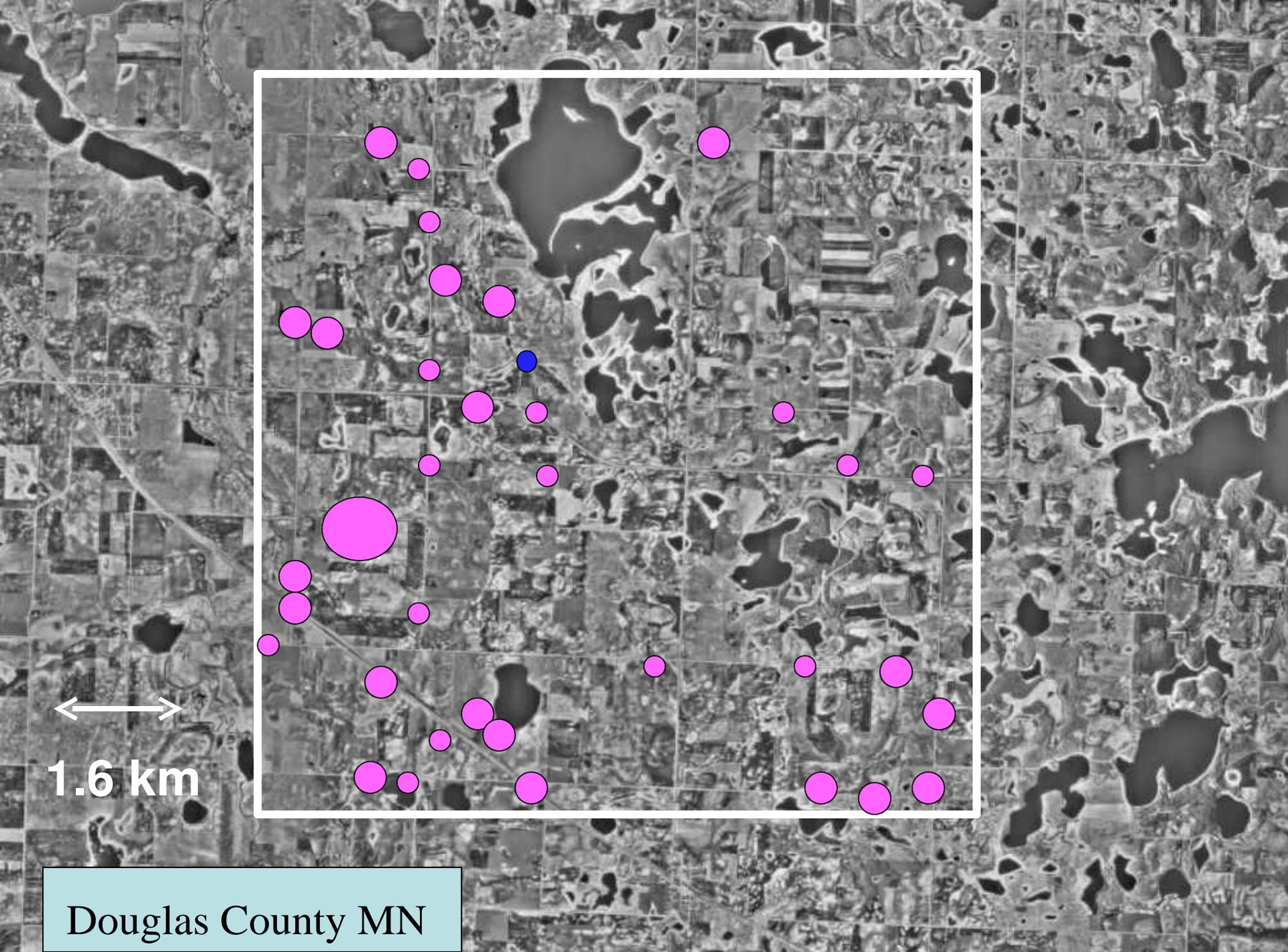
Maximum likelihood analysis of forest graph
exponential family canonical statistic models

Sequential life-history analysis
using conditional statistical models

An example:

Comparison of fitness among remnant populations of *Echinacea angustifolia*



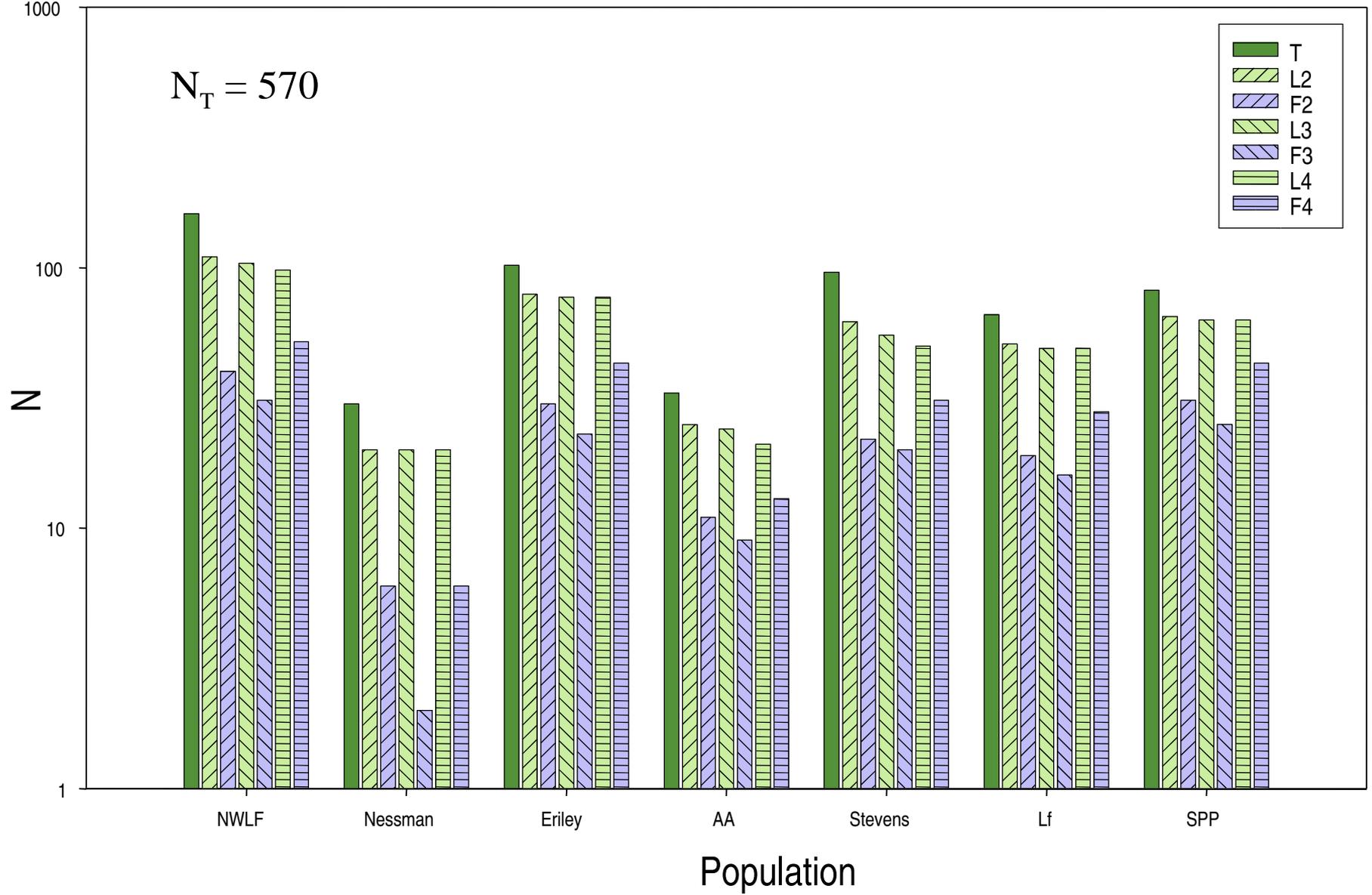


1.6 km

Douglas County MN



N plants in common garden surviving and flowering in 3 years



Survives through year i modeled as Bernoulli

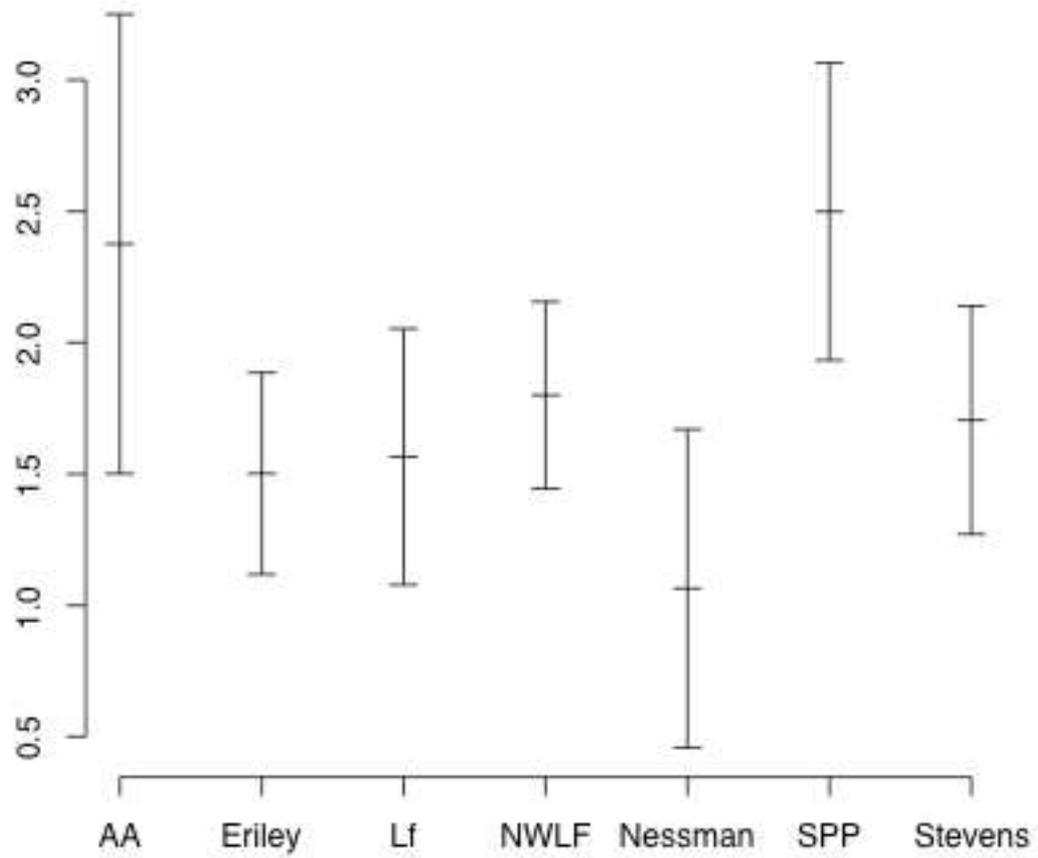
Flowers in year i modeled as Bernoulli

Number of flower heads modeled as Poisson

Model comparisons

	nparm	LR	df	LRT	P
Model 0: Effects of position and year only	15	-2728.7	-	--	--
Model 1: Pop effect on total head count	21	-2712.5	6	16.2	0.0128
Model 2: Pop effect on each component of W	33	-2674.7	12	37.8	0.0002

Expected number of flower heads



Population

Conclusions

This joint analysis of components of fitness:

- yields comparisons that are comprehensive over lifespan.
- allows for flexible choice of distributions for modeling individual components of fitness.
- addresses an important cause of “poor” distributions of fitness.
- amenable to analysis of phenotypic selection on traits.

Acknowledgments

- Janis Antonovics
- Helen Hangelbroek
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- The field crew

