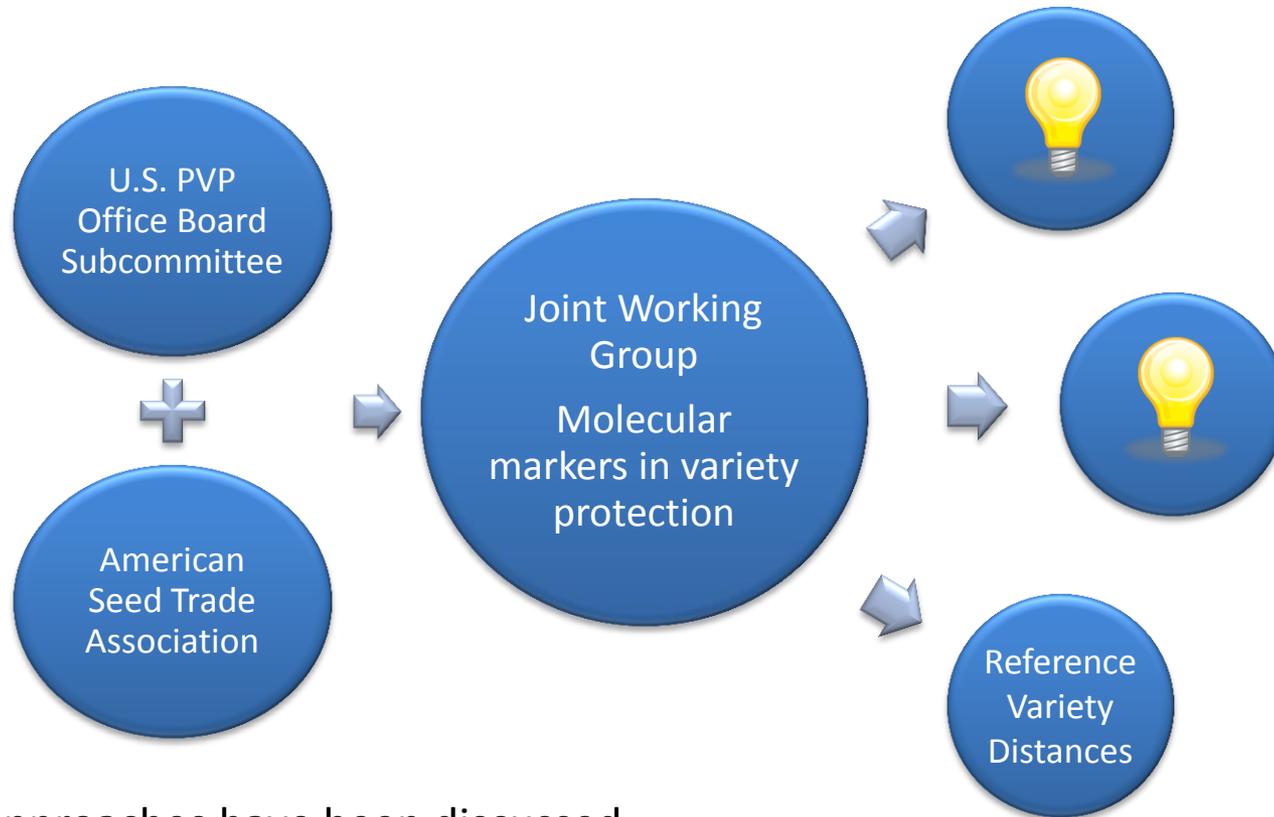# The use of Reference Varieties in Varietal Distinctness:
an Approach under Investigation in the United States of America for Potential Application in Plant Variety Protection

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Coordinated Effort

U.S. PVP Office Board Subcommittee

American Seed Trade Association

Joint Working Group

Molecular markers in variety protection

Reference Variety Distances

Various approaches have been discussed
- None are final
- All need further investigation and vetting

Most importantly: positive momentum and agreement between industry and the PVP office that molecular markers are a valuable tool in DUS.

Reference Variety Genetic Distances

- Utilize genetic relationship between PVP candidate "subject" varieties and known, pre-determined, "reference" varieties.
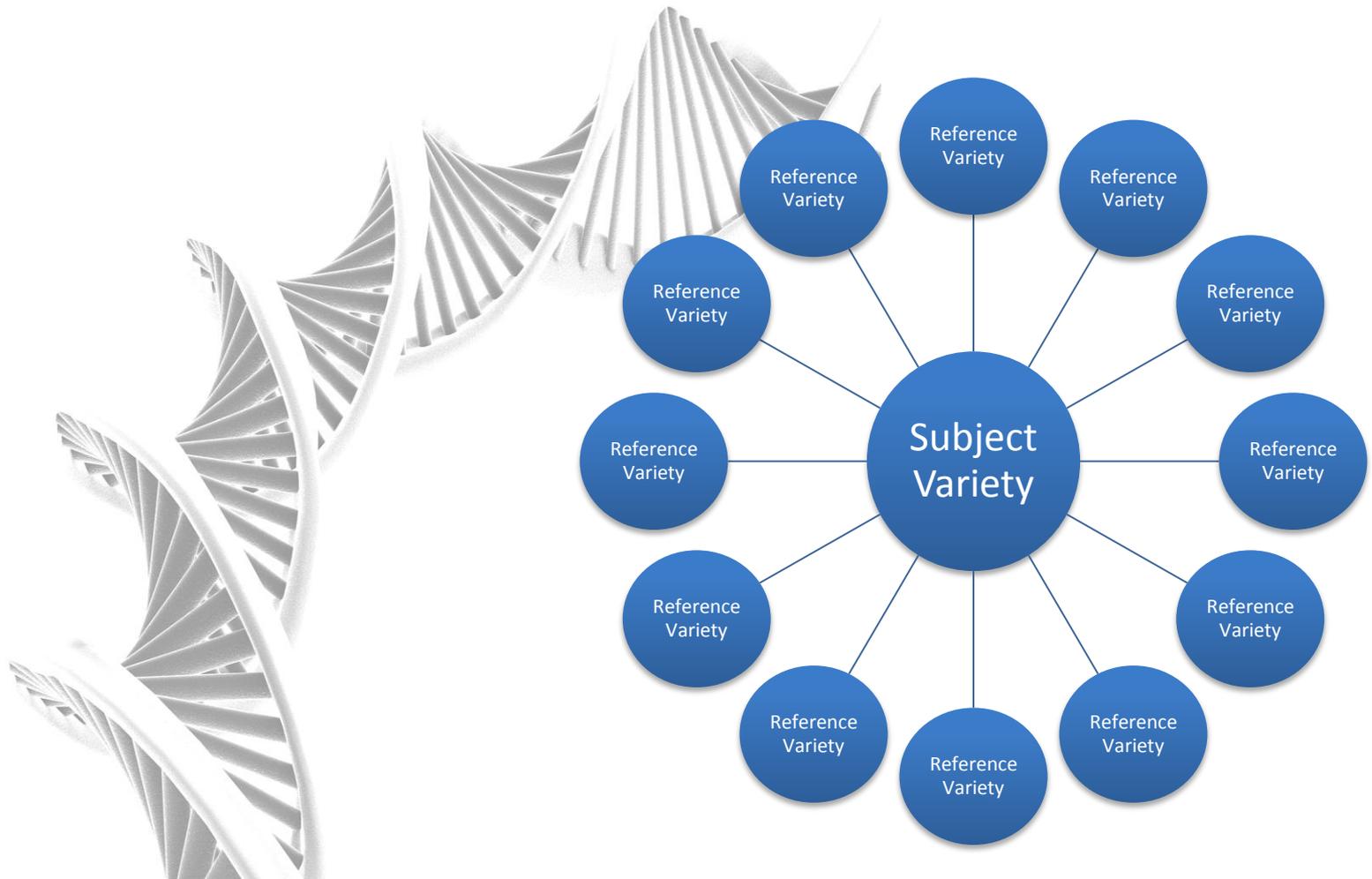
Geographic Analogy

The earth's geographic coordinate system allows for precise placement of every location on earth.

U.S. Cities, Albany, Harrisburg, and Syracuse can be distinguished geographically by their coordinates, latitude and longitude:

City	Latitude	Longitude
Albany	42.6525	-73.757222
Harrisburg	40.26972	-76.875556
Syracuse	43.04694	-76.144444

Geographic Analogy

Another way to distinguish between, Albany, Harrisburg, and Syracuse is by measuring their distances from well-known 'reference' cities:
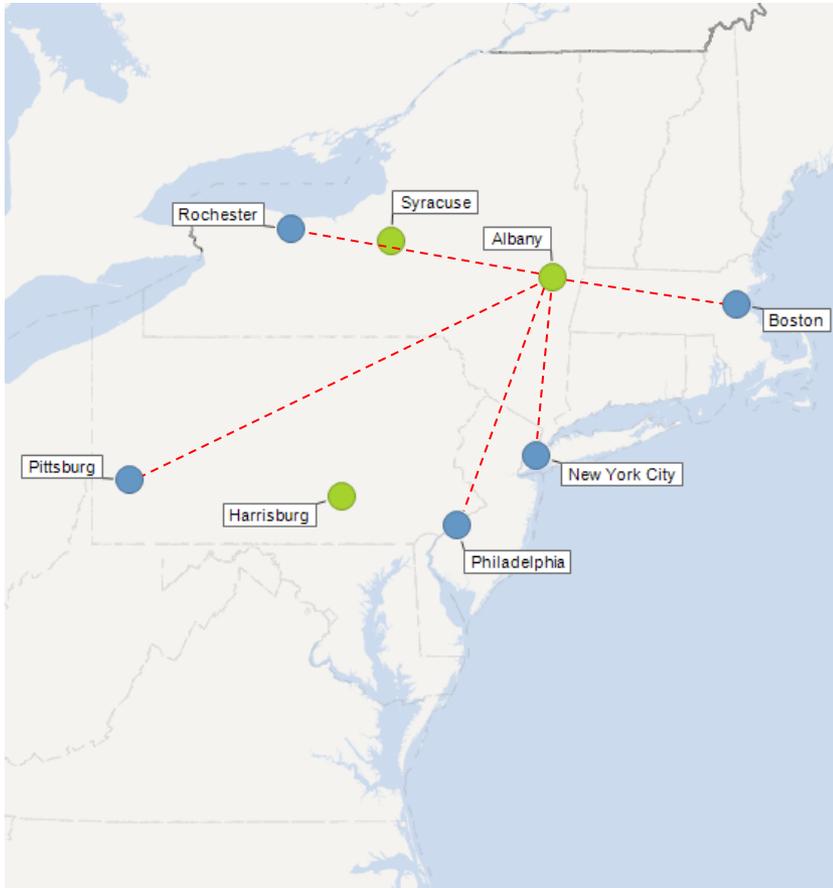
Subject City	Boston	New York	Philadelphia	Rochester	Pittsburgh
Albany	223	217	323	319	575
Harrisburg	539	248	151	327	264
Syracuse	423	314	354	120	432

(Kilometers)

Albany and Harrisburg are very similar in their distance from Rochester, but are distinguished from each other by their distances from the other cities.
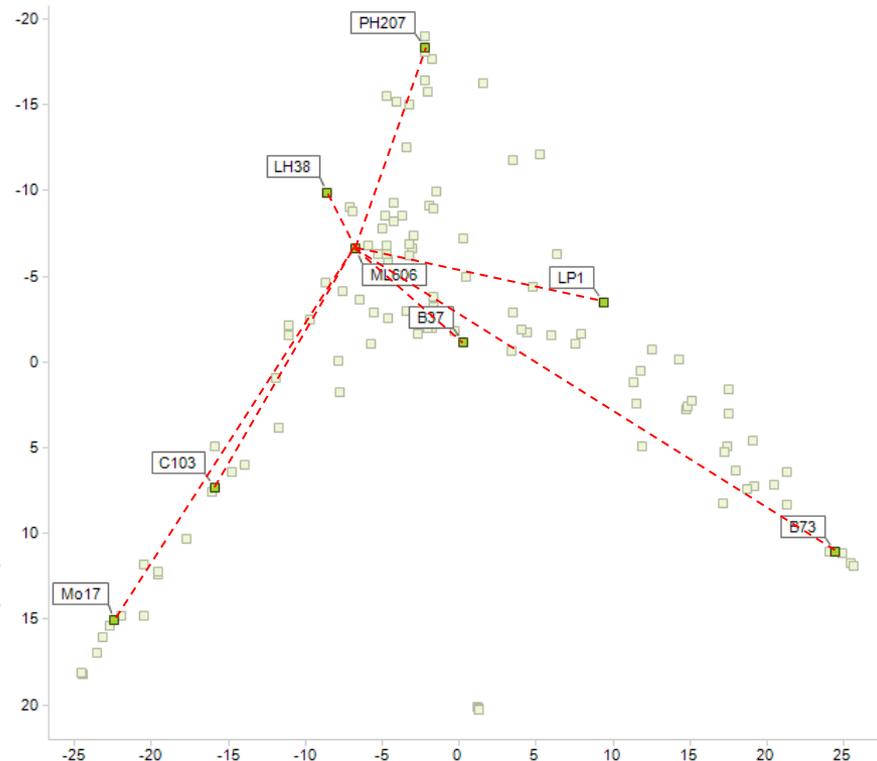
Distance Application to Genotypes

Varieties do not have fixed "coordinates".

However, genetic distances can be easily computed.

Genetic similarities coefficients, with a known set of 'reference' varieties, can be used to distinguish between genotypes.

Subject Variety	B37	B73	C103	LH38	LP1NRHt	Mo17	PH207
NK764	0.474	0.704	0.395	0.397	0.594	0.368	0.466
DK4676A	0.469	0.459	0.372	0.405	0.497	0.376	0.413
ML606	0.484	0.426	0.438	0.732	0.428	0.463	0.484
NK740	0.441	0.341	0.655	0.465	0.400	0.890	0.433
LH132	0.542	0.838	0.371	0.418	0.504	0.355	0.465
NQ508	0.549	0.444	0.428	0.462	0.479	0.445	0.643
PHT77	0.425	0.409	0.437	0.464	0.412	0.445	0.401

Distance Application to Genotypes

Genetic similarity coefficients fit nicely into the existing PVP morphological framework.

Each reference variety is treated as a new 'trait'.

PV #	Variety Name	Kernel Type	Days to 50% Silk	Heat to 50% Silk	Plant Height	Ear Height	Internode Length	No. of Tillers	No. of Ears	B37 Sim	B73 Sim	C103 Sim	LP1 Sim	Mo17 Sim	PH207 Sim
8400157	PHG71	DNT	068	1510	188	084	006	0	1.25	0.435	0.487	0.406	0.598	0.397	0.637
8000011	FR19	DNT	066	1411	175	051	012	0	1.25	0.450	0.442	0.451	0.594	0.425	0.445
8000067	LH39	DNT	063	1360	203.3	78.4	010	0	2.34	0.487	0.401	0.438	0.438	0.433	0.469
7600047	LH1	DNT	069	1625	178	056	011	0	1	0.752	0.467	0.392	0.469	0.422	0.545
8000066	LH38	DNT	062	1338	180.2	49.2	013	0	1.75	0.467	0.389	0.455	0.405	0.441	0.483
7800019	LP1	DNT	069	1520	215	108	012	1.5	1.25	0.448	0.513	0.424	1.000	0.396	0.436
7900077	Seagull-17	DNT	084	1630	170	070	012	0	1	0.444	0.351	0.650	0.408	0.963	0.435
8200062	LH51	DNT	067	1465	207	084	013	0	1	0.462	0.351	0.645	0.397	0.912	0.447
8200063	LH74	DNT	061	1344	189	072	010	1.5	1.75	0.470	0.724	0.375	0.666	0.365	0.448
8200064	LH119	DNT	062	1344	220	067	012	0	1.25	0.536	0.865	0.368	0.498	0.354	0.474
8300102	LH145	DNT	060	1294	207	082	015	0	1.25	0.449	0.479	0.449	0.703	0.409	0.449

Identification of Reference Varieties

Reference varieties must be relevant to the pool of subject varieties under consideration.

Subject City	Boston	New York	Philadelphia	Rochester	Pittsburgh	Sacramento	Fresno
Albany	223	217	323	319	575	4005	3946
Harrisburg	539	248	151	327	264	3799	3719
Syracuse	423	314	354	120	432	3806	3747
Los Angeles	4174	3940	3847	3638	3435	582	330
San Francisco	4338	4133	4055	3795	3641	120	261

(Kilometers)

Model Limitations

- Data reduction = loss of information.

- Distance-derived relationship is biased toward higher similarity.

A   B   C   *Sim*
AB = .5
AC = .5
BC = 0
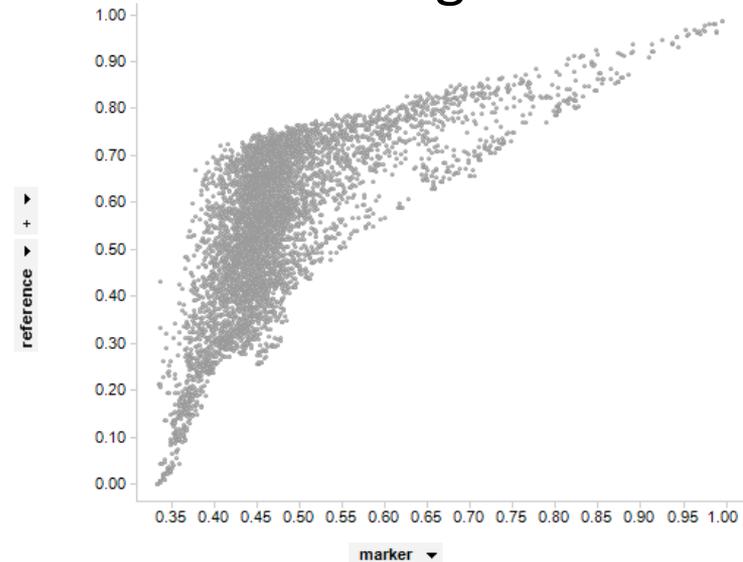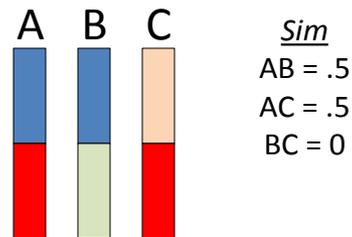
- Fail-safe

  1. Morphology remains the primary means of determining distinctness by the US PVP Office.

  2. Fingerprints can be used to make direct variety comparisons.

Model Features

1. Simplicity in theory and computation.

2. Breeders maintain control of fingerprints.

3. No need to store, maintain, or safeguard fingerprints.

4. The model fits nicely into the existing PVP framework.

5. Genetic similarity coefficients do not replace existing morphological descriptors.

Ongoing Efforts

1. Reference variety identification.

2. Definition of thresholds for distinctness.

3. Determine viability of application across crops.
   – Consensus that methodology under development will be applied on a crop specific basis.