Table 3. Comparison of shoot propagation rates for nine muscadine grape varieties[1].

Variety	Apices tested/shoots per apex
'Carlos'	60/3.7 a[2]
'Fry'	60/3.7 a
'Welder'	60/3.3 ab
FL-AA6-48	60/3.0 ab
'Jumbo'	55/2.9 abc
'Dixie'	45/2.7 bc
FL-AA7-44	35/2.7 bc
'Nesbitt'	60/2.2 cd
FL-AA5-37	45/1.7 d

[1]Apical meristems were cultured on MS medium with 5 μM BA for 6 weeks prior to determination of shoot number. Data reflect pooled results from 3 successive culture cycles.
[2]Means with the same letter are not significantly different at $\alpha = 0.01$ and 0.05, respectively, according to Duncan's New Multiple Range Test.

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Proc. Fla. State Hort. Soc. 103:302-306. 1990.

THE FLORIDA GRAPE INDUSTRY: WHAT'S AHEAD IN THE 90'S?

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Abstract. **In the last decade, important developments have occurred in the grape industry, both globally and in Florida. Some of these trends will have a positive impact and are to be exploited. Others are negative and must be countered by comprehensive planning, research and execution. Based upon the record of the 1980's, it is useful to reassess the strengths and weaknesses of the Florida grape industry and plan for the 90's.**

Opportunities are: the positive health image of fresh fruit and whole juice beverages; increased health concerns of Florida's large and growing resident and tourist populations; the state's thrust in value-adding crops and processes; the coordinating potential of the Viticultural Advisory Council; progress and promise of biotechnology relating to grape quality and cultivation efficiency; and improved beverage and wine manufacture techniques.

Challenges are: the urgent need for seedless cultivars with resistance to Pierce's disease; increased restrictions on water, agricultural chemicals and food additivies; a less abundant, more expensive labor supply; intense competition in fresh and processed fruit products; the worldwide economic downturn in the wine industry with decreasing per capita consumption and increasing taxation; and accelerated urbanization of agricultural land.

Florida Agricultural Experiment Station Journal Series No. N-00332.

Prologue

Ten years ago we looked back at the history of the Florida Grape industry and forward to projected needs for the 1980's (4). Now, with benefit of 10 years of hindsight, it is useful to examine the situation and to assess the accuracy of predictions and, most importantly, to establish the needs and priorities for the 1990's.

The catgories evaluated in 1980 were: breeding, culture, harvesting, processing and utilization, and marketing (4). This perspective will be followed again.

The Present

Breeding—Progress has been mixed. The new Florida hybrid green bunch grapes 'Suwanee' (17) and 'Blanc DuBois' (19) have been as well received by the wineries as Stover was in the 70's (15). 'Blanc DuBois' makes arguably the best white wine in Florida as reflected in state and regional wine competitions.

'Conquistador' (17) is a red wine grape that has not lived up to expectation due to uneven ripening and mediocre color stability. Were it not for past low yields, seediness and unevenness, 'Conquistador' potential as a juice and fresh market grape would be intriguing. 'Conquistador' is well suited to field packing fresh fruit into retail cartons as is now done with 'Concord' and 'Niagara' in the Northeast. Yields can be enhanced considerably by using 'Dog ridge' or 'CD9-81' as rootstock (18, 25).

The barrier to seedlessness was finally broken with the introduction of 'Orlando Seedless' (22). While the bearing habits and cultivation characteristics of this cultivar are far from ideal, 'Orlando Seedless' represents an important first step toward practical seedless cultivars.

Several muscadine cultivars introduced in the 1980's such as 'Alachua', 'Black Fry', 'Doreen', 'Golden Isles', 'Granny Val', 'Loomis', 'Nesbitt', 'Regale', and 'Senoia' (9, 20, 24) were primarily suitable for fresh market (23), with no dramatic improvement in wine quality over those developed in the 1970's (Table 1). In general, 'Carlos', 'Dixie', 'Welder' and 'Magnolia' are still the major white wine cultivars, and 'Noble' the preferred red muscadine wine grape. No muscadine wine grape introduction has proved as popular as 'Suwanee' or 'Blanc DuBois' have in the Florida hybrid bunch grape category.

Culture—The weather pattern over the last decade was not particularly conducive to uniform grape cultivation. In 3 of these years, late frosts severely damaged early bearing, hybrid cultivars. Damage was location-dependent and usually more severe in Central Florida, since hybrid grapes may bloom 2 or more weeks earlier in Leesburg than Monticello. In 1987, hail destroyed the hybrid crop at the IFAS Leesburg station. Unusually early budbreaks in 1989 and 1990 were not followed by a freeze, but by heavy rains, resulting in major hybrid losses in many areas of Florida, principally due to fungus diseases. Simulated frost damage (i.e. shoot removal) at a shoot length of 14 cm (5th leaf) to 22 cm (6th leaf) appears to be a threshold length associated with a reduction in yield and a delay of maturity of 'Suwanee'. Simulated frosts occurring when shoot length was less than 14 cm did not significantly impact yield or quality (2).

Another reflection of climatic variability was the near complete destruction of citrus trees by severe freezes in the northern one-third of the Citrus Belt (roughly north of interstate 4) in 1983, 1985 and again in 1989. In contrast, grape vines, which are dormant during the winter, are unlikely to sustain irreversible damage. However, as noted, late spring freezes frequently impair vegetative growth and yield of early maturing Florida hybrids (2).

Mowing continues to be a major cost factor in maintaining sod between the vineyard rows, and increased fuel costs aggravate the problem. Control of weeds in the rows and fungi on the vines is also more costly than previously. Sod that requires little mowing, and grape varieties with reduced spraying requirements are greatly needed.

Harvesting—Despite decreasing labor quantity, quality and reliability and increasing cost, only limited use of mechanization in grape pruning or harvesting has occurred, although important background research on mechanical pruning has been conducted (1, 35). Heavy pruning appears beneficial in the production of 'Dixie' muscadines for the fresh market, where a larger berry size and higher soluble solids may outweigh large yields. However, mechanical pruning with no touch-up could be used for 2 to 3 consecutive years to produce high yields of muscadines for processing (35).

The small size of vineyards (averaging about 3.5 acres) (8) has limited machine harvest developments. Once larger plantings are into production, mechanization will become more common in the state. There is one commercial harvester in state which adequately handles the needs of several wineries. Aside from a modified blueberry picker employed for younger vines of muscadines at the Central Florida Research and Education Center, Leesburg (16), appropriate harvest aids are neither under development nor in use.

The pace of development of new cultivars of bunch grapes has greatly outstripped our ability to determine optimum culture and management practices. *Vitis* hybrid bunch grapes in Florida have the distinction of being grown in one of the most undesirable climates from a viticultural perspective in the nation. Climatological factors important to *Vitis* hybrid bunch grapes in Florida include great fluctuations in winter temperature, a high frequency of spring frosts, the high relative humidity and air temperatures during the summer which increase the incidence of insect and disease problems, and high night temperatures which enhance the respiration loss of acid. Furthermore, Florida's edaphic characteristics (i.e. sandy soils,

Table 1. Sixteen muscadine grape cultivars recommended for various purposes and uses in Florida vineyards.

	Expected Uses							
			U-Pick				Home Gardens	
Variety	White wine	Red wine	Bronze	Black	Fresh Mkt.	Juice, Jelly	Bronze	Black
Alachua				X	X			
Albermarle								X
Carlos	X				X			
Cowart								X
Dixie	X		X			X[y]	X	
Doreen	X					X[y]	X	
Fry[z]			X					
Golden Isles	X							
Granny Val			X					
Jumbo[z]			X					
Nesbitt				X	X			X
Noble		X				X		
Southland								X
Summit[z]			X		X			
Triumph			X				X	
Welder	X					X[y]		

[z]Female variety: requires a self-fertile muscadine nearby for good fruit set (25 ft or less). The other varieties are self-fertile and bear fruit well without a different variety nearby.
[y]Blend juice with Noble for red color.

nematodes, etc.) often necessitate the use of vines grafted onto particular rootstocks (21, 25).

A major limitation in the culture of bunch grapes arises from a lack of quantitative data concerning training systems and levels of pruning severity. Vine training and pruning are among the most labor intensive of vineyard operations. Furthermore, the cane-training system, which is currently employed on bunch grapes, is the most labor intensive of all systems and not adapted to mechanization. A three year experiment was conducted on 'Suwanee' at the Research and Education Center in Monticello incorporating training system and level of pruning severity (2). Yield and berry quality were similar for cane- and bilateral cordon-trained vines, and pruning to 50, 70, 90 or 110 nodes per vine had little or no effect on yield or quality. 'Suwanee' produced a similar number of shoots whether pruned to 50, 70, 90 or 110 nodes per vine. Thus, 'Suwanee' may be trained to the mechanizable-adapted bilateral cordon training system, and pruning to a specific number of nodes per vine is not critical. Although other bunch grape cultivars have not been tested, preliminary data suggests that fruitfulness of 'Stover' is not as self-regulating. Experiments are being conducted to assess the feasibility of manipulating crop load by cluster thinning (P. C. Andersen, personal comm.)

Although research concerning training systems has been conducted on muscadine grapes (1), there is an urgent need for a holistic analysis of mechanization in light of high production costs.

Processing and Utilization—The "Wine Revolution" of the mid 1970's-1980's has run its course world wide. Indeed, wineries are proving to be the most volatile aspect of the Florida Grape industry. Since 1980, 9 wineries with a total (projected) capacity of about 150,000 gallons either opened or expanded operations in state (3, unpublished data). As of July 1990, five have ceased operation—primarily for financial reasons, since wine quality was above the regional (Southeastern U.S.) norm.

On-premise sales at the surviving wineries have been encouraging and Florida wines have a creditable quality record as reflected by in-state and regional wine competitions. However, as numerous wineries in the 40 odd states possessing a commercial wine industry have discovered, marketing in a highly competitive environment is an even more formidable challenge than producing quality wine in the face of cultivar, climatic, seasonal and enological problems. Even when achieved, market success is transitory, unless a major continuous effort is expended.

Still, the failure rate for Florida wineries exceeds national averages and this is cause for concern. Legislative intentions to increase alcohol taxes at both the state and federal level are now a reality. With these problems, can the remaining wineries collectively market over 100,000 gal. of Florida grape wine per year? They must in order to survive.

After the severe freezes of the 1980's many citrus growers were actively seeking alternative crops with grapes receiving some attention. Despite this interest, no increased grape plantings can be attributed to problems in the citrus industry. The impressive costs of bringing a vineyard into production, Table 2 (estimated at $4,500/acre (26), compared to $3,600/acre for citrus), relatively high maintenance costs and the tenuous market demand for local grapes are undoubtedly barriers to financial and time commitments to vineyards.

Table 2. Estimated costs and returns with Florida grape production (26).

	Bunch Grapes	Muscadines
Vineyard establishment (1st 2 years combined per acre costs)	$ 4,600	$ 3,910
Vineyard maintenance (3rd to 25th year, annual per acre costs)	1,170	1,067
Expected yields (t/acre), wine or juice	4-5	5-7
Ton price, wine or juice[z]	550	250
Gross per acre returns, wine or juice	2,475	1,500
Expected yields (t/acre), fresh	3.5-4.5	4-5
Ton price, fresh (grower harvest)[z]	1,000	1,000
Gross per acre returns (grower harvest)	4,000	4,500
Expected yields (t/acre), U-pick	3-4	3.5-4.5
Ton price, fresh, U-pick[z]	2,000	2,000
Gross per acre returns, U-pick	7,000	8,000

[z]Ton prices are based on an average received by Florida growers for wine, juice, or fresh market. U-pick ton prices are based on a dollar a pound, which is what *some* U-pick Florida growers now receive; new growers planning to market U-pick should try to obtain this amount.

While the interest in wines was diminishing, the expectations for juice increased. The unique floral character of muscadine fruit, a negative or at best neutral wine attribute, is well accepted in juice (27). A Mississippi firm has commercialized a range of muscadine grape products with single strength bottled juice being their lead product (28).

Investigations in Florida suggest that quality juices from both bronze and black muscadines are technically feasible (5, 14) and several groups are moving in that direction. With our dynamic Florida citrus industry, grape juice and beverages have possibilities, if favorable economics can be demonstrated.

Hybrid grapes also produce quality juice, but production costs and availability are less favorable for juice compared to muscadines. In fact, the major caveat to commercialization of either grape species is economic—small, widely dispersed, labor intensive vineyards. This is in dramatic contrast to the established grape industry in other parts of the U.S.

Marketing—During the 1980's better cultivars and increased interest in fresh grapes resulted in expansion of the ever popular U-pick business. Vineyards close to urban centers or in regions with a "Scuppernong" tradition have benefited the most.

One very promising thrust was initiated by the Grape Marketing Association (GMA), consisting of a few commercial members of the Florida Grape Growers Association. The driving force was one dedicated grower who commenced a vigorous sales campaign, first by establishing liaison with produce managers in food stores and then by assuring adequate supply and quality from participating grape growers. Despite formidable transportation and holding problems, the GMA was shipping 100 lugs/week over the 6 week harvest period from North Central Florida to as far away as Miami. Plans to expand never materialized due to quality and uniformity problems and complications in collection, storage and delivery logistics. The group fragmented and a few of the more progressive growers with well run vineyards eventually chose independent sales. Others drastically reduced efforts or ceased grape operations altogether to focus on other business goals.

These pioneers must be replaced with individuals possessing the necessary combination of viticultural competence, commitment and realism.

The Future

Breeding—Seedlessness is clearly the most important goal for Florida viticulture. The background research (11, 13) and success with 'Orlando Seedless' has set the stage. The high fresh fruit eating quality of 'Conquistador' would be vastly improved via seedlessness. Uneven bearing in this case is an advantage in a U-pick vineyard. More importantly, a quality seedless muscadine would have a dramatic effect on the popularity and commercial appeal of this hitherto under-recognized grape species (10). Already we have edible skin and pulp with better selections of muscadines, and the need is to combine these traits with seedlessness. Also, the high, balanced dietary fiber in traditional muscadine skin and pulp could be a definite plus, the consumption of which would be greatly facilitated by seedlessness. Use of advanced breeding techniques such as embryo rescue (12, 13) promises more rapid development of seedlessness in both bunch and muscadine varieties.

Cultivation—The major aspects to be addressed are labor and energy efficiency and environmental compatibility. Disease susceptible bunch grapes such as 'Blanc DuBois' and 'Orlando Seedless' will come under increased scrutiny due to associated pesticide load requirements to produce a crop. Along with seedlessness, disease resistance must be a high priority selection criterion.

It is important that the supply of plants be adequate for industry needs and that the plants are of high quality. For example, cultivars that require grafting should only be sold as grafted varieties. Orlando seedless frequently is sold on its own roots, which will result in poorer growth than would occur with grafted vines (11). Also, disease indexing of stock may be important. It is possible that many muscadines carry endemic agrobacterium infections, which is carried through cuttings. This causes crown gall and severe damage during freezes. Tissue culture micropropagation can be used to rid tissue of agrobacterium and produce clean stock. The stock can then be propagated with careful procedures to keep it clean (13). Micropropagation can also be used to quickly supply plants of new varieties when demand exceeds supply.

Despite, or perhaps because of, our severe grape growing environment there is a special factor which bodes well for our still embryonic grape industry. That is the comparative success of breeding and cultivation efforts in the face of formidable obstacles. The disease, insect, pest, climatic, environmental and postharvest problems which Florida viticulturists confront and overcome far exceed those in other grape regions. The successful strategies employed in Florida relating to variety and rootstock development (25), insect and disease control, and other cultivation and handling challenges have been of considerable value to viticulturists in less severe climates. This accumulated experience and knowhow is a valuable state resource which must be encouraged and strengthened in the decade ahead.

Harvesting—Mechanical harvest or harvest aids are essential. The small size, scattered location and wide range of cultivation practices are barriers to efficient mechanization. Wine and juice grapes, particularly muscadine, offer the best potential, since fresh market grapes would receive excessive damage with currently available harvest machines. Machine harvested 'Stover' and 'Noble' grapes generally deteriorated faster and to a greater extent than hand harvested grapes during postharvest holding, but can be held up to 24 hours without large losses in quality (33).

Recent development of a small scale grape harvester in Mississippi with a harvesting rate on muscadines of about 0.7 acres/hour is promising (7). This unit may prove useful in Florida.

Processing and Utilization—Enzymes, pressing regimes, membrane technology (ultrafiltration and sterile filtration) and a better understanding of browning reaction mechanisms, make it possible to produce stable, high quality juices and wines from Florida grapes (29, 30, 31, 32, 35). Sulfur dioxide levels can be reduced substantially without adversely affecting color, quality or stability (29, 34). Experience with citrus evaporators indicates that an acceptable frozen concentrate is technically feasible, although essence recovery and add-back techniques require refinement (6). Currently the economics of scale in production, processing, distribution and marketing preclude Florida grape beverages from competing directly with those from major grape regions. Nevertheless, there are attractive local and regional market alternatives. Of course, these niche markets are also the target of many food firms, including progressive, sophisticated manufacturers of tropical fruit products. These companies possess processing experience and marketing knowhow.

Marketing—The Viticulture Advisory Council has put in place mechanisms for increasing the popularity and market appeal of Florida grapes and grape products. Currently very limited tax monies are being allocated to grape research and promotion, the current breakdown, being 20% and 80%, respectively. Grapes will also have a prominent place in the Florida Department of Agriculture emerging Matched Funds Program for Florida-grown fresh produce.

At present, modest seasonal availability and demand and comparatively high production/distribution/processing costs are primary constraints to expanding fresh and processed markets. Nevertheless, with a large and growing resident and tourist population, Florida is an attractive, better than average market, especially for appealing, healthful food products. The citrus and allied beverage industry has recognized and exploited these circumstances. The grape industry needs to adopt a similar strategy.

At the most basic level grapes have cultural significance beyond agriculture. Attractive vines of appealing fresh eating cultivars have a place in both urban and rural landscapes. Even though 1 or several vines do not a viticulturist make, such efforts provide a favorable image. If widespread vine plantings can be encouraged at the household level, Florida grape popularity and awareness will be greatly enhanced.

Tropical fruits in South Florida are a relevant example. Alongside the small but efficient tropical and semi-tropical industry is a burgeoning interest in tropical fruits. This grass roots attitude and commercial developments are mutually beneficial to home owners and the horticultural industry. A similar symbiosis exists with grapes in other regions of the U.S. and world and could be promoted to a greater extent in Florida.

Table 3. Grape industry development goals for 2000.

Cultivation and Production

- Seedless cultivars of both bunch and muscadine possessing necessary disease resistance, high yield and good eating quality.
- Environmentally sound methods for dealing with the numerous cultivation constraints in Florida, applicable to both commercial and hobby viticulturists.
- Labor saving vineyard management techniques which reduce production and harvest cost without sacrificing grape quality.
- Greater understanding of how to match current and future cultivars to the climatic zones of Florida where they are best adapted as is now done in California.

Processing and Utilization

- Refinement and application of improved processing technologies from pressing through juice/wine stabilization to optimize product quality.
- Efficient handling, transportation and storage techniques for maintaining the quality of fresh and processed grape products throughout the distribution chain.

Marketing

- Revitalization of the Grape Marketing Association and establishment of an effective state-wide network for fresh grape sales.
- An integrated thrust to popularize Florida grapes and grape products involving all industry, institution and association groups.
- Florida Grape Growers Association attention to all segments of the population interested in grapes—the commercial viticulturist to the dooryard grower.

In conclusion, 1989 saw 580 acres of commercial grapes, valued at $821,000 in Florida (8). Over the next decade, if the dollar value (in 1990 $'s) cannot be increased at least 5 fold, we will still have a minor industry and modest progress. Fortunately, the tools and knowledge are in place to do the job. A cooperative, well planned and coordinated effort will be required. This effort will require a continuing intellectual and financial commitment from those organizations, institutions and associations who have contributed so much in the past. Table 3 suggests some but not all items on this important agenda. The 1960's asked the question. The 1970's defined the problem. The 1980's set the stage. Can the 1990's deliver the promise of a dynamic, self-sustaining Florida grape industry?

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Proc. Fla. State Hort. Soc. 103:307. 1990.

DISTRIBUTION AND EFFECT OF GRAPE MATURITY ON ORGANIC ACID AND SOLUBLE CARBOHYDRATE CONTENT OF RED MUSCADINE GRAPES

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Abstract. **The nature and content of muscadine grape organic acids and soluble carbohydrates, their distribution in grapes and changes in their relative concentrations with grape maturity were determined by HPLC. Distribution of the organic acids and carbohydrates was uneven within the berries. Acids were concentrated around the skin, while sugar content was highest in the juice. Unlike previous reports involving non-muscadine varieties, the major acids in the muscadines were succinic acid, tartaric acid and malonic acid. Succinic acid was the most abundant acid immediately after fruitset, but its concentration dropped sharply as the fruits matured. Tartaric acid was the most prominent acid from verasion until the fruits were fully mature. Malonic acid content increased gradually until verasion, after which it decreased as the fruits ripened. Malic acid was only present in minute quantities, a factor that might be responsible for the lack of malo-lactic fermentation in muscadine wines. Glucose and fructose are the two soluble carbohydrates present in the cultivars. The glucose to fructose ratio (2.0 at fruit-set) decreased as the fruits matured. The physiological differences between muscadine and non-muscadine grapes are expected to influence the properties of their processed products.**

Proc. Fla. State Hort. Soc. 103:307-310. 1990.

STRUCTURAL CHANGES IN FLORIDA'S VITICULTURAL INDUSTRY: ANALYSIS AND PROJECTIONS

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Abstract. **The viticultural industry in Florida has undergone significant structural transformation in number of farms growing grapes, acreage and production of grapes during the last decade. Economic conditions and marketing factors have contributed much to restructuring in the industry. Projections using the Trend Extrapolation, Moving Average and Exponential Smoothing techniques showed that 319 farms will be growing about 848 acres of grapes in Florida by 1997. Grape acreage will continue to grow at a modest rate as more growers are attracted to the industry. Annual production is also expected to increase and exceed 2 million pounds by 1997.**

Florida's viticultural industry has undergone significant change during the last decade. These changes have caused industry analysts to speculate on the future of Florida's viticultural industry. Several views have bee expressed, but, they often lacked an empirical and statistical basis. The vineyard and winery survey conducted by the Florida Agricultural Statistics Service in 1989 provides information on the current status of the industry in Florida and the changes that have occurred during the last decade. Identifying and quantifying these changes will provide useful information and help in projecting future changes.

Objectives

The objectives of this study were 1) to analyze the changes in number of farms growing grapes, the acreage of grapes grown, and the production of grapes in Florida between 1978 and 1990, and 2) to project the future structural characteristics for the industry to the year 1997 by using the Moving Average, Exponential Smoothing and Trend Extrapolation techniques.

Sources of Data

Data for the study were obtained from the Census of Agriculture 1978, 1982, 1987 (10) and Florida Vineyard and Winery Report 1989 (4). The census data were used in the analysis and projection of structural characteristics.

Methodology

The analysis of structural change was conducted on a regional basis by dividing the state of Florida into four regions: Northern, Western, Central, and Southern as classified by the Florida Agricultural Statistics Service (Figure 1). Counties that had little grape production and could not be identified in any of the regions for various technical reasons were classified as "All Others".

The sparse census of agriculture data between 1978 and 1989 greatly restrict the statistical techniques that could be used to analyze structural changes. These changes are affected by complex political, economic, and social factors which present a major challenge to economists when forecasting them. Econometric techniques that are often used require a large number of observations. Furthermore, the constraint of limited data could also lead to highly unreliable projections if only one forecasting technique is depended upon. These limitations, and the desire to increase the reliability of the projections make a composite forecast preferable to any one technique. A composite forecast takes into account both the linear and nonlinear effects.