

**Hops: An Economic Assessment of the Feasibility  
of Providing Multiple-Peril Crop Insurance**

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## Executive Summary

U.S. growers harvested more than 42,000 acres of hops in 1994 and produced a crop of nearly 75 million pounds, about 28 percent of world output. The farm value of U.S. production was \$135 million. Acreage and production increased 50 percent between 1985 and 1994.

The Census of Agriculture reports 133 farms with 40,549 acres of hops in 1992. Hop production is concentrated in the Yakima Valley of eastern Washington, the Willamette Valley of Oregon, and in two areas of Idaho, Canyon County in southwestern Idaho and Boundary County in northern Idaho. The latter region has just one large grower. The average hop acreage per farm exceeds 300 acres. The majority of farms are family owned and operated, although at least one brewery and one large dealer have hop-growing operations.

Because of economies of size in hop picking and processing (drying), hop farms tend to be large operations or to be associated with a large operation. Sometimes, several family members have separate hop farming operations, but use a common picking and processing facility.

Hops are used in the manufacture of beer and other fermented malt beverages, such as ale, stout, and porter, where they contribute the bitter taste and other distinctive flavors. Although hops have potential pharmaceutical uses, they have been replaced by penicillium and synthetic compounds.

The commercial hop plant produces climbing annual stems (or vines) from a perennial crown and rootstock. The vines grow rapidly, reaching 20 to 25 feet in a single season. Although the plant dies back to the crown at maturity, the live vines are cut away from the roots at harvest-time in commercial production.

Mature hop cones are 1 to 4 inches long. They are oblong, yellowish-green in color, and papery to the touch. The bracteoles and seeds bear numerous yellowish, glandular bodies called lupulin. The lupulin contain the resins and essential oils that provide flavoring for beer and other malt beverages. The mature cones, after drying, constitute the hops used commercially.

Two bittering compounds have been isolated from the lupulin, identified as alpha acid and beta acid. The alpha acid is the more important of the two components, providing greater bittering effect than does the beta acid. In addition to the bittering effect, hops contain a number of essential oils that impart the unique non-bitter flavor and aroma to beer.

Some varieties, known as aroma hops, are grown primarily for their aroma properties, while others (alpha hops) are grown mainly for their bittering effect. A total of 42,412 acres were harvested in 1994, split roughly 60:40 between bitter and aroma hops. There has been a swing toward production of aroma hops in the last decade: in 1985, the ratio between bitter and aroma hop acreage stood at 75:25.

The United States is the world's largest producer of beer, and as such, it is the most significant user of hops. Although average hopping rates (pounds of

hops per 31-gallon barrel of beer) vary from country to country, the U.S. rate averages about 0.2. The U.S. rate has decline over the past 10 years due to the increased use of high alpha hops.

The season average price received by growers for hops, as reported by USDA, is relatively constant from year to year, ranging between about \$1.40 and \$2.10 a pound for the 1980-94 seasons. This relative stability in season average prices masks extreme variability in the cash (spot) market. Because a very high percentage of hops are contracted, with some contracted up to five years in advance of harvest, as little as 2-5 percent of output is marketed as spot hops.

Hops are sold to dealers (also called merchants), who represent multinational firms that also operate hop extract or processing plants in the U.S. and abroad. Historically, growers and merchants were separately owned and managed, although in recent years, some merchants have purchased hop farms. The larger U.S. dealers also handle the bulk of hop imports. Of the seven dealers, six are owned by European firms.

Trellis collapse is one of the most frequently-cited production perils. A collapse occurs when one or more of the poles snap or break, causing the wires to sag and permitting the vines to slump to the ground. The danger of collapse increases after about August 1, when the mature vines place the greatest weight on the trellis. Heavy dew or rain adds to vine weight, further increasing stress on the trellis.

Excessive moisture is a hazard to hop production because it increases the incidence of mildew. Rain-related mildew is a more serious concern in Oregon than in either Washington or Idaho. Oregon's hops are grown in the Willamette Valley west of the Cascade Mountain range, and experience rainy periods more frequently than the areas east of the Cascades, including the Yakima Valley and southwestern Idaho. The incidence of mildew infections increase rapidly during wet weather.

As a practical matter, drought is not a production peril because all U.S. hop production is irrigated. Hops have a high water requirement, however, and a lack of sufficient irrigation water would result in low yields.

It is our assessment that there will not be significant demand for Federal crop insurance for hops in most areas, particularly for coverage beyond the minimum catastrophic coverage level. Several private companies already offer coverage tailored to the crop's needs, and unless growers could buy equivalent or superior coverage at a lower cost, they are likely to retain their private insurance coverage.

Growers in Oregon, however, specifically indicated that they would like for hops to be a Federally-insured crop so they could qualify for catastrophic coverage. They feel that they would never have area losses large enough to trigger payments under the Non-insured Assistance Program, but that individual growers might incur losses large enough to collect under catastrophic coverage.

## **Hops: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance**

### **Introduction**

From colonial times, hops have been grown in virtually every region of the United States. Commercial culture moved westward during the latter half of the 19th century, driven out of prime growing regions, including New York and Wisconsin, by insects and diseases. The hops industry in the West initially settled in California and Oregon, with production expanding into Washington and Idaho in the 1930's.

Hop production in the 1990's is concentrated in the Yakima Valley of eastern Washington, the Willamette Valley of Oregon, and in two areas of Idaho; Canyon County in southwestern Idaho, and Boundary County in northern Idaho. The latter region has just one large grower.

Hops are used in the manufacture of beer and other fermented malt beverages, such as ale, stout, and porter, where they contribute the bitter taste and other distinctive flavors. Although hops have potential pharmaceutical uses, they have been replaced by penicillium and synthetic compounds (Haunold).

This report provides background information concerning hop production in the United States, and examines the feasibility of developing multiple-peril insurance for hops.

### **The Hop Plant**

The commercial hop plant produces climbing annual stems (or vines) from a perennial crown and rootstock. The vines grow rapidly, reaching 20 to 25 feet in a single season. Although the plant dies back to the crown at maturity, the live vines are cut away from the roots at harvest-time in commercial production. The vines always twine around their support in a clockwise direction.

Hop plants have an extensive root system that may penetrate the soil to a depth of 15 feet or more. In addition to true roots and aerial stems, the crown also produces underground rhizomes. The rhizomes possess numerous buds and are used for propagation.

Hop plants are generally unisexual, producing either male or female flowers. Only the female plants produce the hops of commerce. The female flowers are borne in clusters on the upper part of the main stem and on its side-arms. As the flower matures, it forms a cone-like structure (called cones) composed of a central stem that bears many bracts and bracteoles (small, scale-like leaves).

## **Hop Cones**

Mature hop cones are 1 to 4 inches long. They are oblong, yellowish-green in color, and papery to the touch. The bracteoles and seeds bear numerous yellowish, glandular bodies called lupulin. The lupulin contain the resins and essential oils that provide flavoring for beer and other malt beverages. The mature cones, after drying, constitute the hops used commercially.

Hops are either seedless or seeded. Seeded hops result when the female flowers are fertilized by pollen from male plants. Seedless hops result when pollination and subsequent seed formation are prevented by the elimination of all male plants in the area.

In general, seeded hops are larger and heavier than seedless hops. However, brewers feel that seeds in hops are undesirable. Further, seedless hops tend to shatter less during picking than do seeded hops. Seedless production predominates today because brewers pay a premium price for seedless hops.

## **Hop Flavors**

The characteristic hop aroma and bitter taste important in brewing are attributed to the combination of essential oils and resins contained in the lupulin. Two bittering compounds have been isolated from the lupulin. They are identified as alpha acid, or simply "alpha," and beta acid. The alpha acid is the more important of the two components, providing greater bittering effect than does the beta acid (Nickerson).

In addition to the bittering effect, hops contain a number of essential oils that impart the unique non-bitter flavor and aroma to beer. Some varieties, known as aroma hops, are grown primarily for their aroma properties, while others (the alpha hops) are grown primarily for their bittering effect.

## **Hop Varieties**

Numerous hops varieties have been developed that exhibit superior disease resistance, high yields, high alpha percent, superior storage stability, distinctive aroma, or combinations of these traits. The following discussion provides a brief description of selected important cultivars. Selected characteristics of some of the important varieties are summarized in Table 1. Galena, Cluster, Willamette, and Nugget accounted for the largest acreages in 1994 (Table 2).

### Cluster

Growers cultivated a hop cultivar known as "Pacific Coast Cluster" before 1900, which is thought to have been the result of a North American-European hop hybridization. A number of clones selected from this original variety are still grown today and are referred to as the cultivar "Cluster." As recently as 1980, 55 percent of the hop acreage in the U.S. was planted with Cluster.

Table 1--U.S. hops: variety characteristics

Variety	Maturity group	Average yield (pounds/acre)	Average alpha (%)
Cluster types:			
Bates	Extra early	1,500-1,800	7-9
Rivard	Extra early	1,500-1,800	7-9
Old Early	Early	1,500-1,800	6-8
E-2	Early	1,800-2,000	7-9
L-1	Early medium	1,900-2,200	7-9
Old late	Late	1,500-1,800	6-8
L-8	Late	2,000-2,300	7-9
Talisman	Very late	2,000-2,300	7-9
High alpha acid or extract types:			
Galena	Medium	1,600-2,000	12-14
Olympic	Medium	2,200-2,600	12-14
Bullion	Medium to late	2,000-2,400	8-10
Brewer's Gold	Medium to late	1,600-2,000	8-10
Comet	Medium Late	1,600-2,000	8-10
Nugget	Late	2,200-2,600	12-14
Eroica	Very late	2,200-2,600	11-13
Aroma types:			
Fuggle aroma--			
Fuggle	Early	1,200-1,500	4-6
Columbia	Early	1,400-1,600	8-10
Willamette	Early	1,400-1,600	6-8
Continental Aroma--			
Tettnanger	Early	1,200-1,500	4-6
Hallertauer	Early	1,200-1,500	4-5
Hersbrucker	Early	1,000-1,300	4-6
Perle	Early	1,400-1,600	7-9
Floral Aroma--			
Cascade	Early to medium	1,900-2,100	5-7
Dual purpose, Aroma and high alpha acid:			
Chinook	Early to medium	2,200-2,600	12-14

Source: Washington State University.



Table 2--U.S. hops: main varieties, 1994/95

State, variety	Harvested area	State, variety	Harvested area
	Acres		Acres
Idaho:		Washington:	
Cluster	821	Galena	6,252
Galena	616	Cluster	5,308
Chinook	351	Nugget	4,541
Banner	138	Willamette	2,776
Others	2,111	Chinook	2,305
Total, Idaho	4,037	Cascade	1,334
		Tettnang	2,160
Oregon:		Mount Hood	1,805
Willamette	3,570	Eroica	446
Nugget	2,450	Perle	382
Tettnang	665	Olympia	225
Fuggle	470	Liberty	119
Mount Hood	265	Northern Brewer	57
Perle	175	Other	665
Galena	80	Total, Washington	30,375
Other	335		
Total, Oregon	8,000	Total, U.S. Crop	42,412

Source: USDA, NASS.

Brewers use Cluster for its bittering effect. It is a general-purpose hop with medium bittering potential (6-9 percent alpha), and has the best alpha acid storage stability of any cultivated variety. Cluster is very susceptible to downy mildew. As a result, it is no longer a major cultivar in Oregon, where the disease is more difficult to control than in Washington and Idaho.

#### Brewer's Gold

Brewer's Gold was introduced in the late 1960's in response to the demand for a hop with high alpha acid levels that could be used for producing alpha extract. It was first introduced in Oregon because of its resistance to downy mildew crown die-out. No longer widely planted, the importance of Brewer's Gold lies in the fact that other high alpha acid cultivars trace their origins to this variety.

#### Galena

Galena is a Brewer's Gold seedling that is both high-yielding and has a high alpha acid potential. It is currently grown in Oregon, Washington, and Idaho, and is the leading variety in Washington. Galena's alpha acid ranges from 12-14 percent and it has an "acceptable" aroma. It matures early- to mid-season.

#### Eroica

Eroica, also a Brewer's Gold seedling, is a high-yielding cultivar that matures very late in the season. It has a somewhat lower alpha acid content than does Galena. On a per-acre basis, however, Eroica produces more alpha acid than Galena because of its higher yield.

#### Nugget and Olympic

Both Nugget and Olympic are relatively new varieties, having been released in 1983, and both are largely of Brewer's Gold ancestry. Similar in yield potential and alpha acid content, Nugget and Olympic are close to Galena in alpha percent and to Eroica in yield.

#### Fuggle

Originally from England, Fuggle is an aroma hop that has been grown in Oregon since about 1900. It is resistant to crown die-out caused by downy mildew, and became important in Oregon after the disease killed Cluster plantings in the 1930's. Fuggle is not high-yielding, and Oregon growers, consequently, continue the practice of growing male hop plants in the yard to pollinate female plants. When the female flowers are pollinated, the cones become larger and contain seeds. Both factors add weight to the cone, and thus increase the yield. Fuggle matures early and has good all-round disease and pest resistance.

### Willamette

Willamette is an early-season aroma hop with 6-8 percent alpha acid content. A triploid cultivar selected to resemble Fuggle's aroma, it is described as mild, pleasant, and slightly spicy. Like Fuggle, pollinated Willamette cones increase in size and produce acceptable yields. Because this cultivar is a triploid, however, pollinated Willamette cones have a lower seed content than do pollinated Fuggle cones. Because many brewers prefer seedless hops, the reduction in seed content is a desirable trait of Willamette. Willamette is susceptible to *verticillium* wilt.

### Tettnanger, Hallertauer, and Hersbrucker

These three cultivars are heterogeneous plant mixtures named for the growing regions in Germany from which they originate. All have low alpha acid content and are referred to as "continental" aroma cultivars. Because their yield potential is only 50-70 percent of that realized by U.S. cultivars, production is based on brewery demand for aroma hops. Tettnanger is the most widely grown of the three in the United States.

### Perle

Perle is a new German variety that has a high alpha acid content and an aroma similar to Hallertauer. It is poorly adapted to the high temperatures of the Yakima Valley, and its acreage has declined during the past four years. Its yield potential is about 80 percent of that for U.S. cultivars.

### Cascade

Cascade, released in 1972, is an aroma hop adapted to the growing conditions of Washington state. Its yield potential is superior to other aroma hops, but it loses alpha content rapidly in storage. All reported U.S. Cascade acreage is located in Washington.

### Chinook

Chinook is a new, potentially dual-purpose hop released in 1985. This variety is similar in alpha acid content to the high alpha cultivars, but it also has a useful aroma. It is produced mainly in Washington.

## **The U.S. Hop Industry**

U.S. growers harvested more than 42,000 acres of hops in 1994 and produced a crop of nearly 75 million pounds, about 28 percent of world output. The farm value of U.S. production was \$135 million (Table 3). Acreage and production increased 50 percent between 1985 and 1994.

A total of 42,412 acres were harvested in 1994, split roughly 60:40 between bitter and aroma hops. There has been a swing toward production of aroma hops

Table 3--U.S. hops: acreage, yield, production, grower price, and value of production, 1950/51 to 1994/95

Marketing year 1/	Harvested acreage	Yield	Total production	Season average price	Value of production
year 1/	Acres	Lbs./acre	1,000lbs.	Cents/lb.	1,000\$
1950/51	38,700	1,508	58,351	62.0	36,214
1955/56	23,700	1,556	36,874	40.7	15,007
1960/61	29,200	1,575	45,976	46.9	21,534
1965/66	32,700	1,714	56,060	46.3	25,937
1970/71	27,700	1,656	45,863	56.0	25,681
1975/76	32,100	1,742	55,913	83.0	46,419
1976/77	30,900	1,870	57,774	84.8	48,982
1977/78	30,500	1,796	54,777	89.6	49,095
1978/79	30,900	1,782	55,071	90.1	49,599
1979/80	31,800	1,727	54,929	97.6	53,614
1980/81	37,100	2,037	75,560	151.0	114,194
1981/82	43,100	1,836	79,144	151.0	119,220
1982/83	39,600	1,984	78,558	174.0	136,884
1983/84	36,900	1,846	68,111	193.0	131,483
1984/85	30,800	1,824	56,167	210.0	117,701
1985/86	28,100	1,769	49,713	203.0	101,046
1986/87	25,000	1,962	49,062	178.0	87,257
1987/88	28,300	1,770	50,048	151.0	75,578
1988/89	33,400	1,638	54,696	140.0	76,415
1989/90	34,548	1,717	59,326	138.0	81,582
1990/91	35,463	1,603	56,855	148.0	84,178
1991/92	39,553	1,748	69,155	168.0	115,997
1992/93	42,266	1,759	74,337	174.0	129,328
1993/94	43,100	1,767	76,144	176.0	133,965
1994/95	42,412	1,758	74,560	181.0	134,701

1/ September - August

Source: USDA, NASS. table 3

in the last decade: in 1985, the ratio between bitter and aroma hop acreage stood at 75:25.

Washington is the largest hop producer, harvesting 72 percent of the 1994 crop (Table 4). Because of its importance, the Yakima Valley is the major hop processing and storage center in the United States. Oregon is the second-largest producer, harvesting 19 percent of the 1994 crop. Idaho produced the remainder of U.S. output, with production split between the southwestern and northern part of the state. Most growers in all three states are third- or fourth-generation hop producers.

Hop production requires a large investment in the yard, in picking equipment, and in drying facilities. For example, an investment of \$1 million or more is needed for picking, cleaning, drying, curing, and baling facilities to handle a 200-acre operation--in addition to the initial cost of establishing the yard (Hinman). Consequently, it is financially difficult for new growers to assemble the capital to enter the business, and for established growers to abandon such a large fixed investment and exit from hop production.

### **The Hops Market**

Both domestic and export markets are important outlets for U.S. hops. In the 1993/94 market year (September to August), 41 million pounds were used domestically and 51 million pounds were exported (Table 5). U.S. supplies were supplemented by 13 million pounds of imports.

#### **Supply**

The United States vies with Germany for the top spot in world hop output. The U.S. ranked first in output during 1992 and 1994, and was second-ranked in 1993. Other major world producers include the United Kingdom, the Czech Republic, and the Slovak Republic.

Domestic production accounted for 76 million pounds of the 147 million pounds of total available supplies in the 1993/94 marketing year. The remaining supply consisted of stocks carried over from the previous season (58 million pounds) and imports (13 million pounds). In combination, brewers, dealers, and growers usually hold about a year's supply of hops at the end of a marketing season.

Typically, at least half of U.S. hop imports originate in Germany. Nearly 8 million of the 13 million pounds of hops imported in the 1993/94 season were from Germany. Canada, the Czech and Slovak Republics, France, and Poland also regularly sell hops to the United States, while China, Australia, the United Kingdom, and Yugoslavia, are minor hop sources.

#### **Demand**

The United States is the world's largest producer of beer, and as such, it is the most significant user of hops. Although average hopping rates (pounds of

Table 4--U.S Hops: harvested acreage by states, 1950 to date

Marketing year 1/	Idaho	Washington	Oregon	California	Total
Acres					
1950/51	1,000	13,800	14,600	9,300	38,700
1955/56	1,600	13,000	3,900	5,200	23,700
1960/61	3,200	16,400	4,500	5,100	29,200
1965/66	3,900	21,100	4,600	3,100	32,700
1970/71	3,300	18,700	4,300	1,400	27,700
1975/76	3,700	21,300	5,600	1,500	32,100
1976/77	3,000	21,000	5,400	1,500	30,900
1977/78	2,900	20,600	5,500	1,500	30,500
1978/79	2,700	21,300	5,400	1,500	30,900
1979/80	2,700	22,300	5,600	1,200	31,800
1980/81	2,800	26,900	6,200	1,200	37,100
1981/82	3,400	31,300	7,200	1,200	43,100
1982/83	3,700	28,100	7,300	500	39,600
1983/84	3,600	26,500	6,300	500	36,900
1984/85	3,100	22,700	4,900	100	30,800
1985/86	3,100	19,500	5,500	*	28,100
1986/87	2,500	17,400	5,100	*	25,000
1987/88	2,200	20,100	6,000	*	28,300
1988/89	2,800	23,100	7,500	*	33,400
1989/90	2,800	24,336	7,412	*	34,548
1990/91	2,700	25,663	7,100	*	35,463
1991/92	4,118	28,245	7,190	*	39,553
1992/93	4,000	30,366	7,900	0	42,266
1993/94	3,961	31,239	7,900	0	43,100
1994/95	4,037	30,375	8,000	0	42,412

\* Combined with Washington to avoid disclosure of individual operations.  
 1/ September - August.  
 Source: USDA, NASS.

Table 5--U.S. hops: supply and utilization 1970/71 to 1994/95

Marketing year 1/	Beginning stocks Other	Marketable production	Imports	Total supply	Domestic brewery use	Exports	Ending stocks
1,000 lbs.							
1970	27,950	45,863	13,637	87,450	32,716	24,504	30,120
1975	42,170 110 (544)	55,913	12,485	110,568	32,779	27,933	50,400
1976	50,400 290	57,774	10,433	118,607	38,878	28,959	50,480
1977	50,480 3,373	54,777	10,480	115,737	39,692	25,132	47,540
1978	47,540 3,539	55,071	11,160	113,771	39,399	32,543	38,290
1979	38,290 (6,862)	54,929	16,664	109,883	42,208	41,737	32,800
1980	32,800 2,593	75,560	14,600	122,960	43,972	41,965	34,430
1981	34,430 (1,109)	79,144	17,344	130,918	41,272	43,725	47,030
1982	47,030 4,361	78,558	14,349	139,937	39,763	34,733	61,080
1983	61,080 1,667	68,111	15,672	144,863	42,919	32,181	68,096
1984	68,096 (2,122)	56,167	14,774	139,037	39,347	31,352	70,460
1985	70,460 866	49,615	18,039	138,114	40,207	26,091	70,950
1986	70,950 (8,239)	48,980	14,626	134,556	43,785	28,380	70,630
1987	70,630 (2,055)	50,048	11,138	131,816	43,716	30,155	60,000
1988	60,000 (8,000)	54,643	12,302	126,945	41,585	41,660	51,700
1989	51,700 (8,016)	59,326	17,243	128,269	41,517	42,878	51,890
1990	51,890 1,435	56,855	20,974	129,719	42,784	31,300	54,200
1991	54,200 (4,385)	69,155	18,946	142,301	41,943	48,493	56,250
1992	56,250 (2,486)	74,337	9,264	139,851	40,491	43,786	58,060
1993	58,060 (7,362)	76,143	13,185	147,388	40,741	51,009	63,000
1994	63,000 NA	74,560	NA	NA	NA	NA	NA

NA = not available.

1/ September - August.

Source: USDA, NASS. table 5

hops per 31-gallon barrel of beer) vary from country to country, the U.S. rate averages about 0.2. The U.S. rate has decline over the past 10 years due to the increased use of high alpha hops.<sup>1</sup>

U.S. breweries used almost 41 million pounds of hops in 1993/94, 28 percent of the season's available supplies. The remaining supplies were either exported (51 million pounds) or held in inventory at the end of the season (63 million pounds).<sup>2</sup> Mexico, Brazil, Canada, Germany, the Netherlands, and the United Kingdom are usually the largest export markets. U.S. hops, however, are sold to some 75 countries. South and Central American markets accounted for about half of calendar-year 1994 exports, European markets accounted for about a quarter, and Asian markets accounted for about one-tenth.

### **Prices**

The season average price received by growers for hops, as reported by USDA, is relatively constant from year to year, ranging between about \$1.40 and \$2.10 a pound for the 1980-94 seasons (Table 6 and Figure 2). This relative stability in season average prices masks extreme variability in the cash (spot) market. Because a very high percentage of hops are contracted, with some contracted up to five years in advance of harvest, as little as 2-5 percent of output is marketed as spot hops (see later section on "Marketing").

Consequently, relatively minor supply-demand imbalances cause sharp changes in the spot price. The spot price for Cluster hops, for example, exceeded \$5.00 per pound during October and November of 1980, while the season average price for all hops averaged only \$1.51. In contrast, the Cluster spot price was only \$0.30 in October and November of 1984, compared with a projected season average price of \$1.81.

## **Industry Characteristics**

### **Hop Farms**

The Census of Agriculture reports 133 farms with 40,549 acres of hops in 1992. All of the reported acreage was in Washington, Oregon, and Idaho (Appendix table 1). The average hop acreage per farm exceeds 300 acres. The majority of farms are family owned and operated, although at least one brewery and one large dealer have hop-growing operations.

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"Alpha" refers to "alpha acid," the bittering component of hops. Alpha contents range from about 4 to 14 percent, depending on the variety. Hops with alpha percentages of 10 to 14 percent are referred to as high alpha hops.

The disposition category called "balancing item" is a statistical adjustment to equate total disposition and total supply. It compensates for the inflated hop:extract conversion rates used in the reported brewery use and trade statistics.



Table 6--U.S. hops: season average prices and total crop value

Marketing year 1/	Season average price				Total crop value
	Washington	Oregon	Idaho	U.S.	
	-----\$/pound-----				Million \$
1980/81	\$1.54	\$1.44	\$1.42	\$1.51	\$114.194
1981/82	\$1.50	\$1.47	\$1.65	\$1.51	\$119.220
1982/83	\$1.60	\$1.97	\$2.48	\$1.74	\$136.884
1983/84	\$1.80	\$2.15	\$2.62	\$1.93	\$131.483
1984/85	\$1.99	\$2.10	\$2.92	\$2.10	\$117.701
1985/86	\$1.80	\$2.36	\$3.18	\$2.03	\$98.433
1986/87	\$1.59	\$2.08	\$2.59	\$1.78	\$87.087
1987/88	\$1.32	\$1.78	\$2.74	\$1.51	\$75.578
1988/89	\$1.36	\$1.64	\$1.09	\$1.40	\$76.415
1989/90	\$1.33	\$1.58	\$1.26	\$1.38	\$81.583
1990/91	\$1.44	\$1.63	\$1.50	\$1.48	\$84.178
1991/92	\$1.68	\$1.71	\$1.59	\$1.68	\$115.997
1992/93	\$1.72	\$1.86	\$1.69	\$1.74	\$129.096
1993/94	\$1.72	\$1.95	\$1.77	\$1.76	\$133.965
1994/95	\$1.77	\$1.96	\$1.79	\$1.81	\$134.701

1/ September - August.

Source: USDA, NASS. table 6

Because of economies of size in hop picking and processing (drying), hop farms tend to be large operations or to be associated with a large operation. Sometimes, several family members have separate hop farming operations, but use a common picking and processing facility.

### **Income Diversification on Hop Farms**

Hops tend to be the major source of income on farms growing hops, but not the only source. Hop producers commonly grow other crops typical of the area along with hops.

## **Hop Production**

### **Climate**

Hops are adapted to a wide range of climatic conditions. In the Yakima Valley and in southwest Idaho, they are grown where the annual rainfall is less than 8 inches and where summer temperatures may exceed 110° F. In the Willamette Valley, on the other hand, annual rainfall may be as great as 40 inches, and summer temperatures seldom exceed 100° F.

Established hop plantings can survive winter temperatures as low as -35° F, although the major production areas seldom have such low temperatures. Newly-planted yards are the most susceptible to low temperatures, and are sometimes damaged by long, severe winters.

The climate of the Yakima Valley and southwest Idaho have proven well-suited for production of Cluster cultivars and high alpha acid hops. Because of the arid summers, downy mildew is less of a problem in these areas than in the Willamette Valley. Cascade, an American aroma hop, has also proven well-adapted to the Yakima climate.

The Willamette Valley's milder summer temperatures, which are similar to those in northern Europe, have proven better for growing the Fuggle and German varieties of aroma hops.

### **Soils**

The choicest soils for hop production are loams that are well-drained, deep, and either sandy or gravelly. Poorly-drained soils promote root rots and should be avoided. Deep soils permit the hop plant's roots, which may reach a depth of 15 feet or more, to fully develop. Hop fields in the Yakima Valley are typically light-textured and well-drained. Level and gently sloping fields are preferred to rolling land because irrigation systems and trellises are easier to construct and maintain on flat terrain.

### **The Hop Yard**

The hop plant is a climbing vine, and is supported by strong strings hung from high trellises. Trellises vary in size, with 18 feet the most common height. The trellis consists of a criss-cross of heavy wires that are supported by wooden poles. A typical spacing for the poles is 28 feet within rows and 14 feet between rows.

The poles are set upright in the interior of the yard and extend to the height of the trellis. The anchor poles around the edges of the yard are longer than the interior poles, and are set at an angle of about 70°, leaning away from the yard. Heavy cables extend outward from the tops of the anchor poles to moorings buried in the ground.

These moorings may be concrete blocks or they may be manufactured devices, such as auger-type metal anchors. Heavy wires (the main lines) extend in one direction across the tops of the poles. Lighter-weight wires (stringer wires), supported by the main lines, extend in the other direction parallel with the row of hops.

## Cultural Practices

### Propagation

Hops may be propagated using either rhizome cuttings (usually called roots) or vine cuttings. Rhizomes are the underground portions of the hop plant that contain numerous buds. Vine cuttings are sold to growers as potted plants.

A hop yard has a higher yield potential if it is planted with certified rootstock. The Washington Department of Agriculture has a hop plant certification program which assures virus-free certified rootstock. The University of Washington research station at Prosser supplies certified rootstock to specialized propagators who grow seed plants under strict conditions to maintain their virus-free status. Propagators can sell rhizome cuttings from these plants as certified rootstock for up to 5 years.

Growers establishing a yard with one of the newer varieties typically plant certified rootstock purchased from propagators. Growers frequently propagate their own hop roots, however, when replanting older varieties.

Oregon and Idaho do not have hop rootstock certification programs. Most growers in Oregon use root cuttings from their own plants. Sometimes growers in Idaho and Oregon purchase certified rootstock from propagators in Washington.

### Planting

Rhizome planting is usually done during March and April in Washington. In Oregon and Idaho, rhizomes may be planted either in the spring or fall. The young plants (baby hops) produce a small crop their first year. Fall-planted hops may produce a larger crop during their first season because they have had more time to become established. Fall-planted hops, however, are more likely to suffer losses from rotting, frost heaving, or desiccation than are spring-planted hops. Potted plants may be set-out at any time between May and July. Potted plants do not produce a crop their first year.

Different growers use different plant spacings, but 7½ feet between plants on rows that are 7½ feet apart (774 plants per acre) is a common planting distance. Other plant spacings are 8 feet by 8 feet (680 plants per acre), 7 feet by 7 feet (889 plants per acre), and 3½ feet by 15 feet (830 plants per acre). The latter spacing is becoming more common because it permits the use of larger equipment and has resulted in improved pesticide application (Haunold).

Several rhizome cuttings may be planted in a hill. Planting a larger number of cuttings increases the cost of propagative material, but assures a more satisfactory stand.

Cuttings are planted vertically (with buds pointing up) in holes made in the hill. The soil must be firmed around the cutting and a thin layer of loose soil spread over the top to assure that air does not desiccate the rhizomes.

### Fertilizing

Hops use the major plant nutrients (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O) in approximately a 3-1-3 ratio. Growers apply fertilizers, however, according to soil test results, tissue analysis, and direct plant observation. Soil analysis provides guidelines for predicting fertilizer requirements from year-to-year. Analysis of plant tissue and direct field observation of the plants provide a day-to-day check on crop nutrient levels.

Commercial fertilizer use is reduced if growers return the harvested vines to the field, although the release of nutrients from crop residues takes time. Trace elements such as boron, zinc, magnesium, and molybdenum may need to be applied depending on soil and tissue analysis results (Washington Cooperative Extension Service; Gingrich, Hart, and Christensen).

A deficiency or excess of one or more elements may reduce crop yields or quality. Excessive nitrogen, for example, can lower alpha acid and essential oil contents. Research evidence suggests that higher phosphorus applications raise alpha content, but this has not been fully substantiated in commercial production.

### Pruning

In late March, the hop plant is pruned with a tractor-drawn mechanical pruner to prepare it for the new growing season. Pruning consists of removing the remains from the old vine, a portion of the crown, and some roots and rhizomes. Pruning confines the plants to the desired size and keeps runners to a minimum.

### Stringing

Stringing, or twining, is the operation in which the strings that support the hop vines are tied to the trellis wires. Since the strings are cut down with the vine at harvest, new strings are tied each spring. Coir yarn, a twisted palm-fiber twine, is used for stringing. It is strong, resists binding in the picking machine, and is biodegradable once returned to the field with the harvest refuse.

A typical stringing pattern consists of two strings running to each hill from the overhead wires on either side of the row. The strings are fastened to the ground at the plant forming a V-shaped pattern.

### Training

Training involves wrapping the vines clockwise (because hops will only twine in a clockwise direction) around the support strings. Usually two or three shoots, depending on the variety and grower preference, are wrapped around each string. The remaining shoots are cut from the plant. It is usually necessary to train the vines at least twice a season; the second and any subsequent training are used to replace fallen or missing vines. Vines that are infected with downy mildew or otherwise damaged can be removed at this time and replaced with healthy vines.

When the vines nearly reach the trellis wires, the strings are tied together about 4 feet above the ground. This permits the movement of tractors and implements between the rows.

### Stripping and Suckering

When the vines reach the trellis wires, the leaves and side-arms are removed from the vines below the point at which the strings are tied together. This operation is known as "stripping." Stripping aids circulation of air around the base of the plants and helps control mildew and some insects. Stripping may be done as a hand operation, but some growers apply desiccant sprays on the leaves that they want removed.

Excessive shoots are removed from around the bases of the plants early in the season. This practice is known as "suckering." Suckering helps rid the plants of diseased vegetative material and promotes growth among the selected vines.

### Cultivating

Aside from pruning, the primary cultivation activity is disking between the rows--usually five or more times during the spring and early summer. The season's first cultivation takes place in early April, after the soil has dried from winter precipitation. The last disking is usually in late June or early July as the fibrous root system of the plant is developing. In order to protect the root system, no additional cultivation takes place until after harvest.

## Irrigation

All commercial U.S. hop production is irrigated. Hops have a relatively high water requirement. Research at Washington State University indicates 300 to 450 gallons of water are needed to produce a pound of hops in the Yakima Valley. The maximum daily water use occurs in early August, reaching 0.45 to 0.55 inches per day.

Furrow and sprinkler irrigation are the most widely used systems. Almost all hops in Washington are furrow (rill) irrigated. Furrow irrigation is relatively inexpensive if growers have abundant water, and the reduced incidence of downy mildew under furrow irrigation is an advantage. The potential reduction in downy mildew permits growers to cultivate several hop cultivars in Washington that do not produce well in wetter climates.

Most hops grown in Oregon are irrigated with sprinkler systems. Sprinkler irrigation requires substantial energy consumption. In addition, land may be lost for travel lanes every 60 to 100 feet.

Some hop yards are using trickle (drip) irrigation systems on small acreages. Although drip irrigation has generally performed well and has provided good yields, growers have not widely adopted this method. Drip systems make the most efficient use of water, but cost more to install and require a higher level of management than do furrow or sprinkler systems.

## **Harvesting, Drying, Curing, and Storing**

### **Harvesting Dates**

Hop harvest usually begins in the middle of August and lasts about a month. Actual picking is determined by the date of ripening and by the capacity of the grower's picking and curing facilities. If the tonnage is particularly large with respect to the grower's facilities, picking may begin before and extend after the optimum maturity date.

Hops of a particular variety are in their prime condition for harvesting for only 5 to 10 days. The alpha percent will not have reached its full potential if hops are harvested prior to reaching maturity. For hops harvested after the peak maturity date, however, shatter losses increase and the desired light yellowish-green color is diminished. The harvesting season can be extended if a grower produces several varieties that have different maturity dates (see "Maturity Group" in Table 1).

### **Method of Picking**

The first step in harvesting hops involves cutting the vines about three feet above the ground. The hop-laden vines are then cut from the overhead support wires and fall into truck beds or trailers, which transport them to picking machines located nearby.

The vines are hung upside down at the feeding station prior to entry into the picking machine. Hops and leaves are stripped from the vines as they pass through the picking machine, and the vines are chopped into mulch for return to the soil. Typical picking machines can handle 7-14 acres a day, depending on the variety and length of operating time.

The stripped leaves, stems, and hops fall through a traveling wire mesh and pass over a series of cleaning devices that remove the hop cones from the leaves and stems. The cleaning process takes advantage of the fact that the cones are round and roll easily while leaves and stems are flat and do not roll. The cones and trash move over a series of inclined conveyors on which the cones roll backwards onto a "save conveyor," while the flat leaves and stems are carried over the top onto the trash pile. The leaves and stems are returned to the soil along with the chopped vines.

A few farmers use self-propelled combines, which pull the leaves and cones from the vines in the hop yard. These field-picked hops are then hauled to the processing plant for cleaning and curing.

### **Drying**

Hop cones contain 70 to 80 percent moisture when picked and must be dried to 8 to 10 percent moisture before they can be stored. The dryer, called a kiln, consists of a slatted-floor room positioned over a large air chamber. Hops are loaded about three feet deep onto the drier room floor, which is covered by a loosely-woven burlap cloth. Heated air is forced up through the bed of green hops for about 9 hours. The heated air picks up moisture as it moves through the green hops, and is removed in the exhaust.

### **Curing**

Because the lower layers dry first, hops from the bottom of the drying pile may have as low as 1 percent moisture, while those near the top may contain up to 20 percent. Consequently, the hops are transferred to a curing chamber where they cool and the moisture content equalizes among all cones in the pile.

Hop cones, when they first come out of the kiln, feel dry, papery, and almost flaky. They break or shatter easily when handled. Breakage detracts from the cones' appearance and results in a loss of lupulin and storage quality. In curing, the cones become tough and pliable, and they acquire a finer aroma and improved appearance. Cooling and curing typically lasts from 12 to 24 hours.

### **Baling**

After cooling, the hops are conveyed to hydraulic balers which press the cones into traditional 200-pound bales. However, in practice, bales may weigh from 185 to 215 pounds. The bales are then wrapped in burlap or a poly-fiber wrapper and transported to cold storage warehouses.

### **Inspection**

Bale lots, consisting of 200-400 bales, are inspected and sampled by a USDA state inspector. Core samples from each lot are sent to the USDA State Certification Laboratory, where they are analyzed for leaf, stem, and seed content. Each lot is issued a certificate showing percentages of leaf, stem, and seed.

The head of each bale must be stamped with the official Federal and State Inspection Stamp for the state in which the hops were produced. Certification is necessary for all hops before the grower relinquishes possession. As a result, the identity of each lot of hops can be traced to its original grower.

### **Storing**

All hops lose alpha acid content while in storage. Some varieties, such as Cluster and Galena, may lose as little as 20 percent alpha acid during a year of cold storage, while others, such as Cascade, lose a much higher percentage.

Cold storage provides the best practical method of protecting hops against deterioration, and is the industry standard. Hops in cold storage retain alpha acid substantially longer than those stored at room temperature. The loss after 6 months of room temperature storage is roughly equivalent to the loss associated with 1½ years of cold storage (Nickerson).

Most cold storage facilities are owned by hop dealers. According to one source, dealers provide 95 percent of the available cold storage, growers account for 2-3 percent, and independent warehouses provide the remaining 2-3 percent (McGree).

## **Marketing**

Hop marketing is characterized by several unique features. First, specific quantities at specific prices are contracted for as many as 5 or more years in advance of harvest. At the beginning of October 1994, for example, just 2 percent of the 1994 crop, 9 percent of the 1995 crop, 37 percent of the 1996 crop, 49 percent of the 1997 crop, 57 percent of the 1998 crop, and 77 percent of the 1999 crop remained unsold (Hop Growers of America).

Second, spot-market prices are highly variable, plummeting sharply during market gluts and spiking abruptly when there is a shortage. This is caused by the reluctance of brewers to change the hop content in their beer recipes. Hops impart taste, and brewers want to maintain the consistent taste and character of their specific brands.

Third, and related to the second, hops are not substitutable as far as brewers are concerned. Further, there are no significant alternative uses for hops except for beer production.

Fourth, hops represents a very small portion of the finished product for which they are used. One pound of hops reportedly flavors over 1,500 12-ounce bottles of beer. Consequently, changes in hop prices have a minuscule effect on the cost of producing beer.

Hops are sold to dealers (also called merchants), who represent multinational firms that also operate hop extract or processing plants in the U.S. and abroad. Historically, growers and merchants were separately owned and managed, although in recent years, some merchants have purchased hop farms. The larger U.S. dealers also handle the bulk of hop imports. Of the seven dealers, six are owned by European firms.

Growers ordinarily sell their hops to dealers under contracts negotiated one or more years in advance of delivery. The contracts specify the price and quantity to be delivered at a fixed date.

Some farmers sell directly to breweries. Two large breweries, Anheuser-Busch and Coors, bypass dealers for a portion of their hops and contract directly with farmers. Anheuser-Busch also has a large hop-growing operation in Idaho.

## **Grower Organizations**

### **Washington Hop Commission**

The Washington Hop Commission enforces the state's hop marketing order. The order's purpose is to support production and marketing research and promotion for hops, and to foster fair trade practices in hop marketing. The order is supported mainly through grower assessments of 1.25 cent for each pound of hops sold (or \$2.50 per 200-pound bale).

### **Oregon Hop Commission**

The Oregon Hop Commission primarily provides funding for research to maintain the economic stability of hop production in Oregon. The Commission is funded with mandatory grower assessments of \$2.50 per bale of hops marketed.

### **Idaho Hop Commission**

The Idaho Hop Commission is a state-regulated organization composed of Idaho hop growers, and its main purpose is to advance Idaho hop production. The Commission's main activities include support for production and marketing research and the promotion of Idaho hops. The Commission is funded by a grower assessment on hop production. The assessment varies depending on the Commission's budget in a given year, and was \$1.62 per 200-pound bale in 1995. Assessments are collected at the dealer level and are deducted from grower returns.

### **Hop Growers of America**

The Hop Growers of America is an association of growers, processors, and handlers in Oregon, Washington, and Idaho. The organization facilitates the exchange of information on growing, handling, and processing hops, and promotes the demand for U.S. hops in international markets.

Promotional activities are funded by assessments on the Idaho and Washington Commissions, with matching funds provided by the federal government's Market Promotion Program (MPP). The Oregon Hop Commission chose not to participate in MPP, effective January 1, 1994.

### **Hop Research Council**

The Hop Research Council is comprised of 19 international representatives, including brewers, dealers, handlers, and growers. The Council sponsors research on hop breeding, crop protection chemicals, and the chemistry, pathology, and entomology of the hop plant. The Council is funded through assessments charged to the state hop commissions, and through contributions made by industry participants.

## **Costs of Production**

Hops are a perennial crop requiring a large initial capital investment and high operating expenses. Growers must install permanent field trellis systems, and invest in processing facilities, as well as picking, cleaning, drying, and baling equipment.

Estimates of total fixed and variable costs range from about \$3,520 per acre in the Yakima Valley to \$4,485 in the Willamette Valley (Table 7). Post-harvest expenses account for a relatively small portion of total costs--11 percent in Oregon and 16 percent in Washington.

Fixed costs account for about half of the total cost estimates. Fixed costs include amortized costs for the trellises, the costs of harvesting and drying equipment, and establishment costs for the hop plants. Detailed budgets are presented in the Appendix tables.

## **Production Perils**

### **Trellis Collapse**

Trellis collapse is one of the most frequently-cited production perils and was cited by some sources as the most serious threat faced by growers. A collapse occurs when one or more of the poles snap or break, causing the wires to sag and permitting the vines to slump to the ground.

The danger of collapse increases after about August 1, when the mature vines place the greatest weight on the trellis. Heavy dew or rain adds to vine weight, further increasing stress on the trellis and boosting the chances of a collapse. High winds also create added stress, particularly if the vines are water-laden, and further the potential for collapse. Usually when one pole snaps, the added stress on adjacent poles causes additional breakages, and a large section of the yard collapses.



If the hops are mature at the time of a collapse, a grower can proceed with the harvest and salvage most of the crop, although with added expense for cutting and loading the fallen vines. If the collapse occurs more than a week or two before harvest, the vines may be permitted to continue growing until they are mature enough to harvest.

Table 7-- U.S. hops: costs of production

State	Post harvest variable expenses	Total costs	Post harvest, percent of total
	-----Dollars-----		Percent
Oregon (Willamette Valley)	506	4,485	11
Washington (Yakima Valley)	561	3,520	16

Sources: Hinman; Lisec and Gingrich.

A grower may try to re-erect the trellis and pull the vines up off the ground until they are ready to harvest. A grower's strategy for salvaging the crop may depend on the market prices for the particular variety in the collapsed yard. If prices are high, the grower will invest more in salvaging the vines than if prices are low.

The extent of yield loss caused by a collapsed trellis depends on the crop's maturity, weather conditions, and a grower's investment in salvaging the crop. Hops may yield nearly all of their potential if the collapse occurs just prior to harvest. One contact thought it would be unusual for the loss to exceed 35 percent of the potential yield (Gingrich). In addition to reducing yields and raising harvesting expenses, a collapsed trellis also increases the costs of yard maintenance and repair.

Growers can currently purchase commercial insurance to cover the consequences of a trellis collapse. Full protection covers the added costs of harvesting the downed hops, the value of the reduced yield, and the cost of rebuilding the trellis (Craig). Growers can purchase insurance on the hops only, on the trellis only, or on both.

### **Excessive Moisture**

Excessive moisture is a hazard to hop production because it increases the incidence of mildew. Rain-related mildew is a more serious concern in Oregon than in either Washington or Idaho. Oregon's hops are grown in the Willamette Valley west of the Cascade Mountain range, and experience rainy periods more frequently than the areas east of the Cascades, including the Yakima Valley and southwestern Idaho. The incidence of mildew infections increase rapidly during wet weather.

As noted above, excessive rain also increases the likelihood of a trellis collapsing from the excessive weight of water-laden vines.

### **Drought**

As a practical matter, drought is not a production peril because all U.S. hop production is irrigated. Hops have a high water requirement, however, and a lack of sufficient irrigation water would result in low yields.

### **Cold Weather**

Extremely cold winter weather may kill the roots of dormant hop plants. This is, however, usually only a peril for young plants whose root systems are not yet fully established.

Late spring frosts following an unusually warm winter can delay development of the hop plant and reduce hop yields that fall. The warm winter causes plants to bud out early in the spring. Late spring frosts may kill these early buds, delaying growth while the plants send up new shoots.

In addition, cool weather during the growing season slows hop growth and may reduce yields. Unusually cool weather during the growing season was cited as a reason for yield losses in Canyon County, Idaho (Silver).

### **Excessive Heat**

A hop specialist at the University of Washington indicated that heat by itself is usually not a production peril for most American hop varieties, unless it is accompanied by drought (Kenny). High temperatures increase the water demands of the hop plant, and exacerbate drought stress if irrigation water is scarce. Very few, if any, commercial hops are grown without some irrigation. The Census of Agriculture indicated that all hop acreage was irrigated in 1992.

However, hot, dry weather was cited as a reason for yield losses for which disaster payments were made in Marion County, Oregon in 1992 (Brewster). Some of the hops grown in the Willamette Valley are of northern European origin and do not tolerate extreme heat well.

### **Excessive Wind**

The weight of mature hop vines late in the growing season, particularly if the vines are wet with dew or rain, places extreme stress on the trellis. High winds are a threat in such situations because they cause added stress, raising the likelihood of collapse of the trellis.

### **Fire**

A serious peril in hop production is fire damage to the hop picking and drying facility, not because it happens so frequently, but because the consequences are severe when a fire occurs. Hop picking and drying are indispensable operations. If a fire should occur at harvest, the grower may be stranded with no way to harvest and dry the crop. This situation could result in the loss of the unharvested portion of the crop.

Commercial fire insurance for hop picking and drying facilities is currently available, and covers consequential losses, including production loss due to the inability to pick and dry the crop. Such insurance indemnifies not only the loss of facilities and equipment, but also the value of the lost hops if fire prevents picking and drying the crop (Craigien, Marley, Weathers).

### **Hail**

Hail occasionally causes damage to hop production, particularly in Washington and Idaho. The Willamette Valley of Oregon lies in a relatively hail-free zone, and on the few occasions when hail occurs, it usually is not intense enough to cause serious damage. The commercial insurance presently available provides coverage for losses due to hail.

### **Diseases**

Downy mildew is the most serious disease affecting hop production. Mildew is the prime reason that hop culture moved westward from the East and Midwest (in particular, from New York and Wisconsin) to the arid and irrigated Northwest. Other hop diseases of note are *Phytophthora* crown and root rot, *verticillium* wilt, and several hop viruses.

#### Downy Mildew

Downy mildew is a fungal disease that infects the leaves, vines, floral parts, and crown of the hop plant. It can spread rapidly throughout the yard under moist conditions and moderate temperatures (46° F to 73° F). Infections reduce yields in the current crop and cause crown die-out, which kills the plant. Crown die-out can cause large losses in susceptible cultivars such as Cluster (Washington Cooperative Extension Service).

Fungal spores spread the disease from infected portions of the plant to healthy leaves and cones. During the growing season, the fungus grows from infected spikes into the crown, where it establishes a source of infection for future seasons. When an infected plant begins to grow in the spring, the fungus spreads from the infected crown to new shoots, and from these shoots it spreads to healthy plants. Infected leaves develop watery spots and later die. Infected cones turn reddish-brown and die. Some infected crowns may appear healthy while others are almost completely destroyed.

The disease is only known to overwinter in the crown. Consequently, yards can be replanted without danger of infection from contaminated soil.

Downy mildew can be controlled through management practices, including well-timed applications of fungicides. The roots or crowns used for planting and replanting should be mildew-free and diseased crowns should be removed from the field. Infected spikes should be destroyed when the yards are pruned in the spring. Pruning as late as possible shortens the mildew season for those vines selected for training. Fungicidal sprays usually keep the disease in check through the growing season.

Cluster cultivars are highly susceptible to crown infections and subsequent crown die-out caused by downy mildew. Most other cultivars are moderately resistant to crown infections, but vary in their susceptibility to leaf and cone infections.

#### Phytophthora Crown and Root Rot

*Phytophthora* crown and root rot is a relatively new disease affecting hops in the United States, appearing in California in 1968 and in Washington in 1975 (Washington Cooperative Extension Service). Most infections are associated with poor drainage and high soil moisture.

Also called black root rot, the disease is caused by a fungus that lives in the soil and infects the underground portion of the plant. The symptoms are similar to some of the symptoms associated with downy mildew. Both cause the crown and roots to rot. As harvest approaches in late summer, plants infected by both diseases turn yellow, wilt, and often die. One distinguishing difference between downy mildew and *Phytophthora*, however, is that plants infected with downy mildew are generally distributed throughout the yard, while plants infected with *Phytophthora* are localized in poorly-drained areas.

*Phytophthora* crown and root rot is controlled through the use of resistant cultivars and by maintaining proper drainage and irrigation. Some Cluster cultivars are extremely susceptible. Extremely-resistant cultivars include Cascade, Brewer's Gold, Bullion, Olympic, Talisman, Nugget, Eroica, Comet, Fuggle, Tettanager, Hallertauer, and Northern Brewer.

#### Verticillium Wilt

*Verticillium* wilt is a serious hop disease in Europe, and once established, it becomes a limiting factor in production. *Verticillium albo-atrum* has been found in Oregon, while *Verticillium dahliae* has been found in Idaho, Oregon, and Washington (Washington Cooperative Extension Service). In Washington, researchers have associated the disease with fields in which heptachlor had been used at one time, particularly for the Cluster cultivars. The disease also has been found on plants grown from seed in fields where no heptachlor has been applied.

The symptoms of *Verticillium* begin in early August when the hop plant develops a dull, off-green color. As the disease develops, the leaves yellow and turn brown. In severe instances, the plant wilts and dies.

The *Verticillium* wilt fungus enters the plant from the soil through the roots. From the roots it spreads into the vascular (water conducting) tissue, where it disrupts water movement in the plant.

The best control is to prevent introduction of severe strains of the disease. The Washington State Department of Agriculture administers a hop disease quarantine program, which in essence requires that hop plants be certified free of *Verticillium* wilt. A similar quarantine is in effect to protect the northern Idaho hop-growing area. Varieties currently grown in Washington are resistant to the wilt, except when grown on heptachlor-treated ground. New cultivars also must be resistant to wilt.

#### Hop Viruses

Five different viruses (the hop latent virus, hop mosaic virus, American hop latent virus, and two strains of the *Prunus* necrotic ringspot virus) have been identified as infecting hop plants in the Yakima Valley. The *Prunus* necrotic ringspot virus reduces yields and lowers brewing quality. The effects of the other viruses on yields and quality are unknown.

The Mosaic, American hop latent, and hop latent viruses are spread by the hop aphid. Vectors for the *Prunus* necrotic ringspot virus are not known, but it is readily transmitted by contact between plants.

The most practical control for hop viruses is the use of virus-free stock. A greater threat of infection occurs when old hop plants are not removed at the time a field is prepared for replanting.

### **Insects**

The major insect pests affecting hops are the hop aphid and the twospotted spider mite. Blackvine weevils, hop loopers, and armyworms are considered minor problems.

#### Hop Aphids

Hop aphids feed directly on hop plants, extracting sap from the plants' cells and excreting "honeydew." High aphid populations also weaken the plants and reduce yields. In general, aphid infestations can be expected to reduce yields by 5-10 percent or less (Gingrich).

Aphids excrete prolific amounts of sugary plant sap which has passed through the insect's digestive system. This honeydew is difficult to wash off plants and serves as a food source for sooty mold. Sooty mold discolors the hop cones and can lower their market value. Buyers may reject hops in the field or in the bale due to excessive amounts of honeydew and sooty mold. No chemicals are registered to control sooty mold on hops.

Aphids enter and feed on the cones as well as other plant parts. Insecticides are not highly effective in killing aphids within the cones. Besides, dead aphids remaining in the cones create a contamination problem. Some buyers sample for insect contaminants and may reject bales containing dead aphids.

Aphid populations increase most rapidly during cool, moist weather, and are the greatest problem, therefore, in the spring and fall. Lady beetles, green lacewings, and syrphid and hover fly larvae are natural predators of aphids, and creating a favorable environment for these insects helps restrain aphid populations. Insecticides also help control aphids, although they must be used judiciously in order not to decimate natural predator populations.

#### Twospotted Spider Mites

Twospotted spider mites are microscopic insects (about 1/50-inch in size) that feed on leaf tissue and hop cones. They puncture the leaf and cone tissues while sucking juices, destroying the plant's cells. Damage symptoms appear as stippling or blotching on the leaves. In severe infestations, leaves turn brown or reddish brown and die. Mites spin copious amounts of webbing on the undersurface of leaves, shielding them from pesticides and making chemical control difficult.

A large spider mite population may weaken plants and lower yields. Feeding injury on cones reduces crop market value. Yield losses are generally limited to 5-10 percent of the crop or less.

Two major predators of the spider mite are the western predator mite and the spider mite destroyer lady beetle. The predator mite, which hibernates in hop yards and emerges about the same time as the spider mite, has the potential to keep pest mite populations below economic threshold levels. Foliar miticide applications help reduce spider mite populations, but also reduce the population of mite predators.

#### Blackvine Weevils

Blackvine weevils are a minor pest. The adult weevils are active from June through August, feeding on hop leaves during the night and hiding during the day. The larvae appear in the soil from December to April, and feed on the underground parts of the plant. Although adult feeding causes little or no damage, high larval populations seriously weaken the plant.

### Hop Loopers

Adult hop loopers appear as grey-brown moths, but do not feed on the hop plant. The larvae are slender, pale green, worm-like insects with legs. Although the larvae feed on hop leaves at the base of the plant, they do not cause yield losses.

### Armyworms

Armyworm larvae of night-flying grey or brown moths affect hops. The adults, which do not feed on hops, usually lay their eggs on weeds such as red-root pigweed and lambsquarter. The larvae defoliate these weeds and then move to the hop plants. Yield losses are minimal in well-managed yards. Elimination of weeds in the hop yard reduces the chances of armyworm infestation.

### Long-Horned Beetles

The long-horned beetle, also known as "California prionus," is a soil-borne insect whose larvae feed on hop roots, leaving them hollowed and girdled. The crowns of severely-infected plants are reduced to rotted masses. The first foliar symptoms include loss of vigor and often, one or more of the shoots will wilt and become yellowish. Some affected plants die within a few months, while others become less vigorous over several years. The longevity of a severely-infected yard may be reduced by one-half (Bishop, et al.).

Hop growers in Idaho have noticed damage from the long-horned beetle since at least the 1930's, but it has not been considered a problem in Washington and Oregon in the past. An infested hop yard was discovered in the Yakima area in 1994, however, and Washington producers are now concerned that it may become a problem in their area (Blackmer).

At the present time, there are no above-ground chemicals registered to treat the insect. The current treatment recommendation is to fumigate the soil and replant the yard

### **Nematodes**

Nematodes are not reported as a problem affecting hops. Generally, growers do not need to fumigate the soil prior to planting to control nematodes (Kenny, Gingrich).

### **Weeds**

Weeds can reduce yields, interfere with irrigation, serve as hosts for insects and plant pathogens, and interfere with harvesting. Both annual and perennial grasses and broadleaf weeds infest hop yards. Soil tillage, primarily through disking, is the traditional control method. Several herbicides are available that can reduce the amount of tillage required.

## **State Analyses**

### **Washington**

The Census of Agriculture reported 79 farms in Washington with 30,228 acres of hops in 1992. Except for a few yards in Benton County, all of Washington's hops are grown in Yakima County. Both counties lie east of the Cascade mountains and have semi-arid climates. Washington hop production had a farm value of \$79 million in 1994.

Although producing both alpha and aroma hops, Washington tends to specialize in the alpha types. The Cluster varieties, which are highly susceptible to mildew in Oregon, thrive in the Yakima Valley and account for a large share of Washington's acreage.

Hops tend to be the major crop for Washington growers, but most growers also produce other crops, such as tree fruits (sweet cherries and apples), grapes, mint, and asparagus. The low-profile equipment needed for operation in the hop yard is in many cases the same equipment used in fruit production.

#### Production Perils

The most significant production peril in the Yakima Valley is associated with trellis collapses. The Yakima area has frequent high winds, which are a prime cause of trellis collapse. High winds can also cause hop vines to become unwound from their support strings. This increases production costs because the unraveled vines must be retrained, or new shoots must be trained, if the old vines are damaged.

Downy mildew is the most serious disease problem in the Yakima area. Mildew is less of a peril than in Oregon, however, because Washington's hot, dry climate during the growing season is not conducive to its development.

The hop aphid and the twospotted spider mite are the most serious insect problems. They usually do not cause yield reductions, however, because available pesticides provide adequate control.

The long-horned beetle, a hop pest in Idaho, has recently been discovered in a Yakima Valley hop yard. It is not yet clear whether its presence will become a serious problem in the Yakima area, or whether it will raise production costs.

#### Demand for Insurance

There may not be significant demand for crop insurance for hops in Washington. Most growers reportedly purchase the multi-peril policy presently offered by commercial companies. Federal crop insurance would likely be attractive to growers if it offered equivalent coverage at lower rates than the private policy. FCIC may not want to compete with the private sector, however, which already offers coverage for most production perils.

The Administrator of the Washington Hop Commission indicated that insurance for hops had never arisen as an item of concern at Commission meetings, and that the availability of insurance was not a concern among Washington growers (George). She also indicate that most growers purchase private hop insurance.

#### **Oregon**

Hop production in Oregon is located west of the Cascade Mountain range in the Willamette Valley. The Census of Agriculture reported 43 farms producing hops in Oregon in 1992, with 89 percent of the acreage in Marion County. One large grower reportedly has two farms in Polk County, and hops are also grown in Clackamas County (Gingrich). One contact indicated that there are 48 hop farms in Oregon, but only 28 families grow hops because some families have more than one farming operation (Hiller). Oregon's hops had a farm value of \$27 million in 1994.

Oregon's hop farming operations tend to be diversified with other crops. Reportedly, all but two or three producers also grow other crops such as grass seed, filberts (hazelnuts), and vegetables (Gingrich).

The Willamette Valley has a cooler, wetter climate during the summer than is experienced in the hop-producing areas of Washington and Idaho. Because of greater rainfall and higher humidity, Oregon growers experience more problems with downy mildew than growers in Washington and Idaho.

Some observers indicate that Oregon's climate is similar to that in Germany's hop-producing regions. In fact, Oregon produces several European aroma varieties which perform poorly under the extreme heat in the hop-producing areas of Washington and Idaho.



### Production Perils

Downy mildew and trellis collapses are the major production perils affecting Oregon hop production (Hiller). Trellis collapses usually occur within a week or two of harvest, and growers are generally able to recover a near-normal yield by harvesting immediately. Harvesting expenses rise, however, because the vines have to be cut and gathered off the ground. If the hops are not mature enough to harvest immediately, growers may wait until the cones develop further, but yields suffer because the collapsed plants do not receive full sunlight.

Although trellis collapses represent a potential yield loss and increased expenses, they may not occur as frequently in Oregon as in the Yakima area of Washington (Marley). The Yakima Valley generally experiences greater problems with winds than does the Willamette area, which increases the chances of trellises collapsing.

The extension agent for hops in Marion County indicated that he recalled only two or three hop yards collapsing in the last 15 years. One insurance agent, however, reported that at least one yard collapses in Oregon nearly every year, and mentioned one year when an unusual storm collapsed a number of yards (Craig).

Although frequently mentioned as a peril, yield losses due to downy mildew infections appear to be relatively minor in Oregon. Growers generally are able to combat mildew infections by carefully monitoring plants and following a rigorous fungicide program.

A serious peril in Oregon hop production is fire damage to picking and drying facilities. Fires do not happen frequently, but the consequences are severe. Hop picking and drying facilities are indispensable. If a fire should occur at harvest-time, the grower has no way to harvest and dry the hops, and could lose his or her entire unharvested production.

Commercial fire insurance is currently available for the picker and kiln, and provides coverage for consequential losses, including production losses due to the grower's inability to pick and dry the crop. Such insurance guarantees the grower that the hops can be picked and dried, or it pays a portion of the value of the lost crop. Oregon growers typically purchase this coverage (Marley).

### Demand for Insurance

Hop growers in the Willamette Valley have expressed interest in having Federal crop insurance available for hops. One reason is that the private insurance currently available does not cover losses due to insects, diseases, and flooding, and growers would like to have insurance available for these perils (Weathers, Hiller).

They point out that under crop insurance reform, growers could not qualify for catastrophic coverage (CAT) because hops is a non-insured crop. Furthermore, growers feel they can not benefit from the Non-insured Assistance Program (NAP) because the area-wide hop yield is unlikely to decline the required 35 percent needed for individual growers to qualify for aid. Oregon producers would like for hops to be an insurable crop, therefore, so growers could benefit from catastrophic coverage on the basis of their individual losses.

One source cited an incident where a single grower had incurred a severe yield loss due to an insect infestation, and could not have qualified for assistance under NAP, but may have been able to receive a payment under CAT (Hiller).

### **Idaho**

The Census of Agriculture reported 11 farms in Idaho harvesting 3,054 acres of hops in 1992. The USDA reported 4,037 hop acres in 1994, with a crop value of \$11 million.

Idaho has two hop growing areas. One area is located in Canyon County in southwestern Idaho. The other consists of one large grower in the northern part of the state near Bonners Ferry, in Boundary County. The southwestern region has hot, dry summers similar to those in the Yakima Valley and, therefore, produces the same varieties as grown in Washington. The northern region has a cooler climate, more like that of the Willamette Valley, and reportedly grows some of the aroma varieties produced in Oregon (Blackmer).

Hop producers in southwestern Idaho produce other crops common in the area in addition to hops, including potatoes, onions, dry beans, sugarbeets, and mint (McGree, Silver).

Idaho does not have a hop root certification program. Some growers purchase certified roots from propagators in Washington for planting.

#### Production Perils

Pesticides are generally effective in controlling the twospotted spider mite and the hop aphid, the major insect perils in Idaho. At times, populations build up and cause small losses, usually less than 5 or 10 percent of the expected yield. Other, less serious, insect pests are the blackvine weevil and the long-horned beetle.

Downy mildew is not typically a problem because southwestern Idaho's hot, dry summers retard its development. There has been more mildew than normal during 1995, however, because the weather in southwestern Idaho has been unusually cool and wet.

As in Washington and Oregon, trellis collapses and fires to picking and drying facilities are production hazards. Growers currently can purchase commercial insurance which covers yield losses associated with these perils.

#### **Ad Hoc Disaster Assistance for Hops**

Ad hoc disaster assistance legislation was made available for crop losses in each of the years between 1988-93, and also in 1994. Ad hoc payments provide an indication of the states that were high-loss areas during that period, and may indicate the relative losses under a potential FCIC hop policy. These data may also point to where the demand for crop insurance would be highest.

Under ad hoc disaster assistance legislation, payments were made under the categories of participating program crops, nonparticipating program crops, sugar, tobacco, peanuts, soybeans, sunflowers, nonprogram crops, ornamentals, and at times, aquaculture. Producers without crop insurance--the case for hops--were eligible for payments for losses greater than 40 percent of their expected production. If a producer had no individual yield data to use in calculating "expected production," county-level or other data were used as a proxy. Payment rates for hops were based on 65 percent of a 5-year average price, dropping the high and low years.

Disaster assistance payments for hops totalled \$281,000 over the 1988-93 period. Payments made for hops accounted for far less than 0.01 percent of all ad hoc assistance payments for non-program crops (that is, non-price and income support crops) over the 1988-93 period.

Ad hoc disaster data can be used to indicate which hop-producing areas are most prone to production losses. Idaho received the most significant payments relative to its hop acreage, while Washington and Oregon received minimal payments. With only 9 percent of the harvested area during 1988-93, Idaho received 85 percent of the total U.S. payments made for hop losses (Table 8). In contrast, Oregon and Washington accounted for 20 and 71 percent of the acreage, respectively, but only 7 and 8 percent of the U.S. hop disaster payments.

Low payments relative to the crop's value in the three major producing states suggest a relatively low risk of yield loss due to weather-related production perils. Disaster payments averaged only 0.5 percent of the total Idaho crop

value over the six years (Table 9). In Oregon and Washington, payments amounted to less than 0.05 percent of total crop value. All U.S. hop output is irrigated, so drought is not a production peril. Freezing temperatures are also not generally a problem.

### **Hop Insurance Implementation Issues**

#### **Adverse Selection**

Adverse selection is most likely to be associated with insuring yards that are poorly maintained. Hop yards have a useful life estimated at between 25 and 50 years. Individual poles and wires in the yard, however, may need to be replaced at more frequent intervals because of damage from rot or stress. Weak poles or wires are more likely to collapse under the weight of a heavy crop than are those in well-maintained yards. Growers in such situations may be more likely to buy insurance. If hop insurance is offered, FCIC may wish to require inspection of the yard prior to the attachment of coverage.

#### **Setting Reference Prices**

FCIC provides reference prices (price elections) for insured crops, which become the basis for assigning values to yield losses. When purchasing insurance, growers must choose a price election. One issue would be whether to

Table 8--U.S. hops: harvested acreage and disaster assistance payments, 1988-93

State	Average hop harvested acreage, 1988-93	Share of U.S. acreage	Total hop disaster payments, 1988-93	Share of U.S. hop disaster payments
	Acres	Percent	Thousand dollars	Percent
Idaho	3,396	9	240	85
Oregon	7,500	20	18	7
Washington	27,158	71	22	8
U.S.	38,054	100	281	100

Sources: USDA, NASS, and USDA, CFSA data files, compiled by the General Accounting Office.

Table 9--U.S. hops: crop value and disaster assistance, selected states, 1988-93

State	Total crop value	Total disaster payments	Disaster payments, percent of crop value
	-----1,000 dollars-----		Percent
Idaho	44,315	240	0.5
Oregon	116,188	18	*
Washington	459,121	22	*
Total	619,374	281	*

\* Less than 0.05 percent.

Sources: USDA, CFSA data files, compiled by the General Accounting Office and USDA, NASS.

base price elections on the season average price for all hops or to base it on spot prices for the particular type of hops being insured.

The season average price is a blend of contract and spot prices for various types of hops. The merits of using the season average price are that data are readily available to project prices for a future season and the season average price remains relatively constant from year to year. USDA estimates the season average price annually and reports this estimate in its *Crop Values* publication. The average remains relatively constant from year to year because about 95 percent of the crop is contracted, up to 5 years or more in advance. Contract prices do not change due to short-term market gluts and shortages.

Data on spot prices also are readily available (*Livestock and Grain Market News* in Portland, Oregon reports hop contracts and sales), but spot prices vary widely from year to year. Only about 5 percent of U.S. hop production is sold in the spot market, and short-term market gluts or shortages cause wide swings in spot prices.

#### **Availability of Yield Data**

The hop commissions in all three major producing states charge assessments to growers on the basis of hop production. These data provide a record of production history, but not of acreage. One grower, who also sells hop insurance, indicated that most growers have at least 3 or 4 years of yield records, and usually by hop variety (Weathers).

#### **Estimating "Appraised Production"**

Appraised production for hops could be estimated by harvesting a sample of plants or small plots and measuring the yield and quality of recoverable hops from the sample. Average recoverable yield per plant can be converted to a per-acre basis by multiplying by the number of plants per acre. The number of plants per acre can be calculated on the basis of plant spacing. A hop yard with plants spaced at 7½ feet by 7½ feet, for example, has about 775 plants per acre.

The recoverable yield may need to be adjusted for quality loss, particularly regarding the alpha acid content. Chemical analysis could be used to indicate the alpha acid content.

#### **Insuring Older Plantings**

All hop yards have a history that affects expected yield performance, and the insurer must know this history when offering crop insurance. Some relevant aspects of that history include historical hop yields, disease infections, the hop variety, soil type and fertility, and the age of the planting.

Although hop production declines past a threshold number of years, it is not always possible to specify the age at which the decline begins. Some hop yards produce continuously for 20 years or more, although individual plants in such yards may be less than 20 years old, having replaced disease or weakened plants. On the other hand, some yards show decline after only 10 years, due to severe downy mildew or viral infections.

Most commercial plantings are replaced after 10-12 years of productive life. In general, plantings that are more than 15 years old have begun to realize a decline in yields. Because of the decline in yields from older stands, an insurer may want to specify an age beyond which the planting will no longer be insurable.

#### **Insuring Price Risks**

There appears to be little need for insurance that protects against price risk for hops. Because a high proportion of the crop is contracted, grower prices are relatively constant from season to season. Spot prices vary widely, but spot sales of hops usually account for 5 percent or less of the crop.

**Moral Hazard**

Moral hazard due to economic abandonment is not likely to be a widespread problem with insuring hops. In most cases, growers would realize a higher net return from harvesting and delivering the hops to a dealer than from losing a crop and collecting insurance.

**Private Insurance**

Growers currently have access to private insurance for hops that covers most production perils in the three growing areas. Agents named at least four companies currently insuring hops (Craigen, Weathers). These agents indicated that growers could purchase insurance against losses due to wind, hail, falling objects, consequential losses due to fire, and losses due to vandalism. Growers reportedly can insure the hops, the trellis, or both. According to these agents, most growers purchase at least minimal insurance coverage.

**Demand for Insurance**

It is our assessment that there will not be significant demand for Federal crop insurance for hops in most areas, particularly for coverage beyond the minimum catastrophic coverage level. Several private companies already offer insurance tailored to the crop's needs, and unless growers could buy equivalent or superior coverage at a lower cost, they are likely to retain their private insurance coverage.

Growers in Oregon, however, specifically indicated that they would like for hops to be a Federally-insured crop so they could qualify for catastrophic coverage. They feel that they would never have area losses large enough to trigger payments under the Non-insured Assistance Program, but that individual growers might incur losses large enough to collect under catastrophic coverage.

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Appendix table 1--U.S. hops: farms and acres harvested and irrigated, 1987 and 1992

State/County	-----1992-----				-----1987-----			
	Farms	Acres Harvested	Percent irrigated		Farms	Acres Harvested	Percent irrigated	
			----- Farms	----- Acres			----- Farms	----- Acres
Idaho	11	3,054	100.0	100.0	11	1,799	100.0	100.0
Canyon	11	3,054	100.0	100.0	11	1,799	100.0	100.0
Oregon	43	7,267	100.0	100.0	42	6,790	100.0	100.0
Marion	39	6,452	100.0	100.0	37	5,674	100.0	100.0
Other	4	815	100.0	100.0	5*	1,116*	100.0*	100.0*
Washington	79	30,228	100.0	100.0	96	21,577	100.0	100.0
Benton	9	5,895	100.0	100.0	13	3,826	100.0	100.0
Yakima	70	24,333	100.0	100.0	83	17,751	100.0	100.0

\* Oregon total less Marion County.

**Cost of Production Appendix:**

Yakima Valley, Washington  
(2 pages)

**Cost of Production Appendix:**

Willamette Valley, Oregon  
(3 pages)

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