



HOP VARIETY DEVELOPMENT

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TABLE OF CONTENTS



YCR & HBC



Basics of Hop Breeding



History



Development



Future



Sensory Evolution



**HOP &
BREW
SCHOOL**

Yakima Chief Ranches & Hop Breeding Company LLC

YCR



YCR was founded in the late 1980's by the Carpenter, Smith, and Perrault families. Our purpose is to create, grow, and protect value for all through development of first class hop varieties, a relentless pursuit of quality, and building meaningful relationships.

Starting out with just our three grower owners, YCR has now expanded acreage and licensed growers across three states- Washington, Oregon, and Idaho. Every farm that we work with brings unique value to the hop industry.

HBC



HOP BREEDING COMPANY
YAKIMA CHIEF RANCHES, L.L.C. • JOHN I. HAAS INC.

Formed in 2003, the Hop Breeding Company, LLC (HBC) is a joint venture between Yakima Chief Ranches, L.L.C. (YCR) and John I. Haas, Inc. HBC's mission is to develop pest-resistant and disease-resistant hop varieties with strong commercial qualities.

HBC has increased efficiencies through consolidation of facilities, germplasm, and knowledge. Value creation is at the core of YCR while we strive to produce innovative varieties that aid a sustainable supply chain.



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YCR + HBC Commercial Timeline





BASICS OF HOP BREEDING

Hop Breeding 101



Value Creation

“Hop breeding is as much an art as it is a science.”

- Early breeding efforts were driven by similar goals and objectives, combining disease resistance and desirable brewing characteristics into a plant that produced enough yield per acre to be economically viable within a given growing region.
- The definition of “desirable” brewing characteristic has certainly changed in the past 100 years, but the goals of modern-day breeders are much the same as the past. The purpose of crop breeding can be stated in many ways but in the end, it is a means of value creation. The definition of value is typically expressed in terms of efficiency, diseases resistance, or novel utility.
- The breeding programs are thus front and center in this supply chain, developing varieties that add value at every link, and perhaps most importantly decreasing the inputs required for production of a crop, thus adding to the sustainability of the entire industry.



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Classic Hop Breeding

Hop breeding in a nutshell.

- Every hop breeder develops their own breeding schemes, processes and techniques depending on the objectives of their program. However, hop improvement is the basis for all programs.
- Most commonly this is accomplished through “crosses,” via pollination, made between selected female and male parents resulting in the production of seed. Each seed is a unique genotype, analogous to humans.
- A cross between two parents represents a family, with all the progeny being brothers or sisters of one another bearing some resemblance.
- The job of the breeder is to vet the population over a period of time in a stage-gate process.
- Success is typically defined as a single commercially viable cultivar at the end of the process.



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The Schemes

Different breeding techniques.

The obligate out-crossing, perennial nature of the hop plant dictates the breeding plan or scheme. Dioecy eliminates the ability to self-pollinate and create true breeding seed. This limitation is countered by the fact that hops are easily propagated from cuttings, thus allowing selection of individuals from a population and “fixing” the phenotype in single generation. As a result, most breeding programs employ a combination of traditional “mass” or “phenotypic” selection techniques including clonal selection, open pollination, pedigree breeding, recurrent selection, and polyploidy as the basis for their breeding scheme. These techniques are not mutually exclusive and are most often used in combination.



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The Schemes

Different breeding techniques.

- Clonal Selection: This method is typically used when the goal is the improvement of an existing cultivar after a noticeable decline in performance.
- Open Pollination: At its most basic, open pollination involves the collection of seeds from female plants that have been naturally wind-pollinated by males growing randomly in the vicinity of the female.
- Pedigree Breeding: Pedigree breeding, as the name indicates, places intensified focus on the genetic background or specific pedigree of a cross. It is often used when the parental attributes are part of the targeted outcome.
- Recurrent Selection: This is a commonly employed strategy in which parents are selected from breeding populations and used in further crossing in an effort to increase the frequency of beneficial alleles and thus improved odds of success.
- Polyploid Breeding: An advanced form of pedigree breeding with the target of passing on specific commercially valued traits from well-known cultivars.



The Process of Selection

A decade in the making.

While breeding schemes may vary somewhat from program to program the process of selection is fairly consistent. In a nutshell the process involves vetting the population in a stage gate process with the ultimate goal of screening out the negative while selecting and advancing the superior plants.

In most cases this process will span a period of at least a decade.



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The Process of Selection



Year 1

Breeding Objectives
& Parental Selection
& Crossing



Year 2

Early Selection



Years 3-5

Intermediate
Selection



Years 6-8

Advanced
Selection



Years 9-11

Elite Selections



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HISTORY

Where it all started.



General Breeding History

Discovering the unknown.

- Much of the early intentional cultivation of hops was likely done on a very small scale in personal and monastery gardens.
- Over time brewers would have identified favorite hops for use in brewing based upon availability, ease of growing and their contribution to the beer.
- They eventually learned how to expand plantings via cuttings for their own use and ultimately distributed these plants regionally through commerce as they gained favor.
- These plants would have become highly valued and coveted and thus from these early selection efforts arose varieties that are popular even today.
- Tettnanger, Hallertau Mittelfrüh, and Saazer- They are all hop varieties that came to be known by their association with the region in which they evolved and were grown but over time spread to other regions due to their favorable brewing quality. They are the result of centuries of subtle and nuanced selection.



The Beginnings of Hop Breeding

English Breeding

- 1897- The first documented scientifically driven hop improvement program began with a test yard in the Saaz region. Followed shortly after by similar efforts in Belgium and at the Agricultural College of Wales.
- 1904- The longest continuous efforts in hop improvement were conducted in a program at Wye College in England. The early breeding work was initiated by Howard and continued by Ernest Salmon.
- 1919- Salmon made arguably the most impactful cross in hop breeding history when he openly pollinated a Manitoban wild female (BB1) with English males, resulting in the varieties Brewer's Gold and Bullion. Brewer's Gold has gone on to be used extensively by hop breeders and can now be found in the pedigree of most high alpha cultivars grown today. The English breeders' impact on the modern hop industry extends beyond alpha, including notable work on characterization and breeding for resistance to powdery mildew, downy mildew, and verticillium wilt.



The Beginnings of Hop Breeding

German Breeding

- English breeding for disease resistance was enhanced by cooperation and exchange of plant material with German researchers.
- 1926- An epidemic of downy mildew across Europe motivated the creation of a center for hop research near Hüll Bavaria named the Hans- Pfülf- Institute. The name was later changed to the Hopfenforschungszentrum Hüll.
- Early efforts focused on incorporating downy mildew and wilt resistance into varieties with aroma profiles comparable to the traditional hops, with a primary focus given to Hallertau Mittelfrüh. The hops released from the Hüll breeding program came to define aroma expectations for much of the industry through the late 20th century.



The Beginnings of Hop Breeding

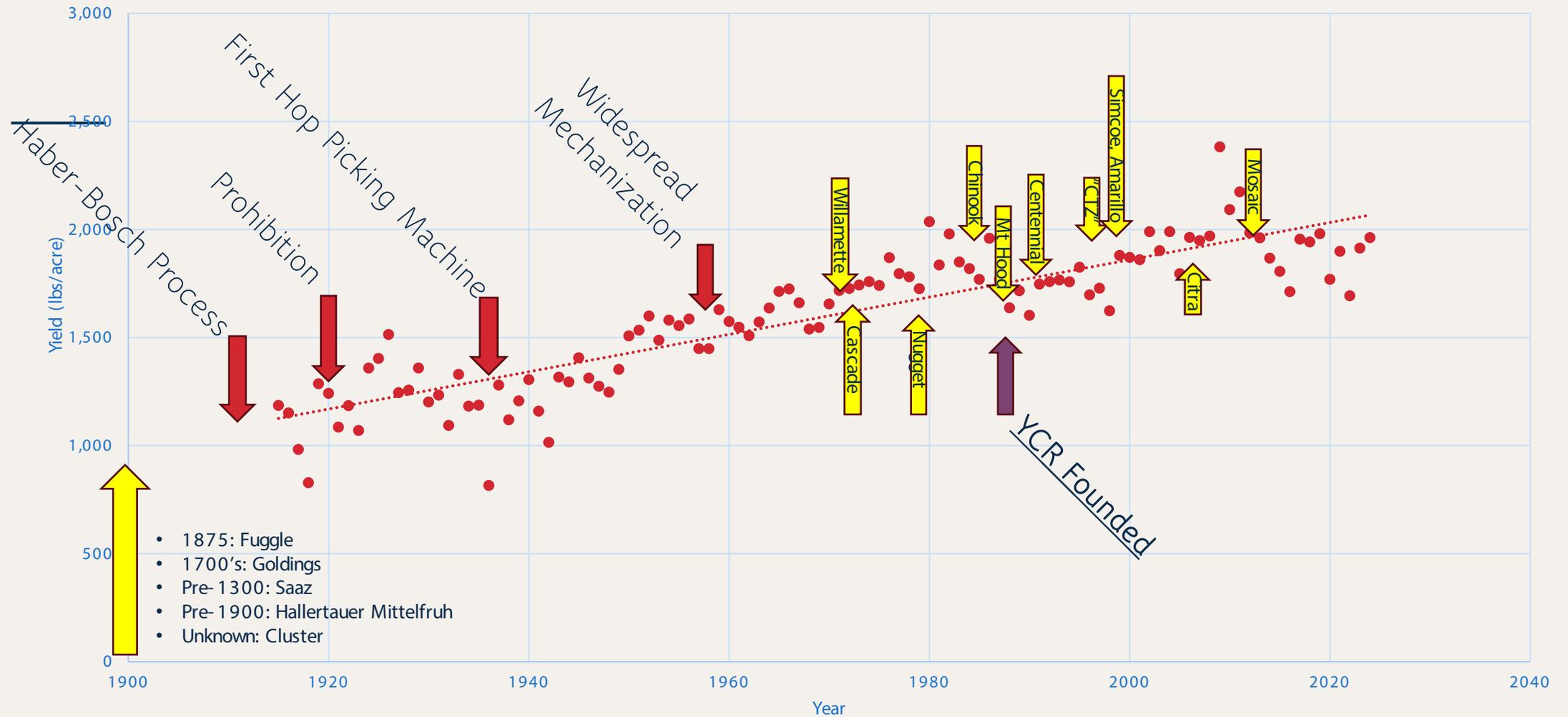
United States Breeding

- Hop breeding in the United States began in the early 20th century only to be derailed by world events..
- 1900- USDA botanist David Fairchild introduced several hop varieties from Europe into the U.S. for evaluation.
- Shortly after, in effort to improve yields, Fairchild crossed these with several American male plants. Similar work was continued by Stockberger in 1908. This early work was disrupted by the outbreak of World War I followed by prohibition.
- 1930- The end of prohibition and, once again, downy mildew, became the impetus for a reenergized research program. This began a long effort that continues today.
- 1955- The early days of the program saw a large amount of turnover in research leads until Stan Brooks took over lead of the program.
- 1965- Brooks held the position until at which time Dr. Al Haunold took over as breeder. Dr. Haunold and a team consisting of Charles Zimmermann, Sam Likens, Gail Nickerson, and C.E. Horner led a very fruitful era in U.S. hop research that resulted in the development of new aroma and alpha cultivars and germplasm that are impactful to this day.
- 1997- Dr. John Henning took over direction of the USDA breeding program with an expanded focus on molecular genetics.



Farm- Based Improvements

Variety- Based Improvements





DEVELOPMENT

Times are changing...



Alpha Hops

The bittering agent.

- The original purpose of using hops in brewing process was to bitter the beer with the Alpha Acid content found in the resin of the lupulin glands. Breeders actively selected varieties with higher alpha, thus requiring less volume of hops to reach desired bittering levels.
- These high alpha hops also made further processing of hops, in the form of extract and downstream products, much more practical, further increasing the efficiency of the supply chain.



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Noble-type Hops

Low alpha with mild aromatics.

- Hops with lower alpha acid levels began being characterized as “aroma” hops.
- Due to the lower alpha acid level these hops are much less efficient at providing requisite bitterness.
- These aroma hops were meant to be used sparingly in brewing late in the boil to add a light hoppy aroma akin to using a spice.
- The traditional noble hops came to define the characteristic aroma hop: low alpha with mild aromatics typically described in general terms such as spicy, citrus, herbal, and earthy.
- The intent of early breeding efforts was typically to conform to the noble character of these old school hops while increasing yield and resistance to pest and disease. For many years pungency and uniqueness was selected against.



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Flavor-Forward Hops

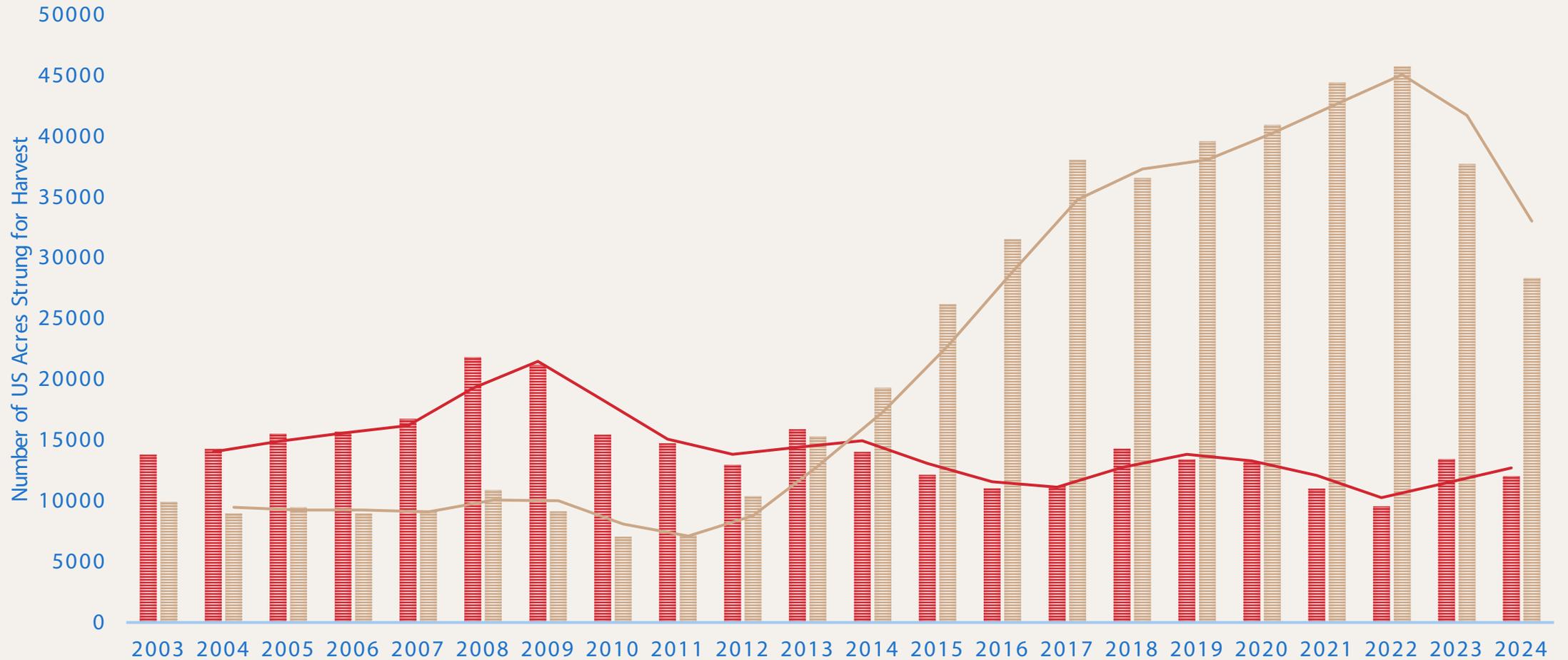
New novel flavors!

- Contemporary hop usage, particularly driven by demand for craft-style beer, is decidedly different.
- As today's brewers and drinkers embrace hop forward beers, the hop breeder has adapted by focusing on impactful and novel aromatics.
- The lexicon used to describe hops has expanded to include adjectives such as catty, berry, tropical, stone fruit, coconut, chocolate, bubblegum and so on.
- This is due to selecting, both consciously and unconsciously, the compounds driving these aromatics.
- As we deepen our understanding of survivable compounds such as the terpene alcohols, esters, ketones, and thiols contained in hops, our ability to select for novel flavors from hops will only improve.



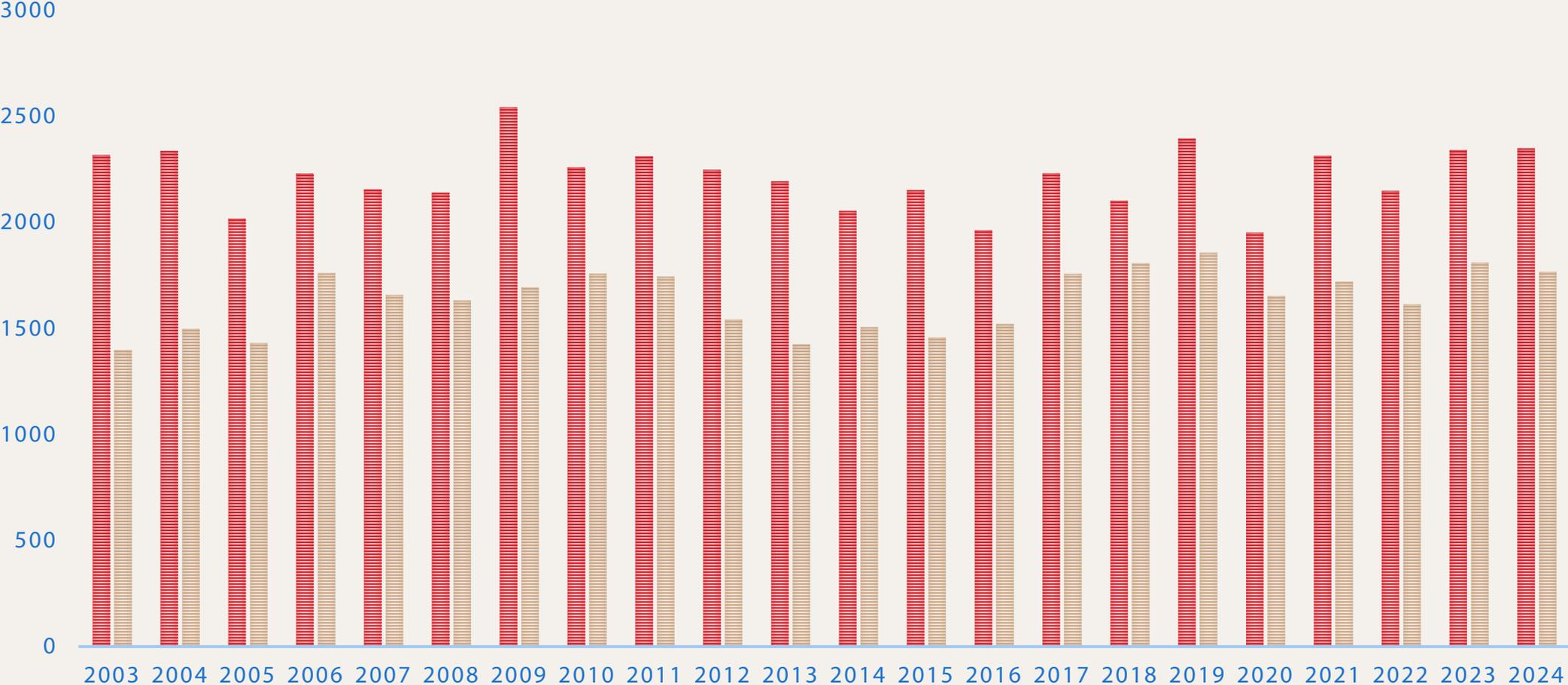
US HOP ACREAGE: ALPHA VS AROMA

■ Alpha ■ Aroma

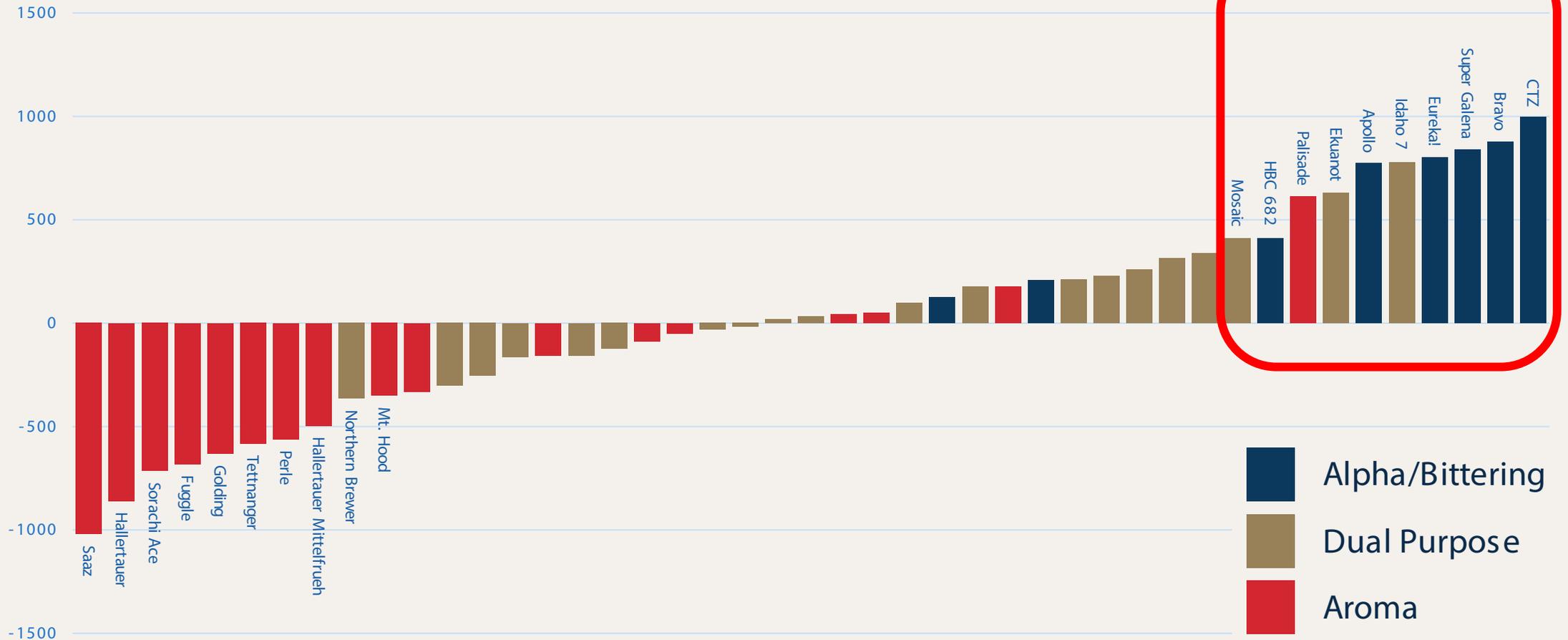


AVERAGE YIELD 2003-2024

Alpha Aroma



Deviation from Population Average 2003-2024



- 6 of the top 10 producers are “super” alpha varieties.
- Mosaic®, Ekuanot®, Palisade®, and Idaho 7® :
 - These varieties offer efficiency for both growers and brewers!

*USDA- NASS; www.nass.usda.gov



FUTURE

Where are we headed?



New Variety Development & Beyond



Between all the hop breeding programs worldwide, hundreds of thousands of potential novel genetic combinations are generated every year. Even with the quickening pace of new variety releases seen in the last decade, it is clear how rare success is. With that said, never in the history of hops and its relationship with beer has there been more effort put forth in attempting to decode and discover the untapped potential of *H. lupulus*' role in this beloved beverage and perhaps beyond. This potential begins at the genetic level, and thus our path to discovery starts with breeding. **Given the gains of the past two decades, it is clear that we have likely just scratched the surface...**



SENSORY EVOLUTION

Timeline of flavors



Sensory Evolution

Timeline of Flavors



Czech Saaz

Cascade

Simcoe® YCR 14

Mosaic® HBC 369

Dolcita™ HBC 1019

HBC 1183

Traditional Hops

Contemporary Brands

HBC's Latest Experimentals

Pre 1900's

2025



THANK YOU!

Questions?

