Other Agricultures of Scale: Social and environmental insights from Yakima Valley hop growers

Hop farmers in Yakima are expanding acreage while vertically integrating research, development, and product marketing at an unprecedented rate. Insights from these rapidly concentrating hop farms are useful to better studying the social and environmental contexts of other agricultures of scale along with the potential environmental outcomes for agriculture more broadly. Drawing on interview and field data collected on 11 farms with 15 farmers I suggest that their approach represents a novel agricultural practice that has the potential to yield incremental improvements in environmental adaptation and industry sustainability. These farmers describe their goal as "decommodifying" hops. This term is used by farmers as a discursive catch-all to describe the way these farmers have vertically integrated to use taste, genetic innovation, and scalability to produce an unusually profitable arrangement for the immediate term. By critically examining the range of farming conducted in this region, and those which contradict this trend, I examine a case study into a new agriculture of scale. This research yields insights on alternative pathways by which power, innovation, technology, and social relationships may appear in the changing biological economies for other agricultures of scale.

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Introduction:

Hops are a bine-habit herb in the *Cannabaceae* family that are cultivated for their small strobili (referred to as cones in the hop growing industry) which are known for their complex and aromatic resin and oil content. These compounds are essential ingredients in the production of all kinds of beer and are used in multiplicatively greater quantities in the growing marketplace for "craft" beer. Understanding how these hops are being developed, grown, and processed along with the farmers who grow them provides an opportunity to observe a specific agriculture of scale and to study its implications for other agricultures on a warming planet. Drawing from interviews and ethnographic data with Washington state hop growers (n=15), I explore the social and environmental worlds of these farmers and their unique relationship with on-farm innovations. I examine a range of practices and agricultural contexts making up the diverse Yakima hop growing bioeconomy, including novel farmer-owned breeding programs that have been successful in increasing the value of hops and marginally improving environmental adaptive capacity in the region. Insights from the hop-growing agricultural arrangement have implications for other, more ubiquitous, agricultures and the possible ways forward if farmers and agricultural researchers are to innovate more sustainable futures.

Most significant changes in plant-genetics and agro-chemical research with direct applications in agricultural praxis in the US over the last half-century have been carried out either by land-grant universities (LGUs) or, increasingly, by research funded by private agrochemical and pharmaceutical companies (Bronson, 2015; Carolan, 2010; Deibel, 2013; Kloppenburg, 1988; Olmstead and Rhode, 2008). While LGUs' public-facing agenda necessitates greater inclusion of local farmers in their plant-research practices, in both the LGU labs and the research departments of private companies farmer inclusion is limited to roles as *participants* or *recipients* whereby a farmer might host a test plot or provide feedback but where plant-breeding, or other technological innovation occurs elsewhere in *expert* contexts (Comi, 2019; Eastwood et al., 2017; Latour and Woolgar, 1986; Wynne, 1996). The unique history of hops production confronts this model and calls into question where applied plant research may take place and therefore reshapes the bioeconomic arrangements of both plant science and agricultures of scale.

Following the end of US prohibition, the Northwest hop growing regions continued to face difficult circumstances as the beer industry concentrated into fewer global buyers and these "big-beer" companies demanded lower prices for higher concentrations of the bittering chemical compounds in hops, known in the industry as "alpha acids" (Dighe, 2016; Kopp, 2016; Larsen, 2016; Reid et al., 2014). By 1980, relatively few hop farmers remained in the Northwest, and these had slim profit margins. Public research engagements for the small sector of hop growers by LGUs in Oregon, Washington, and Idaho remained limited because of their small funding for this niche agricultural sector. While public breeding by LGUs, particularly in Oregon has begun to resurge, in the early 1980's a constellation of hop growers who were unsatisfied with genetics produced by LGUs began their own private breeding operations in the absence of active public

breeding, producing the now well-known, patented genetic lineages that supply the craft beer market and had rebounding effects on hop-growing practices at all levels: Citra™, Simcoe™, Mosaic™, and others (see figure 1). Now these farmers' and their children have continued to grow these large, often family-owned, operations. They have continued employing on-farm innovation, particularly through plant-breeding, as a method for increasing profitability in the hop-growing bioeconomy. While Yakima hop-growers' ability to reshape their engagement with the global hops market, and their growing innovations are both contextually situated and therefore not directly imitable; querying how they conduct their on-farm research and implementation of that research calls into question *where* expert knowledge happens in agricultural innovation and what may be possible if other agricultural sectors mimic this practice.

Figure 1 Hop breeding yard during May, (Fred in Background), most varietals in background are unique, foreground varietals are mid stage multi-hill, clonal propagations to begin testing for consistency.

In my results I highlight three contexts that show how Yakima's unique dominant bioeconomy has produced an alternative agriculture of scale. In the first case I show that these Washington state hop farmers have operated and owned their own breeding programs and have used this capacity for innovation to create more profitable material arrangements, a process they call "decommodifying" hops. Employed here in the emic sense, these farmers used "decommodification" as a broad term to describe how their on-farm innovations have returned pricing power and influence to this group of large hop growers. While this practice concentrates wealth among only a small population of large farm owners, it has also produced improvements

in the Yakima-area industry's environmental resilience and slow, though also positive, reduction in chemical loads on contemporary hop yards. In the second and third cases, I describe two hop farming models which diverge from the first case: those mega-farms which rely on innovative farm's models while including hop growing as only part of a large portfolio of production and those smaller farmers which do not have access to the benefits derived from the unique genetic marketplace of expensive proprietary varietals and must find other avenues to produce value.

In the discussion, I suggest that farmers' efforts to "decommodify" hops represents a novel self-aware disruption of a commodity bioeconomy which has lessons for how human intentionality and material agency converge in the production and maintenance of agricutural practices. In the conclusion I further suggest that the practice of Yakima's farmer driven innovations demonstrates how commodity farmers operating as research *participants* instead of *recipients* yields incremental benefits to financial and environmental sustainability. Such arrangements could also establish frameworks that have the potential to facilitate quicker uptake of technological changes should more immediate, radical, or meaningful policies for adapting to and mitigating climate change be adopted. This incremental improvement is well summed up by this farmer's reported attitude about adaptations being selected in the breeding program for which he is a part owner:

> I do know that we have increased [weather] variability. So, I would say the increased variability has had an effect on the farming. Not so much…to a big negative. But it has...we've had to adjust and in some cases it has had an effect on a variety but not to the industry as a whole because there's new genetics coming out and maybe those genetics were selected based on climate conditions we're used to and maybe older ones have been affected more because they were never selected for maybe a harvesting cycle with early morning dew at the tail end. [Bruce]

This attitude shows how even laissez-faire attitudes about climate change can result in meaningful environmental adaptations in the Yakima growing context where local breeding is part of a robust and profitable bioeconomy. This paper argues that insights drawn from Yakima hop grower's particular experiences have insights for other agricultures of scale which will require large scale adaptive behaviors as global temperatures continue to increase over the coming decades.

Historical Context: Changes in hop growing and beer production

Like many specialty agricultural goods, hops function economically as a commodity. As with apples, much of the minimum pricing depends upon global pressures (land, water, chemical, and petroleum costs), while its desirability and therefore maximum pricing is governed by socio-material constraints of taste and desirability (Legun, 2016, 2015). For decades following American prohibition, hops were an especially low-value agricultural product inextricably linked to the global economies of big beer companies, and the cultural constraint of taste was

determined by the chemical compounds "alpha-acids" which are used to estimate total bittering capacity of the hop. The price-point of these, so-called "alpha hops" were set by the global demand for cheap beer and the petroleum and water dollars that impacted the production, circulation, and distribution of this beer (Cabras and Higgins, 2016; Dighe, 2016; Frake, 2016). However, over the last 40 years, and especially in the last two decades, a large shift in US hop production has occurred, while "alpha hops" are required ingredients in almost every beer, the presence of unique, flavorful "aroma hops" have grown in popularity with the craft beer movement and especially in the now ubiquitous popularity of the India Pale Ale (IPA) style beer. These beers utilize aroma hops in multiplicatively higher volumes per barrel of beer. The hop growing industry has both responded to this beer market demand by proliferating new aroma hop varietals for use in IPAs and increasing volume of production for these hops, but they have also intentionally marketed these varietals, encouraging brewers of all scales to adopt these "aroma hops" in higher quantities in their beer making practices.

Hop yards before the 1980's and 90's were small, family affairs and often barely generated an income at all, let alone a robust livelihood for the hop yard owners and many of the hop growers in this dataset have family connections to these historic growers. As hop growing faced a pricing crisis during the dominance of big-beer in the 1980's the number of hop farms alongside the acres harvested decreased dramatically as the long-stalled price of alpha hops rendered many smaller Yakima hop farms financially untenable (see figure 2). In this era, hop farms followed the trend of a typical agriculture of scale where operations consolidated and grew to try to increase profits by decreasing input costs across a greater number of acres. However, at the turn of the millennium the popularity of "hoppy" beer styles reshaped the flagging economy surrounding this agricultural practice. The small number of remaining hop producers operating in the Yakima valley both encouraged, and responded to, this new demand for "aroma" or "dual-purpose" hops to be used in craft beer and leveraged that market demand into a new kind of hop production. Figure 2 and 3 show the effect of this change: the rising average selling price of hops from 2004 onward is an artifact of the local industry's emphasis on producing so called "aroma" varieties popular in these hoppy beers.

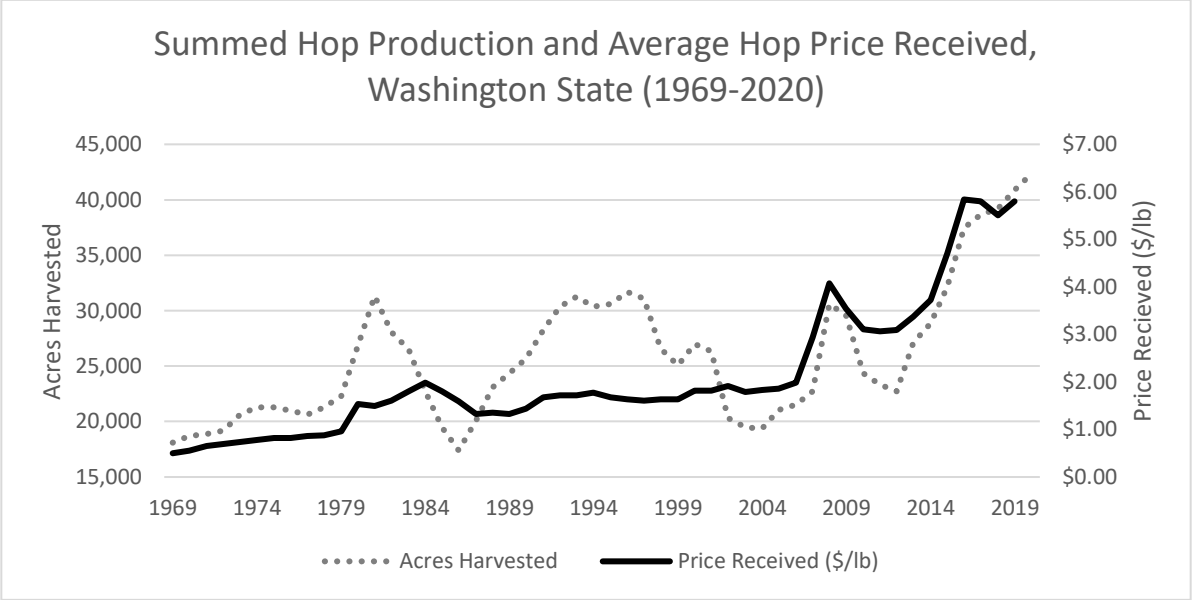

Figure 2: Washington hop growing has oscillated, but trended upward in scale (acres harvested), particularly in the last 10 years. Notably, however, price received ($/lb) for hops remained stagnant until the beginning of the craft beer boom around 2005. The last 10 years (2010-present) have been characterized by rising per-acre price rising acreage harvested. All data retrieved from USDA-NASS. 2020 data drawn from grower-survey projections based on plantings.

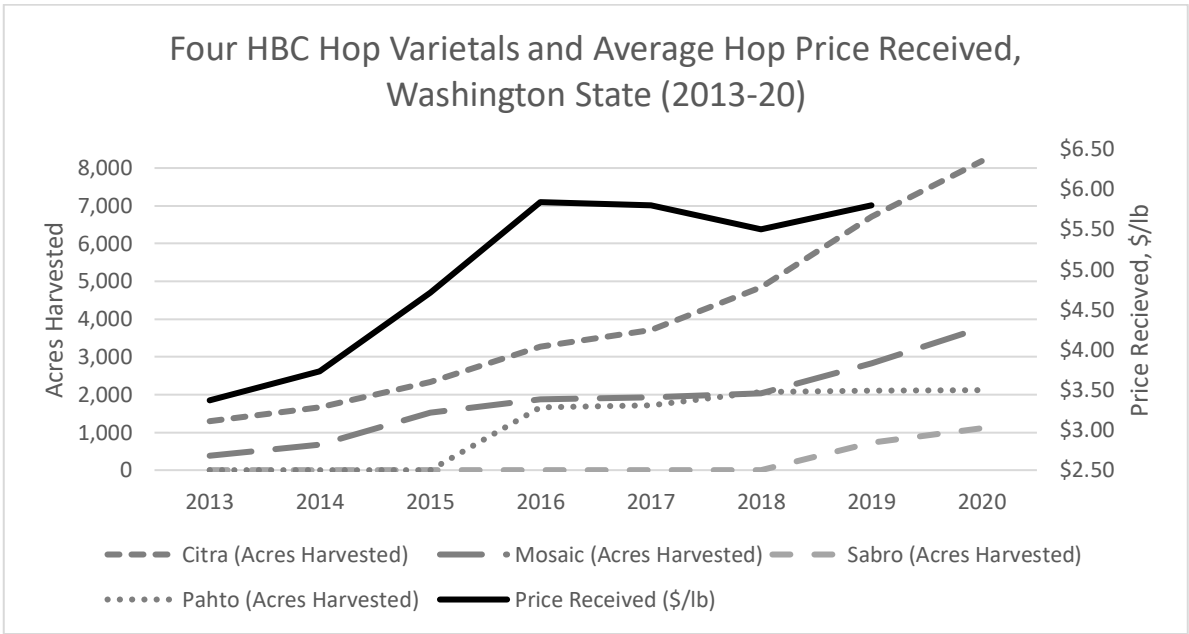

Figure 3: YCR and Haas Inc are the joint owners of Hop Breeding Company, a farmer driven breeding program founded in 2003 responsible for many of the most lucrative hop varietals grown in Yakima. Above, four varietals, including their most popular, Citra™, are charted by acres harvested against the rising average price received ($/lb) of hops during the same period. From 2013 onward Yakima growers have increased profitability by expanding acreage of these varietals popular with craft beer makers. All data retrieved from USDA-NASS. 2020 data drawn from grower-survey projections based on plantings.

Yakima hop yards have continued to scale up both their production of a variety of "aroma" hop varietals and their total volume to nearly match the acreage of Iowa cornfields but the method, technologies, and relationships with input producers and buyers in this new large-scale agriculture vary significantly from conventional row-crop agricultures of scale. These dual developments produced fewer farms that are larger, more profitable, and more genetically diverse (see figure 3). These farms grow in an increasingly wide variety of specialty aroma hops intended for the craft beer market and have continued to slowly divest for "alpha" hops targeting 'big beer' applications. Some of these same farms are involved in breeding and developing the same profitable varietals. In figure 3, the hop varietals listed are new or established aroma hop varietals bred by Hop Breeding Company, a joint/farmer owned private breeding company established in 2003, that is essentially the extension of two older breeding operations Yakima Chief Ranches (YCR) (joint owned by three farming families) and John I Haas Inc. who co-own HBC. Figure 3 demonstrates HBC's success over its short tenure. When considering YCR and Haas's past programs, along with HBC's current program, this small group of owners, many of whom are farmers, have bred a dominant share of the Yakima Valley's most profitable and popular aroma and dual-purpose hop varietals.

Over the last two decades, hop farmers in Yakima have functionally reversed course in their planting plans. This hop region that was once over 70% alpha hops plantings is now over 70% profitable aroma and dual-purpose varietals, many of which are these new proprietary varietals. This shift has not resulted in genetic homogeneity, but rather a proliferation of new hop varietals desired and bred primarily for their perceived taste and novelty. Within this landscape of hop production, the continued success of many aroma and dual-purpose hops bred by HBC and its owners' earlier breeding operations has created a unique share of the hop bioeconomy which lends a large amount of power to those hop growers involved in this company's ownership structure.

The story of Yakima's hop farms, from a historical perspective is one where the unique demands of agricultures of scale have been repurposed by reinvesting in innovations that increase per-acre profitability instead of by merely expanding to mitigate declining per-acre profitability. Environmental social relationships in agriculture are necessarily linked to farming techniques and therefore farming technologies. Understanding the socio-technical arrangements for agricultures of scale impacts social science research on environmental considerations. Hop farms provide a case example of an alternative form of large-scale agriculture where becoming an agriculture of scale coexists with rising per-acre pricing, a contrasting reality from the typical agriculture of scale model. This study examines this 'other' agriculture of scale and considers its lessons for wider agricultural practices on a warming planet.

Assembling the hop-growing bioeconomy

Washington hop growing, in this study, will be treated as a case example which speaks to the wider discourse on agri-environmental outcomes and practices related to agricultures of scale

and rural livelihoods for those involved in food production. Drawing from a vibrant discourse that considers networks of rural inhabitants and food producers to be key units for study (Bentia and Forney, 2018; Dwiartama, 2016; Heley and Jones, 2012), this research looks at Washington growers as themselves a network that forms a small node of wider industrial-food-regime of global hops production. This node has lessons which impact the social and material organization of other agri-food and agri-environmental systems. Here growers are seen as members of an assemblage of actors including many materials which only together engage in farming practices.

This study approaches the hop-growing bioeconomy as a distinct and complex assemblage of diverse farms connected to the hop-growing and selling network. Assemblages are material arrangements of human and nonhuman actors that (re)produce social worlds: they are processual, (re)emergent, and can be studied by the relational flows between materials that make up the assemblage(Müller, 2015; Müller and Schurr, 2016) Assemblage approaches to social problems allow researchers to consider a wide array of materials as agentic actors involved in social practices (such as farming) besides just humans and usefully synthesizes with bioeconomic approaches (Bennett, 2010; Heley and Jones, 2012). Assemblages are not unlike ecosystems, which are a flexible sum of the many beings, actions, and substrates that reproduce the system. However, assemblages highlight the distinct link between material and social worlds/outcomes. In the case of precision agriculture, for example, social ontologies concerning the meanings of data and the ideals of agriculture impact material worlds of the farms which in turn impact these social ideologies in the reproduction of precision agriculture farming techniques (Carolan, 2015). These assemblages are vital units for environmental social science study, and in the case of agriculture, they have revealed that many contemporary farming arrangements produce a so-called “distributed farmer” who makes farming decisions by a whole committee of people, materials, and organisms as opposed to individuals (Comi, 2020).

Assemblage thinking approaches, drawing from the methods of science and technology studies (STS), attempt to *gather* as many of these participants and voices as possible instead of immediately sorting these voices by identifying particular domains of power and delimiting the study to one particular domain (e.g. economic, cultural, political, or environmental) (Çalışkan and Callon, 2009; Callon, 2015; Callon and Law, 1982; Law, 2004). These many materials are then assembled by tracing relationships between members of the assemblage. In this approach power hierarchies and domains/structures of social control are eschewed in favor of flat, networks of power, These networks, following the work of Bennet, are an enlivened collage of things that co-produce social and material worlds on the farm and elsewhere in the world (Bennett, 2010).

Assemblage approaches are especially helpful for examining bioeconomic arrangements which necessarily relate humans to nonhumans in the production of value. This technique of gathering and assembling can effectively identify social relationships which are otherwise obfuscated by conventional critical approaches has been well established in the methodological, theoretical, and empirical literature which employs or analyzes these techniques. This has been

usefully demonstrated by those taking assemblage approaches to better understanding agricultural industries. Jones et al. use an assemblage approach to identify and explore the global wool production assemblage (2018). They find that by gathering the many materials, humans, and nonhumans involved in Welsh wool production they are better able to assemble the complex relational network of rural localities that participate in the wool production network. Put differently, the vast apparatus of things involved in wool production relate to both the local and global social construction of the industry. Similarly, hops production is a social world consisting of a vast array of materials and these can be studied by considering the relational flows between these many materials and people. As with previous research with agricultures of scale (Bell, 2004; Campbell and Rosin, 2011; Konefal et al., 2019), the approach used in this research reveals that such practices, despite monocultural tendencies, still resist monolithic social interpretation and instead present a varied and diverse social and material landscape whereby productive, sustainable interventions and alternative ways forward remain distinctly possible.

Biological economies are those economic arrangements which are reliant on the so-called "natural world" (Pawson, 2018, p. 2). Drawing from agri-food scholarship working in the area, bioeconomies are those economies which depend primarily on live organisms which are non-human in order to produce, maintain, and circulate value (Le Heron et al., 2016). However, the term bioeconomy and bioeconomics has been in use in a variety of discourses from the 1960's onward and its uses have ranged from a general recognition that economic structures necessarily arise from biological functions and apparatuses to the specific economic apparatus that is guided by genomics and life science industries (Birner, 2018; Pavone and Goven, 2017). This study approaches the term with attention to both meanings, examining the specific arrangement of hops growing that is informed by a unique genetic marketplace while viewing the entirety of the agricultural assemblage as a distinct biological economy, whereby value and life systems coproduce socio-material outcomes (Dwiartama et al., 2016; Legun, 2016). I approach the bioeconomy of hops growing similarly to Marsden and Farioli's "eco-economy" which is a mode of economic thinking that sees bioeconomies as "more diverse and fragmented arena[s] for the development of new production and consumption chains and networks" (2015, p. 337). These diverse ecosystems for value production are studied as distinctly social in this inquiry, and because of this I instead adopt an assemblage-thinking approach to the more conventional notion of a bioeconomy.

Each practice of agriculture can be considered both as a particular assemblage but also as a distinct bioeconomy and this paired critical approach generates more holistic understandings of the many plural bioeconomies that make up world food systems (Lewis et al., 2016; Pawson, 2018). Consider the array of actors involved in hop growing require or benefit from such specific environmental and biological factors: one farmer interviewed for this research put it this way

> This is the biggest hop growing region, so it goes downhill from here…There is a band, a latitude that goes with growing hops. I mentioned that hops need daylight units so there's a latitude that is associated with that. 45th 46th parallel or

> somewhere around there. And then it's the corresponding latitude on the southern hemisphere. So, hops need lots of water and sunny warm days, that's what makes hops grow. And good soil. So, if you're on the 45th 46th parallel and you run your finger around the globe there are very, very few areas on earth that allow that. That have the right, that have the water, that have the sun, there's just very few areas…Michigan thinks that they can replicate what we can do, and they can't. They don't even come remotely close to what we can do because of what we have here in this area. [Harry]

In this context, the entire ecosystem alongside the agricultural techniques and those practitioners together make up the bioeconomic assemblage of hops agriculture. This complex, recirculating social world of materials and people relates to larger social and material contexts primarily through the economic production of value in the form of hop material. Further, hop-farmers interviewed in this study are self-aware of their attempts to reshape or, as they say, 'decommodify' the hop growing value-chain largely through modifying organisms and shifting human comprehensions with those organisms and their impacts on value-added applications for hops in beer. This arrangement uniquely exemplifies the bioeconomy as an assemblage: a unique complex social world that involves materials and people in the reproduction of meanings, materials, and value. Examining this bioeconomy further helps to illuminate the complex relationships between local environments, profitability, and agricultural decision making.

To extend this example, the hop varietal Citra™ which is commonly grown in Yakima, has become a desirable hop variety not only in 'local' Yakima and US contexts but in the growing global marketplace for hop-forward India Pale Ale style beers. The genetic lineage of Citra™ is legally protected and its branding is also trademarked. It was bred by a farmer-owned breeding program in Yakima and is jointly owned by Haas Inc and YCH who contract with farmers primarily in Yakima who use merchant certified on-farm nurseries and labs to cultivate and reproduce these plants for production (see figure 4). This is an especially local enterprise, but the practices in this valley account for approximately 30% of the globe's hops production and Citra is both the most common variety in this region as well as one of the highest value hops in the global marketplace. The practices in Yakima are new to the hop industry and their expansion has modified aspects of the greater Yakima valley agricultural landscape. Yakima's growing dominance and profitability inspires a growing trend to vertically integrate and scale hop farms larger around the globe. This project looks at the Yakima Valley Hop farms as a specific assemblage of an agriculture of scale. I ask whether this agriculture of scale has potential to produce categorically or incrementally different environmental outcomes than other more well-known agricultures of scale and if so, what lessons this other agriculture of scale has for food production in other sectors. Further, this bioeconomic examination of these Yakima growers also helps to query the farmer's claim of regional dominance: does the genetic marketplace and ecological niche of Yakima truly produce a dominant hop bioeconomy, or do

local regional growers elsewhere meaningfully contest this dominance in their own hop growing and selling techniques?

Figure 4: Citra™ hop pots, propagated clonally from tissue cultures (reduces disease load by comparison to rhizome cutting clonal propagation) on a nearby farm are being offloaded and prepared for planting on a new hop yard at a smaller, 600 acre farm that contracts with HAAS.

Methods:

This qualitative research draws on data collected through field work conducted during May-June 2019 with hop growers (n=15) operating in Central and Eastern Washington. Participants were initially selected from the farmer member rolls of the Washington Hops Commission and the Hop Growers Union which were obtained from these agencies through a Freedom of Information Act (FOIA) request. Because the number of Washington growers have declined as farms concentrate; every farm listed on the commission rolls (μ=51) was contacted at least once to request their participation for the purposes of this study. Subsequent requests were made by participant referral. This total sample represents 29% of hop growers operating in Washington state which is responsible for cultivating 72% of total us hop-growing acreage (USDA NASS, 2020). Participants recruited for this study were interviewed and asked to provide a detailed tour of their farm with particular time spent showing infrastructure and implements involved in farming practices. During the interview component I used a theme-based interview protocol and audio-recorded and later transcribed interviews. In order to enable more participatory involvement, the field components of the research were not

audio recorded. However, field notes and photos were taken during these times on each farm unless the participant objected to either practice. Data collected during field visits were collated with interview transcriptions and the resulting rich data set is used for this inquiry. These hybrid qualitative methods allow me to more directly study place-based considerations unique to farming practices and additionally allowed me to gain detailed insights into the practices and ontologies of hop growing in Washington.

Results:

The following section is organized into three subsections, which each address one aspect of the broad contours characterizing the contemporary arrangement for Yakima valley hop growing. The first section "'decommodifying' a cash crop" describes how hop farmers have engaged in plant breeding and other innovations to reshape the bioeconomy for hops farming. By visiting farmers that are part owners of hop breading programs, such as Bruce, Van, and Fred, I show how hop growers have chosen to reimagine how hop cones are valued as an agricultural good. This first section demonstrates the trends indicative of the Yakima valley hop growing bioeconomy while the following two sections describe qualifying considerations—large and small farms which somehow differ from this generalized model. The second section: "Diversifying the mega-farm's portfolio" returns to Bruce's farm operation, which is a large grower arrangement including a variety of fruits as well as hops. This shows a variation on the growth of hops farm—a responsive expansion to HBC's success where farmers of fruit and other goods in Yakima recognize the increasing profitability of the innovated aroma hops model and adjust to expand. The third section "Exceptions to the large farm: making it happen on ten acres or less" describe two smaller hop growers in Washington. By visiting Sal and Lynn along with David and Linda, I show how these small farms demonstrate a meaningful but limited method for producing value: the proximity of "local hops" in the small microbrewery marketplace. Together, these results survey specific cases drawn from my collected data to demonstrate the meaningful shifts involved this other agriculture of scale along with those growers that qualify the broad contours of the unique hop growing assemblage in Yakima Valley.

Growing hops: "decommodifying" a cash crop

During interviews with hop farmers, many participants described a long-term goal of "decommodifying" hops. Those who didn't necessarily see this as their project often referred to this concept as an event, a time before craft beer when hops were a commodity, and a time after craft beer when Yakima hops became a different kind of market material with different rules. For these farmers, "decommodifying" hops is a practice (or event) which causes hop cl pricing to be set based upon taste, quality, or other farmer- or brewer-driven markers as opposed to external forces such as petroleum cost or merchant demands. In this sense, I use decommodification in the *emic* sense, and not in its more common social science and Marxist parlance. I do not mean that hops are no longer a commodity, but rather that some group of these farmers are attempting to reset the methods for value production in the hop growing bioeconomy. Has this self-described "decommodification" actually occurred though? Lending greater control over hop

pricing to the farmer or at least some group of farmers? And if so, if this does not constitute a critical decommodification what are the new material arrangements which produce value in the absence of common value standards for other commodities in agricultures of scale?

Even during the years when hops were primarily grown for big-beer applications and were priced largely as a function of transport/petroleum costs, hop farmers were engaged in breeding practices. Perhaps this is because hops have long been a small agricultural good with limited industry and LGU support. Additionally, as perennial plants propagated clonally by root cuttings or tissue cultures, there has never been a vibrant marketplace for seeds. These hop breeding operations have varied in success over the years and include several that have valued different traits than the now-ubiquitous aroma hops bred by HBC. Bruce runs a large fruit and hop farm and is part owner of ADHA (American Dwarf Hop Association) which began breeding hops with dwarfing technologies with the attempt to lower production costs while maintaining yields by pound of alpha acid, the key bittering ingredient large beer companies were functionally buying in the 1980's. While dwarfing technologies are no longer a primary goal of the breeding program, this illustrates how farmer innovations precede craft beer revolution and illustrates how such a practice can be driven by farmer action

> *ADHA is the name of it [our plant-breeding program]. It used to stand for American Dwarf Hop Association when we started...because we started the program around breeding dwarfing varieties for low-trellis hop production when the world was driven by the commodity side of things and the craft beer market was like nothing… [Dwarfing Technologies were about] lowering operational costs specifically so we could keep up with China. So, we embarked on that whole journey. We had one of the only, and largest, blocks of low trellis hop production. The variety we were growing on that came out of the breeding program.* [Bruce]

ADHA shows us that responsive innovation has been an ongoing practice in hop growing in the Yakima Valley. This cost saving approach mimics typical agricultures of scale and could be seen as a gamble which has paid few returns. HBC's predecessor YCR, during this same time and in recent decades took an alternative approach that hinged on the growing demand from craft beer brewers. YCR originally bred its unique aroma hops as high-alpha varietals. However, as they became popular with the few early microbreweries such as *Lagunitas* and *Sierra Nevada*, those with ownership stakes in YCR cultivated this desirability of early varietals such as Ahtanum™ and Simcoe™. These farmer-breeders were able to identify a potentially profitable way to diversify demand for the genetic landscape of hop growing early and leveraged that to make a more valuable hop, a contrasting approach to ADHA's goal of producing a less costly-to-produce hop. Their child company, HBC has continued to innovate popular varietals, including what is largely considered the most popular current aroma hop, Citra™.

While ADHA is an ongoing breeding program, this grower's story illustrates the risk of innovating as a single or small group of growers operating in a vast bioeconomic network where demand, market pressures, and material performance remain unknown quantities. It also

demonstrates that responsive innovation is both risky as well as profitable. When asked if he continues growing any of those varietals, Bruce gave an answer that reflects the surprising demand trend toward small number of especially popular aroma hops despite the increasingly diverse genetic marketplace in recent years: "*We used to, we pulled it all down to put up high-trellis. Now it's all Citra" [Bruce.]* While demand for other hops exists, other aroma hops do not receive the same volume demand as Citra™. Notably, Citra is an HBC varietal co-owned by Haas Inc. and YCR. It can only be planted under contract with these two entities and its highly valued bines are propagated by contracted nurseries and farmers, often by tissue culture, and the purchased by the planting farm most often as pots (see figure 2). Citra is not the only varietal being grown in Yakima, other profitable and popular varieties developed by Hop Breeding Company include Mosaic™, Ekuanot™, and recently Sabro™ while their co-owners have previously developed a range of other popular aroma varietals including Ahtanum™, Warrior™, Chelan™, and Simcoe™, among others. Their dominance in the US hop breeding landscape is unprecedented, no other farmer-driven breeding program has so dominated the plant genetic marketplace for an agricultural good.

One exception to the dominance of Hop Breeding Company and its owners is the varietal Amarillo™. Amarillo™ is legally grown entirely by one family and those who physically grow the varietal on the farm both in the US and elsewhere in the globe through their Amarillo™ program do not legally own the bines but rather contract with the farmer-owner to ostensibly rent Amarillo™ plants on a guarantee buy-back program, the farmer then works with hop buying merchants and large-scale brewers and therefore maintains price-setting power. The buy-back program represents a kind of plant-material rental program, and this otherwise unusual bioeconomic arrangement has similar models throughout hop growing. Yakima Chief Hops is functionally YCR's hop marketing and growing company. YCH serves both its owning members and a number of farms who wish to grow YCH hop varietals, which include those bred by HBS YCH's member and contract farm model is similar: YCH contracting farms are obligated to sell YCH varietals through YCH and receive a percent-share of earnings based on acreage instead of a set price as a typical commodity would function. In both the Amarillo and YCH cases, contracting farmers, those smaller entities, do not have significant leverage. However, for those few farmers who have ownership stakes in breeding and merchant programs, a significant ability to shape the biological marketplace allows them to more freely experiment on-farm and develop new genetics or implements. In short, this agriculture of scale has depended on incremental farmer-driven innovations. Instead of corn and soy agriculture, which scales to reduce per acre costs, hop growers in Yakima have scaled while simultaneous using those earnings to mitigate infrastructure and innovation costs. For those who have been successful, a vast arrangement of people and materials create a system that continually reproduces a new hop bioeconomy: linking farms to breeding programs to the craft beer marketplace.

Participating in a breeding program has significant costs including infrastructure costs. As test varietals and small planting plots begin to scale, owners of the breeding program and affiliated farmers have a vested interest in testing and marketing the new varietal before scaling

larger multi-year perennial plantings of a new varietal. Because hops have a narrow picking window and because hop picking requires significant infrastructure hop growers are met with a particular problem. To switch varietals of hops during picking, they must pause production on some portion of their picking, kilning, and curing apparatuses, thoroughly clean the vast equipment to prevent flavor contamination, and then begin picking this new hop varietal. During the month-long harvest season this is typically managed by planting varietals with varied growing times and managing plots such that the equipment is maximized.

Testing small batches interrupts this picking window and reduces the farms ability to grow at capacity and therefore to justify the large infrastructure costs and maximize production. To moderate this cost, many farms maintain or build smaller picking facilities to manage boutique varieties or to test new varieties. On Fred and Van's farm, which hosts many of the test varieties produced by Hop Breeding Company, they were currently building just such a small facility (see figure 5). As a partially built structure, it demonstrates some semblance of scale for the size of infrastructure required on these farms and though it is significantly smaller than their primary picker, it illustrates the potential cost benefits that I suggest materially encourages on-farm investment in process innovation. One such innovation is the patented de-viner, which negates the need for frontends which strip the arms, leaves, and hops from the vine by removing the vine in the field (see figure 6). These de-viners are custom fabricated trailers pulled behind a tractor, but ahead of a storage trailer, and are cheaper from a material and petroleum standpoint than expensive fixed frontends. Hop farms in the Yakima valley are complex bioeconomic assemblies that attempt to control their eventual market opportunities by vertically integrating not only their market structure of brands, buyers, and inputs but also the vast array of social and material actors that play into this. Participating in mechanical and genetic innovations is a way of (re)producing the social and material world which allows for the unique large-scale profitability that Yakima hop growers have benefited from over the last decade. This has, as mentioned above, come with incremental environmental adaptative improvements and with many farmer benefits. However, these benefits are not equally shared, in the following two sections I describe two outliers: the large farm which diversifies into hop farming and the small farm which must find alternative bioeconomic pathways because of the onerous limitations to access for small farmers to grow the popular, proprietary varietals of large Yakima growers.

Figure 5: Smaller hop picker being built to allow for simultaneous harvest of boutique, test, or uncommon hop varieties without interrupting harvest of larger-acreage varieties (such as Citra™, Simcoe™, etc.). These hop pickers clean and pick hops from bines which are cut in the field and brought to these large warehouse settings for picking, kilning, curing, and baling.

Figure 6:Fleet of home-made, patented "de-viners" in equipment lot. De-viners are patented implements used only on two jointly held large farms in Yakima and are pulled behind tractors while cutting the hops at harvest and separate the bine from the arms, leaves, and hop material while in the field. This incrementally lowers petroleum costs as well as the expensive infrastructure costs of large, static "front ends" which otherwise clean these hops at the site of a hop picker.

Growing hops: diversifying the mega-farm's portfolio

Many hop farms I spoke with operating in the Yakima Valley were primarily hop growers, and only produced other goods as tertiary portions of the farm portfolio, and many of these farms planned to offload excess acreage of orchards or berries so soon as their current fields became unproductive and could be more effectively converted into hop yards. However, this is not a totalizing picture, many of the large fruit farms in Yakima are primarily operations of scale, and at such scales the investment required to begin hop farming is feasible. How do these farms undertake, understand, and operate in this new agriculture of scale as part of a larger portfolio of apples, blueberries, and other fruits? Besides asking how these farms vary, I first suggest that these farms emphasis on scale reveal a generalizable observation about Yakima hop farmers: that their self-professed goal of "decommodifying" hops is not only linked to innovation and vertical integration but also to a particular agricultural technique of scale which allows them to provide unique varieties in significant quantities for large profits. In these contexts, farmers willing to invest and grow at scale quickly are an integral member of the Yakima hop growing assemblage that enables this particular arrangement to continue and remain relevant in the global hops market.

While the scale of farms in all hop yards in Yakima are large by industry standards, those with diversified crops seemed to more consciously assess themselves according to scale. Notably Bruce is a large apple and fruit producer. These markets are truly agricultures of scale, requiring higher hours of human labor inputs than hops and longer investments in plantings. Slimmer margins in the apple industry encourages the plantings of higher value apples which conversely, are riskier long-term plantings. Perhaps because of these compounding factors apples and most fruits truly become agricultures of scale. It may come as no surprise then, that such growers who also grow hops see agency and power in the hops market as a direct function of size:

> *We have the desire to scale the business larger in all the crops that we're involved in right now. Mostly so we can remain relevant and [so] we have a seat at the table in the supply chain because in my opinion, we have... we need that seat at the table. Otherwise we become 'just a grower' and in many ways if you're 'just a grower' you're not going to receive full value for your crop. That doesn't mean you need to own every piece of the supply chain, but you at least need to be relevant so that you have a voice. [Bruce]*

For farmers like Bruce, hops may be part of a larger portfolio, but as with his large fruit operations, he sees scale as vital means for maintaining value-chain relevance in making planting, selling, or pricing decisions. While Bruce's hop breeding has not had the success of HBC, he is able to leverage scale to be recognized in an industry dominated by the vertically integrated large farm.

Other large multiple-crop farms do not mimic Bruce's method, and these hop/fruit operations remain content to grow relatively small acreage hop yards (closer to 600 acres) and either contract with another grower to use their infrastructure or maintain a smaller infrastructure. In this latter case, hop farms are methods for mitigating market risks of fruit production and utilizing ground types more effectively. While many of these cases result in little innovation, one case contradicts this standard. In the case of Bruce, there is an uncommon example of a hop farm which is over 2000 acres being run by a farm with significant holdings in other fruits. This contravenes the trends of the other especially large hop farmers which are reducing other crop holdings or abandoning them altogether.

The lesson of Bruce is that the hop agriculture of scale is not entirely detached from the constraints of other commodities even in the context of a goal to 'decommodify' crops. While Bruce did not speak about decommodifying, he did describe particular innovations including an ownership stake in a private breeding enterprise, and a decision to pelletize hops on farm as oppose to bailing as a means to increase quality and decrease merchant processing fees. These decisions mimic those interested in decommodifying, yet the need to scale to remain "relevant" suggests a particular commodity exercise, that power and agency are functions of socioeconomic status and scale. However, he did not describe scaling as a typical agriculture of scale, a requirement to break even and increase profitability, but rather as a way to have a "seat at the table." He saw scale as a way of leveraging power in the larger hop growing supply chain. In this large operation, we see that the "decommodified" hop operates clearly as an "other agriculture of scale" which is simultaneously beholden to the socio-material arrangements that inform, constrain, and produce what we typically call commodity agriculture, but also materially linked to all kinds of other concerns including taste, social relationships, and place which operate differently than a conventional commodity agricultures of scale.

Exceptions to the large farm: Making it happen on ten acres and less

All farms are not large, and as with vegetable and grain agriculture, there are a small but growing number of farmers that are operating at smaller scales in more local economies. Hop yards are labor-intensive practices which are also highly productive, how do these small farms pay for their hop yard start-ups and what methods do they use to either become profitable or aim to stay solvent over the long-term. Do these farms use notably diverging practices and if so, do they provide lessons, contestations, or useful social science considerations for this mapping of an agriculture of scale developing in the Northwest hops industry? In many cases the small farms do not purposively diverge from the large farms in terms of sustainability practices. However, because of the constraints of scale and the active hop industry bioeconomy of genetic property rights these farmers practices do differ, particularly as they seek to reframe hop varietals as unique due to terroir and locality instead of genetic varieties. Put simply, if you can't legally grow Citra you must find some other way to convince local brewers to purchase a lesser-known hop for use in beer-making applications. For many small-time growers, this is one of the

instances where food-ideals of locality can be leveraged, such as in the case of Sal and Lynn who market 'wild' varieties of hops they've cultivated from shoots found on a nearby ranch. These unique hops are local to the city and therefore have staying power with a small set of purchasing brewers despite their bio-chemical and taste inconsistencies.

Hop farmers tend to use surprisingly analogous techniques across scales. Eighteen-foot poles remain standard, though straight-line trellising on twelve-foot poles sometimes appear on small farms. Like large farms, small farms must have some implements, home-made or otherwise for vine throwing, wrapping, cutting and eventually hop-picking, and cleaning. Most large farms bale their hops while almost all small farms I spoke to pelletize or contract with a pelletizer instead of pelletizing their own. Small farmers I spoke to buy small scale equipment usually from German hop company Wolf™ or build their own as in the case of David and Linda. While many small hop farmers grow primarily land-grant university public varietals as opposed to historic European "noble" hop varietals, some did experiment with new breeds. However, without the structures and money required to produce their own breeding programs, these hop growers who use alternative varietals are often using 'wild' varietals or cross-pollinated subtypes without highly predictable known qualities. While some growers name these varietals and are successful in marketing them as a more local product to brewers, they struggle with the unpredictability of local markets. Generally speaking, one could characterize the key differentiation in technique between large- and small-scale hop growing operation to be the presence or absence of particular genetic lineages and the likelihood of their involvement in the production and maintenance of those lineages.

Discussion:

What lessons are there from examining Washington state hop growing as an 'other agriculture of scale' which reinvests high earnings resulting from their practices in infrastructural and genetic actors to produce value? Using this technique, Yakima hops growers have grown larger while inverting expectations, increasing price-per-pound to maintain profitability instead of increasing acreage to mitigate the lowering price-per-pound indicative of other commodity agricultures of scale. Findings from this research reveal how actors in the Washington State hop growing bioeconomy "decommodify" hops and continue to produce heterogenous meanings in response to this "decommodification." In each of the three previous cases, hop material specifically means and behaves, differently for each farming assemblage. For those in the first case, who are involved in the innovation and proliferation of new varietals, hop material is a collaborator and an enabler of new modes for profit seeking. For the large fruit and hop farms of the Yakima valley, this hop material connects these large farms to the innovative and vertically integrated hop farms that produce new varieties while diversifying their agricultural portfolio. In this bioeconomic setting, hops provide short term profitability and long-term stability by diversifying their agricultural investment. For those small farmers, the "decommodified" hop is a foil that troubles their direct-to-brewery sales specifically because these new proprietary and popular hop varietals are largely unavailable to small growers.

While the bioeconomy for hops growing remains fragmented and varied between these three cases (Marsden and Farioli, 2015) it is clear that the agriculture of scale practiced by Yakima hop growers alongside their vertically integrated breeding and marketing programs does produce a dominant arrangement within the hops growing industry. By "decommodifying" their hops, this small group of large and innovative growers reimagines the particular actor (the hop strobile) in the bioeconomy of hops growing and this disrupts both the local production systems for these large growers but also reshapes the larger industry by modifying others' relationship to plant material involved in the hops growing and marketing assemblage. "Decommodifying" hops, again, in the emic sense of the word, is an encoded way of describing a material and ontological shift in the hops growing bioeconomy. It reveals that farmers may be self-aware of the material disruption to the larger biological marketplace for commodities they are involved in producing.

The "decommodified" hop is new, proprietary, and expensive. It is desirable for craft beer applications and its value arises from a confluence of factors including novelty, availability, and taste. It is a new actor in the hops growing assemblage, and it reshapes the possibilities and limitations for hop farmers. In the context of the fruit and hop megafarm, control over innovative "decommodified" hop material is forgone, rather these large farms aim to increase scale as a method of "having a seat at the table" with those they contract with to grow and sell these hops. For these farmers, the selling power of scale in such a small market can remain an alternative way of accessing agency in the hop growing bioeconomy. For small hop growers, however, this "decommodified" hop operates almost entirely as an outside pressure: a force which inhibits full market inclusion as they struggle to find alternative pathways for producing desirability with local brewers and hop buyers. Exploring the effects of growers' efforts to "decommodify" hops has lessons for other agricultures of scale and for disciplinary understandings of bioeconomies and agricultural assemblages: These farmers' self-conscious efforts to reshape their market reveal both the importance of material actors in the bioeconomy and the importance of human intentionality in the maintenance and disruption of this assemblage.

Conclusion:

This case study yields insights into the ontologies of on-farm innovation and technological adoption, contributing to an ongoing discussion of the impacts of innovation on the world's food system (Darnhofer, 2020; Eastwood et al., 2017; Fraser, 2018; Rotz et al., 2019). Other research has already revealed that innovation arising in the input sectors onerously locks in farmers and limits farmer agency in agricultures of scale (Comi, 2019; Kloppenburg, 1988; Rotz et al., 2019). Agricultures of scale rely on a complex bioeconomy to produce value and a distributed array of actors in order to make farming decisions. While this distribution of agency has locked in many commodity farmers, examining Yakima hop growers and their "decommodified" hops reveals three core contributions to the discourse on innovation and technological adoption in agriculture: **(1)** When a farming operation recognizes their distributed status, unique opportunities to collaborate with a range of bioeconomic actors to innovate

technologies and profit-making pathways can arise. **(2)** Large scale agriculture's lock-in is contingent upon onerous pricing models and therefore pricing models that free farmers, at least in this instance, result in on-farm reinvestment and increased farmer agency in the growing bioeconomy. And **(3)** while changing practices in hop growing have concentrated wealth among only a few farmers in the Yakima valley who continue to practice chemically dependent high-irrigation techniques, these same farmer's reliance on local ecologies encourages technological and praxis innovations with incrementally improved outcomes for environmental adaptive capacity.

This research also responds to problems in applied rural development and environmental policy. On-farm innovation is shown to increase profits for hop farmers, improve environmental adaptive capacity, and result in incremental improvements in sustainability. This insight is consequential for policy makers and research groups targeting sustainable rural development. Initiatives aimed at funding farmer driven innovation and/or incentivizing farmer-driven reinvestment may both result in incrementally better environmental outcomes in the long-term while boosting rural livelihoods in the short term. One distinct problematic revealed in these findings is that positive financial outcomes continue to benefit primarily those farmers of scale who are able to adopt quickly. Additional research is required into the inequities resulting from this bioeconomic system and potential applications resulting from this research should consider these mitigating factors. Research into the specific material character of farmers' practices of innovation would also improve understanding of the links between bioeconomies, value, and taste. Further, continued research is necessary to better map the complex relationships between Yakima farms and other hop farms throughout the US and elsewhere in the world. Understanding the relationship between Yakima and the global hops bioeconomy would help to clarify the meanings of farmer driven innovation and its impacts on industry sustainability in both environmental and financial contexts.

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