Modeling Forage Legume Polycross Pollen-Parent Gamete Contributions to Progeny Based on Empirical Measurements with Implications for Effective Polycross Size

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Random Mating

- Random Mating
  - 1. Every population member has equal chance to produce offspring
  - 2. Any female gamete is equally likely to be fertilized by any male gamete (Allard, 1960)

- Concept origin
  - Synonymous with "Panmixis"
  - "***This suspension*** of the preserving influence ***of natural selection may be termed*** **Panmixia**, *for all individuals can reproduce themselves* and thus stamp their characters upon the species, and *not only* those which are in all respects, or in respect to some single organ, *the fittest*." ("On Heredity"; Weismann, 1883)

Random Mating

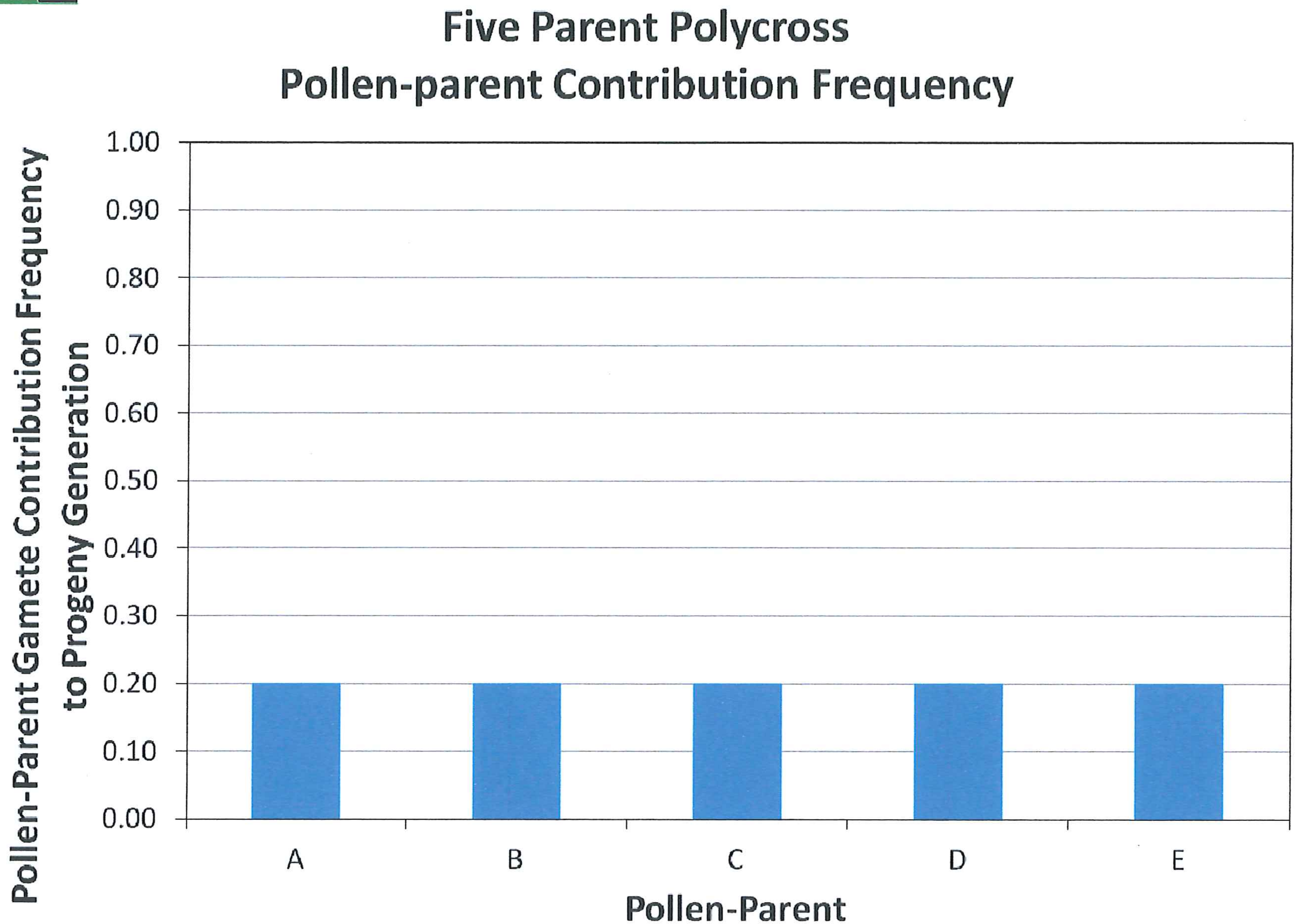
- Is random mating "natural"?
  - "It can be questioned whether the theoretical form of random mating is every fulfilled exactly, because some form of selection, natural or human, is likely to intervene" (Allard, 1960)
  - "The great value of the random mating assumption in experimental population genetics is that is provides a standard of reference . . . To which observed mating distributions can be compared." (Clegg, 1980)

Most likely not Panmixis

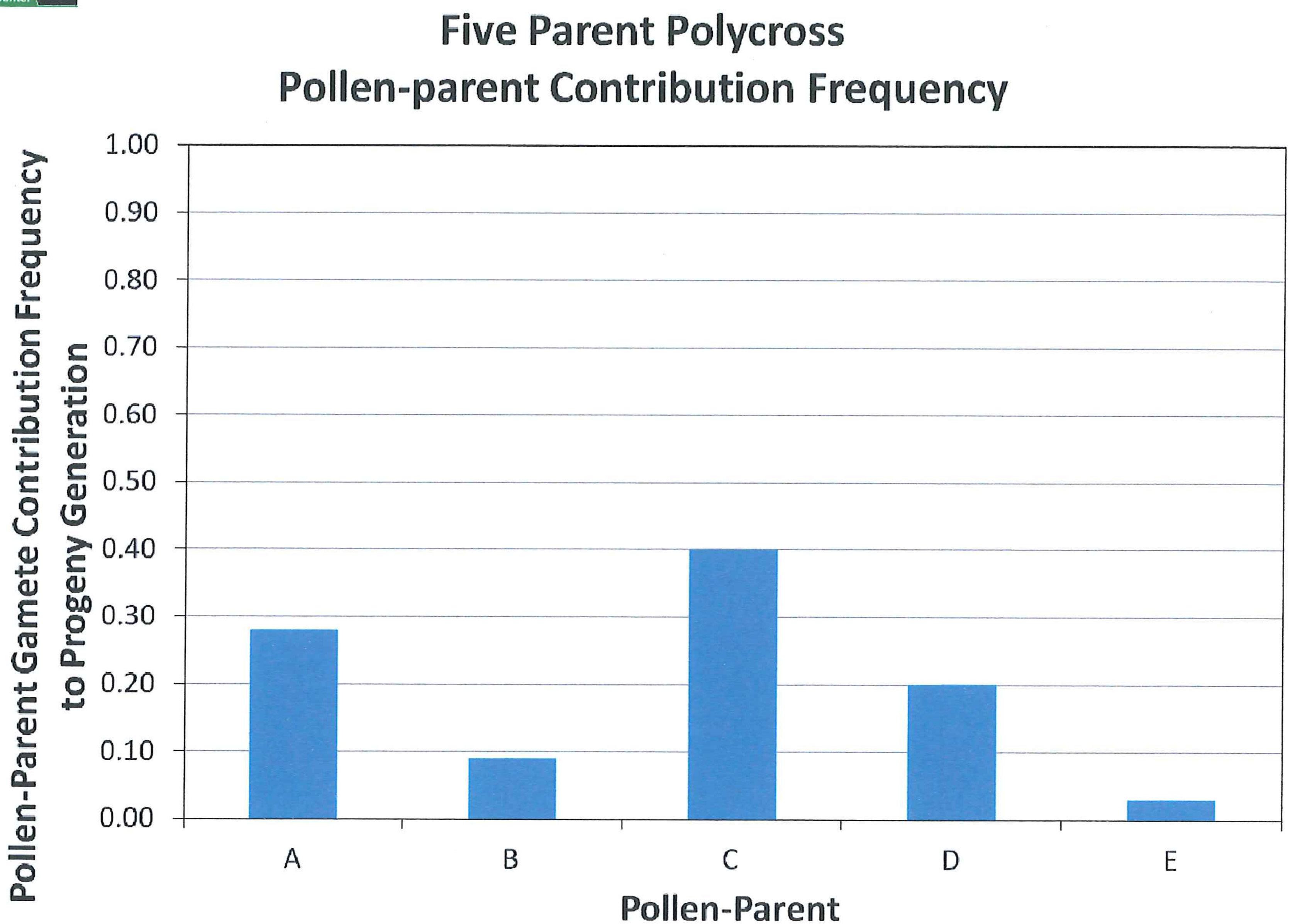
Random Mating

- Has "random mating" (i.e., panmixis) become conflated with human-unassisted/non-interventiatory mating in a plant breeding setting?
  - Plant breeders may assume they are the only source of "selection" in controlled plant breeding matings
  - Plant breeders are aware of unequal seed yield
    - Solution - bulking equal quantities of seed from polycross seed-parents
    - Equal seed bulking artificially creates panmixis for female gametes
  - New term for plant breeding? - "Natural Mating"
- Objectives
  1. Show that pollen-gametes are not contributed panmictically to the next generation in a forage legume polycross (less interesting)
  2. Show that pollen-gamete contribution distribution to the next generation can be predicted knowing only polycross size in bee pollinated forage legume polycrosses (more interesting)
     - Prediction in the absence of knowing anything about selection

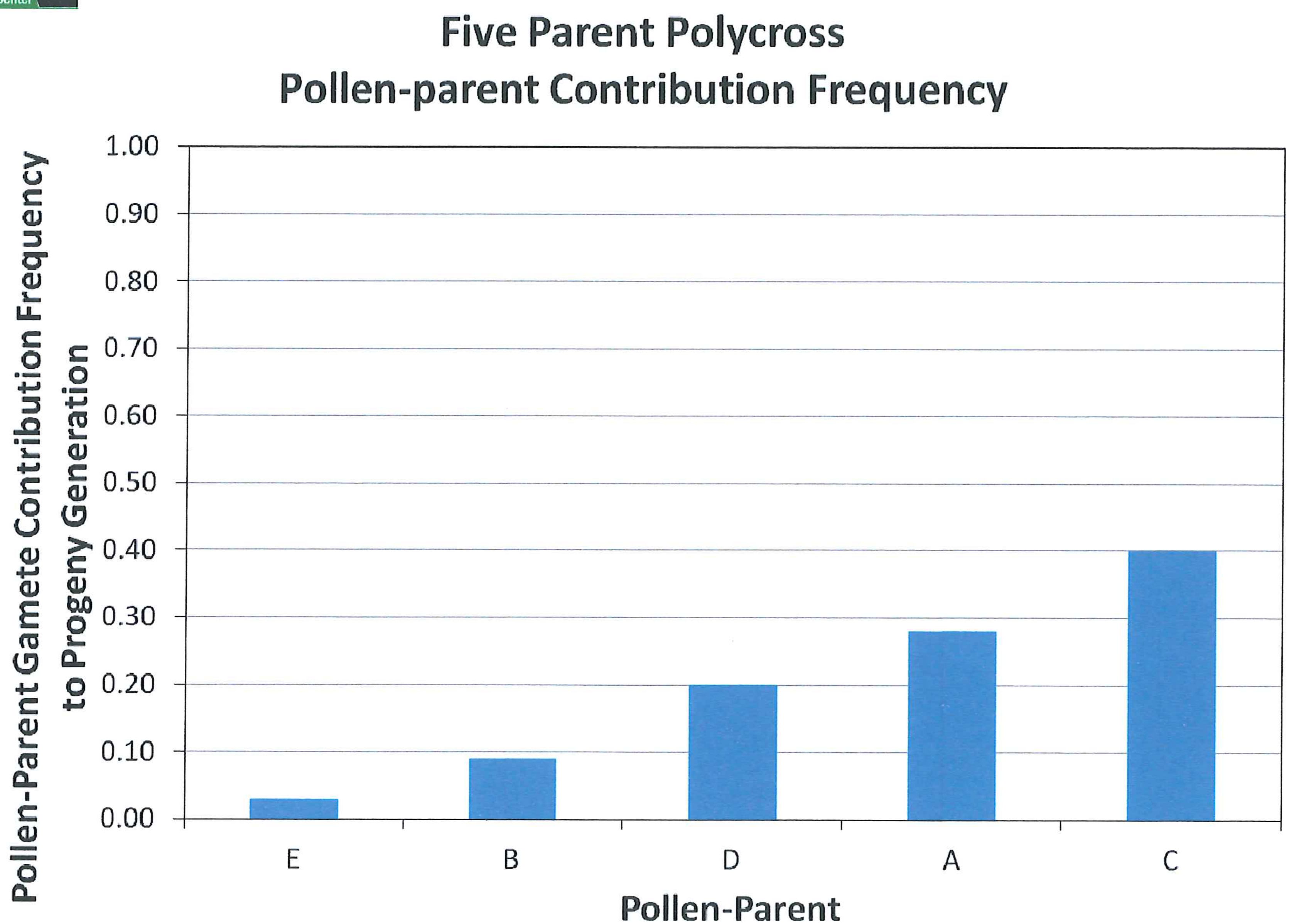
Pollen-Parent Contribution (Panmixis)



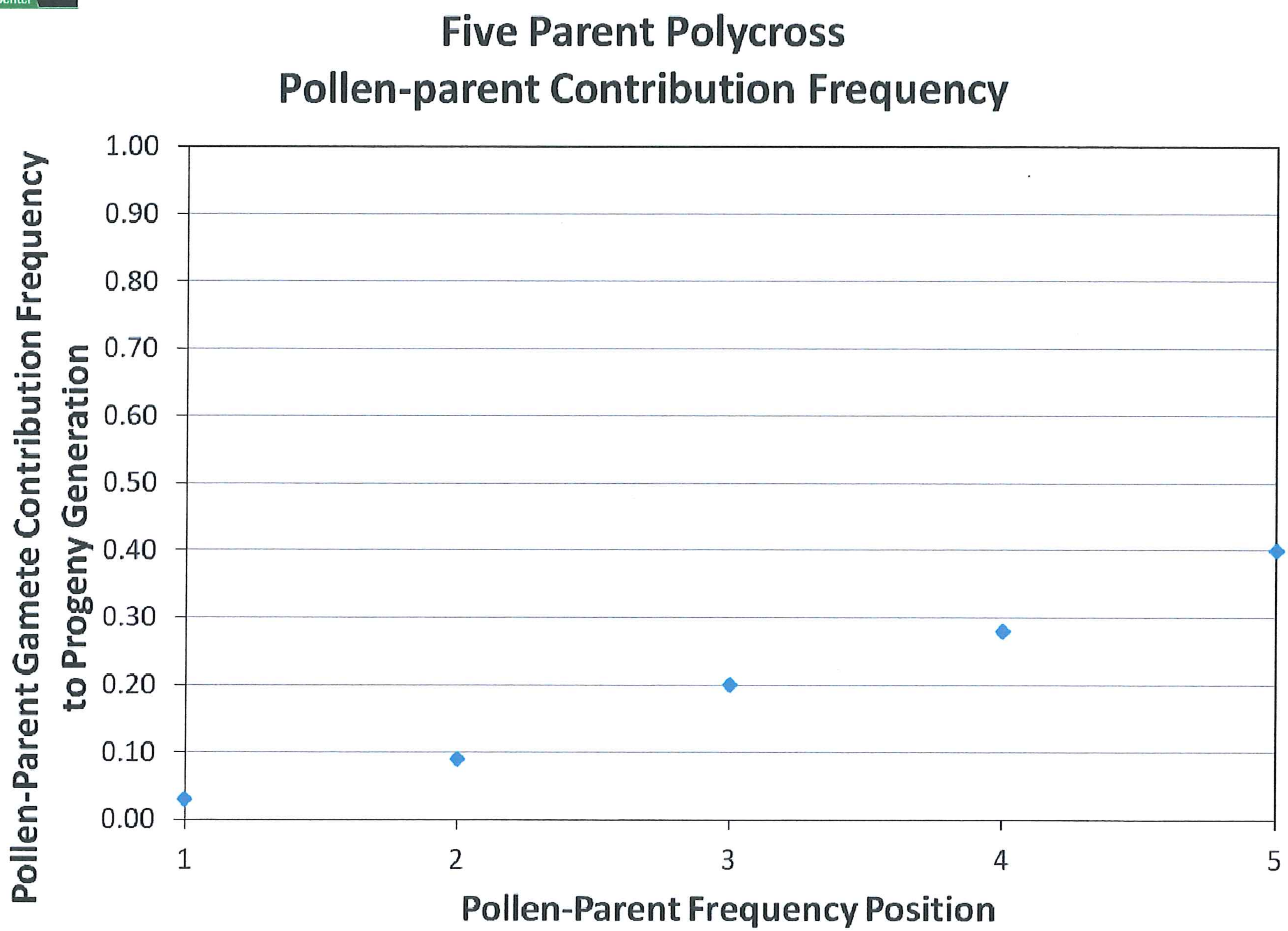
Not Panmixis



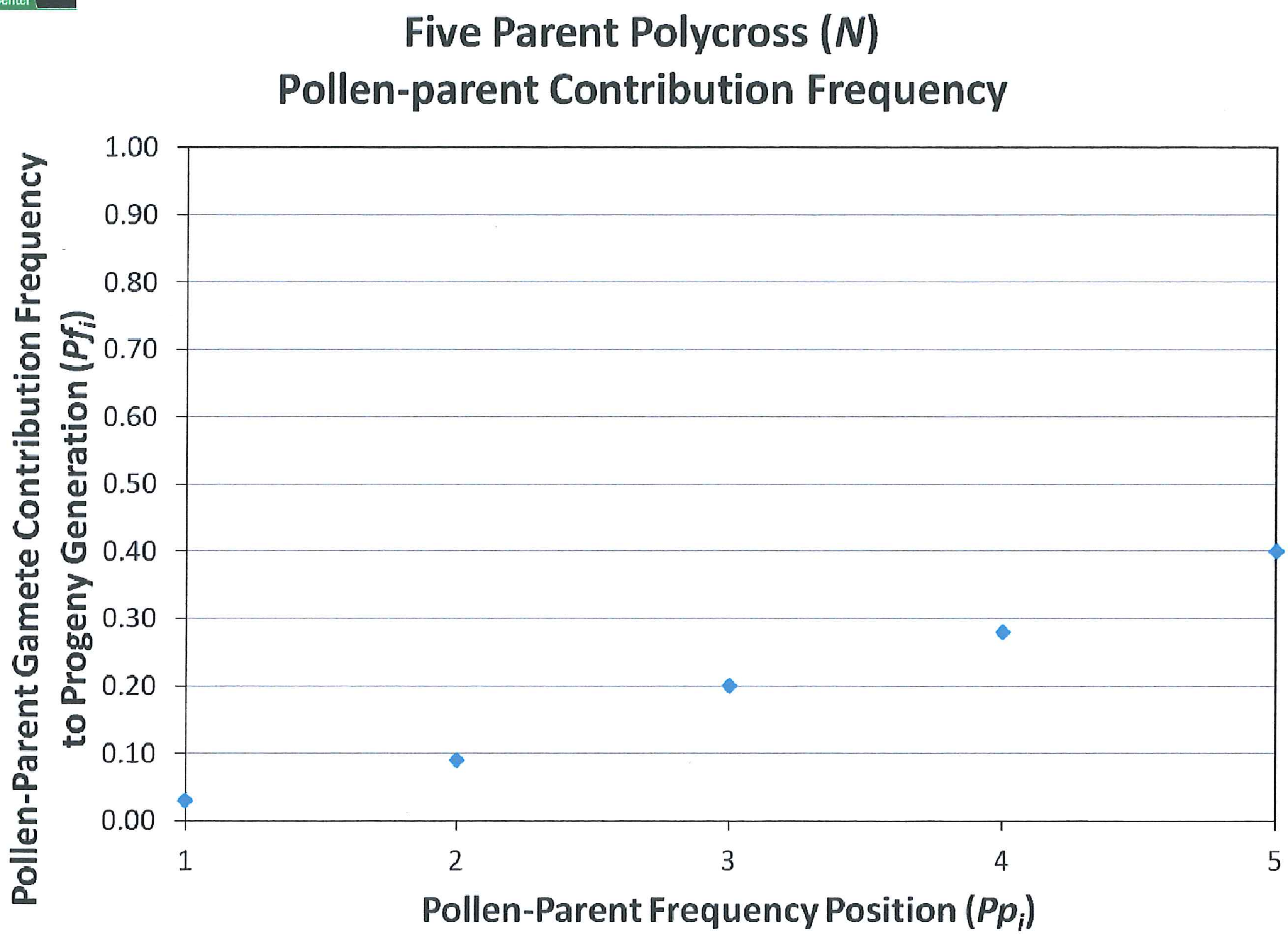
Ordered Pollen-Parent by Frequency



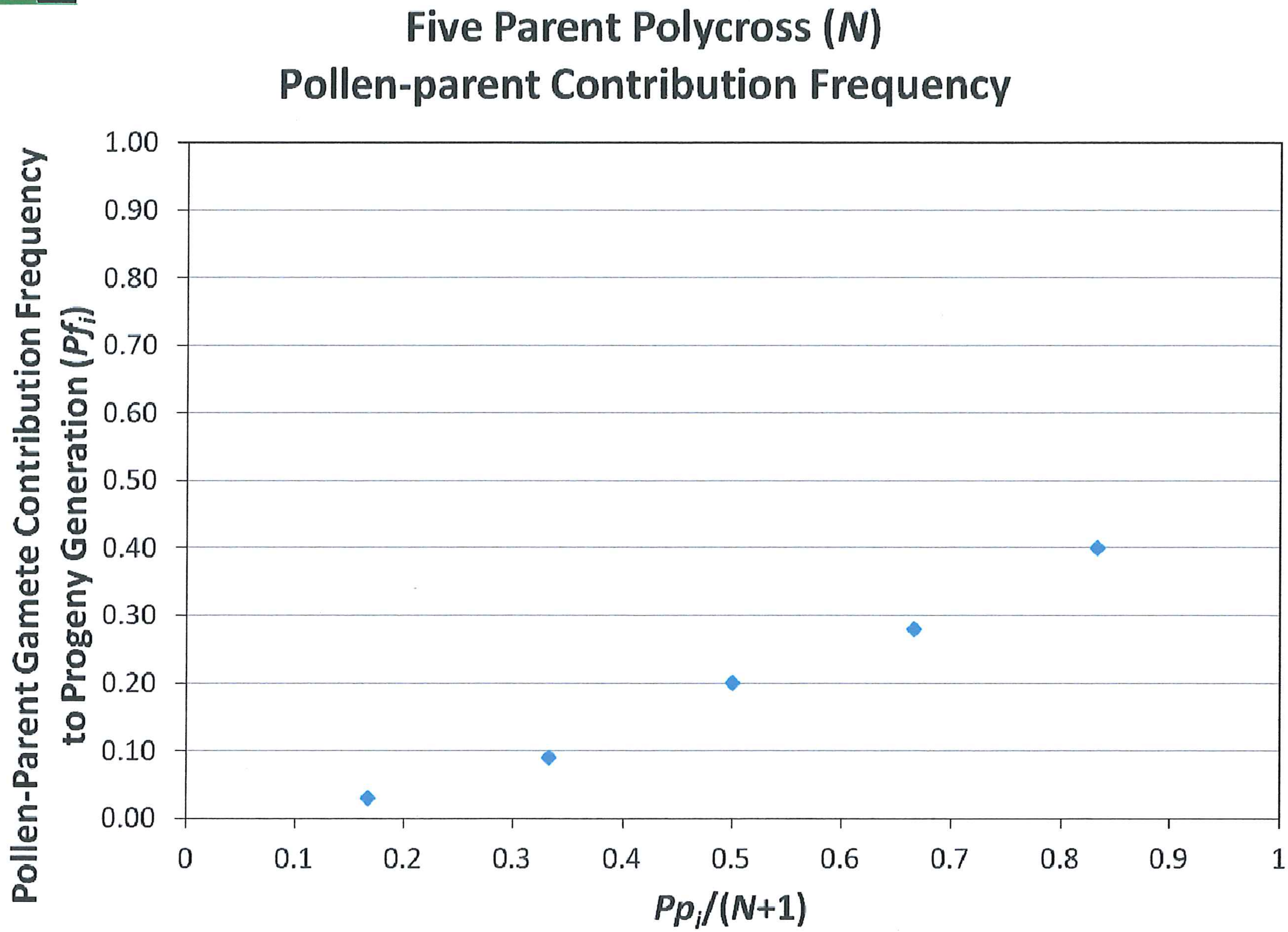
X-axis: Qualitative to Quantitative Scale



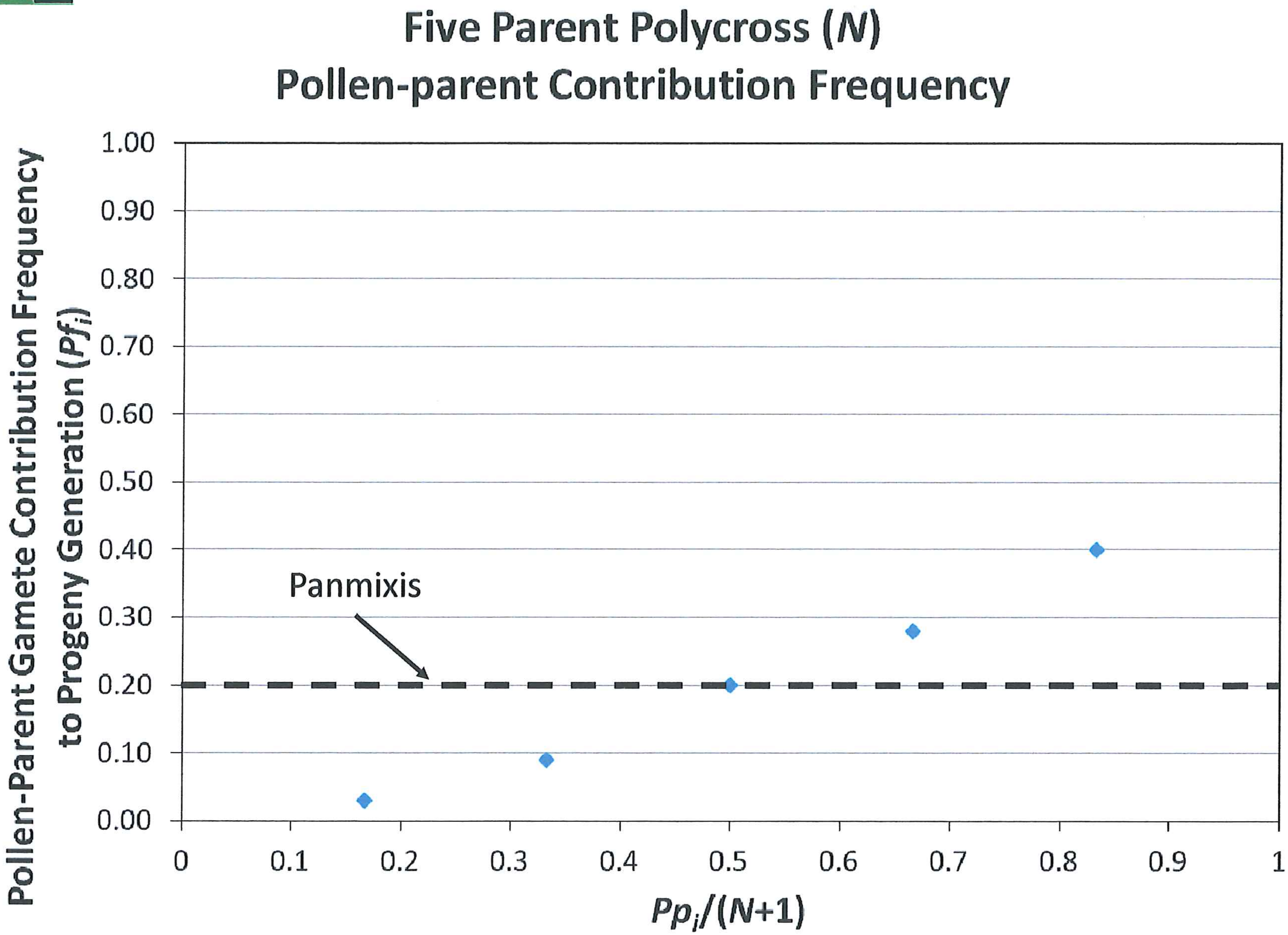
Define Terms (N, Pf_i, Pp_i)



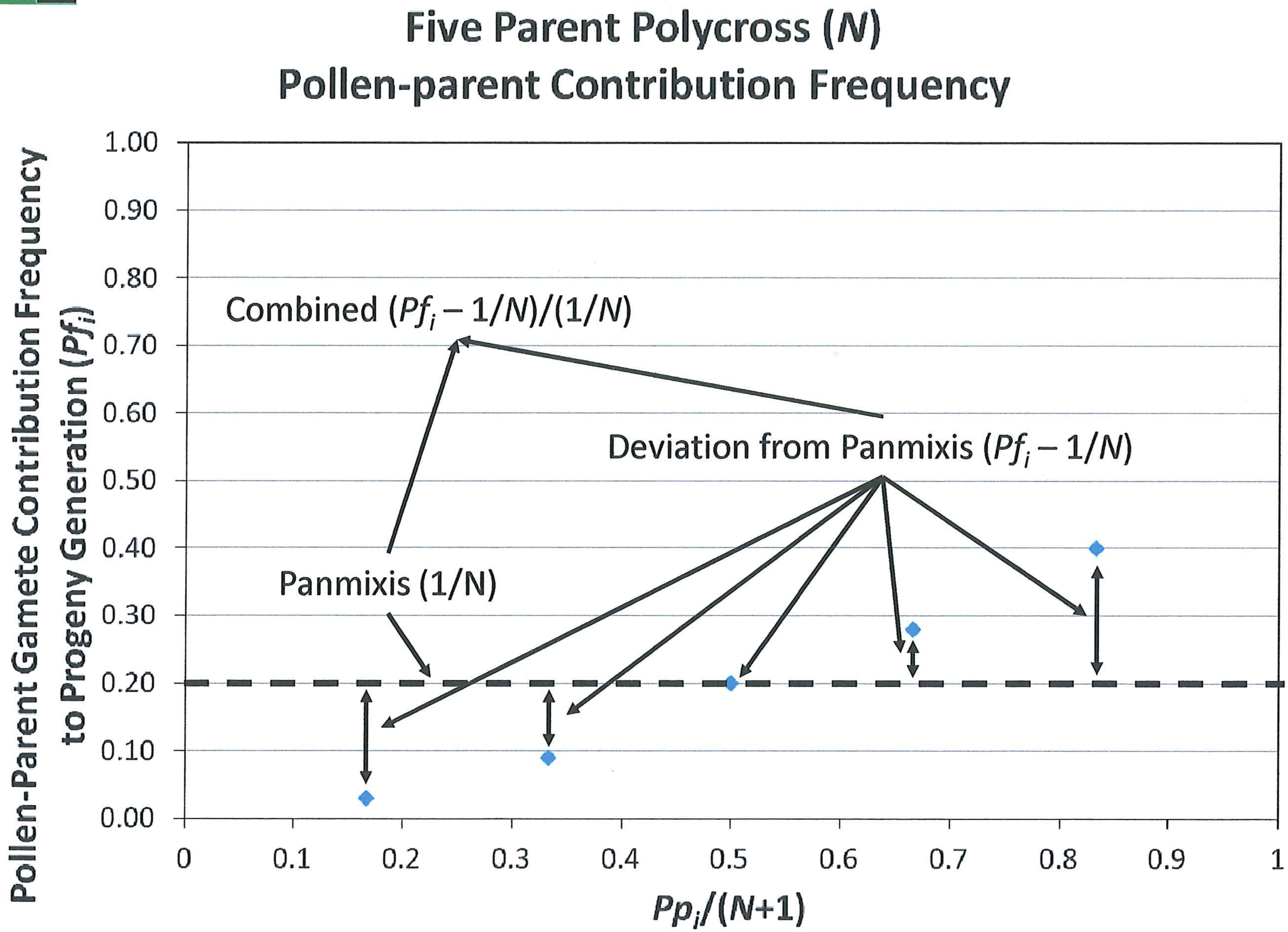
Polycross Size Independent (x-axis)



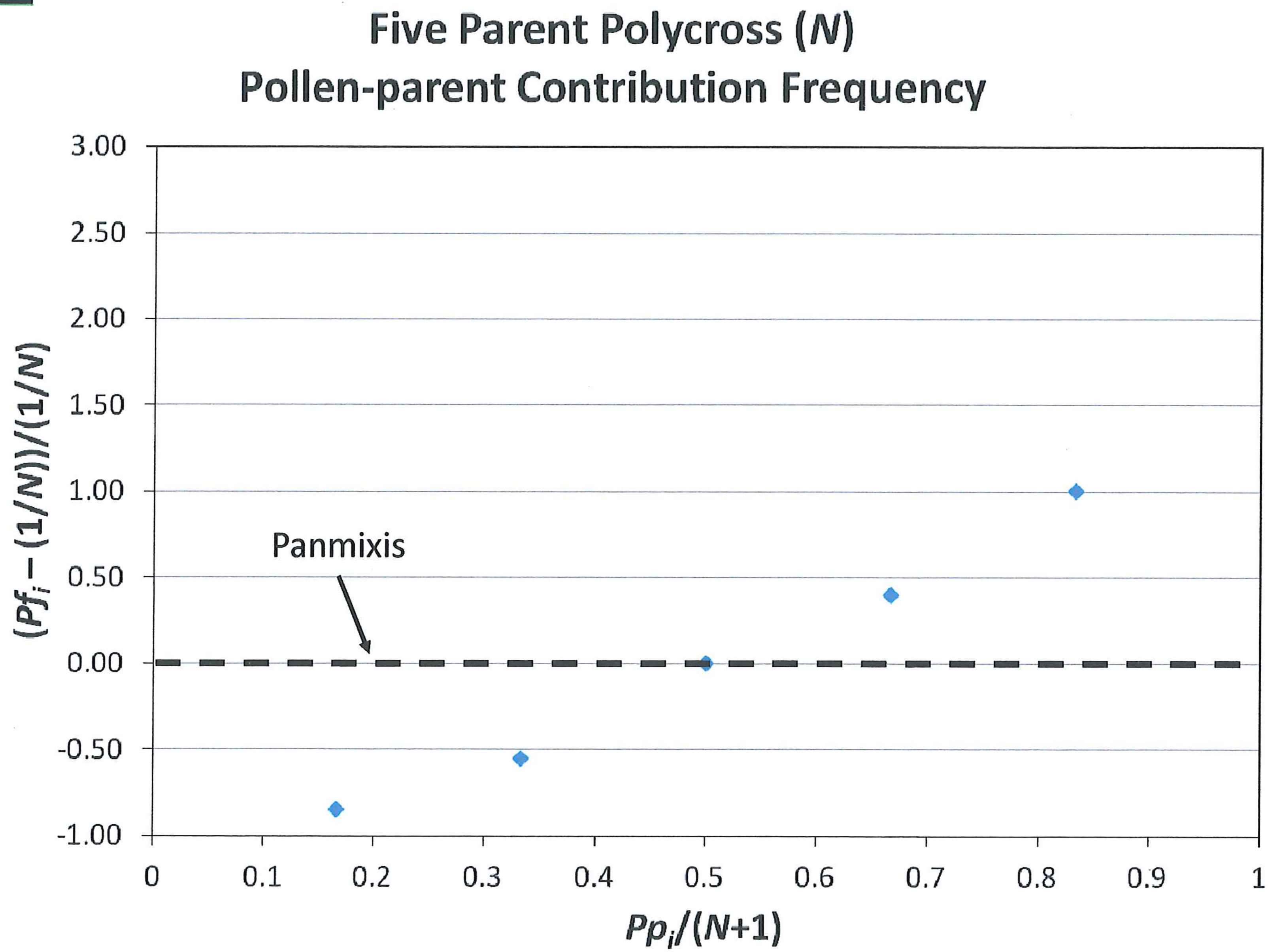
Polycross Size Independent (y-axis)



Polycross Size Independent (y-axis)



Polycross Size Independent (y-axis)



Polycrosses Sampled

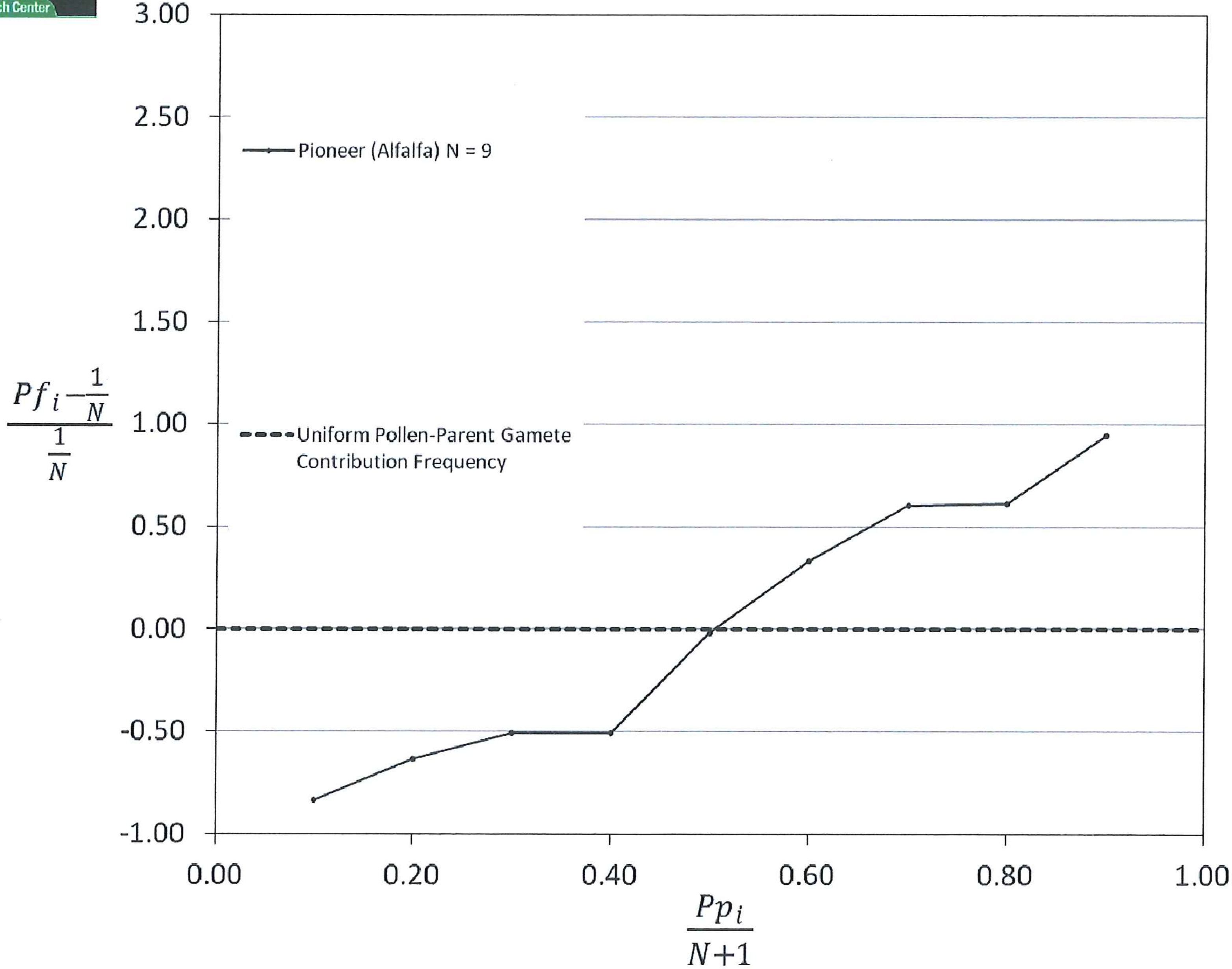
Polycross Name	Size (N)	Species	Pollinator Bee	Clonal Reps	Physical Size	Isolation	Polycross Location	Seed-Parent Sampled	Progeny Sampled
Pioneer	9	Alfalfa	Bumble	Yes	4'x4'†	Indoor Room	WI	6	763*
Alforex	15	Alfalfa	Leafcutter	Yes‡	~9'x60'	Cage	CA	15	536
LP	22	Red Clover	Bumble	No	6'x12'	Cage	WI	8	321
KU09B	26	Kura Clover	Leafcutter & Natural	Yes	30'x60'	Open Isolation	UT	26	656
Vis09	26	Red Clover	Bumble	No	6'x12'	Cage	WI	11	680
C328WS	34	Red Clover	Bumble	No	6'x12'	Cage	WI	12	604
Yld09	74	Red Clover	Bumble	No	6'x12'	Cage	WI	14	513
C584Y	92	Red Clover	Bumble	No	6'x12'	Cage	WI	27	1103
WI21	93	Red Clover	Bumble	No	6'x12'	Cage	WI	31	1704
C276	94	Red Clover	Bumble	No	6'x12'	Cage	WI	27	1043

† Room larger – unrestricted pollinator movement within room

* Numbers include only successfully paternity tested progeny; in alfalfa excludes selfed progeny

‡ Clonal copies not randomized

Pollen-Parent Gamete Contribution Frequencies



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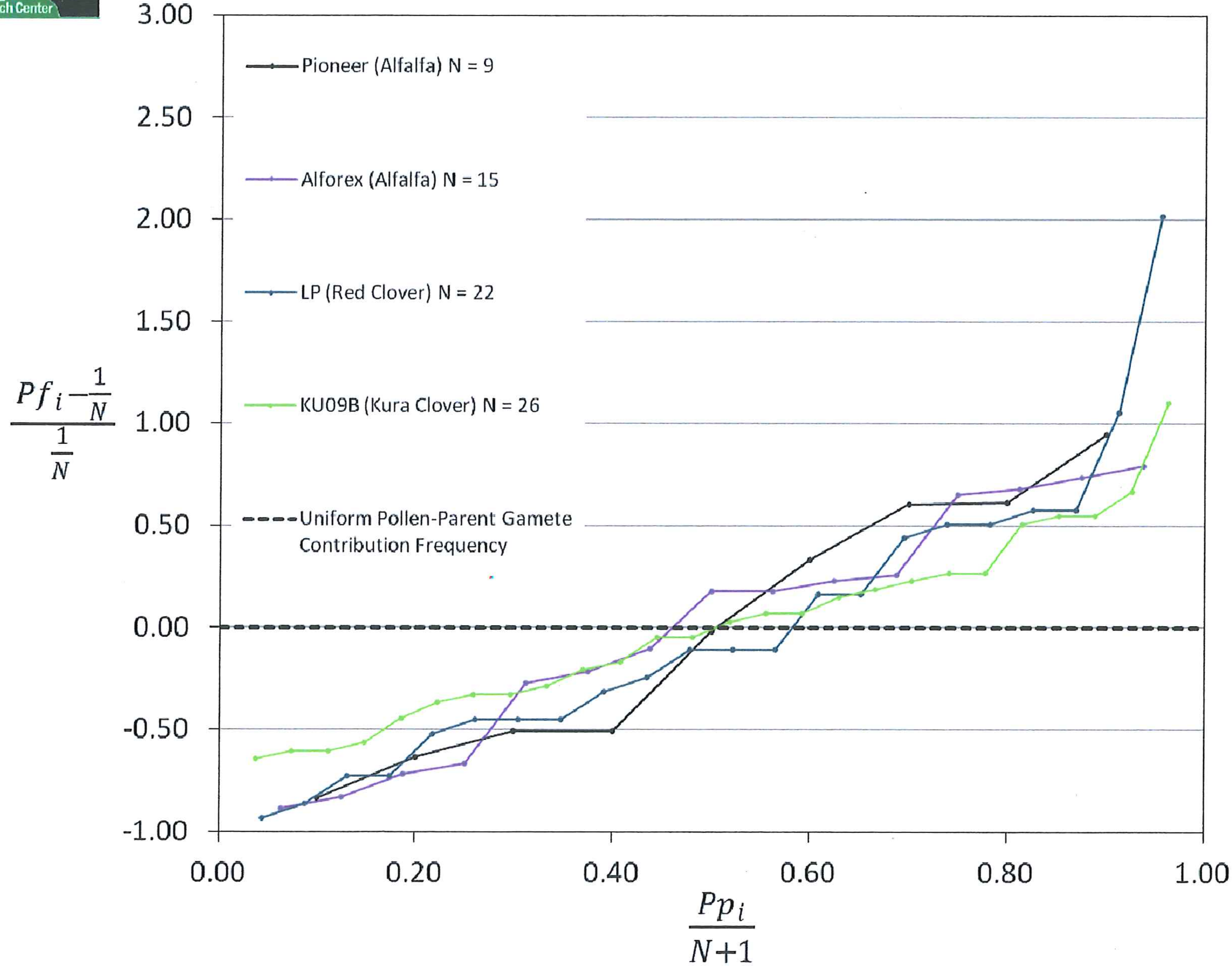

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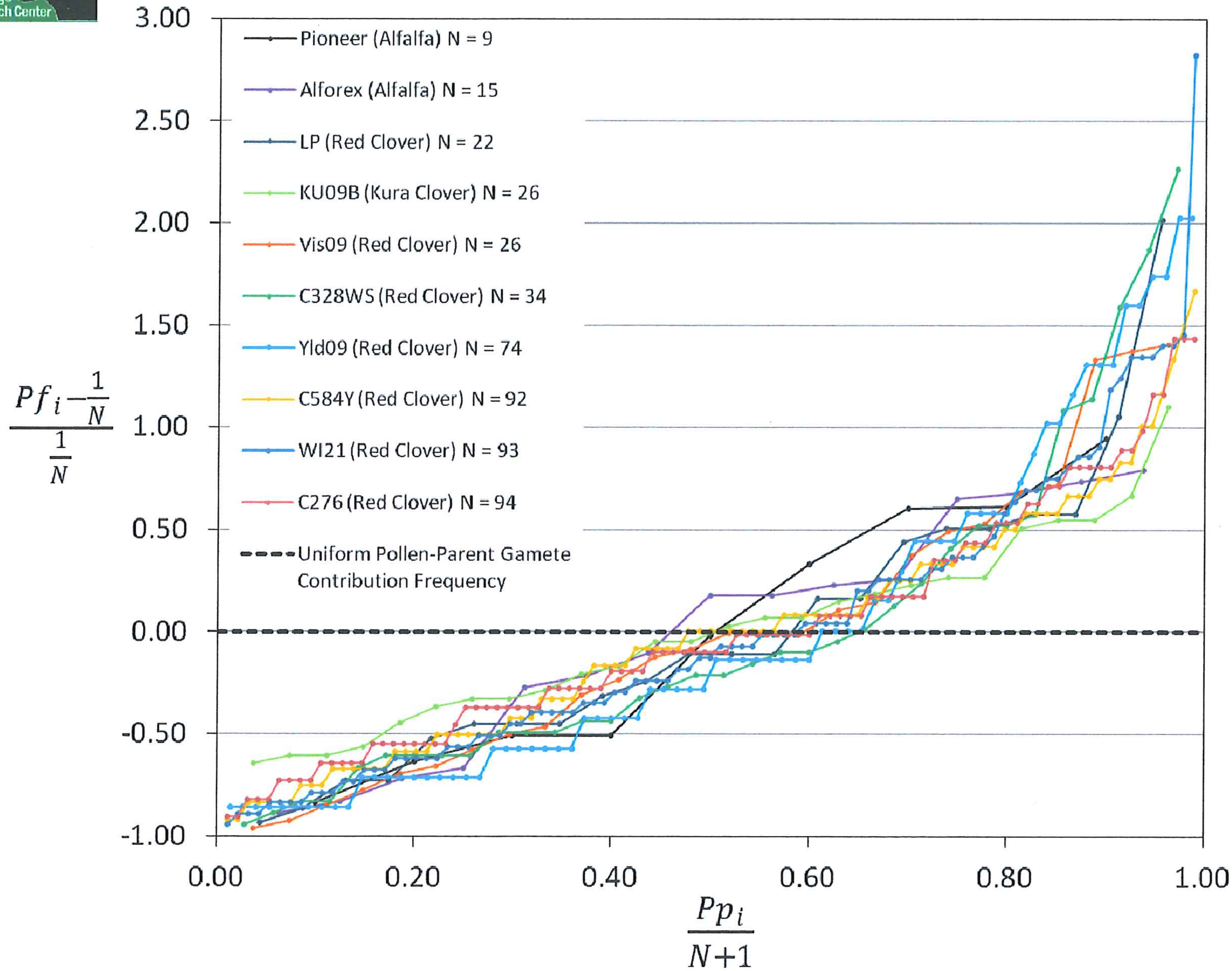

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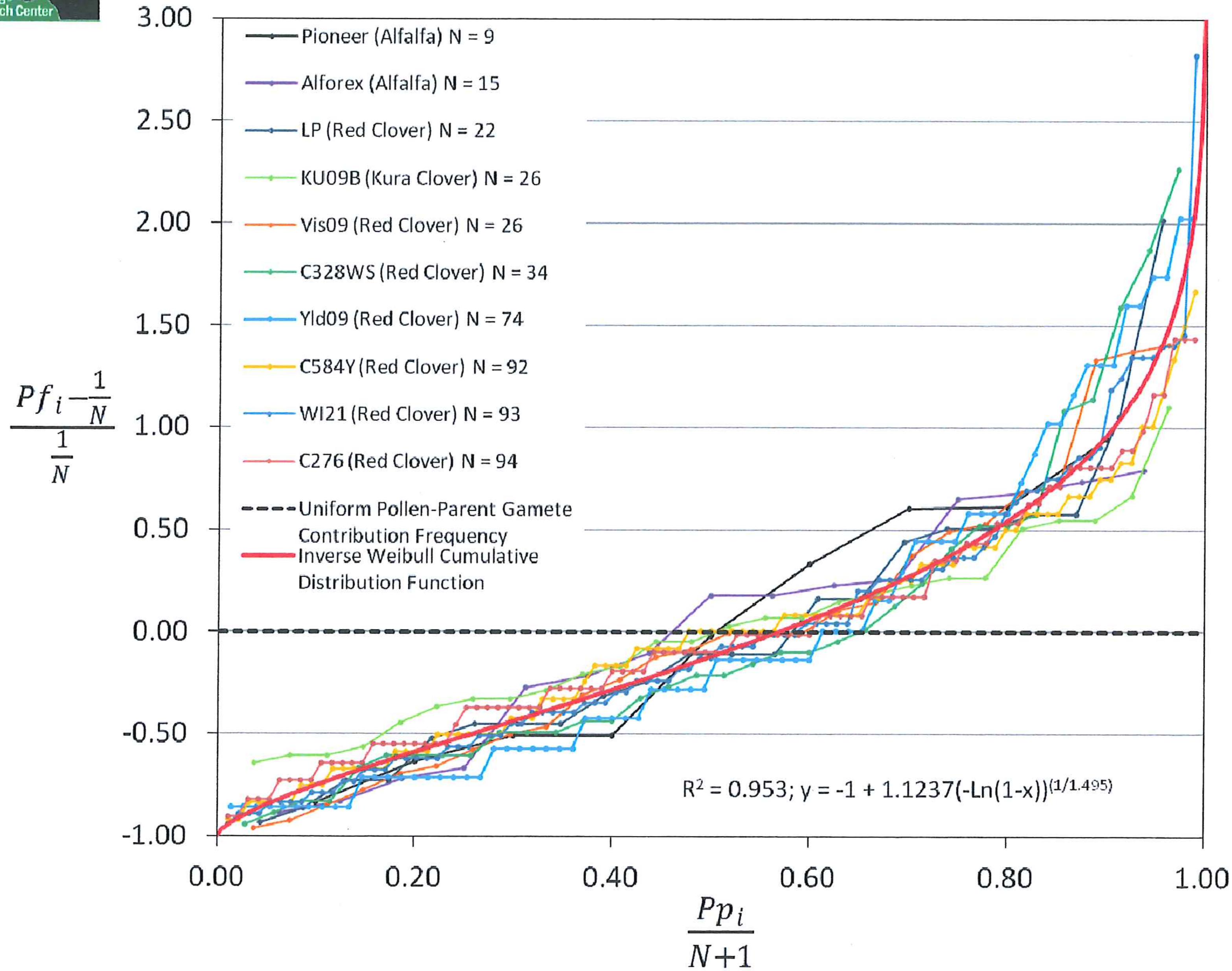
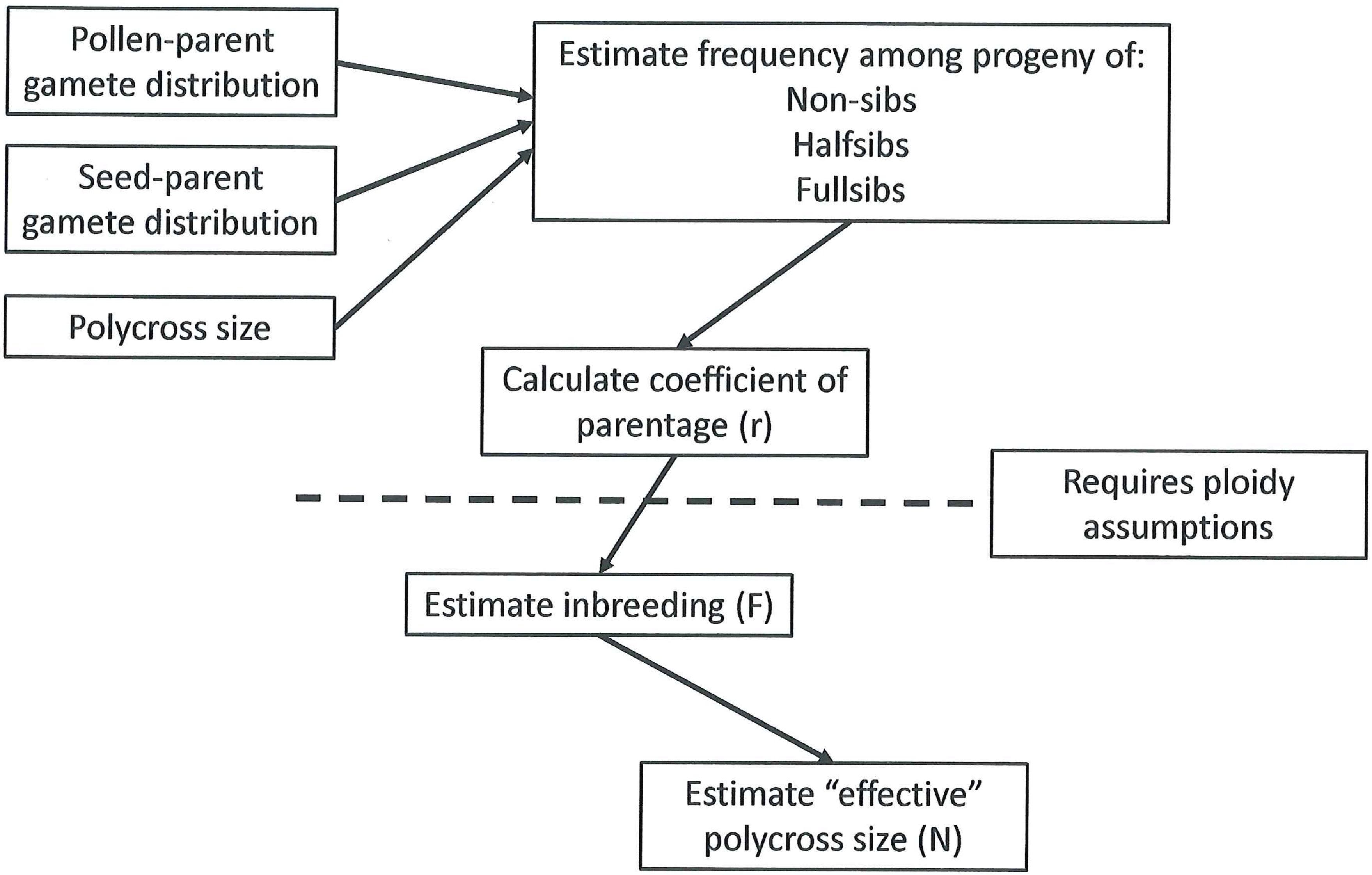
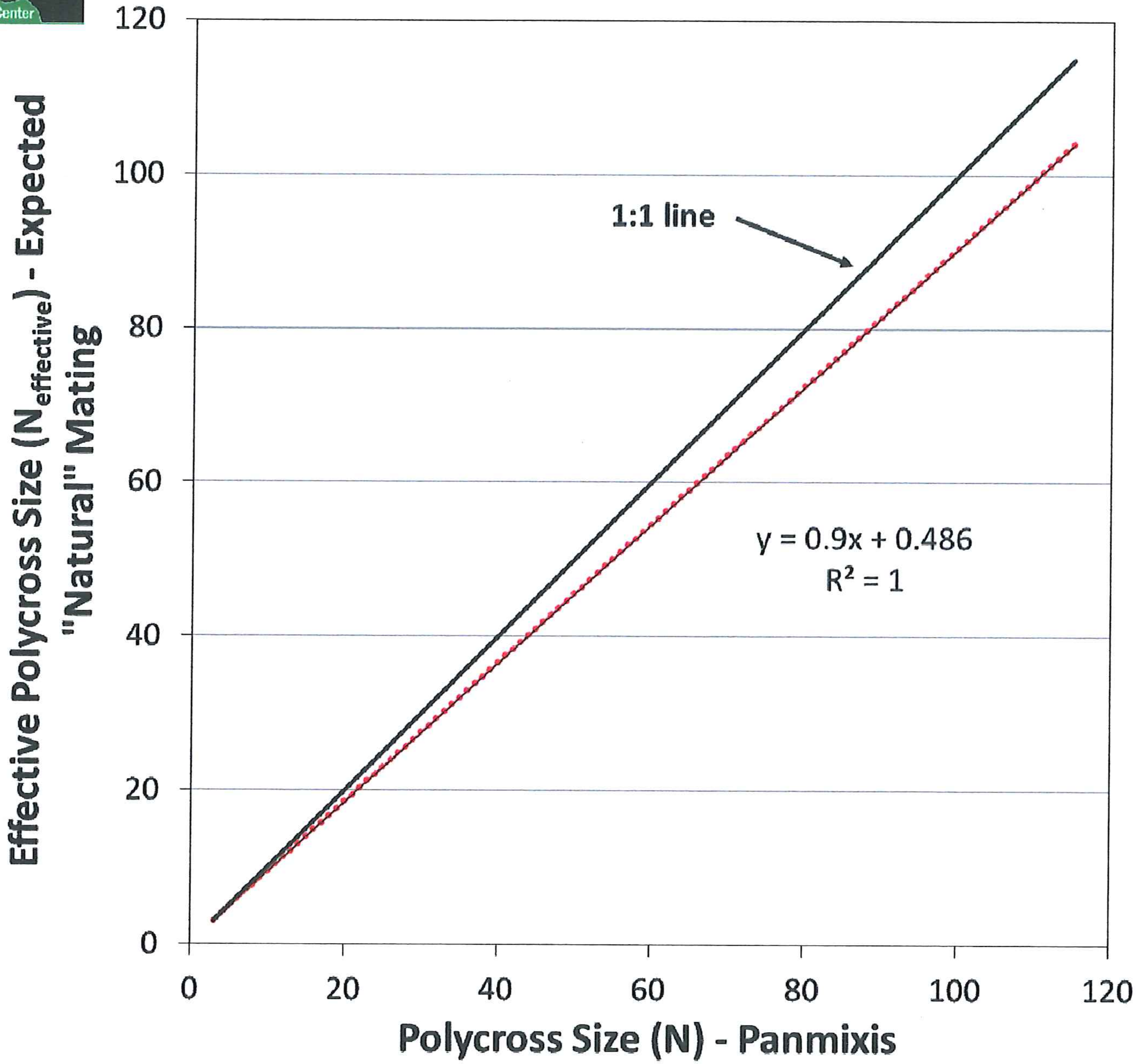


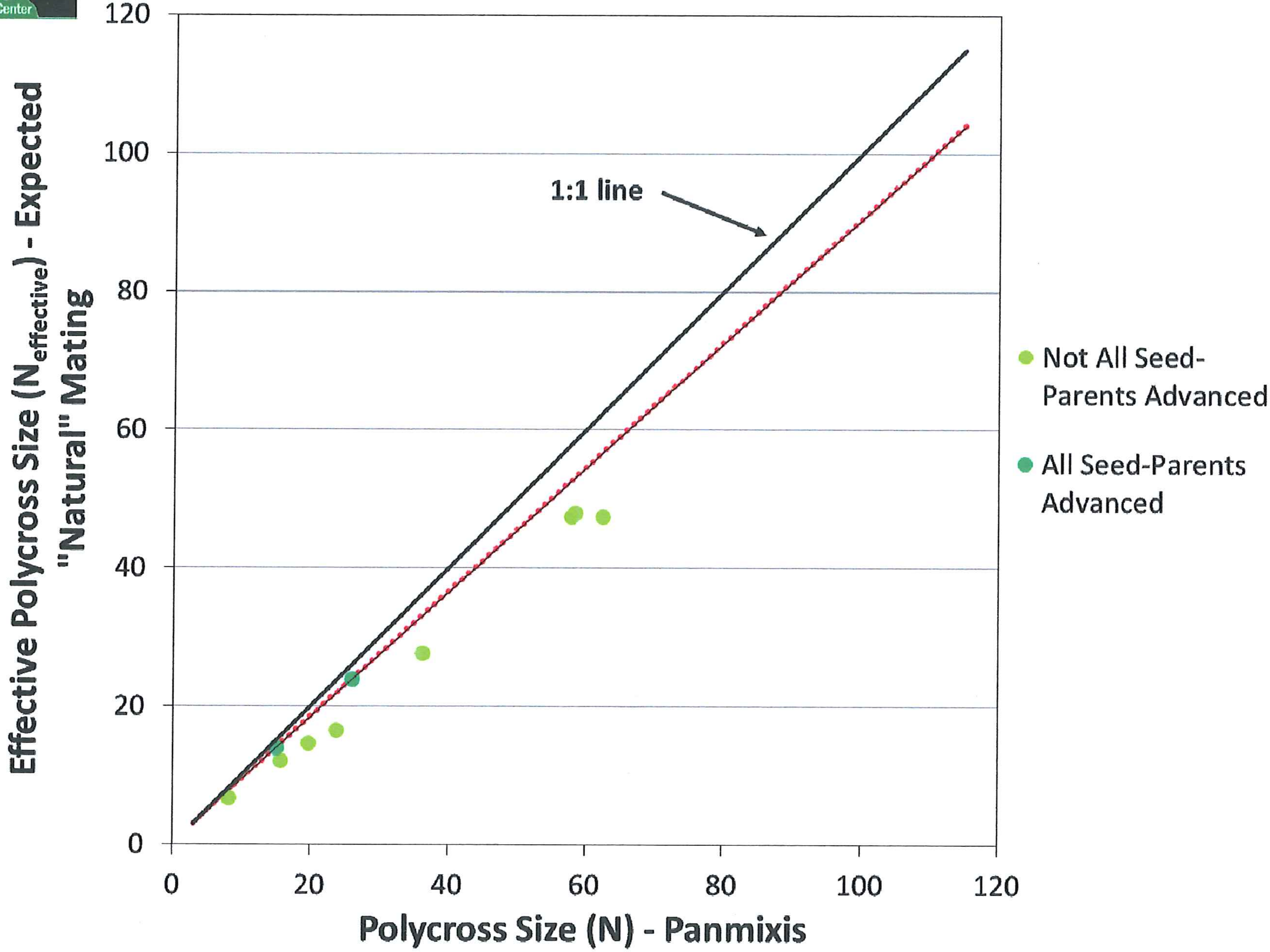
Effects on Inbreeding



Effective Polycross Size (Diploid)



Observed Effective Polycross Size (Diploid)



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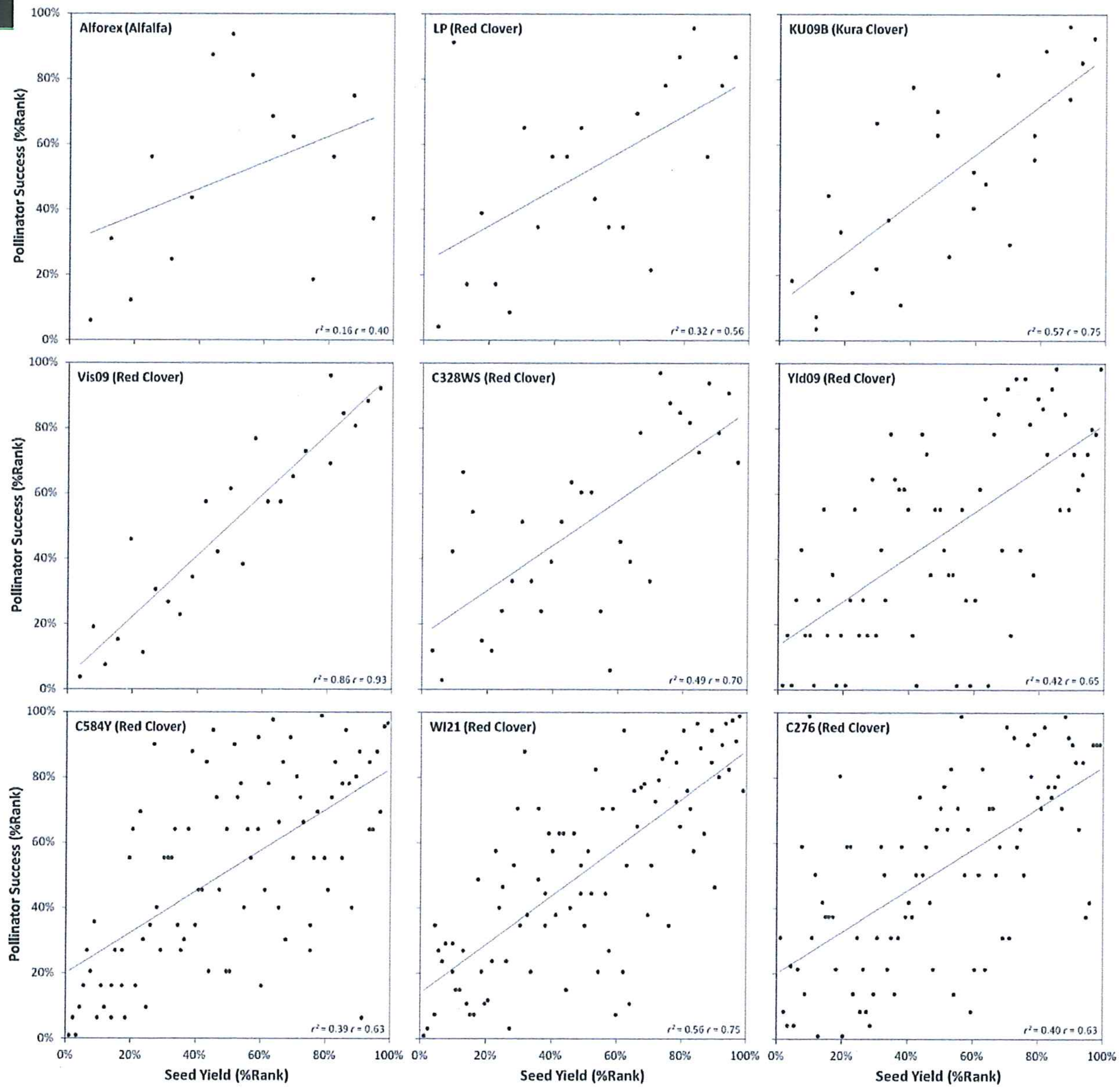
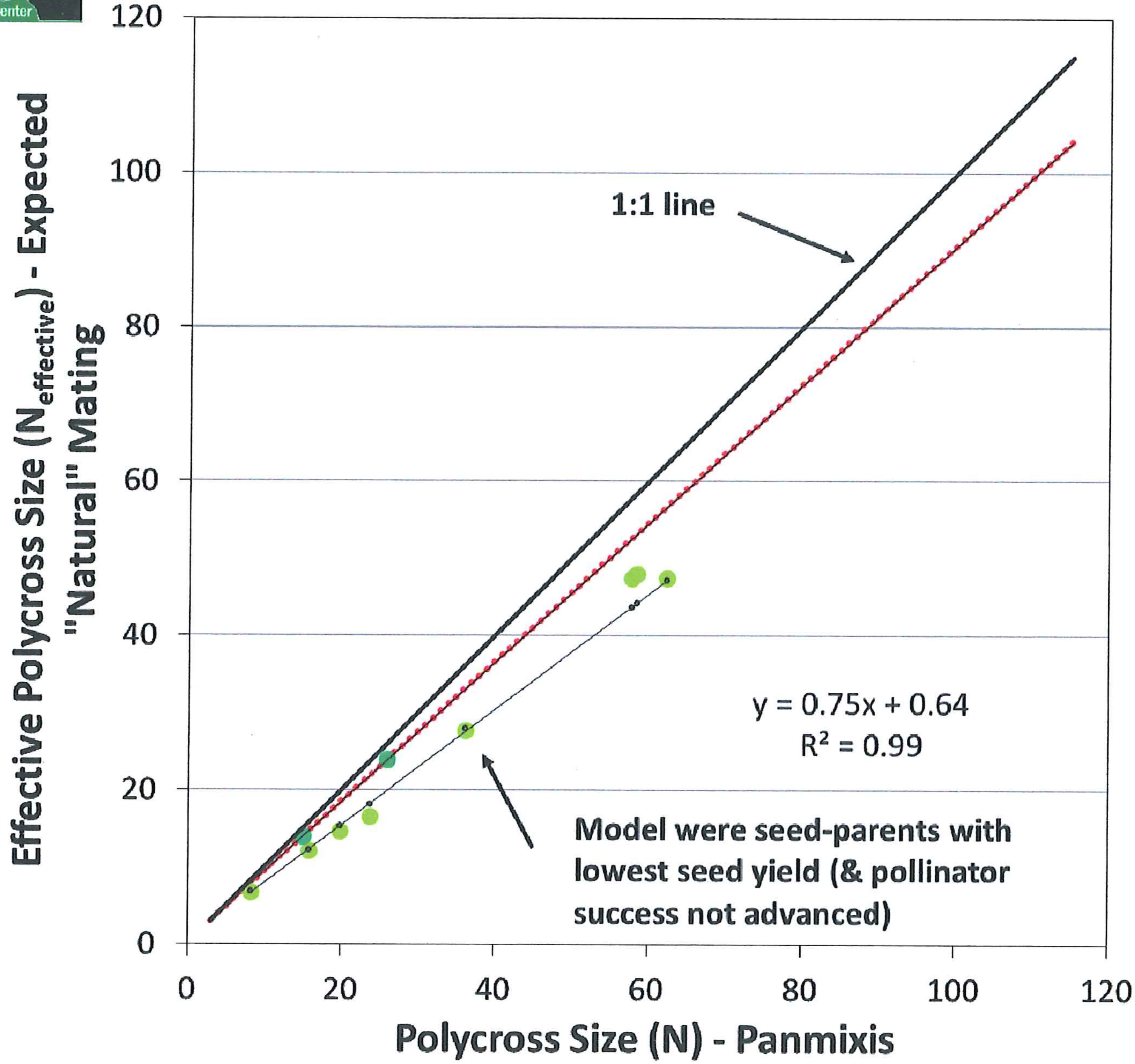
Parent-Plant Seed Yield vs. Pollination Success



Average
$r^2 = 0.46 \quad r = 0.68$

High seed yielding parents also tend to be most successful pollen-parents

Parent Seed Yield Correlated with Pollinator Success



Conclusions & Questions

- Insect pollinated forage legume polycrosses are not “random mating”
  - Pollen-gamete contributions distribution do however follow a predictable Weibull distribution; dependent only on polycross size
- Random mating assumptions underlies almost every quantitative genetic model
  - These models can be re-examined
- Is a Weibull distribution observed in other types of polycrosses?
  - Forage legume hand-pollinated polycrosses?
  - Grass wind-pollinated polycrosses?