Juniperus communis:

Revisiting use of common juniper for modern culinary uses & producing drought resistant cultivars for evolving markets.

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EXECUTIVE SUMMARY

Common juniper, *Juniperus communis*, is a widely distributed conifer with a natural range so vast it is known through out the entire northern hemisphere. It is renowned for its ability to thrive in conditions so harsh most other plants would not be able to become established. *J. communis* has been a widely utilized plant since antiquity; it has been employed by the ancient Greeks and Romans as well as the First Peoples of North America for a variety of cultural and culinary uses. Modern times have seen juniper in use as the principle-flavoring agent for the popular spirit gin, and a veritable explosion of cultivars have taken their place in the nursery market for various uses in the landscape. This review paper attempts to make what is old, new again, by adapting the natural strengths of *J. communis* to changing consumer tastes, as well as a changing climate. In a world of mass production and automation some consumers have gravitated towards the bespoke and the do-it-yourself production of products where possible. A prime example of this shift can be seen in the rising popularity of home brewing; an activity that this review suggests should be extended to distilling. Global climate change also presents an opportunity for new types of juniper production; many regions are facing increasingly droughty conditions that threaten to erase much needed green space from consumers' yards and public spaces. Juniper is naturally a hardy plant with drought resistant qualities and this review seeks to provide an avenue for enhancing those and other traits that would be beneficial for regions stricken by a changing climate.

I. Introduction

A. Study Species

Juniperus communis, common juniper, is an evergreen species in the *Cupressaceae*. It maintains the largest range of any woody plant, with several intraspecific taxa around the globe (Tirmenstein, 1999). While the wood of juniper is seldom used for commercial purposes, its berries have been used for a myriad of cultural, medical, and culinary practices dating back through antiquity; the ancient Egyptians, Greeks, and Romans all had uses for juniper (Wong, 2014). Today, *J. communis* and its various cultivars are most commonly known as the primary flavoring agent for the spirits of gin, and as a widely used ornamental planting in landscapes (Tirmenstein, 1999). Despite its extensive range, juniper populations are declining throughout regions of its native range where its various products are commercially significant. Great Britain, in particular, has seen a decline in the wild populations traditionally used to supply the berries needed for gin production (McCartan & Gosling, 2013). In addition to decreases in wild population in Europe, M. K. Meines, a nurseryman from Bessey nursery in Nebraska notes that, "unpredictable and erratic germination of juniper seeds often results in production quota shortages," in the United States nursery trade, notably throughout the West and Midwest (Meines, 1965). A portion of this review will attempt to provide potential solutions to this shortage, as well as a reimagining of potential culinary uses for a traditionally widely utilized species.

B. Taxonomic Classification and Geographic Distribution in the Wild

Juniperus communis is the recognized scientific name of common juniper. Many varietas have been described throughout the range of *J. communis*; well-known North

American varietas include: var. *charlottensis*, var. *depressa*, var. *megistocarpa*, and var. *montana*. Common names for juniper number at least 150, many of which are derived from the naming of clonal cultivars (Tirmenstein, 1999). There are, however, a myriad of common names associated with *J. communis'* extensive range: Genévrier (France), Ginepro (Italy), Enebro (Spain), Gemeiner Wachholder (Germany), Reckholder (Switzerland), fairy circle, hackmatack, horse savin, Gorst, Aiten (Tirmenstein, 1999).

Common juniper is a shrub or small coniferous tree with highly variable form; while it is often found as a low spreading shrub it can grow upwards of 7-9 meters tall. It has green scale-like leaves in whorls of three, with a single white stomata band on the underside. Younger leaves are often more needlelike, whereas mature leaves are more likened to a scale form. The seeds cones resemble berries, green when young and ripening over 12-18 months into a purple/black with a waxy coating (Tirmenstein, 1999). *J. communis* is dioecious, with male and female cones on separate plants. Yellow male flowers blossom in spring and rely on wind to carry their pollen to the flowers on female trees. The female flowers appear in the form of small, scale-like clusters, and turn into tiny cones after pollination. It does not sprout after foliage has been removed, however, adventitious roots often develop when branches come into contact with the ground (Broome, 2003).

C. Native Habitat

Native habitat types for *J. communis* are extremely diverse. It is well adapted to life in the harsh conditions of northern latitudes where it thrives on exposed cliffs, and ledges. It is also the dominant understory species for a myriad of conifer cover-type classifications as defined by the Society of American Foresters (Tirmenstein, 1999). It can also be found in

open meadowland and while it prefers drier, rocky, upland sites it can also be found in and on the edge of wetland sites as well. While it prefers slightly acidic soils, it has no problem growing well in basic soils either (Tirmenstein, 1999).

D. Geographic Distribution in the Wild

Common juniper is often recognized as the most widely distributed tree and/or shrubs in the world (Tirmenstein, 1999). It is a circumboreal species (Figure 1), distributed across North America, Europe, Northern Asia and Japan; with the exception of a gap at the Bering Sea, common juniper is completely circumpolar as well. It thrives in the harsh conditions beyond the northern tree line. In Europe, its range extends from the Northern most reaches of Scandinavia to the Southern tip of Italy and Spain. In North America, it reaches up into Western Alaska to Newfoundland, and can be found as far south as the Carolinas in the East, and Arizona and New Mexico in the West. Figure 2 showcases common junipers ability to naturalize itself to a wide variety of environmental conditions. *Juniperus communis* var. *depressa* if the most common variety, found throughout North America from the southlands up to the low artic; *Juniperus communis* var. *montana* is the circumboreal, high northern latitude variation. In Asia, *J. communis* is found throughout the Siberian boreal belt, all of Japan, and as far south as Turkey, Northern Iran, and Northern India (Tirmenstein, 1999).

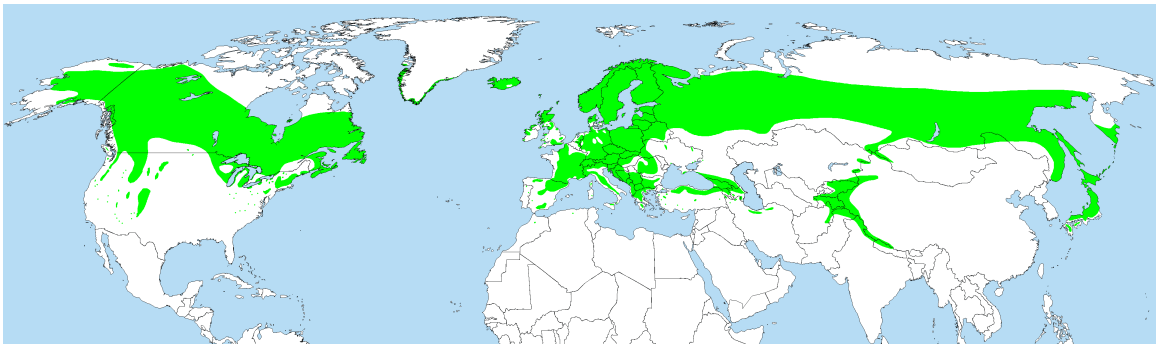


Figure 1. Native global range of common juniper, *Juniperus communis* (USDA Plants Database, 2001).

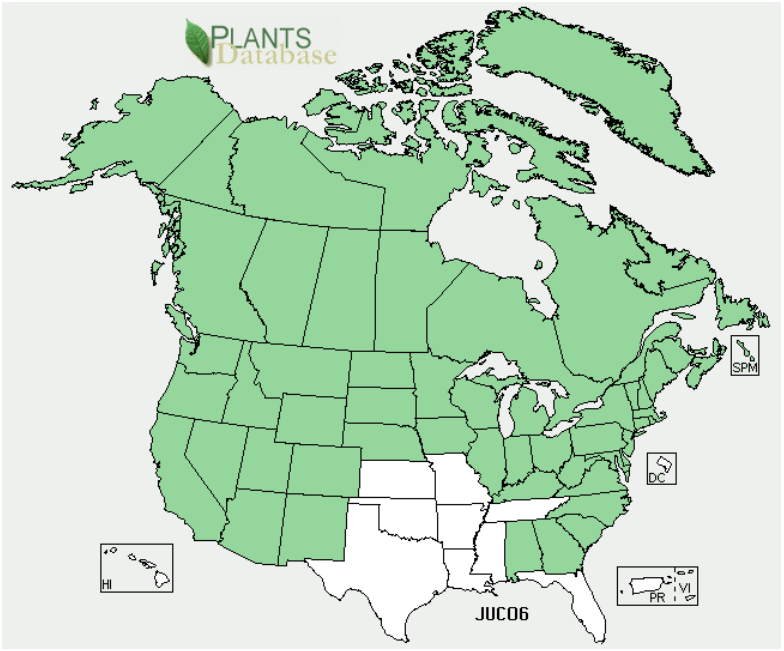


Figure 2. Naturalized North American range of common juniper, *Juniperus communis* (USDA Plants Database, 2001).

II. CROP HISTORY

A. Breeding & Domestication

Common juniper and its associated taxa are perhaps best known for their various medicinal, cultural and culinary applications. The earliest documented use of juniper berries comes from ancient Egypt, as far back as 1500 BCE, where it was used as a remedy to cure tapeworm infestations; as well as serving in the embalming process (Manniche, 1999). The Egyptians most likely obtained their juniper, which is not native to Egypt, from the Greeks who used it as a medicine and stamina enhancer, for which it is closely associated with usage in the ancient Olympic games (Lorman, 1997). In the Middle Ages juniper berries found use as a cure for flatulence, something for which juniper oil is still utilized for today (GinFoundry, 2014). Culinary uses for juniper date back to the time of the Roman Empire, where dried berries were used as a locally produced, and thus cheap, substitute for expensive black pepper imported from India. This legacy can be still be seen today in the British Highlands where ground juniper berries are sometimes added to game dishes to impart a bitter, spicy flavor (Dalby, 2002). Perhaps the most intriguing cultural uses of Juniper come from Iceland, where the wood, which produces a pleasing aroma while giving off little smoke, was used in springtime renewal rituals and to purify sacred spaces (GinFoundry, 2014). In North America, several Native American groups used juniper for medicinal purposes; the tribes of the Great Basin in Nevada made a blood tonic out of juniper, while native tribes in the Pacific Northwest created tonics from the branches to treat colds, muscle aches, and kidney ailments (Tirmenstein, 1999). Today, the most widely known use for juniper is as the primary flavoring agent in gin. British, French, and Dutch laws require that juniper is the only primary botanical used to flavor beverages that are

classified as gin (Wong, 2014). While it was the Dutch that first developed the technique of using ripe juniper berries to flavor the beverage we now know as gin, it has subsequently become known as a primarily British interest (GinFoundry, 2014). Although juniper populations worldwide are not threatened, declining production and widespread disease in the wild population of Great Britain have dramatically reduced the juniper populations. Populations in Scotland, where the majority of wild juniper berries are traditionally harvested for British-made gin, have been devastated by the spread of the fungal disease *Phytophthora austrocedrea* (Alexander, 2015).

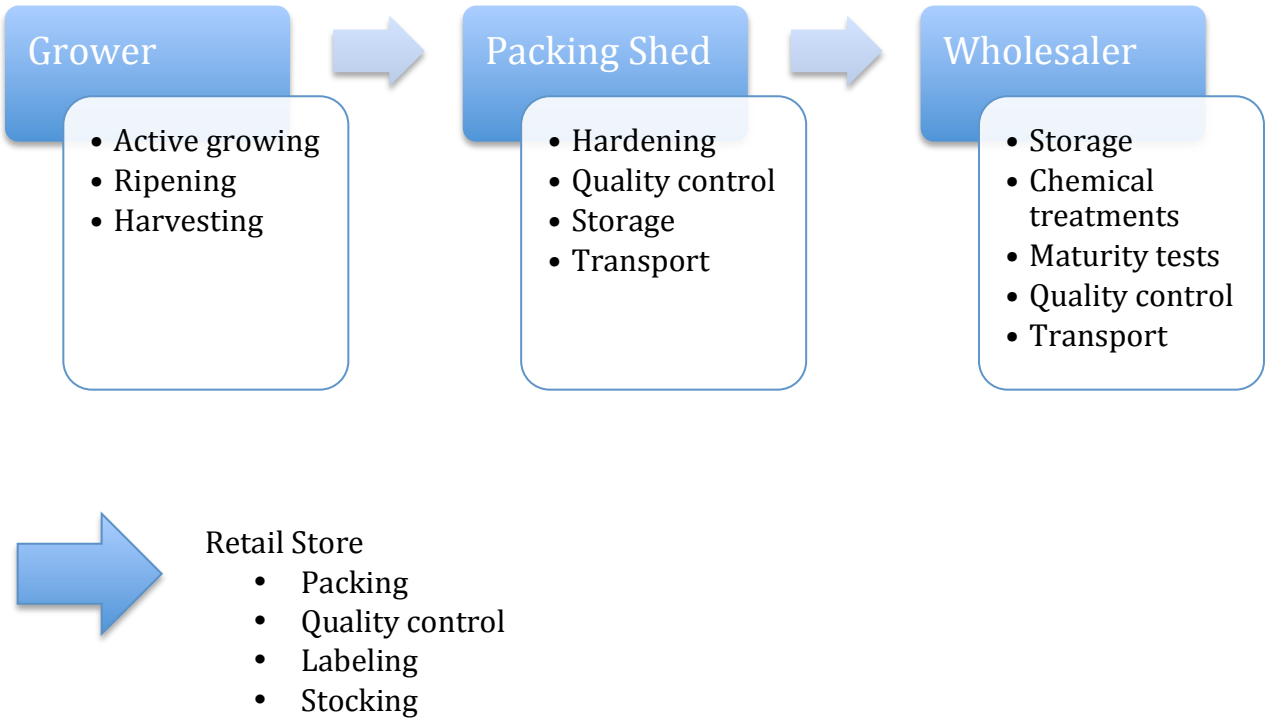
Figure 3. Juniper berry collection (GinFoundry, 2014).

Figure 4: Ripe juniper berries ready for processing (GinFoundry, 2014).

As the species is dioecis, scion grafting was first used in the British Isles to propagate favorable trees for berry production (Janick, 2005). Widely cultivated in the horticulture trade, *J. communis* has three cultivars that have gained the Royal Horticultural Society's Award of Garden Merit: 'Hibernic,' 'Hornibrookii,' and 'Repanda' (Royal Horticultural Society, 2015).

The horticultural distribution chain for *J. communis* in ornamental stock is relatively localized in comparison with many greenhouse and/or herbaceous crops. This can be attributed to the importance of progeny in juniper nursery production and distribution (Zeidler, 2003). The success of a nurseries juniper stock depends on its ability to survive once it is sold and planted; thus local retailers often try to source their stock from nurseries that are as close as possible.

Figure 5. Horticultural Distribution Chain for *Juniperus communis.*



III. Current Production Practices

A. Production

In the general nursery trade, production from seed is a rarity for *J. communis* as germination rates are low, long, and often highly variable (Figure 7). However, as a dioecious species there can be a large amount of genetic variation within a wild population. This allows for many combinations of genetic material from various parents that may provide succeeding generations with greater potential to thrive in changing environmental conditions (Broome, 2003). Thus, it is necessary for some growers to propagate from seed. Juniper seeds are dormant and require stratification to germinate (McCartan & Gosling, 2013). McCartan and Gosling (2013) go on to to describe the steps for germinating seeds, which often require alternating warm and cold periods.

Figure 6. Production From Seed

1. •Sow seeds in trays containing moistened potting medium and then cover.
•Take care not to sow seeds too densely as it will make pricking out the seedlings difficult.
•Place potting trays in loosely tied plastic bags.
•This will reduce water loss, but also allow for proper ventilation.

2. •Transfer trays to an incubator and set to an alternating 10/15 *C for two weeks or more.
•Extending this warming phase can enable more seeds to germinate.

3. •Transfer trays to a refrigerated unit (4*C) for 18-20 weeks.
•The seedlings will then emerge when moved to temperatures above 10*C.

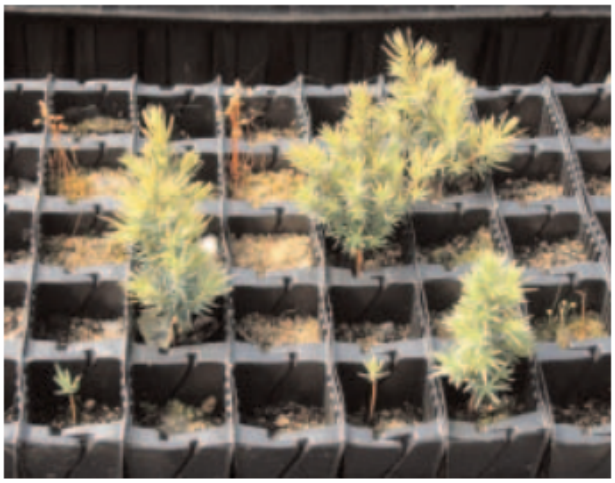


Figure 7. Juniper germination is slow and unpredictable; these seedlings sown at the same time are one year old, and one week old (Broome, 2003).

Producing juniper plants from seed is not easy. The variability in germination time is considered to be an ecological adaptation, deriving from *J. communis'* vast range over largely harsh and unpredictable environments (Broome, 2003). This is why most growers choose to propagate plants from stem cuttings. Taking cuttings is by far the quickest and

most successful method of propagating juniper. Plantable seedlings can be produced from vegetative propagation in two years, as opposed to the four years needed to produce plantable stock from seed (Broome, 2003). Mark Mejerus from the USDA Natural Resources Conservation Service, Plant Materials Program, outlines how to propagate common juniper vegetatively from cuttings:

Collection:

Collect 6-8 inch cuttings in early August back to 2nd year wood with a diameter of at least 0.25 inches. Always store cuttings in a cool place with high humidity, and try to minimize pre-planting storage time.

Pre-Planting:

Trim cuttings to a 5-6 inch length, then recut base of each cutting at an angle, wounding the basal end of each stem.

Growing Area:

Any sterile, highly drained media such as sand, vermiculite, or perlite should be adequate. Moisten the media and make holes to place each cutting. Use hot water to maintain the propagation media at 21°C (70 °F) during the root initiation phase, the first 12-16 weeks. Intermittent misting from a 'Mist-o-Matic,' controller will ensure proper hydration during this stage. Maintain greenhouse at 21-24* C during the day and 15-18* C at night. Photoperiods should be 14-16 hours.

Establishment Phase:

Cuttings initiate roots within 12-16 weeks, and develop well rooted systems after 24 weeks. Fertilize the cuttings twice a week with 150-250 ppm of (9-45-15 fertilizer) as soon as bud break occurs. Length of active growing phase is between 4 and 6 months depending on desired size of root ball when transferring to pots for next phase.

Hardening Phase:

Hardening phase begins when natural dormancy would be taking place. No fertilizer is applied during this phase. Irrigation frequency and duration is shortened and applied only when needed. The hardening off phase should last 2 months.

Harvesting, Storage, and Shipping:

Lift seedlings while they are still dormant and undercut at a depth of 10-12 inches. Transfer to appropriate sized pots filled with a peat-lite mix. Store in a cooler between 2-5* C at a relative humidity of 92-98% with good air circulation. (Scianna, 2003).

The primary customer base for this type of propagation are commercial nurseries who will then take the rooted stock and grow it for another 1-3 years before selling it to other whole sale nurseries or directly to consumers (Zeidler, 2003). The use of controlled environment structures, such as a green house, for this type of propagation is advisable when a grower desires to move from the establishment phase to a salable product in under 2 years. Otherwise, growing from seed or stock can be done in a greenhouse until the establishment phase, at which point seedlings can be moved outdoors. However, the environments in which juniper naturally grows will necessitate more care and protection

from inclement weather conditions in addition to a longer active growing phase (Scianna, 2003).

IV. Current Production Statistics

A. Current Production Information

Current production information for *J. communis* is, unfortunately, not available. The USDA Nursery Crops Summary Report from 2007, the most recent national horticultural production statistics for nursery crops, only delineates to the level of coniferous evergreen producers, sold quantities, gross sales, and percent of sales at wholesale by state – from the years 2003 to 2006. It also notes the number of coniferous evergreens sold by form: bare root, balled and burlap, container, and other, by state, from the years 2003 to 2006 (USDA, 2007). "In general, coniferous evergreens are the fourth largest sales category with gross sales of $562 million, 27 percent grater than 3 years earlier, and 12 percent of the 17 state total. Oregon led the category, with 32 percent of sales, followed by California with 12 percent, and Florida with 6 percent. Arborvitae, balled and burlapped Christmas trees, cedar, fir, pine, and other coniferous evergreens make up this category" (USDA, 2007).

Gin is a popular spirit worldwide and its production represents a significant usage of juniper. *Euromoniter* estimated that in 2012, 274.8 million liters of gin were produced globally (ginvodka.org, 2015). Premium brands, mostly produced in the UK, have established footholds in all global markets, but it is the locally produced brands that make up the bulk of sales, with nearly 80% of worldwide sales. This trend is most clearly reflected in The Philippines, the worlds largest gin market with over 50 million cases produced annually, where 98% of sales are generated by local brands (ginvodka.org, 2015).

Of this, 62% of sales were from the Philippine brand San Miguel, which is aggressively marketed to the local population. Globally locally produced Philippine gin represents about 43% of the world market (ginvodka.org, 2015). After The Philippines the United States makes up the second largest market with 10.3 million, 9-liter cases sold in 2013, which represents a value of $866 million (ginvodka.org, 2015). The US is also the largest importer of premium brand gins, some of which is distilled in the US itself (ginvodka.org, 2015).

B. Important Cultivars on the Market

There are several important *J. communis* cultivars currently available on the market. For the purposes of this review the selection has been narrowed down to six widely available cultivars.

'Corielagen' – Form: prostrate, USDA Zone: 3, Rate: intermediate, Color: green Description: Fine, feathery foliage covers the long and flexible branches of this Scottish juniper. Stems reach out in all directions, carpeting the ground and conforming to contours. Hardy, less formal, and faster growing than the 'Green Carpet.'

'Effusa' – Form: spreading, Zone: 3, Rate: intermediate, Color: green, Description: This low, spreading juniper grows into a reliable circular form that adapts to most gardens, even in shady locations. Its small needles grow close to the flexible, reddish stems, which show off soft, brown tips that mature into bright green as the season progresses.

'Gold Cone' – Form: narrow upright, Zone: 4, Rate: Dwarf, Color: Yellow, Description: The bright yellow foliage of this upright juniper illuminates the garden, especially in the winter months. The narrow, columnar form and brilliant color make 'Gold Cone' a superb accent in many types of garden. It responds well to shearing to achieve a denser, narrower form. It reaches its best color in full sun.

'Green Carpet' – Form: prostrate, Zone: 4, Rate: intermediate, Color: green Description: The bright green, spring growth on this densely textured, ground-covering juniper darkens as it matures into a thick carpet. The tidy, compact plant is extremely hardy and adaptable to a wide range of soil and climate conditions. It takes several years to fully cover the ground.

'Miniature' – Form: narrow upright, Zone: 4, Rate: dwarf, Color: Green, Description: More durable, adaptable, and dense than the widely popular 'Compressa,' this improved selection offers the same compact, bluish-green foliage and upright habit. It differs, though, in its broader pyramidal shape and its better tolerance to wind, cold, and reflected winter sun.

'Depressa' – Form: prostrate, Zone: 3-4, Rate: dwarf, Color: green, Description: Spreading shrub, with trailing branches ascending stiffly at the tips, this juniper often forms circular mats several yards in diameter. Whorled awl shaped needles, forming sharp points. The foliage is gray-green to blue-green in summer, sometimes assuming a yellow or brownish cast in winter (Iseli Nursery, 2015; Lady Bird Johnson Wildflower Center, 2014).

V. Proposed Crop Production Changes for the Future

A. Production Changes

Efforts to transform current production practices of juniper to a more sustainable model should be balanced with trying to restore native juniper ecosystems. *Juniperus communis* is a hardy species that can thrive in dry, exposed sites where other plants struggle to become established; this should be considered when trying to restore native sites and revamp current production methods (Tirmenstein, 1999). Some of the most successful juniper germination models require greenhouse propagation and, thus, methods

that use significantly more resources than field propagation, notably water and electricity (Scianna, 2003). To create a more sustainable model of juniper propagation, growers should revert to field-grown methods that play to the strengths of junipers natural hardiness; this may make it possible to meet crop production needs and restoration planting needs (Cregg, 1994). Propagating juniper in controlled environment structures speeds up the time from planting to producing a saleable crop, but it needs to be more sustainable. There are several field propagation methods, which may be used in tandem, that use the harsh growing conditions of juniper to their advantage, the tradeoff is the time taken to produce a crop. Sowing seeds in fields and then covering them with plastic to retain heat and moisture has been successful in producing 'good' germination rates in rocky mountain juniper, *Juniperus scopulorum*, and eastern red cedar, *J. virginiana*; perhaps these methods can be used to propagate *J. communis* (Cregg, 1994; Meines, 1965). It may also be possible to combine field and greenhouse methods, moving greenhouse grown cuttings into outdoor sand/gravel beds for the active growth phase. This combination method would produce hardy stock that could be used for establishing restoration plots. Studies have shown that *J. communis* has a 'high value' for long-term restoration of disturbed sites, particularly in preventing soil erosion (Tirmenstein, 1999). Admittedly, this method would take longer and might not be economically viable for mass nursery production, most likely the production costs would make saleable stock too expensive.

While common juniper is already known as a drought-tolerant, tough-site species it could be possible to use another of its features to produce even more adaptive cultivars. As stated before, the dioecious nature of *J. communis* allows for a wide variety of genetic combinations; perhaps crosses between *J. communis* and other hardy junipers could lead to

cultivars that would thrive in water stressed areas where other plant species have difficulty establishing. There are a number of other juniper species, e.g. alligator juniper, *Juniperus deppeana*, one seed juniper, *Juniperus monosperma*, and rocky mountain juniper, *Juniperus scopulorum*, that thrive in the US Southwest, and the Great Basin, incredibly harsh growing environments where water is scarce temperatures can fluctuate wildly (Cregg, 1994). By crossing these species with *J. communis* it might be possible to bring much needed green space into droughty areas without overusing already stressed water supplies.

Another consideration in rethinking the use of juniper is the potential for utilizing its berries for the production of spirits directly by consumers. The rise of home brewing and boutique spirit production opens a new market avenue for juniper berries, both fresh and dried. There is already a variety of home gin making kits available on the market today. Companies like Williams-Sonoma and The Homemade Gin Kit provide full service, do-it-yourself kits (Figure 8) as well as a wide variety of juniper berry and herbal blend mixes to create custom gins at home (Figure 9) (Williams-Sonoma; The Homemade Gin Kit, 2015). There is also the potential for the foraging of wild juniper 'berries,' as an added allure to making homemade gin. Where it would be very difficult for amateur brewers to grow their own grains for beer production in sufficient quantity and quality at home, the foraging for wild juniper berries offers a chance to produce a homemade concoction that is truly do-it-yourself while reconnecting with nature in a profound way by utilizing its bounty directly.

Figure 8. An examples home gin-making kit (Williams-Sonoma, 2015).

Figure 9. An additional home-making gin kit currently available on the market (The Homemade Gin Kit, 2015).

VI. New Production Schedule

As noted in section III, producing juniper stock from seed is a difficult and lengthy ordeal, therefore the new methods for production will also start with cuttings. Greenhouse culture will also increase propagation success. Both of these methods will be employed in the new production schedule, however, they will be altered to improve production rates and overall sustainability. Another important change in this new model is the focus on propagating prostrate rather than upright forms. Species that grow upright are considered more difficult to proliferate than prostrate forms, and despite obvious concerns about

dense foliage and close packing leading to outbreaks of disease it has been shown that this type of propagation can be carried out successfully (Edson, 1996). Along with ease of propagation the emphasis on producing a prostrate form of juniper is consumer driven as well. As noted in the previous section, plants that can thrive in drought stricken areas are favorable for a changing climate and a juniper cultivar that is adapted to these conditions has the potential to be a popular yard and landscape plant in areas where efficient water use is necessary. Included in the production schedule are two different active growing phases; the first will produce plantable stock in a little over a year, while the second will extend the active growing phase simply to yield a larger plant. Junipers are slow growing and it is expected that some consumers will opt for a larger, more mature plant to fill out their yard or landscape faster, and will pay extra for the option.

Collection of cuttings:

The prostrate cultivars 'Depressa', 'Green Carpet', 'Effusa', or 'Corielagen' could be used in this schedule. Collect 6-8 inch cuttings taken from 2-5 year old plants that were container grown, vegetatively propagated 'daughter' plants, which have shown to produce better root systems than cuttings taken from field grown stock (Edson, 1996). This methods allows for the direct transplant of cuttings into 12.7 cm deep plug trays and so avoids the challenges associated with keeping cuttings from field grown stock cool and moist during the collection process.

Pre Planting:

Trim the cutting to a 5-6 inch length, and then recut the base of each cutting at an angle, wounding the basal end of each stem. **The cutting should then then be dipped in a commercial auxin formula to promote faster rooting.**

Growing Area:

Vermiculite or perlite should be the desired growing media. Moisten the media and make holes to place each cutting. Use hot water to maintain the propagation media at 21* C during the root initiation phase, **the first 8-10 weeks**. Intermittent misting from a 'Mist-o-Matic,' controller will ensure proper hydration during this stage. **To ensure efficient water use a recirculating hydration system should be utilized throughout the growing process.** Maintain greenhouse at 21-24 °C during the day and 15-18 °C at night. Photoperiods should be 14-16 hours.

Establishment Phase:

Cuttings should initiate roots within 8-10 weeks, and well-developed root systems should be present after 16 weeks. Fertilize the cuttings twice a week with 150-250 ppm of (9-45-15 fertilizer) as soon as bud break occurs, **approximately 10 weeks**. **This stage will last approximately 4 months.**

Active Growing Phase:

After 4 months cuttings should be between 10-12 cm (3.9-4.7") tall. When this size is reached transplant the stock to 4-L pots and fertilize twice a week with 20:20:20 (N/P/K) for an additional 6 months. At 10 months the juniper stock is ready for two months of hardening off, and then sale ready.

Alternatively, the 10-month-old stock can be transplanted to 8-L pots for another 6 months, during which time the stock should be fertilized with the same 20:20:20

formula as before. By this point in the growing process the recumbent form of the juniper stock will make spacing an issue, but individual plants crowding one another is not a concern if proper sanitation protocols are followed.

Hardening Phase:

Propagation in a controlled environment, such as a greenhouse, gives the grower the opportunity to bypass the dormancy period that would take hold of field grown stock during the first year. The hardening off phase beings when natural dormancy during the second season would be taking place. No fertilizer is applied during this phase. Irrigation frequency and duration is shortened and applied only when needed. **The hardening off phase should last approximately 2 months.**

Harvesting, Storage, and Shipping:

The 12 and 18 month old plants can be kept in their containers, 4 and 8 liter pots respectively, for storage and shipping. They should be stored in a cooler between 2-5* C at a relative humidity of 92-98%, sufficient air circulation is necessary. At this point the stock can be sold to other commercial nurseries that can choose to continue growing the junipers for increased size and spread, however, this production schedule is designed to provide yard-ready stock for direct consumer consumption.

VII. Crop Ideotype

The diversity amongst juniper species allows for consumers to be selective when choosing which plant is right for their landscape needs. However, global climate change and limited water reserves restrict the types of plant species consumers living in an

increasing number of arid, drought stricken areas can choose from. Junipers can provide much needed green space in these regions while conforming to droughty conditions. To this end, the juniper crop ideotype put forth here is the ideal phenotype for areas afflicted by drought and those with limited water supplies such as southern California and the South West. To meet the needs of a changing climate and limited water supplies seven traits have been identified that if incorporated together could produce a marketable juniper ideotype. (1.) The first and most important trait is drought tolerance, an obvious necessity for plants being utilized in dry regions. (2.) Shade tolerance, as well as the ability to grow in the full sun, a common occurrence in droughty areas. Many juniper species are naturally shade tolerant, especially when young, but can also thrive in full sun, an adaptation necessary for living in the harsh, exposed climates within *J. communis*' native range. This trait is also important in regards to consumer desirability for the new ideotype; with fewer yard/landscape plants to choose from consumers want species that can thrive at any spot in the yard. (3.) Cultivating a prostrate form juniper is not only easier for propagation, once placed in the landscape they require less water and are more efficient at utilizing the water they receive. Prostrate forms require less moisture for survival than upright species, and because their low, spreading branches shelter the soil water that falls from above (rain or watering from a hose) is shaded from the hot sun and thus less likely to evaporate before saturating the soil and being taken up by the plant. (4.) Procumbent branching is already a trait of horizontal juniper forms, but by selecting for enhanced procumbent branching the new plant ideotype will be more aesthetically appealing, as well as using available water more efficiently. (5.) An increased growth rate would cut down on the time juniper stock, naturally a slow growing genus, would take to become sale/yard ready. This means an

increase in the cost effectiveness of the crop for growers, a potentially lower price point for consumers, and a shorter active growing time implies a more water efficient system. (6.) Sterile plants or production of only male stock could be important for keeping the new ideotype from becoming an invasive or noxious species, especially in harsh/droughty environments where this new juniper cultivar could potentially escape domestication and outcompete native species. (7.) Reducing the genetic variation of the final ideal cultivar will help ensure all of the desirable phenotypes will be present during mass production of the juniper ideotype.

There are some distinct challenges ahead of making a new juniper ideotype. First and foremost of which is junipers ability to become invasive or perform like an invasive species, even in areas where it is native. Western juniper (*Juniperus occidentalis*) and eastern red cedar (*Juniperus virginiana*) have already proven to be invasive, or have invasive tendencies, within their native ranges (USDA, 2011). In eastern Oregon western juniper has expanded its range by over 9 million acres, as illustrated in the following figures 10 & 11. Western juniper is often found in fire dependent ecosystems where it is periodically burned away allowing for the proliferation of other native species. However, a century of intense fire suppression and an increasingly dry climate have allowed *J. occidentalis* to expand its range dramatically. Its low, spreading form, combined with its resistance to droughty, harsh conditions, and its notable longevity have led it to outcompete other species (sustainablenorthwest.org, 2015).

Figure 10: Photograph from 1890 showing a hillside sparsely populated by western juniper at the Keystone Ranch in eastern Oregon (Sustainablenorthwest.org, 2015).

Figure 11: Photograph from 1990 showing the same hillside at the Keystone Ranch that is now completely dominated by western juniper (Sustainablenorthwest.org, 2015).

Avoiding the excess proliferation of juniper in the regions where the crop ideotype would be marketed is of great concern. To ensure the ideotype does not escape domestication it may be possible to breed a sterile cultivar. This may prove difficult and so it may be easier to instead select for male plants. Once planted it is possible that the male-

only junipers will cross-pollinate with native female junipers. However, this is unlikely unless the new junipers are planted within close proximity to existing female plants. A simple solution would be to instruct distributors to give ample warning to consumers in areas where cross-pollination could potentially be an issue.

Another hurdle for creating this juniper ideotype is the extremely slow growth rates seen in most juniper species, a trait often possessed by long-lived species. There is only so much that can be done on this front, but by breeding with relatively faster growing cultivars like 'Corielagen,' and selecting the faster rooting/growing individuals from within those trials a faster growing juniper cultivar may be produced. Increasing growth rates or forcing maturity has always been a goal within the nursery trade, and there are still significant gaps in our understanding of how such a goal could be accomplished, more research would be needed. As noted before, accelerating growth rates would improve cost effectiveness and end up being beneficial for growers and consumers alike.

To achieve desired phenotypic traits like drought tolerance, prostrate forms, procumbent branching, and shade/full sun tolerance plant breeders need only to look within the cannon of juniper cultivars that already exist in the market. The challenge is breeding them all into the phenotype of one plant. Breeding trials would be necessary to funnel these traits into a single cultivar. As many juniper species are more shade tolerant during immaturity it is possible that maximum performance in the landscape would require a longer growing time in the nursery to fully develop shade/full sun tolerance. Developing cultivars that can withstand droughty conditions and thrive in poor soils is essential for maintaining green space in areas devastated by ongoing climate change and inadequate access to water. For many of these unfortunate regions the problems posed by

climate change will only continue to worsen; finding plants that can adapt to these adverse and evolving conditions is important for maintaining a full quality of life.

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Literature Cited

Alexander, Saffron. 2015. Fungal Disease Threatens Gin Production. The Telegraph Online http://www.telegraph.co.uk/food-and-drink/news/gin-crisis/

Broome, Alice. 2003. Growing Juniper: Propagation and Establishment Practices. UK Forestry Commission. Edinburgh. Crown Copyright http://www.forestry.gov.uk/pdf/FCIN050.pdf/$FILE/FCIN050.pdf

Botanicals: Juniper. 2014. The Gin Foundry. http://www.ginfoundry.com/botanicals/juniper/

Cregg, B., Lee, S., Hovland, T., Fleege, C., Gleason, J. 1994. Propagation of Juniper for Conservation Planting. National Nursery Proceedings. Access: Restoration, Nurseries, & Genetic Resources (RNGR) Database. http://www.rngr.net/publications/proceedings/1994/cregg.pdf/?searchterm=juniper

Edson, J. Wenny, D. Leege-Brusven, A. 1996. Mass Propagation of Rocky Mountain Juniper From Shoot Tip Cuttings. Tree Planters Notes. Vol. 47, No. 3. . Access: Restoration, Nurseries, & Genetic Resources (RNGR) Database. http://www.rngr.net/publications/tpn/47-3/mass-propagation-of-rocky-mountain-juniper-from-shoot-tip-cuttings/?searchterm=juniper

Dalby, A. 1997. Siren Feasts: A History of Food and Gastronomy in Greece. Routledge Press.

Dalby, A. 2002. Dangerous Tastes: The Story of Spices. University of California Press.

Gin Making Kit. 2015. Williams-Sonoma http://www.williams-sonoma.com/products/gin-making-kit/

Gin Market Global Picture. 2015. Gin & Vodka. http://www.ginvodka.org/factsheets/Gin_Market_Global_Picture.asp

Gosling, P. McCartan, S. 2013. Guidelines for Seed Collection and Stratification of Common Juniper. Tree Planters Notes. Vol. 56, Issue 1. Access: Restoration, Nurseries, & Genetic Resources (RNGR) Database. file:///Users/colinmckeon/Downloads/Guidelines%20for%20Seed%20Collection%20and%20Stratification%20of%20Common%20Juniper.pdf

'Hibernica,' 'Hornibrookii,' 'Repanda." 2015. RHS Plant Selector. Royal Horticultural Society. https://www.rhs.org.uk/plants/details?plantid=1075 https://www.rhs.org.uk/plants/details?plantid=1076 https://www.rhs.org.uk/plants/details?plantid=1077

J. J. 2005. The Origins of Fruits, Fruit Growing, and Fruit Breeding. Plant Breeding Review. Issue 25 (255-320). https://hort.purdue.edu/newcrop/origins%20of%20fruits.pdf

Manniche, L. 1999. Sacred Luxuries: Fragrance, Aromatherapy, and Cosmetics in Ancient Egypt. Cornell University Press.

Meines, M.K. 1965. Juniper Germination Simplified. Tree Planters Notes. Issue No. 70

Access: Restoration, Nurseries, & Genetic Resources (RNGR) Database. http://www.rngr.net/publications/tpn/16-1/pdf.2005-05-09.0920109236/?searchterm=juniper

Scianna, J. 2003. Propagation protocol for production of Container (plug) *Juniperus communis* L. plants 4.5-inch azalea pots. USDA NRCS - Bridger Plant Materials Center Bridger, Montana. http://www.rngr.net/npn/propagation/protocols/cupressaceae-juniperus-2777/?searchterm=juniper

The Homemade Gin Kit. 2015. Homemade Gin. http://www.homemadegin.com/collections/all-products

Tirmenstein, D. 1999. Juniperus communis. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

United States Department of Agriculture. 2007. Nursery Crops 2006 Summary. National Agricultural Statistics Service. http://usda.mannlib.cornell.edu/usda/current/NursProd/NursProd-09-26-2007.pdf

Western Juniper. 2015. Sustainable Northwest. http://sustainablenorthwest.org/what-we-do/success-stories/western-juniper

Wong, T. 2014. Foraged Flavor: All About Juniper. Serious Eats. http://www.seriouseats.com/2014/01/foraged-flavor-all-about-wild-juniper.html

Zeidler, S., Justin, J. 2003. Propagation Protocol for Production of Bareroot, Field Grown Juniper. Native Plant Network. Access: Restoration, Nurseries, & Genetic Resources (RNGR) Database. http://www.rngr.net/npn/propagation/protocols/cupressaceae-juniperus-2674/?searchterm=juniper