Comprehensive Crop Reports

Blueberry Production Trends in North America, 1992 to 2003, and Predictions for Growth

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Summary. **Blueberry production area in North American increased 30% from 1992 to 2003 to 239,818 acres (97,054 ha); most of this increase occurred in Canada. During this period, lowbush blueberry (*Vaccinium angustifolium*) area increased 33% and highbush 24%. In the United States, the area planted to highbush, which includes northern (*V. corymbosum*) and southern highbush (*Vaccinium* sp.) and rabbiteye (*V. ashei*) blueberries, increased from 48,790 acres (19,745 ha) to 55,898 acres (22,622 ha) from 1992 to 2003, a 15% increase. In 2003, the midwestern region of the U.S. accounted for 35% of the area of highbush blueberries planted. The southern, northeastern, and western regions accounted for 29%, 19%, and 13% of the planted area, respectively. Specific states in the U.S. that had considerable growth from 1992 to 2003 were California, Mississippi, North Carolina, Oregon, and Washington. In Canada, the area planted to highbush blueberries increased 105% to 11,010 acres (4456 ha). Commercial blueberry plantings in Mexico were estimated at 70 acres (28.3 ha) in 2003. In the U.S., total lowbush area increased 6% in 10 years, with Maine accounting for 97% of the area planted. In Canada, lowbush area increased 57% since 1992 with 37% and 34% of the total area present in Quebec and Nova Scotia, respectively. The blueberry industry is still projected to grow considerably in the next 5 to 10 years. Highbush blueberries in the U.S. are expected to increase in area planted by 14% and 31% in the next 5 and 10 years, respectively. In Canada, planted area of highbush blueberries is expected to increase by 22% in 5 years and 26% in 10 years. If projections are correct, planted area in Mexico will increase by almost 30-fold in 10 years. The managed area of lowbush blueberries is expected to increase by 5% to 10% over the next 10 years. Data on typical yields, types of cultivars grown, markets, proportion of machine harvest, major production problems, and changes in production practices are presented.**

Blueberry cultivation in North America is thought to have started when Native Americans burned wild stands of native lowbush blueberry (*Vaccinium angustifolium* and *V. myrtilloides*) in eastern North America to tend them and to increase production. European settlers began managing wild stands in the 19th century (Eck and Childers, 1966). Cultivation of rabbiteye blueberries (*V. ashei*) began near the end of the 19th century (Mowry and Camp, 1928). Elizabeth White and F.V. Coville are credited with starting cultivation of the northern highbush blueberry (*V. corymbosum*) in the early 1900s (Eck and Childers, 1966). The first southern blueberries (complex hybrids based largely on *V. corymbosum* and *V. darrowi*), 'Sharpblue' and 'Flordablue', developed by R. Sharpe and W. Sherman at the University of Florida, were released in 1975. Development of plantings were, however, slow with only 10 to 15 acres (4.0 to 6.1 ha) of pick-your-own southern highbush in Florida in 1978. The first fresh southern highbush blueberries were shipped out of Florida in 1982 (P. Lyrene, personal communication). The initial increase in area planted to cultivated blueberries in North America was slow. In 1930, 10 years after the first cultivars were introduced from Coville's program, there were fewer than 200 acres (80.9 ha) in production. However, by 1965 there were 20,000 acres (8094 ha) of cultivated blueberries planted. In 1992, James Moore (1994) conducted a survey of blueberry production in

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Table 1. Area of highbush and lowbush blueberries in North America (1 acre = 0.4047 ha). Data for 1992 are from Moore (1994) except for California, Prince Edward Island, and Mexico.

Country (*region*)	State or province	Area (acres)				Change (%)		
		1992	2003	2008	2013	1992–2003	2003–08	2003–13
U.S.								
Highbush								
Northeastern	Connecticut	200	200	200	200	0	0	0
	Delaware	75	75	75	75	0	0	0
	Massachusetts	500	500	500	500	0	0	0
	Maryland	170	85	100	100	–50	18	18
	Maine	200	195	200	200	–3	3	3
	New Hampshire	245	245	245	245	0	0	0
	New Jersey	8200	7400	7400	7400	–10	0	0
	New York	1210	1000	1000	1000	–17	0	0
	Pennsylvania	495	500	550	600	1	10	20
	Virginia	210	225	290	400	7	29	78
	Vermont	100	100	100	100	0	0	0
	West Virginia	10	40	50	50	300	26	26
Southern	Alabama	495	370	400	500	–25	8	35
	Florida	2100	2400	2500	3500	14	4	46
	Georgia	4125	6000	8000	9000	45	33	50
	Mississippi	1110	2000	2500	3500	80	25	75
	North Carolina	3900	5000	5500	7500	28	10	50
	South Carolina	395	395	400	400	0	1	1
	Tennesse	170	275	400	500	62	46	82
Midwestern	Iowa	5	25	40	80	400	60	224
	Illinois	200	100	100	100	–50	0	0
	Indiana	740	795	795	795	7	0	0
	Kansas	5	50	50	75	900	0	50
	Kentucky	50	100	150	150	100	50	50
	Michigan	17,025	18,000	18,100	18,200	6	1	1
	Minnesota	75	120	150	150	60	25	25
	Missouri	300	300	300	300	0	0	0
	Ohio	270	280	280	280	4	0	0
	Wisconsin	5	30	35	40	500	17	33

Table 1 continued on next page.

North America. He reported that the area planted to blueberries increased 19% from 1982 to 1992; cultivated types increased 47% and lowbush 11%. He projected that the total area planted to blueberries in North America would increase 14% by 2000 (Moore, 1994). However, demand for blueberries has exceeded supply in the last 10 years, causing larger than predicted growth.

Blueberries have become a major crop worldwide. This paper reports on the results of a survey conducted in 2003 on production in North America. The objectives of this survey were to determine how many acres of blueberries were planted, what types of blueberries were being grown (northern or southern highbush, rabbiteye, or lowbush, and what cultivars), average yield, harvest methods, amount of area in organic production, markets for fruit, types of production system changes, significant pest and other problems, and expected trends for the next 5 and 10 years. This paper does not include information on harvest of any native *Vaccinium* species (e.g., in Montana or Alaska), other than the lowbush blueberry, *V. angustifolium*. Surveys were sent out to extension and research colleagues and key industry leaders in states in the U.S. and provinces in Canada that were known to have at least 50 acres (20.2 ha) of blueberries planted. Key industry leaders provided information on production in Mexico. Large wholesale blueberry nursery owners were asked to check the survey results for any obvious discrepancies with plant sales. Greater detail on who provided help with this survey is provided in the acknowledgments section.

Production regions

Although blueberries are likely cultivated to some extent (e.g., home gardens or small test evaluation trials) in most regions of North America, commercial cultivation was not present or was considered very minor in 2003 in Alberta, Manitoba, Northwest Territories, Nunavut, Saskatchewan, the Yukon, Alaska, Arizona, Colorado, Hawaii, Montana, Nebraska, New Mexico, North Dakota, Rhode Island, South Dakota, Utah, and Wyoming. The discussion of highbush and lowbush blueberries is separated within each of the following sections to simplify presentation and due to their very different production systems.

HIGHBUSH. In the U.S., the area planted to highbush blueberries (northern and southern highbush and rabbiteye) increased from 48,790 to 55,898 acres from 1992 to 2003, a 15% increase (Table 1). This is considerably higher than the 40,965 acres (16,579 ha) reported by the U.S. Department of Agriculture (USDA, 2004). The difference is likely because USDA reports harvested area rather than total area, acreage in some states may be underreported, and many states that had significant blueberry plantings were not included in the 2003 USDA report (e.g., Mississippi, Texas).

Table 1. Continued from previous page.

Country (*region*)	State or province	Area (acres)				Change (%)		
		1992	2003	2008	2013	1992–2003	2003–08	2003–13
Southwestern	Arkansas	1285	350	350	350	–73	0	0
	Louisiana	395	360	370	380	–9	3	6
	Oklahoma	200	150	150	150	–25	0	0
	Texas	1310	760	990	1110	–42	30	46
Western	California	50	1500	5000	8000	2900	233	433
	Idaho	100	125	125	125	25	0	0
	Oregon	1655	3700	4200	4700	124	14	27
	Washington	1210	2150	2400	2700	78	12	26
U.S. highbush	Total	48,790	55,898	63,995	73,455	15	14	31
Lowbush								
	Massachusetts	240	240	240	240	0	0	0
	Maine	60,050	64,000	67,200	70,559	7	5	10
	Michigan	0	200	200	200	na	0	0
	New Hampshire	1385	1000	1000	1000	–28	0	0
U.S. lowbush	Total	61,675	65,440	68,640	71,999	6	5	10
Canada								
Highbush	British Columbia	4497	10,000	12,000	12,000	122	20	20
	Nova Scotia	50	160	200	220	220	25	37
	Ontario	680	400	600	800	–41	50	100
	Quebec	150	450	650	850	200	45	89
Canada highbush	Total	5377	11,010	13,450	13,870	105	22	26
Lowbush	New Brunswick	8005	24,200	25,402	26,674	202	5	10
	Nova Scotia	28,195	37,000	38,852	40,796	31	5	10
	Newfoundland	495	1200	1260	1322	142	5	10
	Prince Edward Island	1630	5000	5251	5510	207	5	10
	Quebec	30,220	40,000	42,000	44,095	32	5	10
Canada lowbush	Total	68,545	107,400	112,764	118,398	57	5	10
Mexico								
Highbush		25	70	500	2000	183	614	2757
Total North America:								
Highbush		54,192	66,978	77,946	89,325	24	16	33
Lowbush		130,220	172,840	181,404	19,0397	33	5	10

In 2003, the midwestern region (see Table 1 for states included in each region) of the U.S. accounted for 35% of the area of highbush blueberries planted. The southern, northeastern, and western regions accounted for 29%, 19%, and 13% of the planted area in 2003, respectively (Table 1). The relative importance of these production areas in the U.S. has changed relatively little since 1992, except the proportion of area in the western region increased from 6% to 13%; this increase was due to relatively little change or a decrease in area planted in the northeastern and midwestern regions (Fig. 1). In fact, the only two regions of the U.S. that have significant projected growth in the next 5 to 10 years are the western and the southern regions (Fig. 1). The relative proportion of total area planted located in the major states and provinces is presented in Table 2.

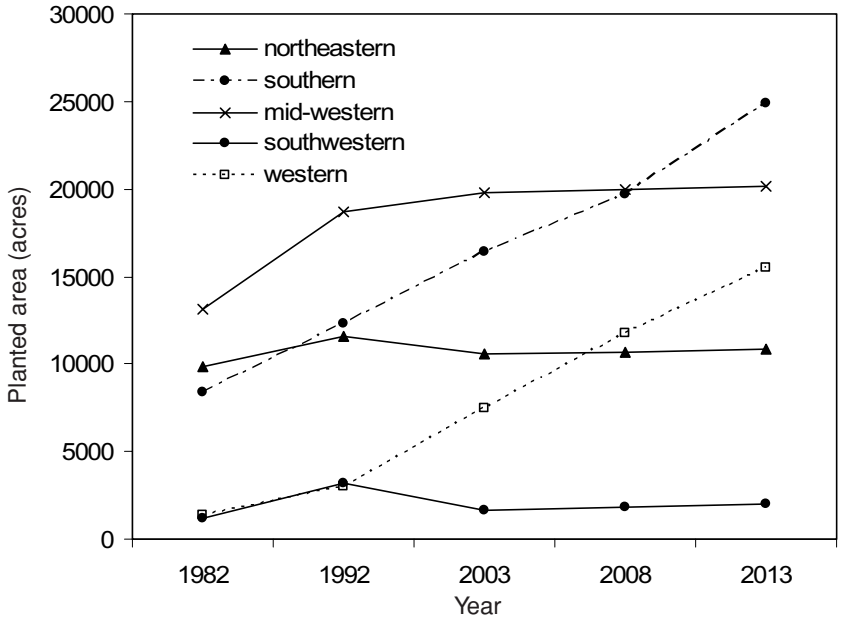

Fig. 1. Total highbush blueberry (northern, southern, and rabbiteye) planted area by region (see Table 1) in the U.S. from 1982 through 2003 and projected for 2008 and 2013 (1 acre = 0.4047 ha). Data for 1982 and 1992 are from Moore (1994).

Table 2. Utilization and the importance of machine harvesting in highbush blueberries produced in the major states or provinces in the U.S., Canada, and in Mexico.

Country (state/province)	Proportion of total area planted within country			Utilization			Machine harvested		
	1992[z]	2003	2013[y]	Processed	Fresh	PYO[x]	Processed	Fresh	Change[w]
	---------- % ----------						--------- % ---------		
U.S.									
Michigan	35	33	25	70	30	?	100	90	Slow +
New Jersey	17	13	10	20	80	0	91	10	0
Georgia	8	11	12	40–70	30–60	2	100	60	–
North Carolina	8	9	10	20	76	4	99	20	0
Oregon	3	7	6	55	40	5	85	15	++
Washington	2	4	4	75	25	?	50	0	+
Mississippi	2	4	5	50	49	1	100	50	+++
California	0	3	11	0	100	?	---	0	0
Florida	4	4	5	0	90	10	---	0	0
Others	21	14	12						
Canada									
British Columbia	84	92	87	40	58	2	25	5	+
Ontario	13	3	6	5	95	?	50	10	0
Quebec	0	4	6	0	35	65	---	0	0
Others	3	1	1						
Mexico	---	---	---	0	100	0	---	0	0

[z]From Moore (1994).
[y]Estimated.
[x]PYO = pick-your-own farms.
[w]Change expected from 2003 to 2013; 0 = stable or little change in proportion of production that is machine harvested; "–" = a decrease; "+" = an increase.

Specific states in the U.S. that had considerable growth in highbush blueberries planted from 1992 to 2003 were California, Mississippi, North Carolina, Oregon, and Washington (Table 1). The growth or loss in area from 1992 to 2003 is based upon our data collected in 2003 and the 1992 data presented by Moore (1994).

In Canada, the area planted to highbush blueberries increased 105% from 1992 to 2003 (Table 1). British Columbia continued to account for the majority of the area planted (Table 2), but there was also a large increase in highbush plantings in Quebec.

There was no recorded blueberry production in Mexico in 1992 (Moore, 1994), but some respondents felt there were likely some plantings there 10 years ago (Table 1). Commercial blueberry plantings in Mexico were estimated at 70 acres in 2003 (Table 1).

North America accounted for 75% of the acreage and 83% of total highbush blueberry production in the world in 2003 (Brazelton, 2004).

The blueberry industry is projected to continue to grow considerably in the next 5 to 10 years (Table 1, Fig. 2). The area of highbush blueberries planted in the U.S. is expected to increase by 14% and 33% in the next 5 and 10 years, respectively. Of particular note, is the huge projected increase in plantings in California to 8000 acres (3238 ha) in 2013. Planted area in Mississippi is expected to double in the next 10 years (Table 1). In Canada, planted area of highbush blueberries is expected to increase by 22% in 5 years and 26% in 10 years (Table 1); thus there is lower projected growth in Canada in the long-term. If projections are correct, planted area in Mexico will increase by almost 30-fold in 10 years (Table 1).

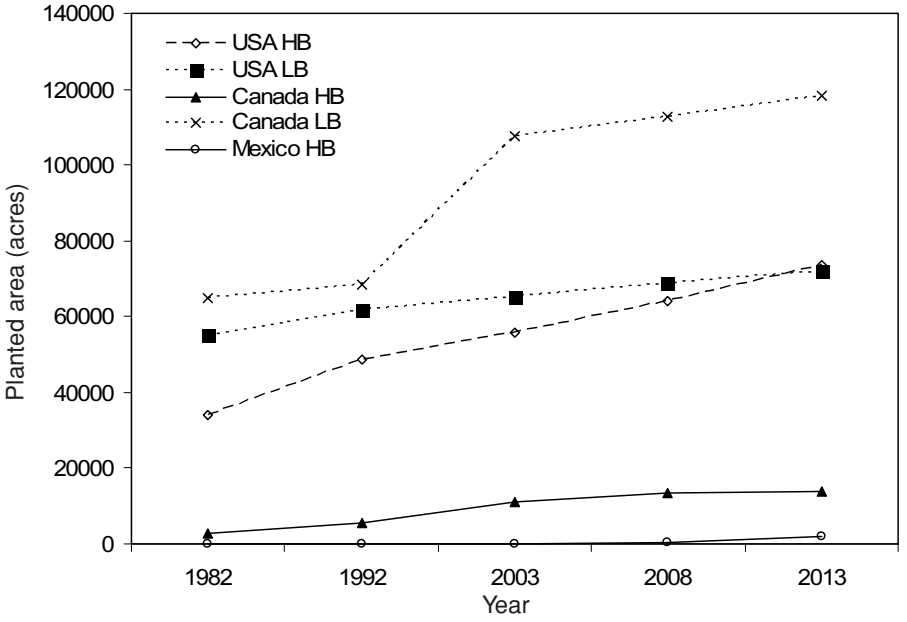

Fig. 2. The area (1 acre = 0.4047 ha) of highbush blueberries (HB; northern, southern, and rabbiteye) and lowbush blueberries (LB) in the U.S., Canada, and Mexico from 1982 through 2003 and projected for 2008 and 2013. Data for 1982 and 1992 are from Moore (1994).

Farm size in 2003 averaged 5 to 25 acres (2.0 to 10.1 ha), with a range

of 1 to 900 acres (0.4 to 364.2 ha) depending on production region.

Respondents estimated that there were 480 acres (194.3 ha) of highbush blueberries produced organically in the U.S. and 60 acres (24.3 ha) in Canada in 2003. All respondents expected the amount or proportion of organic plantings to increase in the near future.

Average yield per acre reported by respondents and national statistics (USDA, 2004) was consistently lower than the "typical" yield reported for each region of North America. This is expected when statistics agencies calculate the average yield per acre from total production and harvested area data—this greatly underestimates average yield of mature fields as many of the harvested fields are not yet in full production. This inaccuracy in national statistics is expected to continue while the blueberry industry in North America continues to grow. Typical yields for well-managed, mature highbush blueberry fields were reported as 3 to 4 tons/acre (6.7 to 9.0 $Mg \cdot ha^{-1}$) for the northeastern, southern, and southwestern regions, 4 to 4.5 tons/acre (9.0 to 10.09 $Mg \cdot ha^{-1}$) for the midwestern region, and 9 tons/acre (20.2 $Mg \cdot ha^{-1}$) for the western region (excluding Idaho where blueberries are less well adapted and California where there were few mature fields in 2003). Of course, yield amongst fields within a region is extremely variable due to effects of microclimate, cultivar, and management practices. If all fields were managed to yield their full potential, production in the U.S. would be projected to achieve 340,060 tons (308,502 Mg) when all the present planted area is mature, not accounting for any increase in planted area! This type of production is likely not achievable.

In Canada, typical yields for highbush blueberry ranged from 5 tons/acre (11.2 $Mg \cdot ha^{-1}$) in Ontario and Quebec to 8 to 9 tons/acre (17.9 to 20.2 $Mg \cdot ha^{-1}$) in British Columbia.

Total highbush blueberry production in North America in 2003 was 115,450 tons (104,736 Mg) with approximately 60% sold for fresh market (Fig. 3).

Lowbush. The total area of lowbush blueberries harvested from managed wild stands also increased in the last 10 years. In the U.S., total lowbush area increased 6% since 1992 with Maine accounting for 97% of the area in 2003. In Canada, lowbush area increased 57% since 1992 with 37% and 34% of the total area in 2003 in Quebec and Nova Scotia, respectively. There were also large increases in lowbush blueberry area in New Brunswick and Prince Edward Island (Table 1). Since lowbush blueberries are native, this increase in area reflects a larger portion of the native stands being managed for harvest due to positive blueberry markets. The managed area of lowbush blueberries is expected to increase by 5% to 10% over the next 10 years (Fig. 2). Only half of the total area of lowbush blueberries is harvested annually because of alternate year pruning practices (Yarborough, 2004). Average yields of lowbush blueberries were 1.3 tons/acre (2.91 $Mg \cdot ha^{-1}$) but in a well-managed field yields of 5 tons/acre (11.2 $Mg \cdot ha^{-1}$) can be achieved. There were an estimated 295 to 495 acres (119.4 to 200.3 ha) of lowbush blueberries produced organically in 2003—this area is also expected to increase in the near future.

Total lowbush blueberry production in North America in 2003 was 100,750 tons (91,400 Mg) with approximately 99% sold for processing (Fig. 3).

Total processed production of highbush and lowbush blueberries in North America increased by 29% from 1993 to 2003; whereas total fresh production increased 64% in the same time period (Fig. 3).

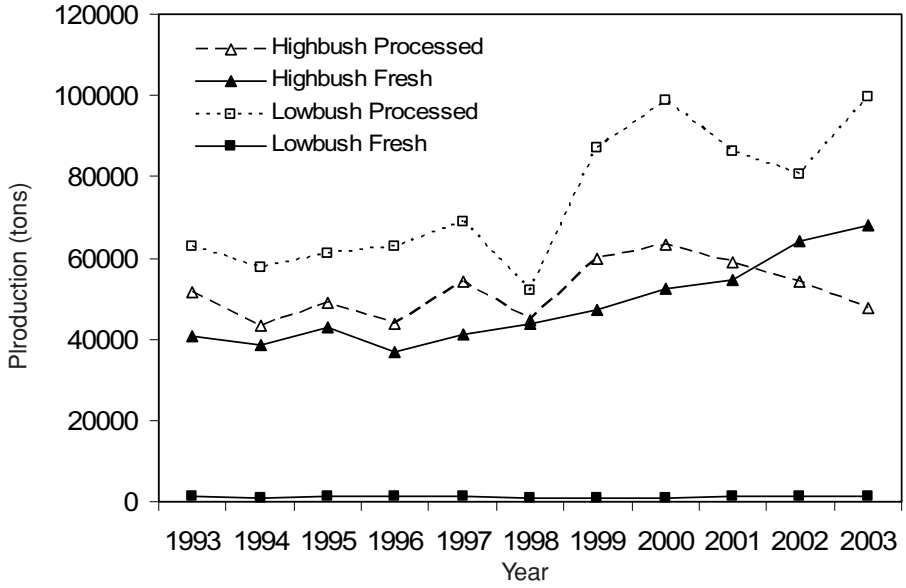

Fig. 3. The production (1 ton = 0.9072 Mg) of highbush blueberries (northern, southern, and rabbiteye) and lowbush blueberries for the processed and fresh markets in North America from 1993 through 2003 (source: North American Blueberry Council, Folsom, Calif.).

Table 3. Area of northern highbush, southern highbush, rabbiteye, and lowbush blueberries in North America from 1982 to 2003 (1 acre = 0.4047 ha); 1982 and 1992 data from Moore (1994).

	Area (acres)		
Blueberry type	1982	1992	2003
Northern highbush	31,382	43,525	50,030
Southern highbush	395	1015	6400
Rabbiteye	4818	9637	10,548
Lowbush	119,900	130,220	172,840

Cultivars

Highbush. The area planted to northern highbush and rabbiteye blueberries in North American increased 15% and 9%, respectively from 1992 to 2003 (Table 3). There was over a 6-fold increase in the area planted to southern highbush blueberries in the last 10 years, due mainly to new, well-adapted cultivars released by the University of Florida, North Carolina State University, and the USDA, Agricultural Research Service, New Jersey. The proportion of the total area planted to northern highbush blueberries declined from 1992 (80%) to 2003 (75%), whereas the proportion of southern highbush increased from 2% in 1992 to 10% in 2003 (Table 3).

Northern highbush blueberries

accounted for 100% of the planted area in the midwestern region, 99% of the northeastern region, 81% of the western region, and 15% to 17% of the southern and southwestern regions. Respondents were asked to provide a list of cultivars in mature northern highbush plantings and in newly established ones. The most common cultivars in established plantings in the midwestern and northeastern regions were 'Bluecrop', 'Jersey', 'Blueray', 'Rubel', 'Elliott', and 'Duke'. In newly established plantings, 'Bluecrop', 'Elliott', 'Duke', 'Nelson', and 'Brigitta' (Indiana only) were mentioned. In Minnesota, however, about 40% of the area was planted to half-high blueberries developed at the University of Minnesota ('Chippewa', 'St. Cloud', 'Polaris', and 'Northblue') in 2003, due mainly to the extreme winter temperatures that occur in this region. In the northeastern region, new cultivars that "show a lot of promise" were listed as 'Draper', 'Aurora', and 'Liberty', from Michigan State University, and 'Duke'.

In Oregon and Washington in the western region, the predominant cultivars in established, mature plantings were 'Bluecrop', 'Duke', 'Elliott', 'Berkeley', the advanced selection 1613-A (sometimes called "hardyblue" by growers), 'Bluejay', 'Earliblue', 'Jersey', 'Blueray', 'Reka', 'Rubel', and 'Brigitta'. In new plantings, 'Duke', 'Bluejay', 'Reka', 'Ozarkblue', 'Elliott', and 'Bluecrop' were listed. Again the new releases 'Draper', 'Liberty', and 'Aurora' show great promise. In California, there was very little northern highbush blueberry production, as this type of blueberry is not well adapted to this growing region.

Southern highbush blueberries accounted for 23% of the planted area in the southern and southwestern regions and 18% of the western region (only in California). In the southern region, 'O'Neal', 'Bluecrisp', 'Reveille', 'Southern Belle', 'Star', 'Bladen', 'Emerald', 'Jewel', 'Sharpblue', 'Misty', 'Millenia', and 'Windsor' were listed as being planted in mature fields. In newer plantings, 'Star', 'Emerald', 'Jewel', 'Millenia', 'Sebring', 'O'Neal', 'Legacy', 'Reveille', 'Sampson', and 'Jubilee' were planted. There was a long list of promising new southern highbush for the southern region: 'Emerald', 'Millenia', 'Bluecrisp', 'Craven', 'Lenoir', 'Pamlico', 'Arlen', 'Jewel', and 'Sebring'.

In Califonia, there were not many mature plantings in 2003. The most common southern highbush planted were 'Misty', 'O'Neal', and 'Star'. The newer cultivars from Florida, 'Jewel' and 'Emerald', also show promise in this state.

In 2003, rabbiteye blueberries were predominantly grown in the southern and southwestern regions, accounting for 62% of the planted area in these regions, whereas in the northeastern and western regions (only in Oregon), rabbiteyes only accounted for 1% of the total area planted. 'Climax', 'Tifblue', 'Brightwell', 'Premier', and 'Powderblue' were found in mature plantings in the southern and southwestern regions. In Oregon, 'Powderblue', 'Centurion', 'Rahi', and 'Brightwell' were in mature plantings. 'Powderblue', 'Rahi', and 'Maru' were being planted in Oregon whereas 'Powderblue', 'Brightwell', 'Tifblue', 'Premier', and 'Columbus' were being planted in the southern and southwestern regions. New rabbiteye cultivars showing promise in the southern region were 'Ochlockonee', 'Alapaha', and 'Onslow'.

In Canada, the northern highbush cultivars being planted in British Columbia were very similar to those being grown in Washington and Oregon. Also, Ontario and Quebec have similar cultivars to the northeastern U.S. with the exception that the cold hardy 'Patriot' is more widely planted in Canada. There are no southern highbush or rabbiteye blueberries planted in Canada due to the cold winter temperatures or risk of spring frost damage. Southern highbush blueberries and a few acres of rabbiteyes were being grown in Mexico in 2003.

The major thrusts of breeding programs included development of low chill (California, Florida) to moderate chill (Georgia) cultivars, increased cold hardiness (Minnesota, New Jersey), better adaptation to climate (Arkansas, California, Florida, Oregon), adaptation to mineral soils (Arkansas, Georgia) or soils with a high pH (California), early ripening (California, Florida, Georgia, Mississippi, North Carolina, Oregon) or late ripening cultivars (Georgia, Michigan, Oregon), high yield (Florida, Mississippi), large fruit or other qualities for fresh or processed markets (Florida, Georgia, Michigan, Minnesota, Oregon, Washington), suitability for machine harvest (Georgia, Michigan, New Jersey, North Carolina, Oregon), disease resistance (North Carolina), insect resistance (North Carolina), and higher nutraceutical properties (Idaho). However, priorities vary depending on the region. Cultivar evaluation trials are located in many production regions in order to find the best suited cultivars for specific microclimates.

Respondents felt that plant patenting of new cultivars, which is becoming more common, provided increased stability for public breeding programs. Some programs felt they would not exist without income from royalties from patented cultivars. However, patenting may limit grower trial of advanced selections, limit availability of plants, restrict sharing of germplasm amongst programs, and increase the costs of nursery plants.

LOWBUSH. Although there are a few named cultivars of lowbush blueberry, these are not used to establish new stands, but are available in a few nurseries for the homegarden. Commercial lowbush fields consist of native clones of *V. angustifolium* and/or *V. myrtilloides*.

Production systems

HIGHBUSH. Blueberry production in many areas has undergone changes in the last ten years. In the southern and southwest regions, respondents mentioned the influence of better southern highbush and rabbiteye cultivars that target certain markets and production windows, have a higher yield, and higher berry quality (Florida, Georgia, North Carolina), cultivars that can be hand harvested at a higher picking efficiency (Florida), and cultivars that can be machine harvested for fresh market (North Carolina). In addition, changes such as higher density plantings, particularly in pine bark beds in southern highbush (Florida, Georgia), raised beds with irrigation in rabbiteyes (Georgia), machine pruning postharvest in southern highbush (Georgia, North Carolina), annual pruning of rabbiteyes (Mississippi), more machine harvest (Mississippi), and better post harvest fruit handling to improve fruit quality (Florida, Georgia, Mississippi, North Carolina). Use of growth regulators such as dormex to enhance leaf development in spring and advance ripening in southern highbush (Florida,

Georgia), gibberellic acid to improve fruit set and for frost "rescue" in rabbiteyes (Georgia), and ethephon to delay bloom in rabbiteyes (Georgia) has also increased in the last 10 years.

In the northeastern and midwestern regions, respondents mentioned a shift in cultivars with more 'Elliott' and 'Duke' planted (Michigan, New Jersey), greater use of tissue analyses and use of split applications of nitrogen to improve fertility management (Michigan, New Jersey, New York), machine harvest of half-high blueberries (Minnesota), increased use of electronic color sorters (Michigan), increased use of controlled atmosphere storage (Michigan), and increases in japanese beetle (*Popillia japonica*) have prompted some growers in Michigan to go to clean cultivation (removes sod that larvae feed on).

In the western region, the largest changes in Washington are higher density plantings, trellising for machine harvest, and a new production region in the eastern part of the state where modification of soil pH is necessary. In Oregon, highbush blueberry growers are now planting at an in-row spacing of less than 1 m, using trellising to improve machine harvest efficiency, raised beds are more common, there is less use of surface sawdust mulch to reduce production costs, there is a greater focus on maintaining pH within the desired range, and split applications of nitrogen fertilizer are now used. In California, where production is very new, pH management has been critical with acidification of soil and irrigation water using acid infiltration systems.

In Canada, testing of higher density plantings (Quebec), a shift to an in-row spacing of 1 m (British Columbia), earlier fruiting cultivars (British Columbia), and a greater focus on soil pH measurements and fertility management (British Columbia, Quebec) were mentioned as major changes.

In the U.S., there is considerable blueberry planted area that is not irrigated: 56% in Indiana, 50% in New Jersey, 45% in North Carolina, 30% in Michigan, 20% of the rabbiteye acreage in Georgia, and some of the mature northern highbush blueberry fields in northwestern Washington and in British Columbia. In new plantings, some areas are seeing more drip irrigation installed than overhead (Arkansas, California, Indiana, Minnesota, Mississippi, New York, and Washington; all areas in Canada; Mexico). In contrast, overhead sprinkler irrigation is much more common in new plantings in Florida, Michigan, New Jersey, North Carolina, and Oregon.

Most of the highbush fruit going to the processed market was harvested by machine in 2003, with the exception of Washington where only half was machine harvested (Table 2). A large change in the last 10 years has been the use of machine harvest for fresh marketed fruit, ranging from 0% in California and Florida with no expected changes in the near future to as high as 60% for fresh market rabbiteyes in Georgia (Table 2). Most production areas expected an increase in the use of machine harvesters due to the high cost and poor availability of labor.

Lowbush. Major changes in the lowbush blueberry industry include increased use of fertilization, irrigation, bee hives for pollination, and herbicides for weed management and management of soil pH, all of which have led to increased yield per acre.

Over 99% of the lowbush blueberry production was processed in 2003 (data not shown). Machine harvest of lowbush blueberries has increased in all production areas the last 10 years to 40% in Maine and 80% in Nova Scotia, 55% in Prince Edward Island, and 25% in New Brunswick. In Quebec, 75% of the acreage is harvested using mainly walk-behind machines. Use of machine harvesters is expected to increase in lowbush blueberry production also.

Production problems

Cultural

Highbush. The cultural problems associated with production of highbush blueberries in North America in 2003 included: spring frost injury (Florida, Georgia, Mississippi), winter cold damage (Minnesota, Quebec), soil problems such as drainage or undesirable pH (Arkansas, California, Georgia, Minnesota, North Carolina, New York, Mexico), pollination issues (Georgia), excessive rain at harvest, decreasing fruit quality (Georgia), difficulty managing irrigation (North Carolina, Oregon), short plant life (Florida), poor planting establishment (Mexico), aging fields of low yielding 'Jersey' (Michigan), keeping adequate fresh fruit quality in machine-harvested fruit (Michigan), erratic yields due to wet springs during bloom (Washington), and lack of knowledge of fertility requirements other than nitrogen (Oregon). In British Columbia a reduction in extension programs has resulted in many inexperience-induced production problems.

Lowbush. Cultural problems in this crop are predominantly spring frost or winter cold damage, dry weather or heat during the season, especially in un-irrigated fields, and variability in yield and quality of clones within and among fields.

Diseases

Highbush. Disease problems were listed as prevalent in all production areas in highbush blueberries; specifically mentioned were blueberry scorch or shock viruses or stunt phytoplasma (Indiana, North Carolina, New Jersey, New York, Oregon, Pennsylvania, Washington, British Columbia), mummy berry (*Monilinia vaccinii-corymbosi*) (Georgia, Indiana, Mississippi, North Carolina, New Jersey, Washington, British Columbia), anthracnose (*Colletotrichum gloeosporioides*) and alternaria (*Alternaria tenuissima*) fruit rots (Michigan, Minnesota, North Carolina, New Jersey, Oregon, Washington, British Columbia, Ontario), phytophthora root rot (*Phytophthora cinnamomi*) in southern highbush or northern highbush (Florida, Georgia, New Jersey, Oregon, British Columbia), botryosphaeria stem blight (*Botryosphaeria dothidea*) and cane canker (*B. corticis*) Florida, Georgia, North Carolina), bacterial canker (*Pseudomonas syringae*) (Oregon, British Columbia), various leaf diseases (Florida, Georgia, North Carolina) and rusts (*Pucciniastrum vaccinii*) (Florida, Mexico), and phomopsis (*Phomopsis vaccinii*) and fusicoccum cankers (*Fusicoccum putrefaciens*) (Michigan, New Jersey, New York).

Although many of these diseases were found in all production regions, of particular note is blueberry scorch virus, a relatively new virus to the western part of Canada. Blueberry scorch is an aphid-transmitted virus that was originally detected in New Jersey in the late 1970s. The East Coast strain, formerly known as the Sheep Pen Hill strain, causes symptoms on all cultivars except 'Jersey'. Growers

with blueberry scorch virus are advised to rogue infected bushes and apply aphicides accordingly to control the spread of the virus. In 2003, this eastern strain of blueberry scorch virus was only found in British Columbia and in several eastern U.S. states. This virus is spreading in British Columbia and may have implications on production potential in the near future.

LOWBUSH. Botrytis (*Botrytis cinerea*) and mummy berry are the major disease problems in lowbush blueberry fields.

Insects

HIGHBUSH. The importance of insect pests in highbush blueberry production varies tremendously by region. Insect pests are relatively few or minor in Arkansas, Oregon, Washington and British Columbia (other than aphids as a vector of blueberry scorch virus). Thrips (*Franklinia* spp.) and blueberry gall midge (*Dasineura oxycoccana*) were mentioned in the southeastern U.S. Blueberry maggot (*Rhagoletis mendax*), cranberry fruitworm (*Acrobasis vaccinii*), sometimes cherry fruitworm (*Grapholita packardi*), and japanese beetle were significant pest problems in Michigan, New Jersey, Indiana, and Pennsylvania. Cranberry fruit worm was listed as an important insect problem in Ontario and Quebec.

LOWBUSH. Blueberry maggot is the most important insect problem in lowbush blueberry production.

The other problems mentioned were weeds and birds (in highbush and lowbush fields) and deer (New Jersey, British Columbia, Quebec) and voles (*Microtus* spp.) or other rodent pests (Arkansas, California, Oregon, British Columbia) mainly in highbush fields.

Economic and regulatory concerns

There were various economic concerns listed for highbush blueberry production in particular including: high costs of production, especially at high density (Georgia, Oregon), high costs of pine bark culture (Florida), high pruning costs (Indiana, New York, Oregon), high labor costs (Georgia), decreased availability of labor (New York), competition from California (mentioned by Georgia), competition from the U.S. (mentioned by Mexico), cost of bringing packing sheds up to third-party audit standards, such as the Food Quality Protection Act, Good Farming Practices, Good Handling Practices (North Carolina), potential for lower prices due to increased area planted to blueberries (California, Indiana), competition from other production areas (Mississippi), low yields and thus low return for growers (Indiana, Mexico), instability of production/supply (Washington, Georgia, Minnesota), impending changes in packaging (California), and pressure for urbanization (Michigan).

Regulatory concerns included: access to migrant labor (Georgia, North Carolina, Oregon, British Columbia), wetlands or other water regulations (North Carolina, Washington, British Columbia), water use permits (Florida), third party audits for food safety assurance (Michigan, Mississippi, North Carolina), japanese beetle and blueberry maggot tolerances (Indiana), permits for bird control devices (British Columbia), and maintaining adequate pesticide registrations (California, Florida, Michigan, New Jersey, Oregon, British Columbia). The listing of the atlantic salmon (*Salmo salar*) as endangered is limiting water access for lowbush blueberry growers in Maine.

Limits to expansion

HIGHBUSH. Most areas producing highbush blueberries have some limitations to expansion of the area planted: cold winter climate and insufficient cold hardiness of present cultivars (Minnesota, Wisconsin, Nova Scotia, Ontario, Quebec), lack of suitable soils (California, Michigan, North Carolina, Pennsylvania), lack of sufficient planting stock (British Columbia), pressures for urbanization (British Columbia), and cost of establishment (Arkansas, California, Florida, Georgia, Mississippi, New York, Oregon).

LOWBUSH. The major limitation for expansion of this industry is finding native stands that can be brought into production economically.

Conclusion

In the last 10 years, the area planted to all blueberries in North American increased 30% to 239,818 acres, much more than the 14% growth Moore (1994) projected from 1992 to 2000. From 1992 to 2003, the area of lowbush blueberries increased 33% and highbush 24%. This industry is projected to grow another 8% to 17% in the next 5 and 10 years, respectively, despite the listed limitations to expansion. Lowbush blueberries account for a large portion of the total blueberry area in North America—this type of blueberry is harvested on an alternate year production cycle. The proportion of total area planted to southern highbush blueberries has increased in the last 10 years; these blueberries, as well as the rabbiteyes, greatly increase the area in which blueberries are adapted and will likely increase further in proportion of total area planted in another 10 years. The amount of area machine harvested for processing is expected to increase significantly. In addition, a relatively large share of fresh market blueberries are machine harvested—this is a significant change from 10 years ago.

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