Relationship between age, size and reproduction in populations of American ginseng across a range of harvest pressures

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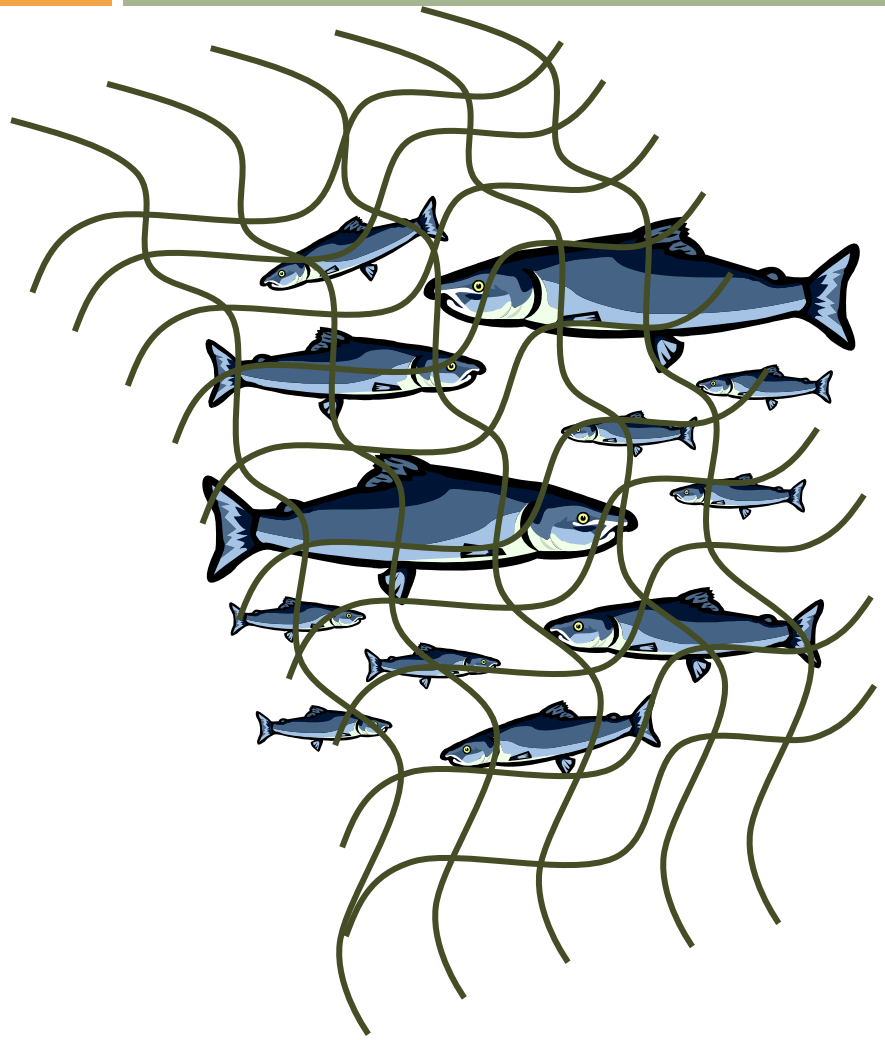
Overview

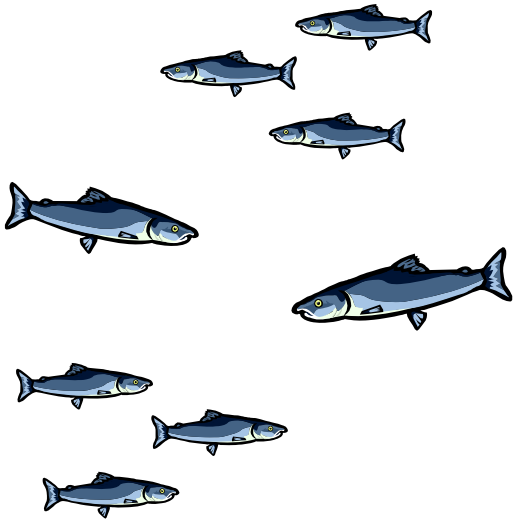
- Evolutionary implications of harvest
- Case studies from animal and plant species
- Evidence for selective harvest in American ginseng
- Study details
  - Methods
  - Results
  - Conclusions

Wild harvested species

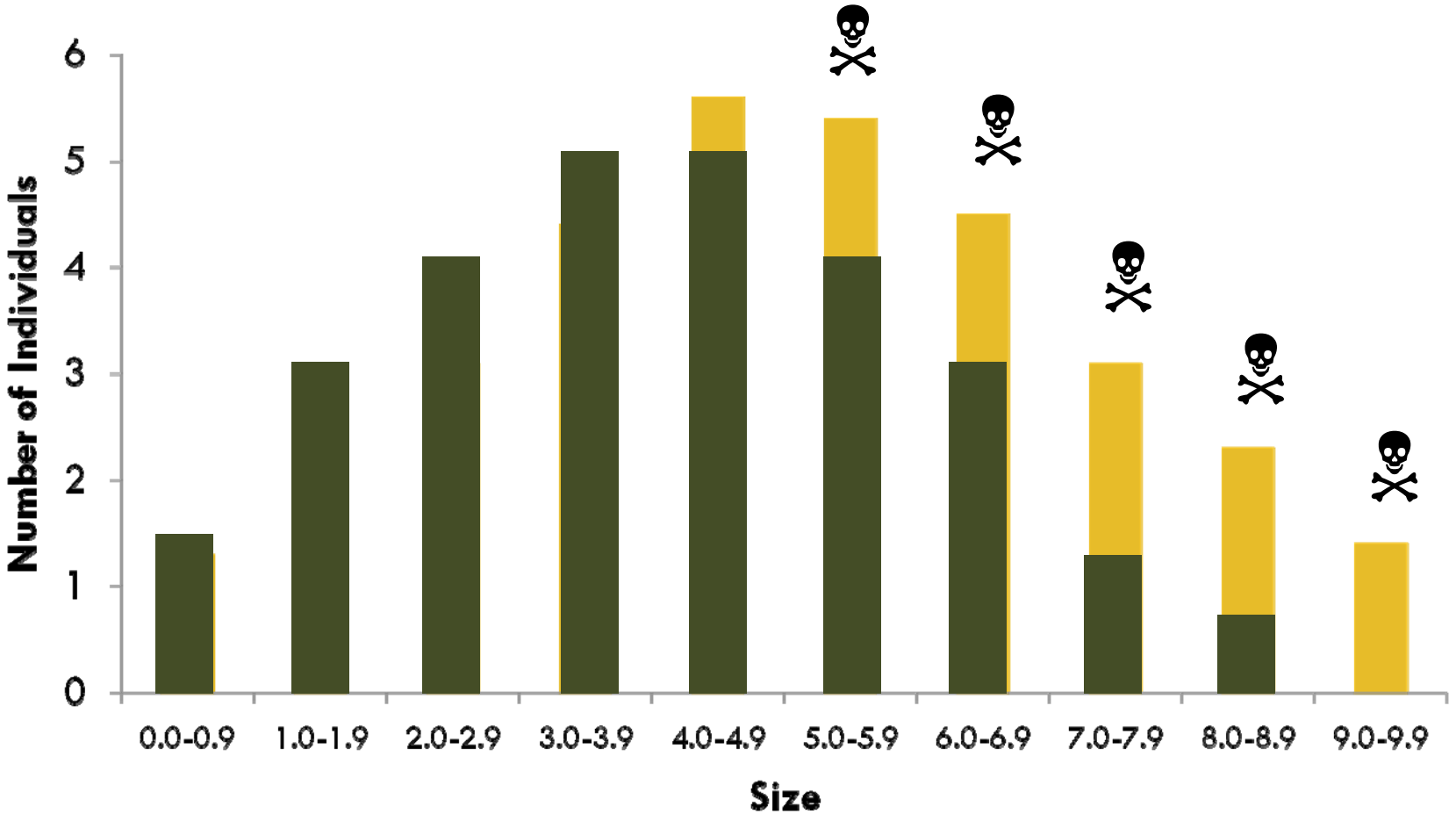
All images from www.wikimedia.org

Harvest often targets specific phenotypes



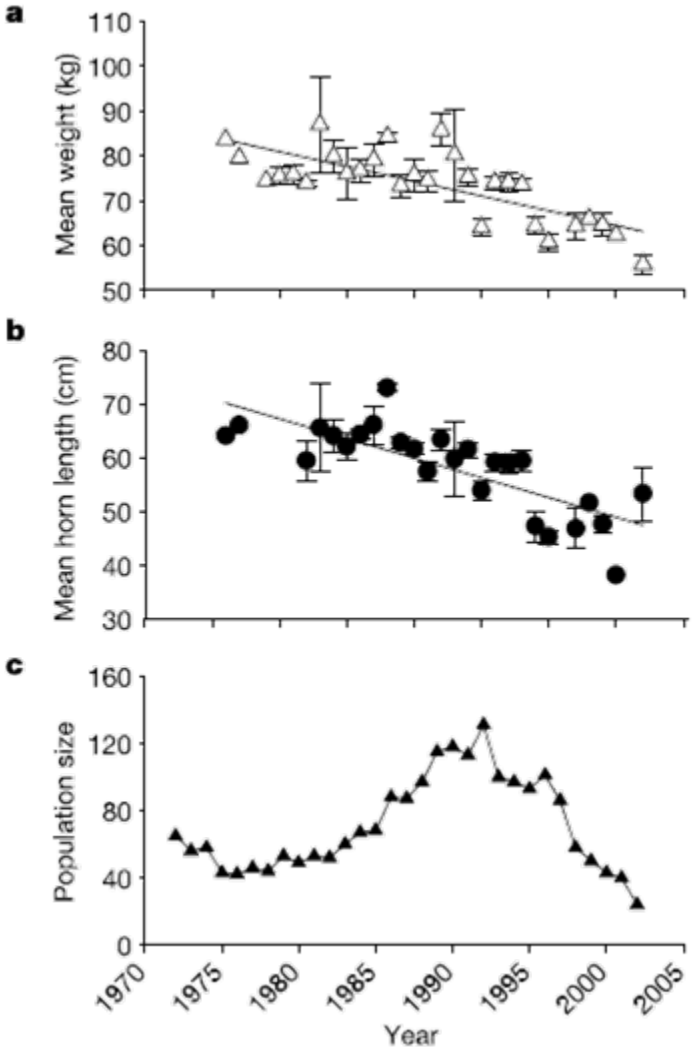


Harvest can lead to evolutionary change in natural populations



Assuming portion of variation is genetically determined

CASE STUDY: declines in horn and body size linked to trophy hunting in bighorn rams, *Ovis canadensis*



Coltman et al. 2003. *Nature*. 426: 655-658.

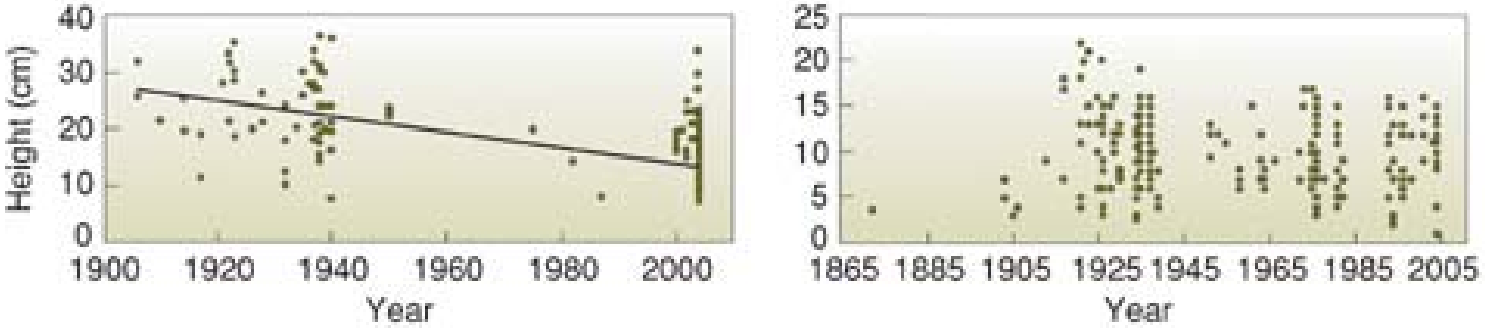
CASE STUDY: Size selective harvest in fisheries can result in life history change

Fish Species	Selection response
Lake whitefish, *Coregonus clupeaformis*	Smaller body size; slower growth
Atlantic salmon, *Salmo salar*	Smaller size at maturity
Pink salmon, *Oncorhynchus gorbuscha*	Smaller size at maturity
Chinook salmon, O. *tshawytscha*	Smaller size at maturity
European grayling, *Thymallus thymallus*	Earlier age at maturity
Atlantic cod, *Gadus morhua*	Earlier age at maturity
Orange roughy , *Hoplostethus atlanticus*	Increased fecundity
European plaice, *Pleuronectes platessa*	Earlier age at maturity

Hutchings, JA, Fraser, DJ. 2008. *Mol Ecol.* 17: 294–313

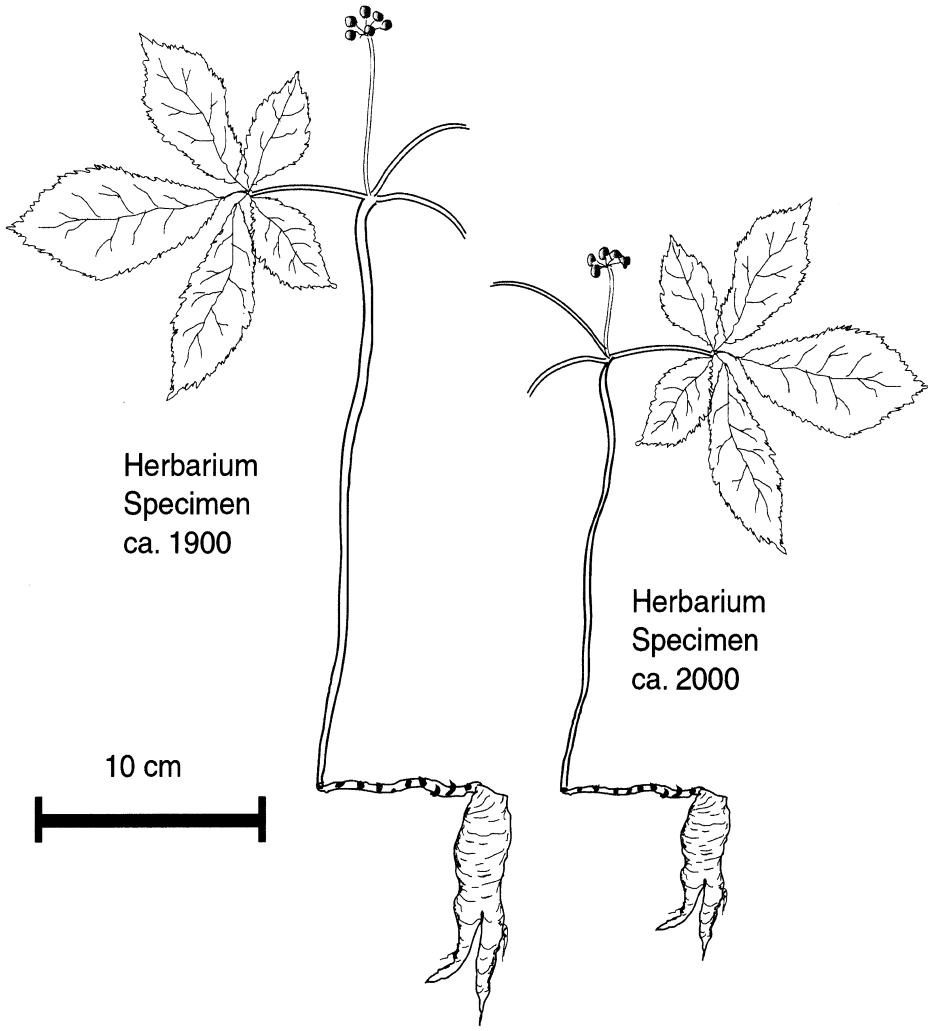
CASE STUDY: Decline in height of the harvested snow lotus, *Saussurea laniceps*

S. laniceps | *S. medusa*



Law, W, Salick, J. 2005. *PNAS*. 102(29): 10218-10220.

Similar declines observed in ginseng from herbarium specimens



Ginseng collected in Lambton County, 1912.
University of Guelph herbarium collection.

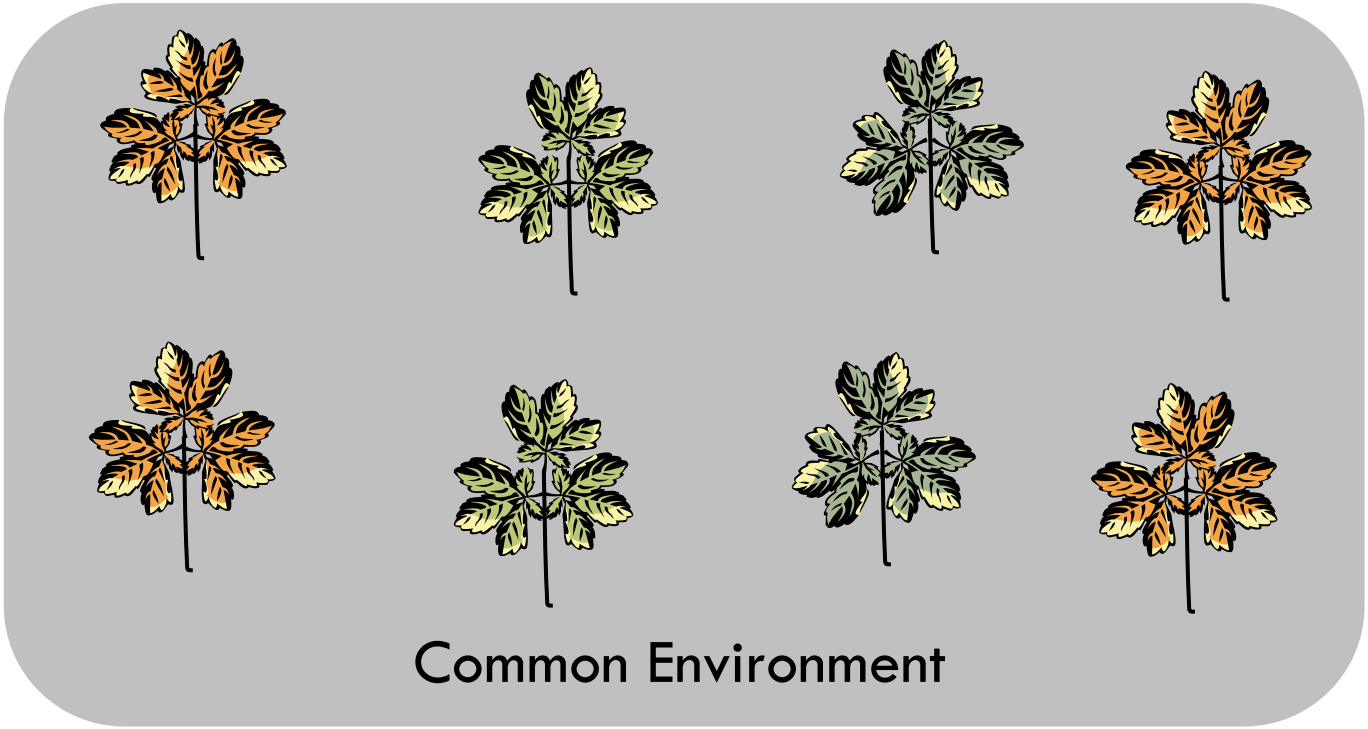
McGraw, JB. 2001. *Biol Cons.* 98(1): 25-32.

Harvest of ginseng is size selective

1. Harvest often restricted to plants with 3 or more leaves
2. Harvesters are likely motivated to leave behind juvenile plants
   a) Larger plants yield more valuable roots
   b) Traditional conservation ethics
3. Larger plants are more apparent

Mooney, EH, McGraw, JB. 2007. *Cons Gen*. 8: 57-67.
Price, ET. 1960. *Geog Rev*. 50: 1-20.
Van der Voort , ME, McGraw, JB. 2006. *Biol Cons*. 130: 505-516.

Is variation in size genetically determined?



- Germplasm bank planted by Bob Beyfuss
- Plants collected from wild populations in eight states
- Differences in leaf area and sympodium height persisted

Research Question

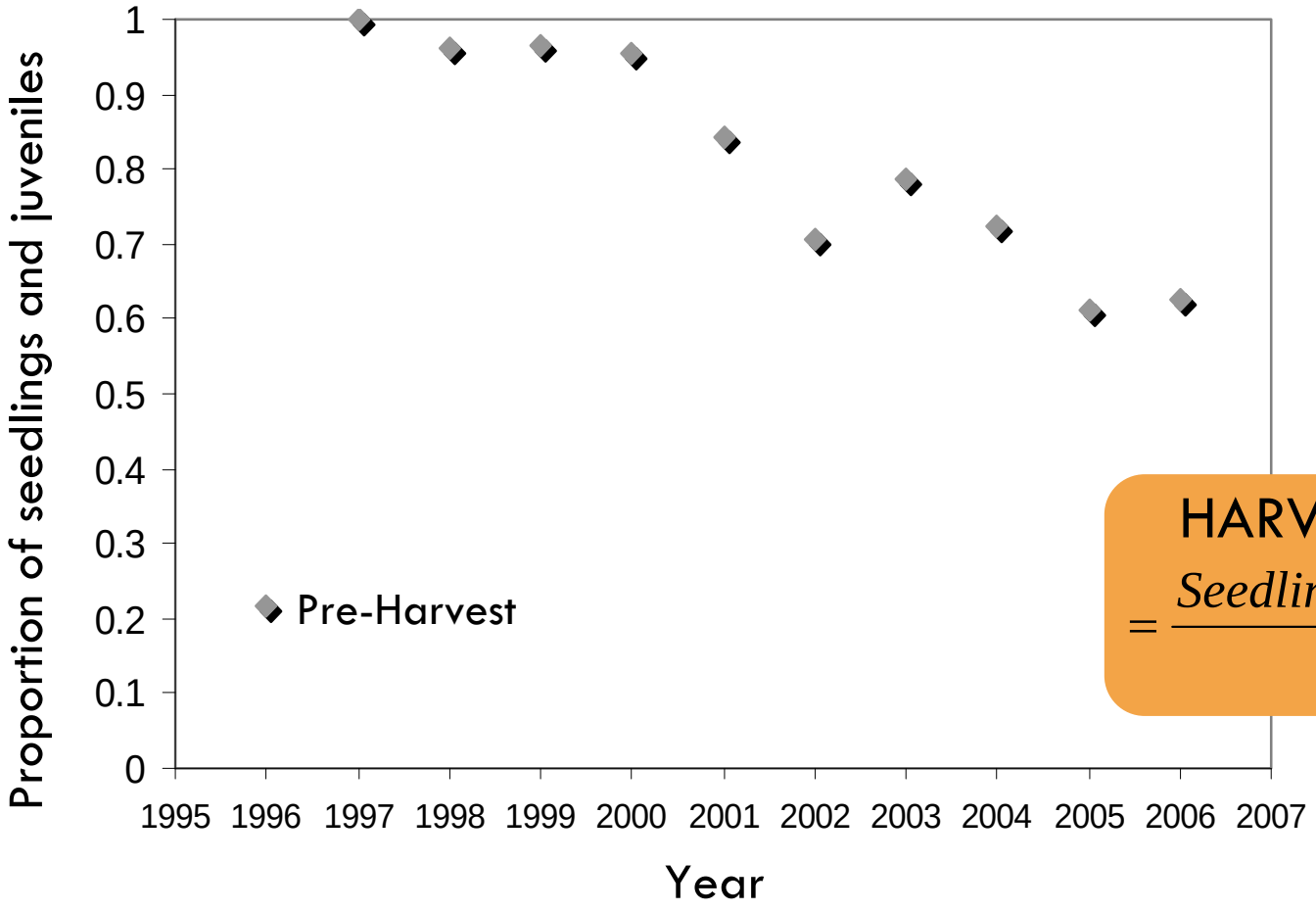
Do life-history traits vary among populations with different harvest pressures?

How to assess harvest pressure?

Ask harvesters	…potential for bias
Monitor population	…harvest infrequent
Legal status of location	…poaching common
Stage-structure impacts	

Bailey, B. 1999. Ph.D. Dissertation. WVU, Morgantown, WV
Van der Voort , ME, McGraw, JB. 2006. *Biol Cons.* 130: 505-516.
van Manen, FT et al. 2005. *Nat Areas J,* 25: 339-350.

Experimental harvest

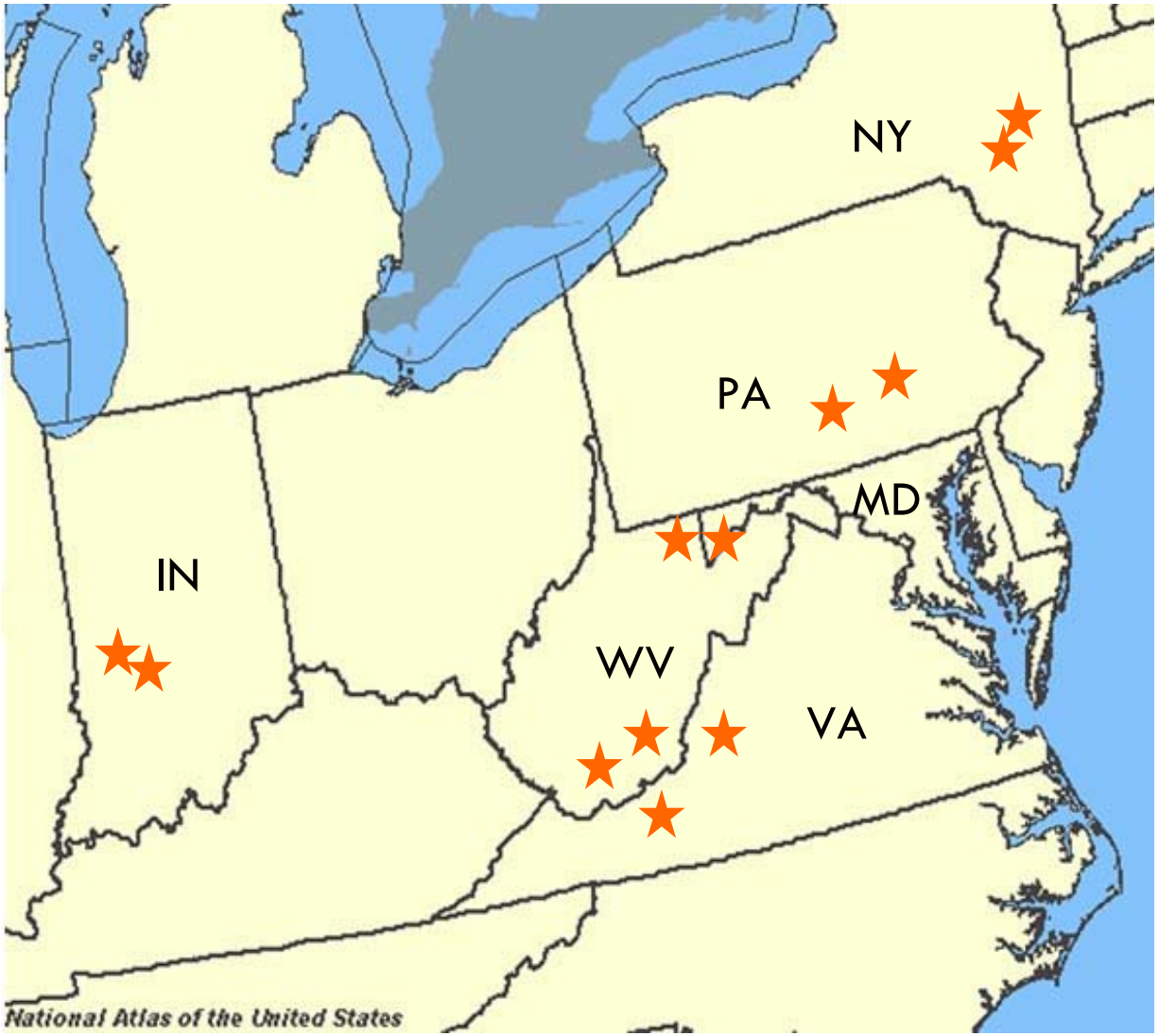


HARVEST INDEX

$$= \frac{Seedlings + Juveniles}{N}$$

Van der Voort, ME, et al. 2003. *Am. Midl. Nat.* 149: 282-292

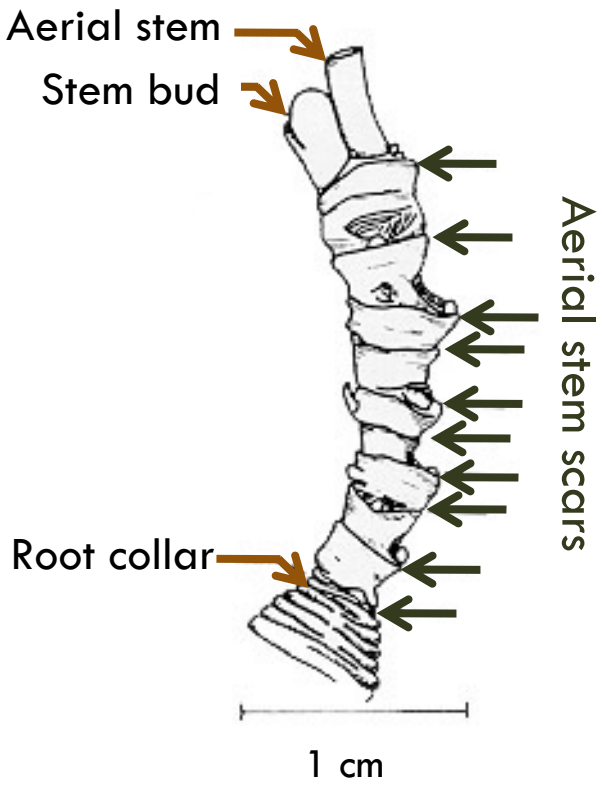
Study populations

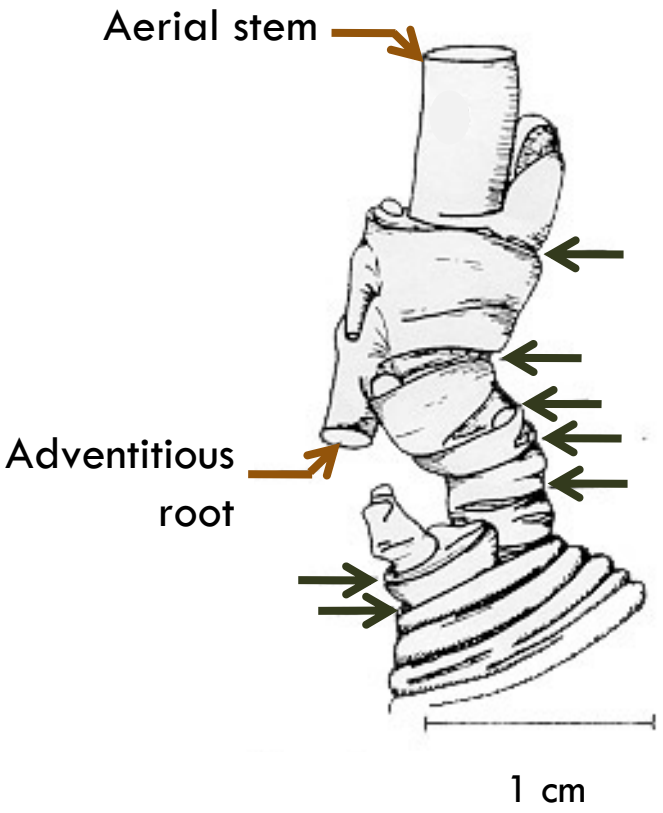


Data collection

- 2004-2006
- Size
  - Sympodium (stem) height
  - Leaf area
- Reproductive data
  - Flowering (Y/N)
  - Seed production (Y/N)
  - Number of seeds
- Age
- Frequency of deer browse

Aging plants using stem scars

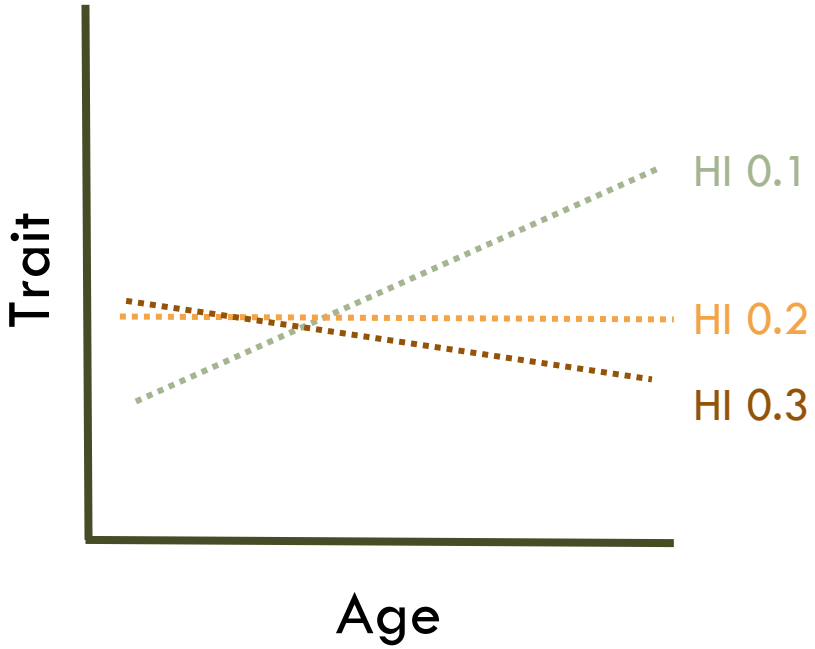




Camera lucida drawings from www.fws.gov

Data analysis

- Regression with model effects:
  - Age
  - Harvest Index
  - Age X Harvest Index
- Correlation between deer browse and Harvest Index
- Statistical software: SAS JMP v. 6.0



Sokal, RA, Rohlf, FJ. 1995. Biometry. W.H. Freeman and Company, New York.

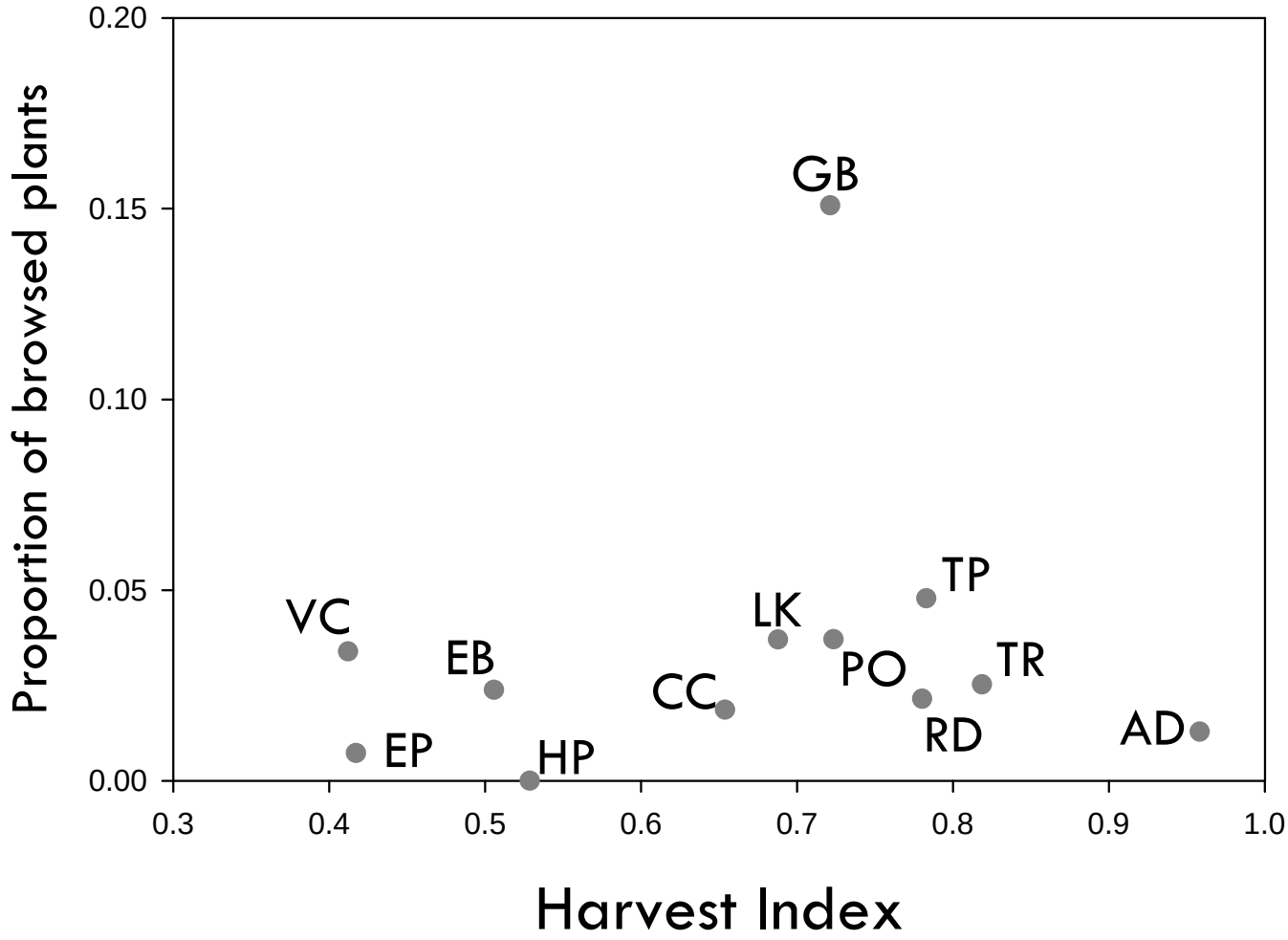
Results

Population	Location	N	Harvest Index
VC	Vermillion Co, IN	173	0.4122
EP	Lancaster Co, PA	99	0.4173
EB	Preston Co, WV	46	0.5057
HP	Albany Co, NY	280	0.5286
CC	Garrett Co, MD	154	0.6538
LK	Franklin Co, PA	349	0.6879
GB	Greenbrier Co, WV	123	0.7213
TP	Albany Co, NY	62	0.7235
TR	Parke Co, IN	133	0.7802
PO	Bedford Co, VA	300	0.7829
AD	Mercer Co, WV	75	0.8486
RD	Pulaski Co, VA	129	0.9583

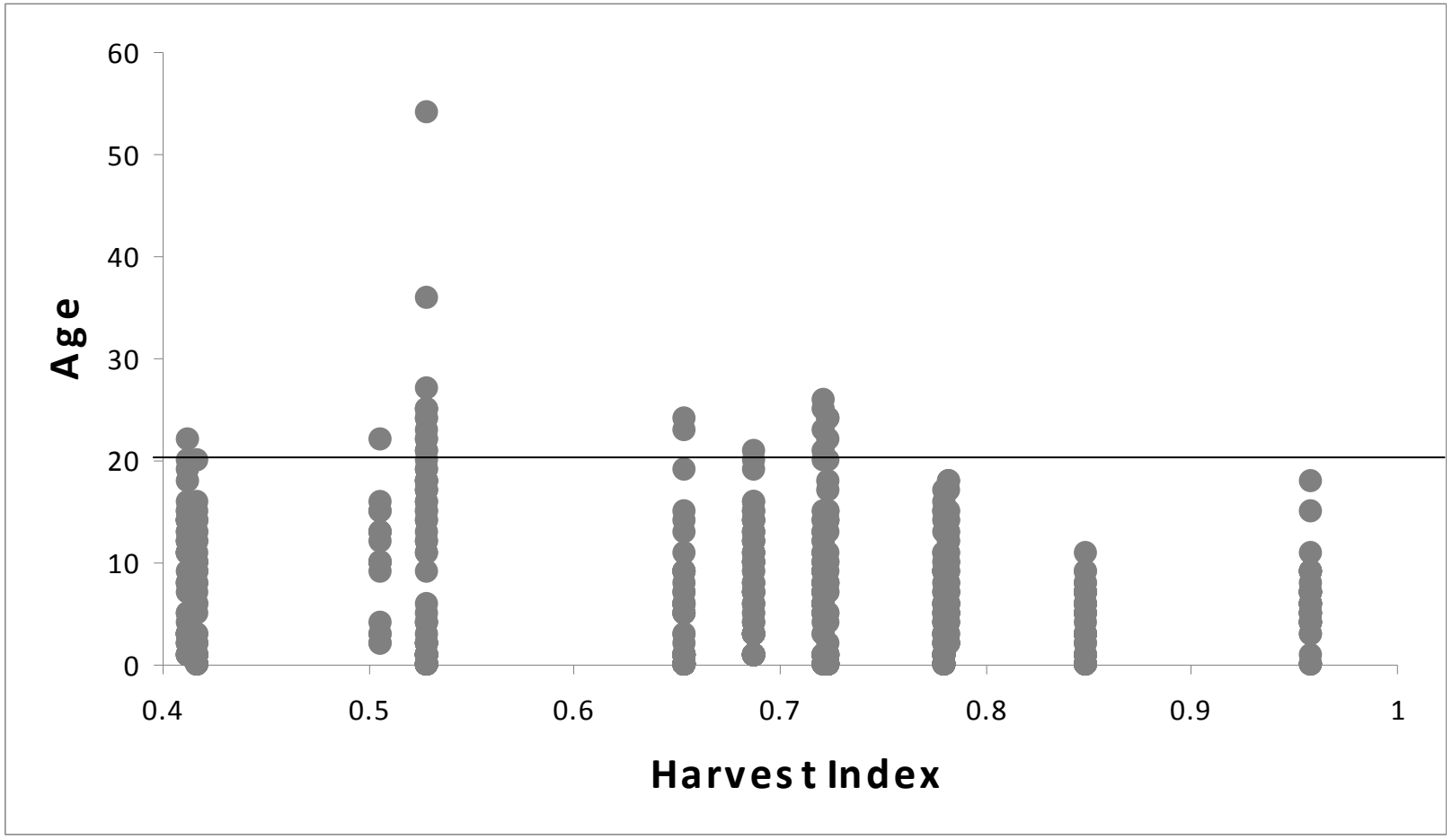
Table 1: Study populations, their locations by county, mean population sizes over 2004-2006, and harvest indices.

Results

$r = 0.2348$, $p = 0.4871$



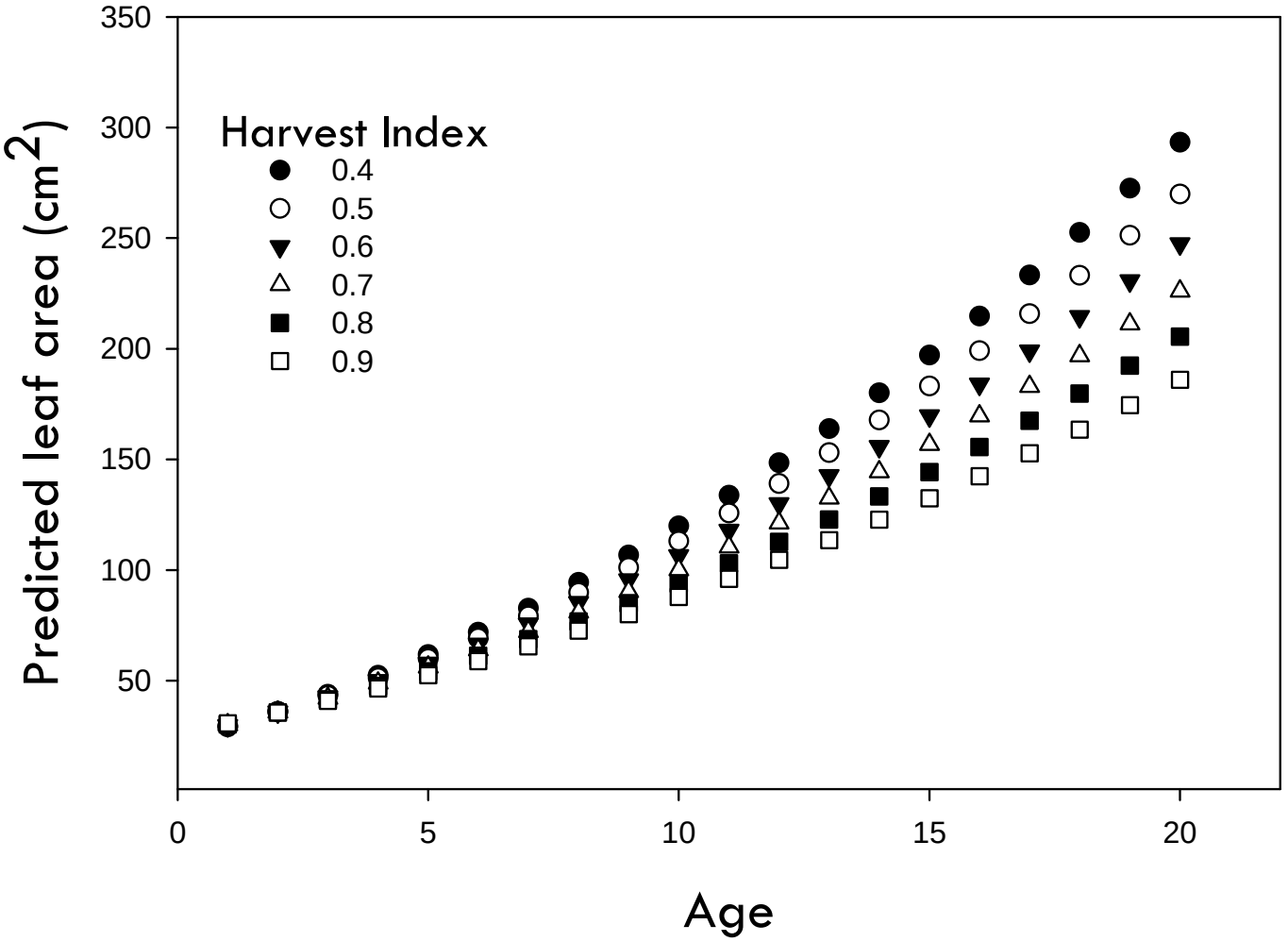
Results



Results

Table 2: Regression results for 2006

N	Model Term	*F* ratio	p-value
650	Age	908.905	<0.0001
	Harvest Index	6.756	0.010
	Age X Harvest Index	10.739	0.001



Results

Table 3: Regression results for 2006

N	Model Term	*F* ratio	p-value
653	Age	300.699	<0.0001
	Harvest Index	0.262	0.609
	Age X Harvest Index	12.046	0.001

Results

Table 4: Regression results describing the relationship between age and reproductive traits for plants in the 12 study populations. .

Year	Reproductive?	Produced Seeds?	Number of seeds
2004	χ^2= 11.985, p=0.001	χ^2= 2.510, p=0.113	*F*=3.293, p=0.074
2005	χ^2= 44.953, p<0.0001	χ^2= 13.630, p=0.0002	*F*=2.383, p=0.125
2006	χ^2= 50.293, p <0.0001	χ^2= 4.390, p=0.036	*F*=1.780, p=0.185

Likelihood of inflorescence production consistently increased with age

Age did not consistently predict seed production

Results

Table 5: Regression results describing the relationship between harvest index and reproductive traits for plants in the 12 study populations. .

Year	Reproductive?	Produced Seeds?	Number of seeds
2004	χ^2= 3.259, p=0.071	χ^2= 4.740, p=0.029	F=2.714, p=0.104
2005	χ^2= 2.582, p=0.108	χ^2= 0.580, p=0.446	F=23.041, p<0.0001
2006	χ^2= 0.078, p=0.780	χ^2= 22.630, p<0.0001	F=23.594, p<0.0001

Harvest index reduced likelihood of seed production in several study years

Conclusions

- Populations with higher harvest indices had plants with smaller leaf areas and sympodium heights
  - Appears to be the product of slower growth
  - Consistent with the effects of size selective harvest

Conclusions

- Seed set and number of seeds was reduced in plants from populations with higher harvest indices
  - Not necessarily the product of size selective harvest
  - Allee effect
  - Similar density-dependent reductions in fecundity observed in fisheries

Hackney, EE, McGraw, JB. 2001. *Cons Biol.* 15: 129-136
Law, R. 2000. *J Mar Sci.57*: 659-668.

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