Cooperative Chestnut Breeding in the USA

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Route 9 Cooperative

Premise

1. Demand for domestically-produced chestnuts in the USA exceeds supply. Therefore, growers are investing in new plantings.

2. Existing orchards and available nursery stock have not yet captured the genetic potential of the genus. Existing material is obsolete; there is substantial room for improvement.

3. By planting offspring from the best available parents, new plantings can be used as seedling trials and progeny tests, while profitably producing more and better chestnuts for sale.

Definitions

- **Seedling** – a tree derived from a seed
- **Clone** – genetically identical copy (usually multiple copies) of a seedling
  - By grafting, budding, cuttings, *in vitro* culture, incl. somatic embryogenesis
- **Cultivar** – short for "cultivated variety": when a clone is given a name
- **Ortet** – the original seedling
- **Ramets** – the ortet's clonal copies
- **Family** – the offspring, AKA progeny, from a parent or set of parents.
- **Siblings** – members of the same family
  - **Full-sib family** – offspring from 2 known parents = **controlled cross**
  - **Half-sib family** – offspring from known mother and mixture of fathers, AKA **open-pollinated (OP) progeny**

History

After 30 yrs of collecting, evaluating, and collaborating, I have arrived at the following.

- The gene pool for breeding chestnuts is huge, overwhelmingly huge, including 7 species.
- For eastern North America, the anchor species is the Chinese, *Castanea mollissima.* It exhibits the best overall characteristics.
- Highly variable: Selection within
- Defects: Vegetative propagation, yield
- Hybrids can bring in improvements, but also hybrid dysgenesis, incl. internal kernel breakdown (IKB)

Current Status

- A number of good Chinese cultivars have been identified.

- A number of good Chinese parents have been identified.

- A large portion of offspring from good parents perform as well as good cultivars. This allows the success of seedling orchards. Again, seedling orchards work only for Chinese chestnuts and perhaps some Chinese hybrids.

Current Situation

- Up until the mid 1900's, cultivars were selected within local populations over many generations, both pure species and hybrids.

- Since the mid 1900's, cultivar collections from wide geographical areas have been assembled.

- Offspring from the spontaneous wide crosses within cultivar collections have resulted in some outstanding individuals. Progeny tests are revealing good parents. Families with high proportions of good offspring occur in pure Chinese only.

- Very wide crosses or species hybrids result in high variation including a high proportion of poorly-performing individuals (hybrid dysgenesis).

Current Recommendation

- For seedling orchards over 50 trees in size, plant a number of different families
  - Generally open-pollinated offspring from good mothers
  - Preferably pollinated by diverse good fathers, e.g. grafted cultivar collection

- Prefer a somewhat balanced design including a large portion of “standards” such as ‘Gideon’, ‘Peach’, ‘Qing’, ‘Kohr’, ‘Sleeping Giant’, ‘AU-Homestead’ (dropped off ‘Eaton’)

- Plant dense enough to allow culling after trees come into procuction; e.g. 20x40 ft (or as close as 15x20)

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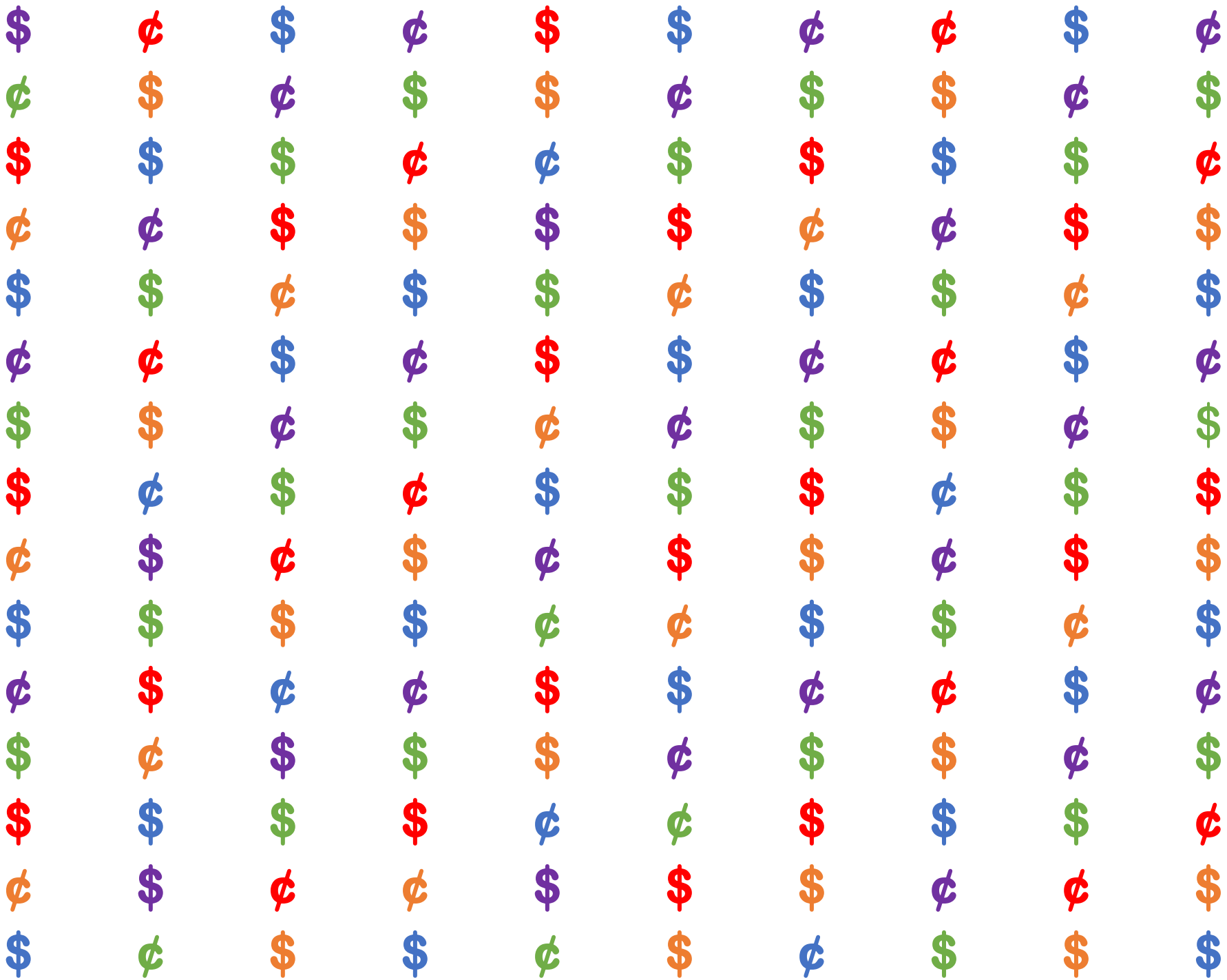

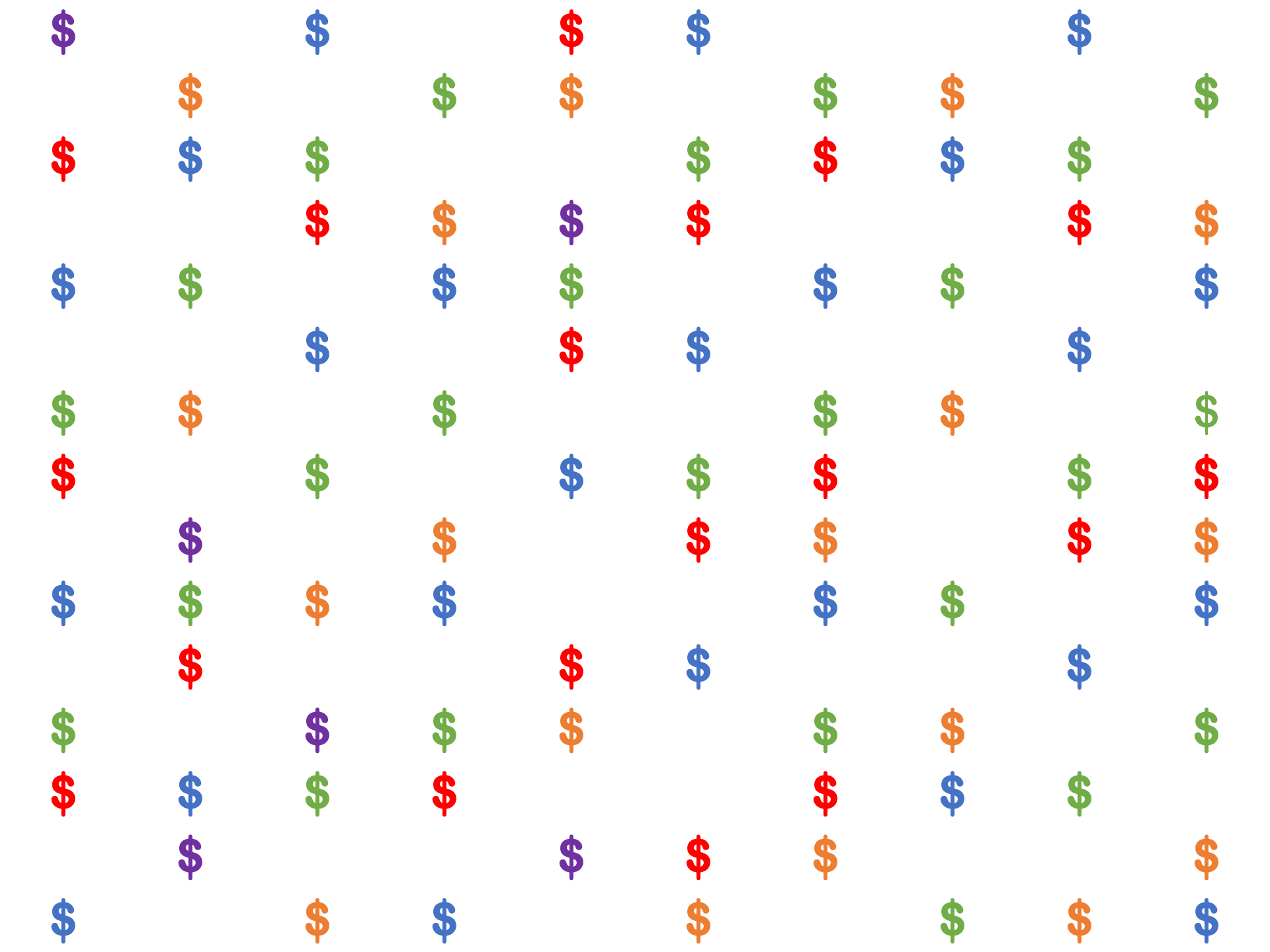

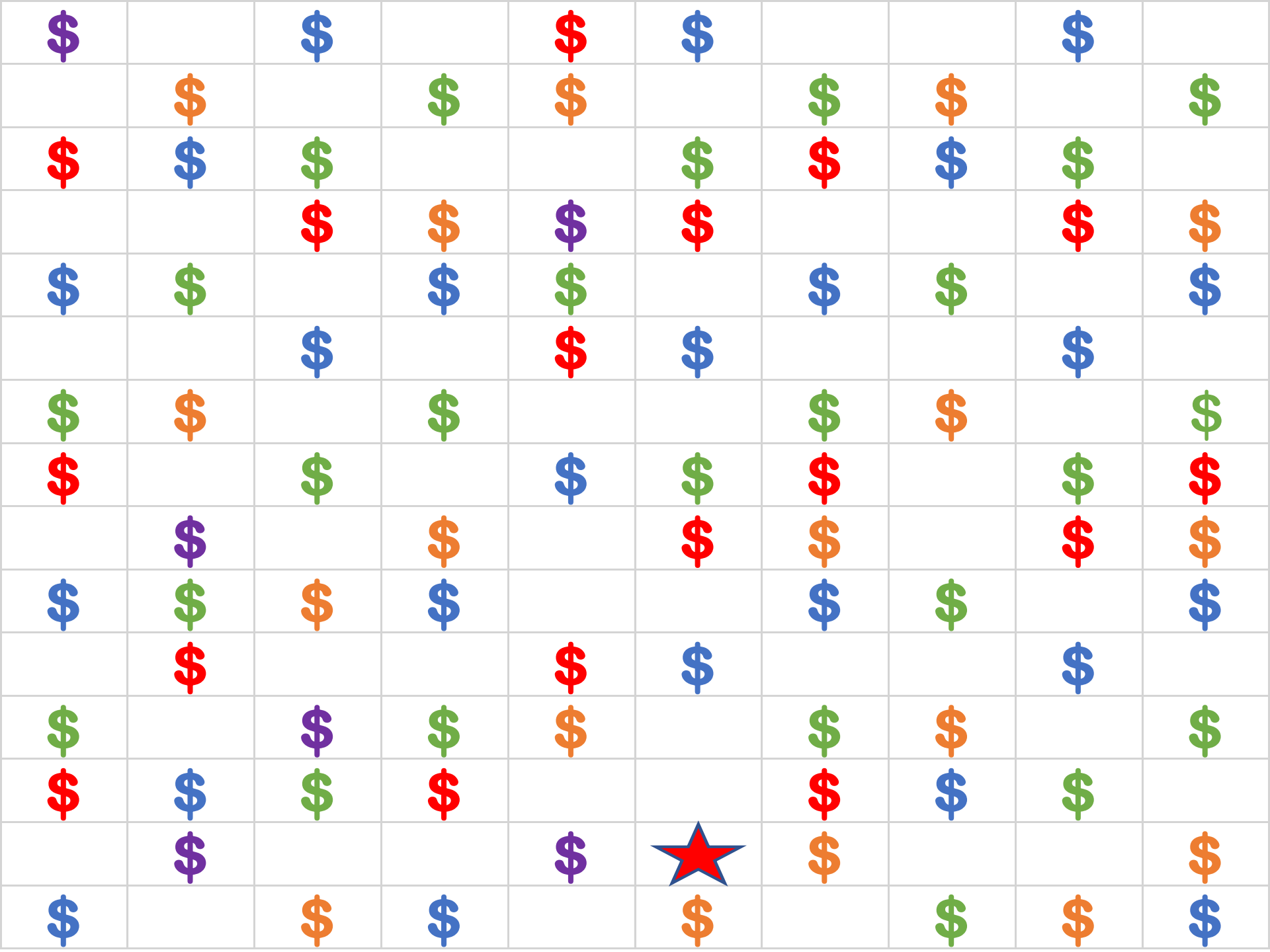

Net Results

1) Production from variable seedlings will be improved by selection and adjusted to grower's needs and conditions.

2) Comparative performance of families w/in and across regions has implications for roguing seed orchards, regional adaptation, specific traits.

3) Detailed ancestry of elite selections has implications for next generation parental combinations.

4) Use of production orchards as seed orchards vs creation of elite selection (grafted) seed orchards

5) Use of elite selections for clonal production orchards

Yield

- Direct selection for yield is slow and inefficient.

- Yield Components:

g/nut
nuts/bur
burs/fruiting shoot
fruiting shoots/tree
trees/hectare

- From a breeding standpoint, burs/shoot is the primary variable (selectible) component.
- Fruiting shoots/tree is dependent on tree size, but is also related to crown architecture and growth rate which are genetically variable.

Yield

- It's easy to find Chinese chestnuts that have a large number of burs/shoot. However, when the number of burs exceeds 3-4 per shoot, nut size and/or nut filling goes down

- Thus, there appears to be compensation which results in a **yield ceiling**.

- Some cultivars have a **higher yield ceiling**, esp male-sterile hybrids and some European and Japanese cultivars, esp hybrids. Why not pure Chinese?

Yield

- Looking at early yield data from U of MO, two of the highest yielding cultivars are ‘Luvall’s Monster’ and ‘Colossal’, both of which are male sterile. Also, many (but not all) of the high-yielding European cultivars are male sterile.

- Chinese researchers found that removing small, immature male catkins results in substantially increased yield.

- It thus appears that the copious pollen production of typical Chinese chestnuts may lower the yield ceiling.

- Chinese chestnuts produce at least 10X (guess) more pollen than they need for nut set.

Reduce Pollen To Increase Yield

- Populate the orchard with 90% male sterile trees and 10% pollenizers.

- 'Luvall's Monster' produces nothing but male sterile offspring when pollinated by Chinese chestnuts.

- Populate the orchard with male fertile trees that produce 10% of the "normal" number of male flowers and twice the "normal" number of female flowers.

- Remember 2 male-sterile cultivars: **'Luvall's Monster'** and **'Ace'**

High Yield Resulting from Vigor

- Highly productive cultivars tend to be vigorous growers with thick twigs, large leaves, and a “loose” crown structure. Productive cultivars are not necessarily male sterile.

- Let’s consider ‘SZEGO’

Szego - Crenata/Pumila x Mollisima

Szego is a very complex hybrid, a seedling of the California hybrid Linden, which is predominantly Crenata/Pumila. The pollen parent of Szego may be the hybrid Dunstan Revival. Szego is a very vigorous and erect tree. It grafts well on almost anything. It is a heavy pollen producer. Nuts are uniformly large (12-16 per lb), but easy peeling and fairly dense, like most Chinese nuts. Nuts are sweet and flavorful, one of our best eating chestnuts. The nuts drop mid season (2-3 weeks after Colossal) and store very well. The tree is resistant to phytopthora root rot. Its blight resistance is not known but it has been growing for more than seven years in blighted areas without signs of blight. The tree is named after New York NNGA member Al Szego, who worked with many types of hybrid chestnuts before passing away in 1991. Mr. Szego was known for his generosity in providing others with nuts, scion wood and advice.

Also, very cold-hardy, more so than many Chinese.

Jenny - Castanea mollisima

Jenny is an open pollinated seedling of the old Ohio cultivar Kintzel. Like Kintzel, Jenny is a tall tree with a very erect growth pattern. It does not have an orchard type growth pattern like many Chinese chestnut trees. The nuts are large and very flavorful - one of our favorite eating buts. Despite their size, the nuts drop early in the season. Additionally, all nuts drop within a very short period of time once the first nuts start dropping.

Current confusion about the identity of “Kintzel” at U of MO

Jenny - C. mollisima - 82 grams (16.6 per lb)

Combining Forces

- Wouldn't it be interesting to put 'Szego' and 'Jenny' pollen onto the male sterile trees, 'Luvall's Monster' and 'Ace'? We'll be harvesting with a front-end loader.

- In the meantime, hundreds of open-pollinated seedlings of the above cultivars, plus many more have been and will be planted in commercial orchards.

Kernel decay

- Fungal decay of chestnut kernels is one of the biggest problems we face.

- In general, Chinese chestnuts hold up relatively well in storage (better than most European and Japanese chestnuts). Nevertheless, there is considerable genetic variation in storage quality.

- Presumably, there are chemical and physical components that can be measured and selected for, but it hasn't been done yet.

Current Status

After storing dozens of cultivar nuts for seed we discovered one outstanding cultivar that had near zero blossom end rot and near zero storage rots for 2 years running: Namely **‘Liu’**.

Another good one, after 1 year’s look, is ‘WC’

Putting Ideas Into Action

- Univ of MO has collected and evaluated cultivars. The pollen cloud that lands on good cultivars comes from a diverse array of other good cultivars. This is some of the best chestnut seed available in the country.

- Empire Chestnut is turning this good seed into trees and distributing them to growers. These plantings can serve as seedling trials, progeny tests, and production orchards.

- Ultimately, the process is funded by selling chestnuts

Advantages of Grower-Based Breeding Program

1. Huge numbers of offspring can be evaluated across a wide range of environments

2. Growers know what they are looking for: goals and ideotypes can evolve and be pluralistic

3. We have a small industry spread over a large geographic range with a large genetic base – NOT suited to institutional breeding

4. It's self-funded through sales of chestnuts produced

5. It's relatively cheap to pool and analyze data and to utilize DNA tools – let academics do what they do best

6. Working for the common good maximizes benefits for the individual good: Cooperation trumps competition

Participating Growers

Planter	State	n
Alan Apelt	OH	250
Bill Krusling	OH	100
Bob Stehli	OH	3190
Brian Stoffer	OH	360
Caney Fork Farms	TN	1000
Colin Dunphy	MD	100
David Hoff	OH	100
Derek Waltchack	AL	410
Dominick Damiano	IA	50
Ernie Grimo	ON	630
Henry Fuller	WI	200
Hill Craddock	TN	500
Ismet Basic	IL	200
Jonathan Carr	MA	100
Jorge Rodriguez	NY	210
Kevin Wolz	IL	150
Lesley Dell	MO	100
Luke Smith	PA	415
Marvin Russell	NY	1064
Matt Eusner	KY	400
Michael Schwerin	IL	1255
Randy Morgan	OH	200
Richard Mitchell	PA	40
Robert Nunemacher	MO	30
Robert Rowell	SC	400
Ronald Plemmins	OH	100
Shealy Company	SC	600
Stewart Perkins	AL	200
Zach Petersen	NC	217
		12571

29 Growers

15 States

12,571 trees

Numbers of Trees Planted per Family

Szego	781	B71	426
Luv Monster	874	72-76	106
Ace	836	Dunstan	20
Kintzel	420	Jers Gem	90
Liu	890	PQK	300
Peach	976	**Perry**	120
Qing	1024	**Payne**	120
Kohr	1124	**Yixian**	120
Gideon	1049	Wynn Mill	10
Sleeping Giant	909	**Hong Kong**	380
AU-Home	730	Chandler	10
AU-Super	280	B68	130
B65	416	Damiano	430

23 Families
3 Populations
12,571 Individuals

Next Steps

- Controlled pollinations between selected parents.

- Institutionalization of the program. It could continue as the spontaneous process that it has up to this point, but it will soon be too big to be just a fun project for an enthusiastic person.

- Exploiting DNA sequencing techniques will be essential to sort out the confusion we have and guide us to where we want to be.

- What about West Coast states? Improvement within European and Japanese types.