WORLD BREWING CONGRESS
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#ElevateBeer

Hop Breeding

Why, how, and the impact of new variety evaluation and selection

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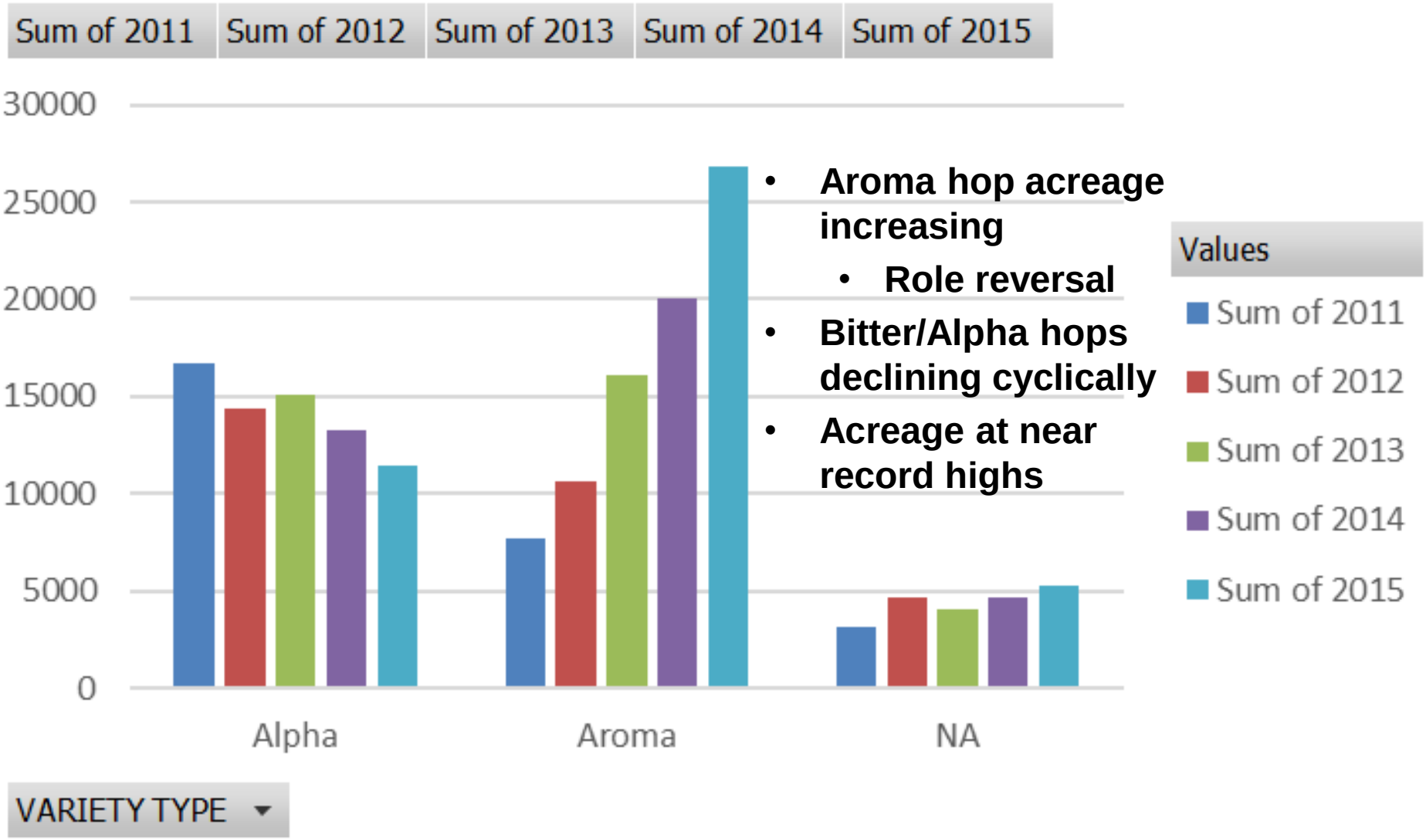
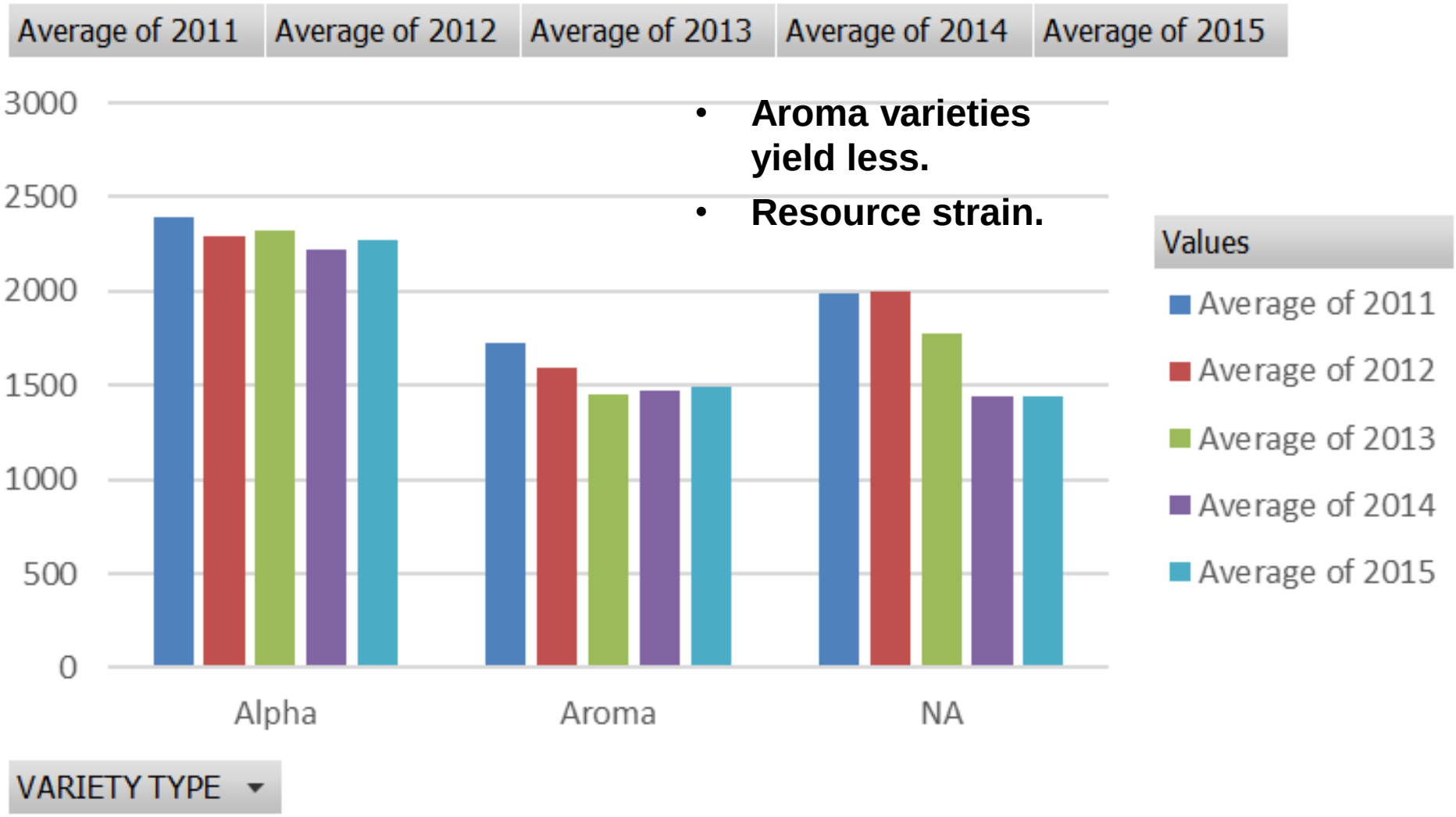
Acreage Trend: aroma versus alpha



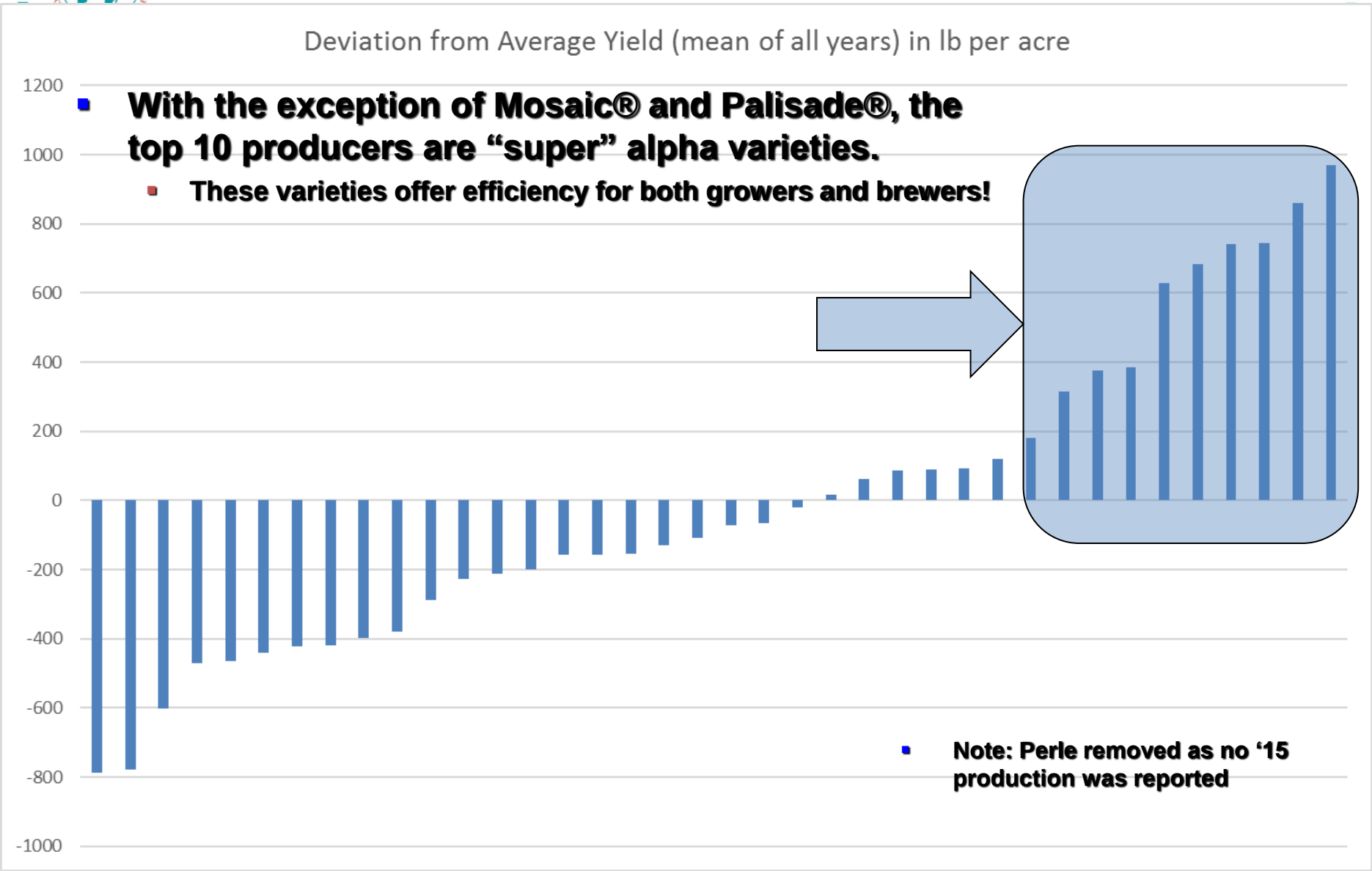
- **Aroma hop acreage increasing**
  - **Role reversal**
- **Bitter/Alpha hops declining cyclically**
- **Acreage at near record highs**

Average Yields (# per acre): aroma versus alpha

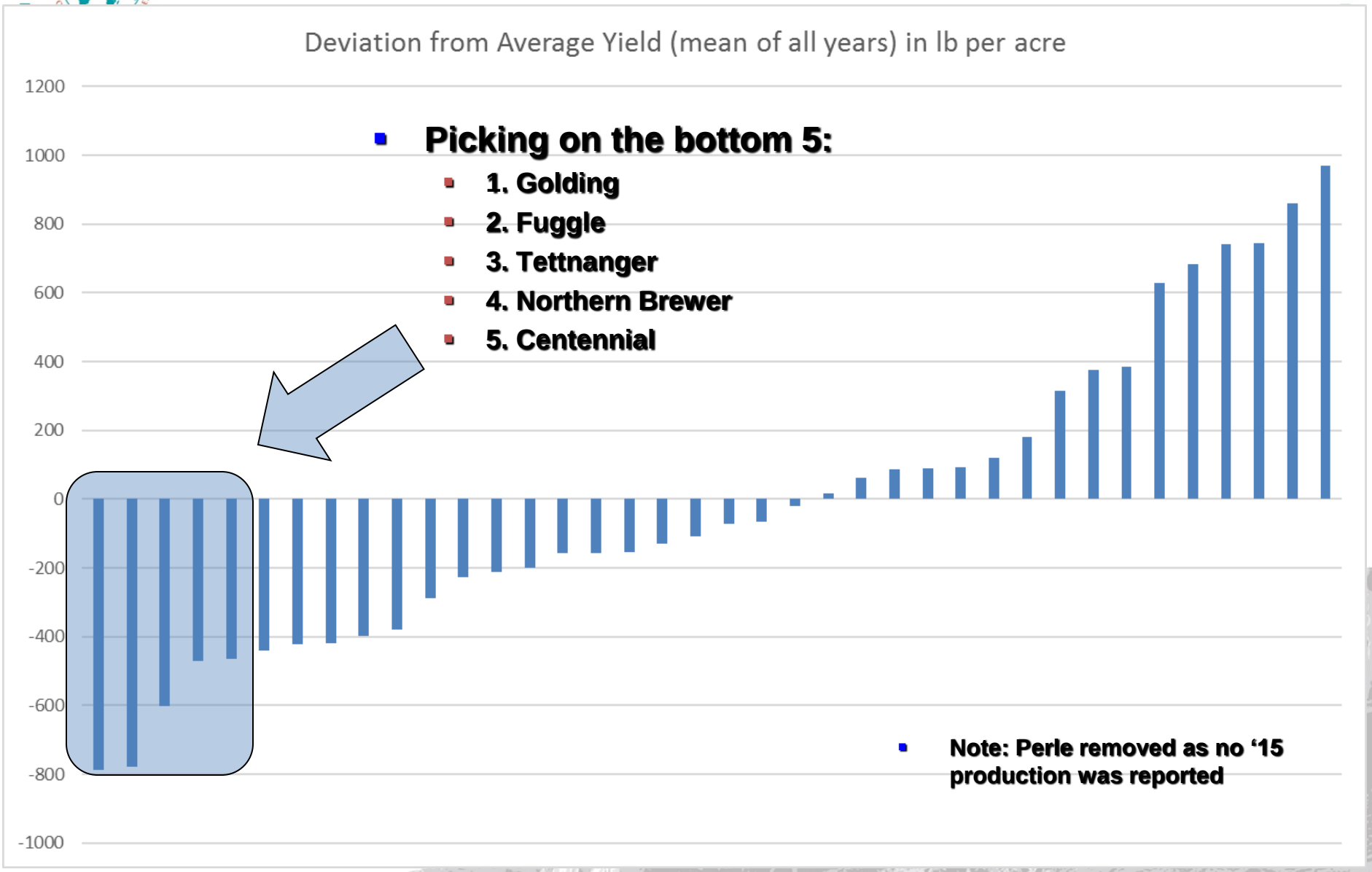


- **Aroma varieties yield less.**
- **Resource strain.**

Alpha Hop Efficiency



Average Yields: deviations from the mean



Varietal Impact

- Physiology and development are genetic.
- Crop management is varietal dependant.
- There is a strong genetic x environmental interaction.
- **The goal: Realize the maximum genetic potential.**
- **The problem: Maximum genetic potential cannot be reached in all environments.**
- **Answer is breeding and selection**

How important is this?

- Hop Supply Chain: Each link on the supply chain affects subsequent links.
  - The efficiency of a hop has a corresponding impact on the chain.

Breeding Program

New Variety:

-Good yield

-Disease resistant

-Good quality

-Stores well

Farm

Cost/Acre

Yield

COST/UNIT

Handler

Cost

Storage

Pellet Recoveries

Extract Recoveries

Shipping

Brewery

Efficiency

Quality

Flavor

Cost

Breeding Objectives

- High yielding high alpha cultivars.
  - Super
  - Varietal
- High yielding aroma cultivars.
  - Improvements on the classics
  - Specialty / dual purpose
- Goal is to combine the above with:
  - Pest and disease resistance.
  - Good storage stability.
  - Desirable brewing characteristics (i.e. low cohumulone, specific oil components).

Humulus lupulus: Complexity

- “Hops”
- Dioecious, perennial, climbing vine
- Indigenous to the Northern Hemisphere
  - Origins in Europe:
    - *H. lupulus* var*. lupulus*
  - Origins in Asia (mainly Japan):
    - *H. lupulus* var. *cordifolius*
  - Origins in North America:
    - *H. lupulus* var*. pubescens*
    - *H. lupulus* var*. neomexicanus*
    - *H. lupulus* var*. lupuloides*

Humulus lupulus: Complexity

- Dioecious (male and female plants).
  - Genetically complex.
  - Obligate out-crossers, cannot self pollinate.
    - High level of diversity (heterozygosity).
    - Hybrid vigor (Heterosis).
    - Seed propagation not possible.
- Annual above ground, perennial below.
- Easily clonally propagated- traits can be “fixed” in single generation.
  - Each new variety results from a single plant.
    - Millions from one.

Mature Female “Cones”

Male flowers at anthesis

Mature Female “Cones”

Male flowers at anthesis

Hop Breeding Scheme

Population Dynamics

Crossing

Left: Collection of male flowers for isolation of pollen.
Above: Application of pollen to a bagged receptive female.

From Crosses to seedlings

Typically start with 20,000 – 50,000 genotypes in any given year.

Seedlings are screened in the greenhouse for Powdery Mildew, then planted to the field.

Typically eliminate 75 – 90% of the starting population.


HBC EXPERIMENTAL SAMPLE
Sample ID: 1020215086
Location: PFI
Date: 9/21/2014

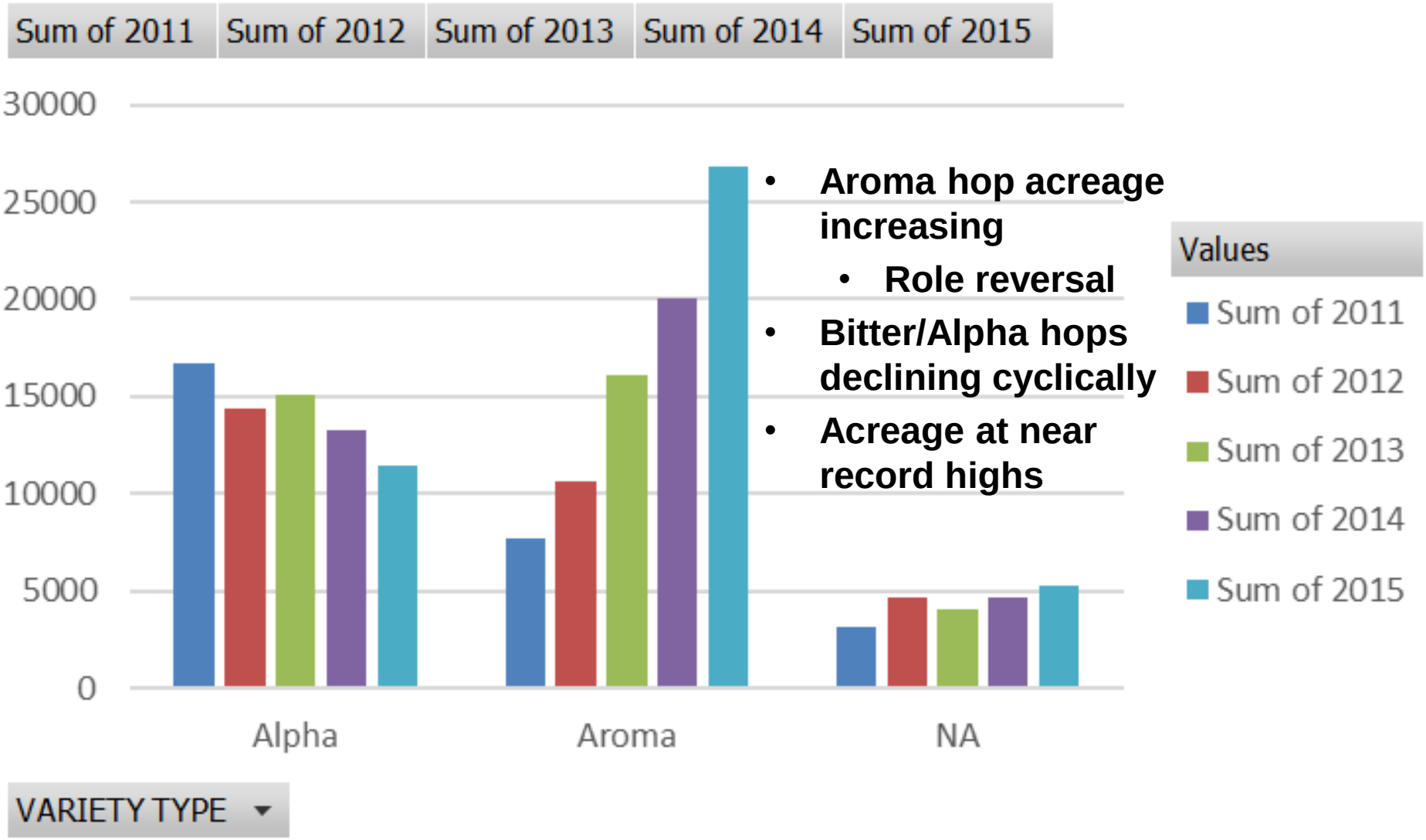
Cultivar Release: Year 11

- After 8 - 10 years of evaluation, release is considered.
  - Private varieties: PVP begins.
- The work is far from over, success is dependant on:
  - Continued agronomic success.
  - Grower acceptance, usually short term.
  - **Brewer acceptance, long term.**

Future Trends in Hop Breeding

- Molecular research
  - Marker assisted selection
  - Gene mapping
  - Gene functionality
- Non-brewery usage
- Continuing conversion to new varieties
  - Driven by disease pressure, storage issues, basic economic pressures, and continued growth in craft brewing.
  - Increases focus on AROMA

Acreage Trend: aroma versus alpha



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Impact of Breeding: Top Varieties

Of the top 10

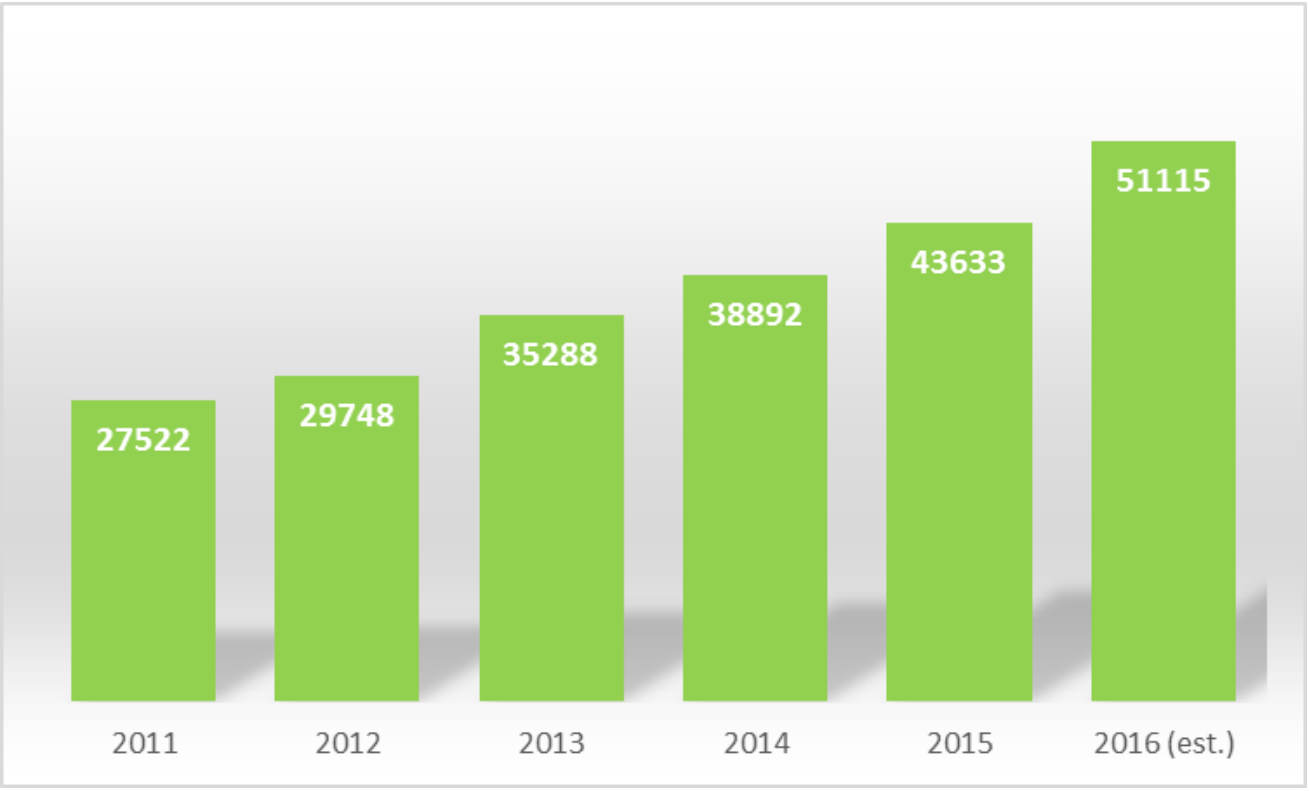
- **4 released since ‘00**
- **28% of top 10**
- **Including other >40%**

USDA lists 41 varieties in ‘16

- **19 released since ‘00**

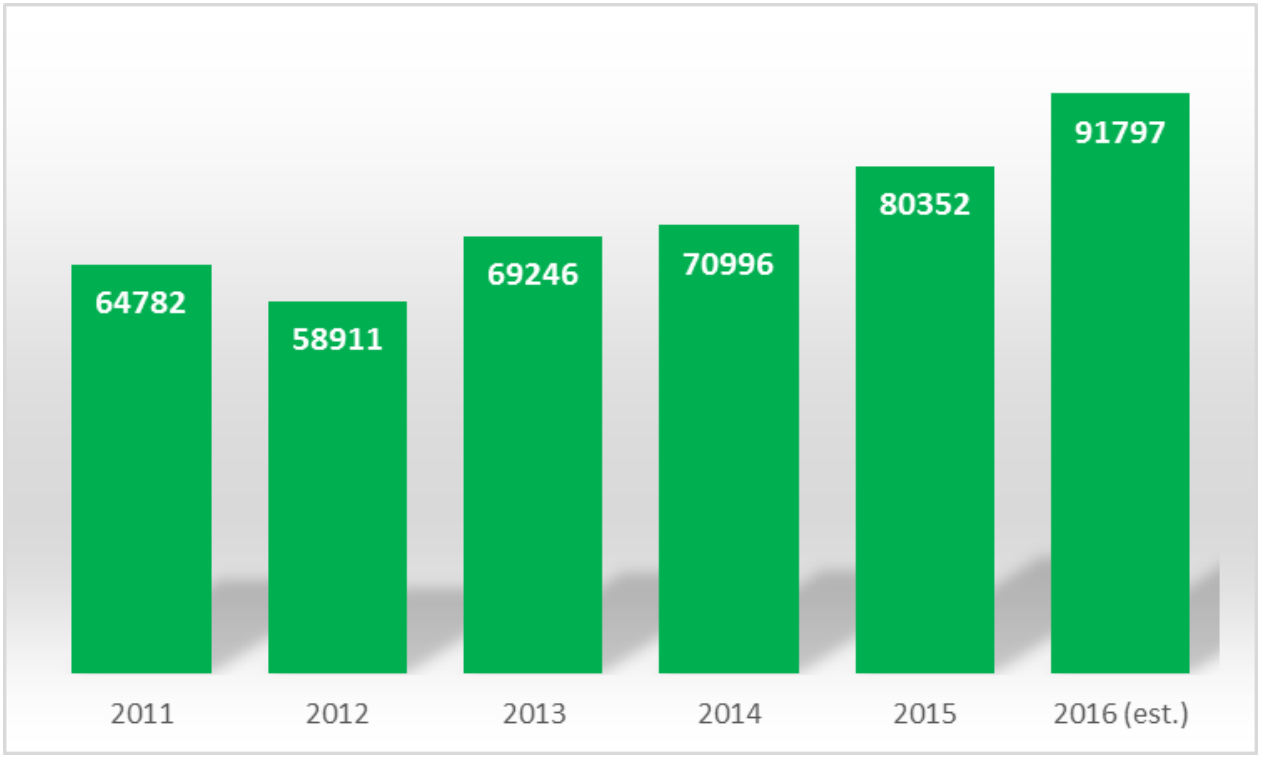
Rank	Variety	2015 Acres
1	Cascade	6790
2	CTZ	5323
3	Other	4909
4	Centennial	4401
5	Simcoe® (YCR 14)	3306
6	Citra® (HBC 394)	2993
7	MosaicTM (HBC 369)	1800
8	Chinook	1787
9	Nugget	1686
10	SummitTM	1620

U.S. Hop Acreage



Est. 2016 Up > 7000 Acres (15%)

U.S. Hop Production (x1000)



Est. 2016 > 90MM

Thank you

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All acreage and production data can be found at www.usahops.org