THE GEOGRAPHY OF THE PINEAPPLE INDUSTRY OF PUERTO RICO

By

William Wesley Burchfiel Jr.

Thesis submitted to the Faculty of the Graduate School of the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy

1953

f

UMI Number: DP70285

All rights reserved

INFORMATION TO ALL USERS
The quality of this reproduction is dependent upon the quality of the copy submitted.

In the unlikely event that the author did not send a complete manuscript
and there are missing pages, these will be noted. Also, if material had to be removed,
a note will indicate the deletion.



UMI DP70285

Published by ProQuest LLC (2015). Copyright in the Dissertation held by the Author.

Microform Edition © ProQuest LLC.
All rights reserved. This work is protected against
unauthorized copying under Title 17, United States Code



ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346



Harvesting Pineapples in Manatí

PREFACE

The writer became interested in the pineapple industry of Puerto Rico during World War II when American grocery stores displayed signs stating that no pineapples were available and newspapers told of thousands of tons of pineapples rotting in the fields of Puerto Rico for lack of transportation to continental United States markets. During the spring of 1944 he had the opportunity to visit Puerto Rico and witness the sudden, though temporary, disruption of the pineapple industry due to wartime restrictions on shipping.

Subsequent investigations showed that during the intervening years the pineapple industry of Puerto Rico made a remarkable comeback, replacing coffee as the third most important cash crop. The writer's curiosity as to the reasons for this upsurge was aroused. Numerous individuals directly connected with the pineapple industry and various members of the faculty of the University of Maryland encouraged him to investigate the reasons for this comeback as well as the problems of the industry.

The principal objectives of this investigation are: (a) To determine the physical and cultural factors affecting location of the pineapple-growing area and its associated industrial establishments; (b) to examine carefully agricultural practices, processing methods, marketing practices, and associated problems; (c) to portray the

relative position of the pineapple industry in the economy of the island; and (d) to make suggestions for solving some of the industry's major problems.

One of the special features of this investigation is a comparison of practices, techniques, and methods employed in Puerto Rico with those used in other major pineapple-producing areas. Throughout this study, the writer points out many of the shortcomings of Puerto Rico's pineapple industry and suggests promising avenues for further investigation.

All proper names used in this study have been spelled according to those recommended by the Board on Geographic Names, U.S. Department of Interior, and the U.S. Army Map Service. The few Spanish names and technical terms, most familiar to persons connected with the pineapple industry, are used sparingly in the text and are defined in the Glossary. All elevations are given in feet; distances, in feet or statute miles; weights, in pounds or short tons; and temperatures, in degrees Fahrenheit. Unless specifically indicated, land area is stated in cuerdas. A cuerda is equivalent to 0.9712 acre or 43,305 square feet.

The field work for this investigation was undertaken in the spring of 1944 and spring and early summer of 1951. The small area of the island, together with only a slight language barrier, made it possible for the writer to become

182682

intimately acquainted with most of the pineapple-producing section and to interview many of the growers.

The writer was fortunate in being able to conduct his field work during the period when the number of workers, volume of output in the canneries, and movement of pineapple and pineapple products were at their peak. He visited nearly fifty individual pineapple farms and all nine pineapple processing plants. A large volume of data and information collected from these farmers and canners, by means of a comprehensive questionaire, prepared by the writer, proved invaluable in formulating many of the recommendations and conclusions of this study. Maps and production data were closely checked in the field for accuracy and reliability. Numerous photographs were taken in each of the ten municipalities which comprise the Pineapple Area. Several special tests and experiments were made for the writer by research technicians in order to show the need of continued investigation to further improve the quality of both fresh and processed pineapple. Finally, thirty or more conferences were held with individuals who were directly connected with or interested in long-range planning of the pineapple industry of Puerto Rico.

DEDICATION

This study is dedicated to my parents, Mr. and Mrs. W. W. Burchfiel, and to my aunt, Mrs. Eva P. Temple, and her late husband Andrew J. Temple, who lent encouragement at all times.

ACKNOWLEDGEMENTS

In connection with the research and the field work for this dissertation the writer is deeply indebted to so many individuals that it would be almost impossible to make separate acknowledgements of their assistance. To all of them a debt of gratitude is hereby extended, even if their names may not appear on these pages.

The writer wishes to thank most heartily for their cooperation: Dr. Clarence F. Jones and Mr. Luis A. Nazario for a Scientific Research Grant awarded to him; Dr. Rafael Picó, Dr. Luis A. Alvarez, Dr. John A. Bonnet, and Dr. Frank Wadsworth for productive discussions which are reflected in this investigation; Victor E. Levene, Hector H. Berrios, and John F. Lounsbury for personally conducting experiments or making extended trips into the Pineapple Area with him.

He also wishes to express his deep obligation and sincere thanks to Messrs. R. Colón-Torres, Arthur S. Mason, John G. Paton, John E. Raymer, Francisco Vazquez, M. Perez García, Frank Zorrilla, Enrique Landron, Harry Partridge, Elmer F. Hogan, Ernesto Hernández, George H. Wildman, William Pennock, George M. Kendall, Thomas L. Long, Norman Horsey, and the late Luis A. Serrano for providing valuable material and for offering excellent suggestions while conducting field work.

The writer is grateful to Messrs. David S. Campbell, Herbert C. S. Thom, Charles Williamson, and Louis E. Leipold, who patiently read and criticized the original or final draft. Special thanks go to Mr. Milton Venezky and to the cartographers of the Department of Geography of the University of Maryland who drafted the maps and charts and to Mrs. Herbert C.S. Thom who did the typing. To the Revista de Agricultura de Puerto Rico, Martinez Rogers, Fotografo, and Food Machinery and Chemical Corporation go his thanks for six photographs used in this study. Indebtedness to numerous farmers, canners, government officials, and private individuals, not mentioned above, who aided the author during the investigation, is also acknowledged.

The late Dr. Oliver E. Baker suggested the topic of this dissertation and encouraged the writer during the initial stages of this investigation, after which Dr. Raymond E. Crist served as advisor until his departure. The study was completed under the able supervision of Dr. F. Webster McBryde. To my advisors and to Dr. William Van Royen, Dr. John P. Augelli, Dr. Charles Y. Hu, go the greatest share of acknowledgements. To them is owed an everlasting debt of gratitude for their enlightened direction and constructive criticism of all phases of this dissertation.

William Wesley Burchfiel Jr.

Washington, D.C.
June 1953

TABLE OF CONTENTS

Page

LIST OF TABLES xi

LIST OF FIGURES xiii

SOURCES OF MAP COMPILATION xv

LIST OF PLATES xviii

Chapter

I. REGIONAL SETTING OF THE PINEAPPLE INDUSTRY

1. Introduction 1
2. The Pineapple Area 5
3. Landforms and Drainage 6
4. Climate 14
5. Soils 22
6. Population Growth, Distribution, and Urban Development 26

II. PROBLEMS OF GROWING OF PINEAPPLES

1. Introduction 38
2. Relief Factors 39
3. Climatic Factors 41
4. Soils and Soil Erosion 45
5. The Pineapple Plant 56
6. History of Pineapple 60
7. Early Growth, Development, and Changing Structure 64
8. Actual Land Use and Recommended Land Use 81
9. Major Land-Use Patterns 84
10. Representative Land-Use Patterns . . . 86
11. Commercial Varieties 90
12. Propagation 98
13. Methods and Time of Planting 101
14. Cultivation 103
15. Methods of Regulating Fruit Maturity . 109
16. Harvesting 112
17. Yields 117
18. Diseases and Pests 121
19. Fertilizers 126
20. Crop Rotation Practices 133
21. Degree of Mechanization 136
22. Research and Experimentation 139
23. Summary 141

Chapter Page

III. PROCESSING AND MARKETING

A. Processing

1. Introduction 145
2. Processing Facilities 145
3. Processing Stages 149
4. Materials and Equipment 159
5. Subsidiary Industries and By-Products. 161
6. Possible Utilization of Pineapple Waste 163

B. Marketing

1. Introduction 168
2. Marketing Problems 168
3. Foreign Market 171
4. Domestic Market 191
5. Future Outlook 196

IV. THE PINEAPPLE INDUSTRY IN THE ISLAND'S ECONOMY

1. Introduction 199
2. Relative Importance of the Pineapple Industry 199
3. Land Needs and Capital Requirements . 202
4. Financial Structure 206
5. Mortgage Indebtedness and Credit Structure 210
6. Income and Wage Contributions 213
7. Labor Contribution 220
8. Available Food Supply and Growing Needs 226
9. Local Pineapple Consumption 228

V. PROBLEMS FACING THE ISLAND'S PINEAPPLE INDUSTRY AND RECOMMENDED STEPS IN SOLVING THEM

1. Inherent Problems, Adjustments, and Long-Range Considerations 232
2. Summary and Conclusions 238
3. Recommended Steps 240

GLOSSARY 252

SELECTED BIBLIOGRAPHY 256

LIST OF TABLES

Table		Page
1.	Landform Types of the Pineapple Area Compared with Those of the Island as a Whole	9
2.	Mean Monthly Temperatures for Selected Stations in Puerto Rico	15
3.	Mean Monthly Rainfall for Selected Stations in Puerto Rico	15
4.	Hurricane Occurrence in Puerto Rico, 1759-1950.	20
5.	Major Soil Types on which Pineapples are Grown.	25
6.	Population of Puerto Rico (1765-1950) and the Pineapple Area (1899-1950)	28
7.	Soils of the Pineapple Area Best Suited to Pineapple Production, by Type, Productivity Rating, Area, and Competing Crops	47
8.	Yields of Pineapples and Other Crops per Cuerda in Puerto Rico	51
9.	Commercial Pineapple Production in the Pineapple Area, by Municipalities, Fiscal Year 1949-50	68
10.	Common Sizes of Fresh Pineapples Exported from Puerto Rico	95
11.	Area and Yields of Pineapples Harvested in Puerto Rico, Crop Years, 1948-49 and 1949-50	99
12.	Approximate Number of Pineapple Plants Required per Cuerda	104
13.	Calendar of Agricultural Activities on Pineapple Farms Compared with Other Crops Competing for Land in the Pineapple Area	105
14.	Factories Processing Pineapples in Puerto Rico	120
15.	Pineapple Diseases and Pests in Puerto Rico	122
16.	Application of Fertilizer to Pineapple Fields	129

(Tables continued)

Table		Page
17.	Value of Pineapple Exports from Puerto Rico, Fiscal Years 1920-21 to 1949-50	148
18.	Output of Processed Pineapple in Percentage of Total Pineapple Production in Puerto Rico and Hawaii	150
19.	Annual Production of Canned Pineapple in Actual Cases for Leading Countries of the World, 1938-1950, Inclusive	169
20.	Puerto Rican and Cuban Pineapple Sales at New York Auction, April 1951	173
21.	Pineapple Production and Fresh Exports from Puerto Rico, Crop Years 1928 to 1951	174
22.	Exportation of Canned Pineapple from Puerto Rico at 5-Year Intervals from 1927 to 1948 . .	185
23.	Average Allocation of Production Cost per Case in Canning Crushed Pineapple, 1948	192
24.	Disposition and Farm Price of Pineapples Harvested in Puerto Rico, 1948-49 and 1949-50 . .	193
25.	Known World Production of Commercial Pineapples, 1940-1950	197
26.	Value of Fresh and Preserved Fruits Exported from Puerto Rico, Fiscal Years 1940-1950 . . .	201
27.	Average Number of Weeks of Work per Year, Average Weekly Income, and Estimated Annual Income of 346 Workers Employed in the Agricultural Phase of the Pineapple Industry, Puerto Rico, 1947-48	215
28.	Daily Wages Paid Farm Workers in Puerto Rico and Hawaii	217
29.	Average Number of Man-Days Required to Produce One Cuerda of Pineapples in Puerto Rico, 1947-48	223

LIST OF FIGURES

(Maps and Graphs)

Figure		Page
1.	Hypsometric Map of the Pineapple Area (Map)	7
2.	Mean Annual Rainfall (Map)	17
3.	Climatic Data for Selected Stations in the Pineapple Area (Graphs)	19
4.	Transportation Pattern of Puerto Rico (Map)	37
5.	Soil Erosion in the Pineapple Area (Map)	46
6.	Soil Productivity in the Pineapple Area (Map)	49
7.	Distribution of Pineapple Processing Plants and Packing Sheds (Map)	66
8.	Distribution of Commercial Pineapples under Cultivation, by Municipalities, in Cuerdas, 1949-50 (Map)	70
9.	Distribution of Commercial Pineapples Harvested, by Cuerdas, 1939-40 (Map)	71
10.	Distribution of Commercial Pineapples Harvested, by Cuerdas, 1949-50 (Map)	72
11.	Distribution of Commercial Pineapples Harvested, in Crates, 1939-40 (Map)	74
12.	Distribution of Commercial Pineapples Harvested, in Crates, 1949-50 (Map)	75
13.	Distribution of Commercial Pineapple Production, by Municipalities, in Crates, 1949-50 (Map)	76
14.	Distribution of Commercial Pineapple Yields, by Municipalities, 1939-40 (Map)	78
15.	Distribution of Commercial Pineapple Yields, by Municipalities, 1949-50 (Map)	79
16.	Land Utilization in the Pineapple Area, 1950-51 (Map)	82

(Figures continued)

Figure		Page
17.	Land Suitability and Recommended Land Use in the Pineapple Area (Map)	83
18.	"Typical" Land-Use Patterns of Selected Pineapple Farms (Map)	88
19.	Distribution of Commercial Pineapples under Cultivation, by Varieties, 1949-50 (Map) . .	93
20.	Principal Pineapple-Producing Countries Serving the United States' Market (Graphs) . . .	183

SOURCES OF MAP COMPILATION

Figure 1: Hypsometric Map of the Pineapple Area (approx. scale, 1:300,000) compiled from "Local Aeronautical Chart of Puerto Rico", Base No. 1-R, U.S. Aeronautical Chart Service, 1948, scale 1:250,000; "Puerto Rico and Contiguous Islands under Its Jurisdiction", No. 8-R. U.S. Dept. of Agriculture (Forest Service), 1939, approx. scale, 1:300,000; and "Topographic Map Series of Puerto Rico", No. E-835 (66 sheets), 1946-48, U.S. Army Map Service, scale, 1:25,000.

Figure 2: Mean Annual Rainfall (approx. scale, 1:1,100 - 000) adapted from "Soil Survey of Puerto Rico", U.S. Dept. of Agriculture, 1942, scale, 1:800,000; slight modifications were made, based on postwar information obtained from the U.S. Weather Bureau, San Juan Station, 1951.

Figure 4: Transportation Pattern of Puerto Rico (approx. scale, 1:625,000) compiled from a base map obtained from the Puerto Rico Planning Board, (no number), approx. scale 1:200,000; and from "Puerto Rico e Islas Limitrofes", No. 8831, Insular Dept. of Interior, 1950, approx. scale 1:225,000.

Figure 5: Soil Erosion in the Pineapple Area (approx. scale, 1:175,000) adapted from "Reconnaissance Erosion Survey of Puerto Rico", (no number), Puerto Rico Soil Conservation Service (Field Office) in co-operation with the U.S. Dept. of Agriculture, 1935, approx. scale, 1:100,000. Revisions to map in 1950 were made at a scale of 1:250,000.

Figure 6: Soil Productivity in the Pineapple Area (approx. scale, 1:175,000) adapted from "Soil Survey of Puerto Rico" (East Central and West Central Sheets), U.S. Dept. of Agriculture in co-operation with the Puerto Rico Agricultural Experiment Station, 1942, scale 1:50,000. Slight modifications were made in regard to assigning productivity ratings.

Figure 7: Distribution of Pineapple Processing Plants and Packing Sheds (approx. scale, 1:1,100,000) based on information collected during field work in 1951; original base map, scale 1:750,000.

(Sources of Map Compilation Continued)

Figure 8: Distribution of Commercial Pineapples under Cultivation, by Municipalities, in Cuerdas, 1949-50 (approx. scale, 1:1,100,000) adapted from unpublished statistics obtained from the Bureau of Agricultural Economics, Insular Dept. of Agriculture and Commerce, 1951; scale of original base map, 1:750,000.

Figure 9: Distribution of Commercial Pineapples Harvested, by Cuerdas, 1939-40 (approx. scale, 1:1,100,000) adapted from "La Industria de la Piña en Puerto Rico", Puerto Rico Minimum Wage Board, 1950; scale of original base map, 1:750,000.

Figure 10: Distribution of Commercial Pineapples Harvested, by Cuerdas, 1949-50 (approx. scale, 1:1,100,000) based on published and unpublished statistics obtained from the Puerto Rico Dept. of Agriculture and Commerce, and the Insular Agricultural Experiment Station, 1951; scale of original base map, 1:750,000.

Figure 11: Distribution of Commercial Pineapples Harvested, in Crates, 1939-40 (approx. scale, 1:1,100,000) based on data obtained from "La Industria de la Piña en Puerto Rico", Puerto Rico Minimum Wage Board, 1950; and from unpublished data obtained from the U.S. Dept. of Agriculture, 1951; scale of original base map, 1:750,000.

Figure 12: Distribution of Commercial Pineapples Harvested, in Crates, 1949-50 (approx. scale 1:1,100,000) adapted from unpublished data obtained from Puerto Rico Dept. of Agriculture and Commerce, 1951; scale of original base map, 1:750,000.

Figure 13: Distribution of Commercial Pineapple Production, by Municipalities, in Crates, 1949-50 (approx. scale, 1:1,100,000) based largely on unpublished statistics supplied by the Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1951; scale of original base map, 1:750,000.

Figure 14: Distribution of Commercial Pineapple Yields, by Municipalities, 1939-40 (approx. scale, 1:1,100,000) based on unpublished data available in the Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1948; scale of original base map, 1:750,000.

Figure 15: Distribution of Commercial Pineapple Yields, by Municipalities, 1949-50 (approx. scale, 1:1,100,000) based on published and unpublished information obtained from the Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce; from preliminary estimates obtained from the Insular Agricultural Experiment Station, 1951; scale of original base map, 1:750,000.

Figure 16: Land Utilization in the Pineapple Area, 1950-51 (approx. scale, 1:175,000) based on maps and statistical data from the Rural Land Classification Program (Programa de Utilizacion de Terrenos Rurales), Insular Dept. of Agriculture and Commerce, 1950-51; 66 sheets at a scale of 1:10,000.

Figure 17: Land Suitability and Recommended Land Use in the Pineapple Area (approx. scale, 1:175,000) adapted from "General Land Capability Map of Puerto Rico" (no number), U.S. Dept. of Agriculture, Soil Conservation Service, in co-operation with the Insular Soil Conservation Service, 1950; scale of original map, 1:100,000.

Figure 18: "Typical" Land-Use Patterns of Selected Pineapple Farms (approx. scale, 1:1,200) based on maps and other data obtained from Puerto Rico Soil Conservation Service (Field Office), 1947-48; scale of original base map, 1:600. Corrections and additions were made from field observations in 1951.

Figure 19: Distribution of Commercial Pineapples under Cultivation, by Varieties, 1949-50 (approx. scale, 1:1,100,000) based on unpublished information obtained from the Insular Agricultural Experiment Station together with field investigation in 1951; scale of original base map, 1:750,000.

LIST OF PLATES

Harvesting Pineapples in Manatí (in color) . . . Frontispiece

Plate — Page

I. Typical View of Foothill Section in Corozal. . . 11

II. Comparison of Red Spanish and Cabezona Varieties 94

III. Pineapple Suckers Ready for Planting 100

IV. Three-Row System of Cultivation 103

V. Use of Mulch Paper 107

VI. Sole Method of Transporting Fruit from Field to Road 113

VII. Treating Pineapples for Fresh Fruit Market . . 114

VIII. Typical Packing Shed Used in Grading, Sizing, and Crating Fruit 115

IX. Pineapples Pests and Diseases (in color) . . . 126

X. Scientific Experimentation to Increase Yields. 132

XI. "Complete" Ginaca, a Labor-Saving Device . . . 153

XII. Hand Labor in Processing Pineapples 155

CHAPTER I

REGIONAL SETTING OF THE PINEAPPLE INDUSTRY

1. Introduction

Puerto Rico is the smallest and easternmost of the four islands-- Cuba, Jamaica, Hispaniola (Dominican Republic and Haiti), and Puerto Rico--which comprise the Greater Antilles. These four islands, together with the Lesser Antilles, form a chain of some 200 islands beginning south of the tip of Florida and extending to the northeast coast of South America. Puerto Rico lies wholly within the Trade Wind Belt between 17°55' and 18°31' north latitude and 65°39' and 67°15' west longitude.

The island is nearly rectangular in shape; it has a maximum length of 113 miles from east to west and an average width of 41 miles. It has a total area of approximately 3,423 square miles, or an area about one-third larger than the state of Delaware. Puerto Rico's strategic position as an insular possession of the United States[1] is exemplified by the following distances: 970 miles southeast of Miami, 880 miles northeast of the Panama Canal, and approximately 500 miles northeast of Venezuela.

Agriculture is by far the most important source of income for the island as well as the most important employer

---

[1] Throughout this study, the term "United States" refers to continental United States.

of labor, for almost the entire population of 2,211,000 gains its livelihood either directly or indirectly from it. Agriculture is characterized by specialization in and dependence upon a few major crops that can be sold largely in the markets of the United States. The sugar cane industry represents the greatest source of employment and outranks all other industries in the total number of cuerdas devoted to a single crop. The sugar industry employs about 139,000, or 22 per cent of the total number of persons gainfully employed on the island. The tobacco industry, including production and processing of tobacco products, employs nearly 28,000 (4.5%) workers.[2] The coffee industry employs roughly 12,500 (2.0%) workers, practically all of which are utilized in the growing, grading, or transporting of coffee since very small amounts of coffee are actually processed on the island. Lastly, the fruit industry, including production, processing, and marketing, employs 10,500 (1.7%) workers.

The sugar cane industry overshadows all other major industries on the island with regard to the total number cuerdas devoted to a single crop. In the crop year of 1949, there were nearly 355,000 cuerdas of sugar cane under cultivation, 187,000 cuerdas of coffee, 33,000 cuerdas of tobacco, and 28,000 cuerdas of fruit. Therefore, on the basis of labor requirements and number of cuerdas devoted

---

[2]H.S. Perloff, Puerto Rico's Economic Future (Chicago: University of Chicago Press, 1950), p. 401.

to all crops mentioned above, it is readily seen that sugar cane is more important than tobacco, coffee, and fruits combined.

Pineapples are the most important cash crop among the fruits of the island. Their production, like sugar cane, tobacco, and coffee, is regionally concentrated. Nine-tenths of all commercial pineapples are produced in the north central coastal region, but in general sugar cane is grown on the periphery of the island, tobacco in the central interior, and coffee in the western uplands.

Agricultural crops in Puerto Rico differ widely in their ability to show a profit. The income from all export crops is influenced to a considerable degree by laws and changing economic conditions in the United States. Fruit and sugar production are considered to be among the safest and most profitable ventures over a long period. The growing of tobacco and coffee, especially the latter, is considered to be a marginal venture, in part, because of the comparatively high cost of land in Puerto Rico and the low, natural fertility of the land on which these marginal crops are grown. Moreover, competition from other crops, particularly sugar cane, have forced farmers growing marginal crops farther and farther back into the interior of the island where topography, climatic conditions, and land tenure favor the growing of coffee and tobacco far better than along the coastal fringe. Government regulations and

restrictions, competitions with other countries, and wide fluctuations in price all play a role in determining a profit or loss for each of these crops.

The operational structure of the four leading agricultural activities mentioned above differ markedly. For example, in the coffee area there are a large number of small, independently owned and operated farms (fincas) functioning with practically no capital on a quasi-subsistence basis. Tobacco farms today, although typically small in size, in general, lack the necessary capital to be operated efficiently. In the east central part of the island alone, there are more than 20,000 tobacco farmers, most of whom operate small farms of not more than 10 cuerdas. In the fruit areas there are medium-sized land holdings, comparatively few in number, that rely largely upon local capital and labor for their operation. Pineapple plantations are of this type. Until recently, pineapple growers have been slow to adopt modern scientific farming techniques and to utilize their land skillfully. This can be attributed partly to the lack of capital and proper management. In contrast to the small and medium-sized land holdings, there are a few large, highly co-ordinated sugar cane interests operating under corporate structure. They depend primarily upon American capital for financing and have effectively introduced the latest scientific methods and machinery.

In a broad sense, there are close economic ties between Puerto Rico and the United States. In trade, Puerto

Rico imports nearly twelve times as much merchandise from the United States as from all other countries combined. The island exports nearly eight and one-half times as much merchandise to the mainland as to all foreign countries. Currency, credit, and credit structure are closely integrated as shown by identical currency used by both countries;[3] credit needs of one are supplied by banks of the other. There is an integration in public financing whenever fiscal revenues of one country are in part derived from payments by the government of the other. Puerto Rico lies within the United States' tariff structure; thereby the prosperity of the former is dependent upon the prosperity of the latter. Finally, there are close economic ties due to American ownership of investments.

2. The Pineapple Area

The principal pineapple-producing section, hereafter referred to as the Pineapple Area, consists of approximately 424 square miles or 12.5 per cent of the island's territory. Of this 424 square miles in the Pineapple Area, only 6.5 square miles (1.5%) were actually devoted to pineapple production in the 1949-50 crop year. The Pineapple Area coincides with the political boundaries of ten municipalities. These municipalities (municipios), from east to west, are Bayamón, Toa Baja, Toa Alta, Dorado, Corozal, Vega Alta, Vega Baja, Manatí, Barceloneta, and Arecibo

---

[3] Perloff, 1950, p. 110.

(Fig. 1). Available data for pineapple growing are recorded on a municipality basis, and only 54 widely scattered commercial pineapple farms were within the Pineapple Area in 1950.

The maximum dimensions of the Pineapple Area are about 42 miles from east to west and 16 miles from north to south. In shape, it vaguely resembles a skeleton key. Almost nine-tenths of all commercial pineapples grown in Puerto Rico are produced in this area. In the 1950 crop year, 89.9 per cent of the total cuerdas harvested and 91.3 per cent of the total farm value of pineapples were derived from the Pineapple Area. The remaining one-tenth was produced in the municipalities of Camuy, Cidra, Lajas, Las Piedras, and on the island of Vieques. Vieques Island produces 4 per cent, and the combined municipalities outside of the Pineapple Area in Puerto Rico proper produce but a fraction over 6 per cent.

The areal concentration of the pineapple industry within the Pineapple Area was not merely the result of chance, but of adaptation to several physical and cultural factors. These factors include: relief, drainage, climatic conditions, soil characteristics, and the course and pattern of settlement.

3. Landforms and Drainage

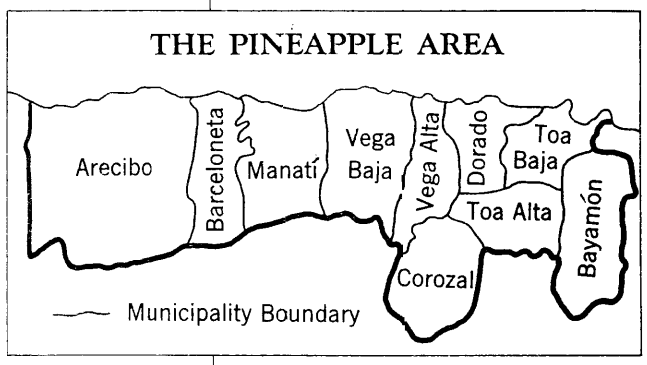
Puerto Rico possesses large areas of rugged and thoroughly dissected relief (Fig. 1). A mountainous

HYPSOMETRIC MAP OF THE PINEAPPLE AREA

ELEVATIONS IN FEET

0-250
250-500
500-1,000
1,000-1,500
1,500-2,000
Over 2,000
The Pineapple Area

5 0 5
Miles



66°45′ 66° 30′ 66°15′

18° 30′ 18° 15′

Arecibo
Barceloneta
Manatí
Lake Tortuguero
Vega Baja
Vega Alta
Dorado
Toa Baja
Toa Alta
Bayamón
Corozal
SAN JUAN
Río Piedras
Caguas
Morovis
Bocas Dam
Arecibo
Manatí
Cibuco
La Plata
Bayamón

67°00′ 66° 30′ 66°00′ 65°30′

18° 30′ 18° 00′

ATLANTIC OCEAN
CARIBBEAN SEA
Aguadilla
Mayagüez
Ponce
Guayama
Arecibo
SAN JUAN
Río Piedras
Caguas
Coastal Lowlands and Foothills
Uplands and Mts
CORDILLERA CENTRAL
SIERRA DE LUQUILLO
VIEQUES ISLE
Culebrinas
Guajataca
Camuy
Añasco
Guanajibo
Arecibo
Manatí
Cibuco
La Plata
Bayamón
1,207
2,493
3,468
4,390
3,950
2,612
2,490

Major drainage divide
The Pineapple Area
Under 250
250-1,250
1,250-2,000
Over 2,000
Spot elevation in feet

0 5 10 15 20
Miles

HYPSOMETRIC MAP OF PUERTO RICO

Compiled by William W. Burchfiel

Sources: U.S. Aeronautical Chart Service, Map No. 1-R, 1948, and U.S. Dept. of Agriculture, Map No. R-8, 1939.

Fig. 1 - Hypsometric Map of the Pineapple Area.

backbone, called the Cordillera Central, extends almost the entire length of the island and averages 2,500 feet in elevation, with a number of peaks exceeding 3,500 feet. The main crest lies to the south of an east-west line passing through the center of the island. Numerous spurs, some terminating in sea cliffs, branch fanwise from the main crest into the coastal plains. In the easternmost part of the island lies the rocky, steep, forest-covered Sierra de Luquillo, culminating at a point 3,500 feet in elevation. In the northwestern corner of Puerto Rico there are some isolated mountains that rise to 1,000 or more feet above sea level. In addition, there are many smaller and less extensive features such as ridges, knobs, and hills oriented in a general north-south direction and notched by deep valleys and narrow gorges, especially in the foothills along the north and south flanks of the central mountains.

The Pineapple Area is divided roughly into three sections based on landform types (Table 1): (1) rugged uplands, (2) foothills, and (3) coastal lowlands. The rugged uplands, comprising approximately 36 square miles (9%) and ranging in elevation from 1,250 to 2,500 feet, lie in the extreme southern part of the municipalities of Bayamón and Corozal (Fig. 1). Because of steep slopes, susceptibility to erosion, mature volcanic soils, and comparatively low winter temperatures, this section is considered, for the most part, unfavorable for commercial pineapple production.

TABLE 1

LANDFORM TYPES OF THE PINEAPPLE AREA COMPARED WITH THOSE OF THE ISLAND AS A WHOLE[a]

Landform Type	Pineapple Area			Puerto Rico		
	Area in Cuerdas[b]	Area in Sq. Mi.	Per Cent of Area (approx.)	Area in Cuerdas	Area in Sq. Mi.	Per Cent of Area (approx.)
Uplands (including mountains and plateaus)[c]	23,731	36	8.5	598,400	935	27.3
Foothills (including inner plains and basins)[d]	151,516	230	54.2	873,600	1,365	39.8
Coastal Lowlands (including terraces, floodplains, marshes, and swamps)[e]	104,153	158	37.3	720,000	1,125	32.9
Total, All Types	279,400	424	100.0	2,192,000	3,425	100.0

[a]Sources: Adapted from Colón-Torres, Soils of Puerto Rico Classified by Geological Formations, Series, Types, and Phases, with Productivity Ratings of Each Based on Inherent Qualities of the Land, Area, and Per Cent of Total Area (Rio Piedras: University of Puerto Rico Agricultural Experiment Station, 1941), (no page number), and Rafael Picó, The Geographic Regions of Puerto Rico (Rio Piedras: University of Puerto Rico Press, 1950), pp. 2 and 220.

[b]One cuerda is equivalent to 0.9712 acre.

[c]Elevation mostly above 1,250 feet above sea level.

[d]Elevation mostly between 250 and 1,250 feet above sea level.

[e]Elevation mostly below 250 feet above sea level.

The foothills, comprising roughly 230 square miles (54%), lie approximately between the elevation of 250 and 1,250 feet. This section averages from 5 to 8 miles wide and extends the entire length (42 miles) of the Pineapple Area. Soils are derived mainly from limestones, although there are some soils derived from shales, tuffs, and andesites along the southeastern margin of the foothill section. Toward the south, with increased elevation, the topography, in general, becomes more and more rugged so that the land becomes more difficult to cultivate. Many long, steep parallel ridges and a series of smooth, rounded hills extend northward from these rugged uplands to form the framework of the foothill section (Plate I). The ridges and hills separate valleys with narrow floodplains and terraces, and frame partially enclosed basins which are intensively cultivated. Most pineapple production is concentrated on terraces, or in the better-drained sections of the basins and floodplains. Of the total pineapple production within the Pineapple Area nearly three-fifths is in the foothills.

Finally, the coastal lowlands, lying mainly below 250 feet elevation, comprise the remaining 158 square miles (37%) of the Pineapple Area. This section, averaging from 3 to 5 miles wide, is level to slightly rolling although interrupted in places by ridges and haystack hills, either isolated or in chains, which rise sharply above the general level of the lowlands. Such features are particularly numerous west of Toa Alta. Below 100 feet elevation,

generally within one or two miles of the coast, there are several marshy belts, lagoons, and seasonal ponds. The only body of water of any importance is Tortuguero which is located some 3 miles northeast of Manatí. For the most part, the narrow coastal fringe lacks proper drainage necessary for pineapple production, and soils are either too compact or too wet. Therefore, in the coastal lowlands pineapples are grown for the most part along a narrow, discontinuous strip between 100 and 250 feet above sea level.



Plate I. Typical View of Foothill Section in Corozal.

Main ridge in background is flanked by lower parallel ridges that are separated from each other by small, sinuous valleys. Here pineapples are planted both with the slope and with the contour of the land. Jibaro huts dot the countryside. April 1942. (Courtesy of Revista de Agricultura de Puerto Rico.)

In the Pineapple Area the coastal plain attains its maximum width, about 10 miles, and its maximum elevation, roughly 1,500 feet. The limestone beds which underlie the plain dips about five degrees to the north, but the present surface dips north at a much lower angle. In Arecibo, for example, the surface slope averages roughly one degree.

The upland portion (8.5%) of the Pineapple Area is underlain largely by igneous and volcanic rocks of Cretaceous age. The foothill region, to the north, comprising about 54 per cent of the Pineapple Area, is underlain mainly by Cretaceous and Tertiary limestones with estimated thicknesses of up to 300 feet.[4] These limestone formations range from 7 to 15 miles in width and from a point near the town of Corozal extend westward for 50 miles to Aguadilla. In part of the foothill region, the relief is that of a moderately dissected plateau; where solution has been the most active agent, the plateau form has been destroyed and the surface consists of a series of conical limestone hills, known as "mogotes" or "pepinos." Such hills range in height from 200 to 400 or more feet above the plain, and range in diameter from 300 to 600 feet at their base. These hills are especially numerous and conspicuous on either side of the Arecibo river below Bocas Dam (Fig. 1). At elevations

---

[4]H.A. Meyerhoff, Geology of Porto Rico, Monograph of the University of Puerto Rico (Rio Piedras: University of Puerto Rico Press, 1933), pp. 145-151, and map in jacket.

of less than 250 feet along parts of the north coast the limestone hills continue to be conspicuous features of the landscape; but other features such as alluvial floodplains and deltas, swamps, and lagoons are predominant within three to five miles of the coast.

For an area of its size, Puerto Rico has an extremely large number of rivers and streams. A dendritic drainage pattern prevails, particularly north of the major divide (Fig. 1). The divide, for the most part, is situated less than 15 miles from the south coast and 25 to 30 miles from the north coast. South-flowing streams generally follow independent courses from the Cordillera Central to the sea; streams north of the divide show a tendency toward consolidation into a few larger systems. Four of the island's seven largest systems flow directly across the Pineapple Area. From west to east, these include the Arecibo, Manatí, La Plata, and Bayamón. Each contributed its share of alluvial sediments to the levelness and richness of the coastal lowlands. They rise in the rugged uplands and mountains to the south and flow northward in comparatively straight, consequent courses,[5] traversing the foothills and coastal sections at intervals of 10 to 12 miles.

---

[5]A.K. Lobeck, "The Physiography of Porto Rico," Scientific Survey of Porto Rico and the Virgin Islands, (New York: New York Academy of Science, 1922), p. 329.

4. Climate

Puerto Rico has a tropical marine climate.[6] It is characterized by an abundance of sunshine, mild temperatures for its low latitude, and prevailing easterly winds. Both the annual and monthly range of temperature are small and there is no well-defined rainy season; elevation and local topographic exposure to moisture-laden winds are the chief factors affecting both temperature and rainfall.

The average annual temperature decreases from 78°F. along the coastal fringe to 68° or less on the interior slopes. Mean monthly temperatures for coastal stations range from a low of 72° to 74°F. in January or February to a high of 78° to 80°F. in July or August (Table 2). Stations located at 2,000 or more feet in elevation have average monthly minimum temperatures of 60°F. or slightly less, and average monthly maximum temperatures of 84° to 88°F. In general, throughout the year the more elevated hilly and mountainous areas are about 4° to 8°F. cooler than stations along the coast.

Extreme changes in temperature within a 24-hour period are very rare, except during hurricanes. The temperature rarely rises higher than 90°F.; even in the

---

[6] W. Köppen places Puerto Rico in the broad Amw climatic group (Tropical monsoon climate with two distinct rainfall maxima separated by two dry seasons). Thornthwaite includes Puerto Rico in the BA'r climatic classification (P-E index, B-64-127-humid, T-E index, A' 128 +- Tropical, r with adequate rainfall at all seasons). G.T. Trewartha, An Introduction to Weather and Climate (New York: McGraw-Hill Book Co., 1943), pp. 517-521.

TABLE 2

MEAN MONTHLY TEMPERATURES FOR SELECTED STATIONS IN PUERTO RICO*
(in degrees Fahrenheit)

Station	Elev. (in Feet)	Length of Period (Years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Arecibo	50	45	74.1	74.0	74.8	76.2	78.5	79.5	80.0	80.6	80.5	80.0	78.0	75.4	77.6
Bayamón	75	41	72.7	73.0	73.8	75.4	77.7	78.7	79.0	79.3	79.3	78.6	76.9	74.4	76.6
Cidra	1,400	27	69.3	69.2	70.1	72.2	74.0	74.8	75.5	75.6	75.7	74.9	73.5	71.0	73.0
Corozal	400	28	72.6	72.4	73.1	74.8	77.1	77.9	78.2	78.4	78.4	78.0	76.2	73.9	75.9
Manatí	100	32	73.2	73.4	74.2	76.0	78.0	79.4	79.7	80.0	79.6	78.8	76.8	74.6	77.0
Rio Piedras	75	28	73.1	73.3	73.8	75.5	77.7	78.8	78.8	79.1	79.6	78.9	77.0	73.9	76.6
San Juan	47	41	74.9	74.8	75.4	76.6	78.8	79.7	80.0	80.5	80.5	79.9	78.3	76.3	78.0
Vieques Isle	86	26	76.7	77.0	77.8	78.8	80.0	81.0	81.4	81.8	81.5	80.8	79.0	77.6	79.5

*Sources: R.C. Roberts, Soil Survey of Puerto Rico (Washington: Government Printing Office, 1942), p. 49, U.S. Department of Agriculture, Climatic Summary of the United States, Section 106 (Washington: Government Printing Office, 1934), pp. 13-16, and unpublished data from the U.S. Weather Bureau, Washington, 1951.

TABLE 3

MEAN MONTHLY RAINFALL FOR SELECTED STATIONS IN PUERTO RICO*
(in Inches)

Station	Elev. (in Feet)	Length of Period (Years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Arecibo	50	45	4.94	3.61	3.40	3.65	6.50	3.75	4.48	4.86	4.97	5.12	7.23	5.32	57.83
Bayamón	75	41	5.15	3.35	3.72	4.63	7.45	7.09	8.26	8.46	7.82	6.45	7.62	6.14	76.16
Cidra	1,400	25	6.77	3.96	4.29	4.96	7.53	7.12	8.07	9.70	7.26	5.66	6.66	6.64	78.02
Corozal	400	41	5.25	4.16	4.50	6.27	7.40	5.28	7.36	7.76	7.81	7.26	7.71	7.25	79.01
Manatí	100	45	5.00	4.01	4.49	5.00	5.60	4.01	5.71	4.90	6.24	5.32	8.10	6.51	64.89
Rio Piedras	75	42	4.84	3.49	3.90	4.80	6.71	6.24	7.71	7.55	8.12	6.49	7.35	6.48	73.68
San Juan	47	32	4.19	2.71	3.04	4.07	5.38	5.13	5.76	6.09	6.15	5.58	6.84	5.39	60.33
Vieques Isle	86	31	2.49	2.28	2.03	1.42	3.92	3.62	4.03	4.53	6.15	5.41	6.94	2.97	45.72

*Sources: R. C. Roberts, Soil Survey of Puerto Rico (Washington: Government Printing Office, 1942), p. 48, U.S. Department of Agriculture, Climatic Summary of the United States, Section 106 (Washington: Government Printing Office, 1934), pp. 6-12, and unpublished data from the U.S. Weather Bureau, Washington, 1951.

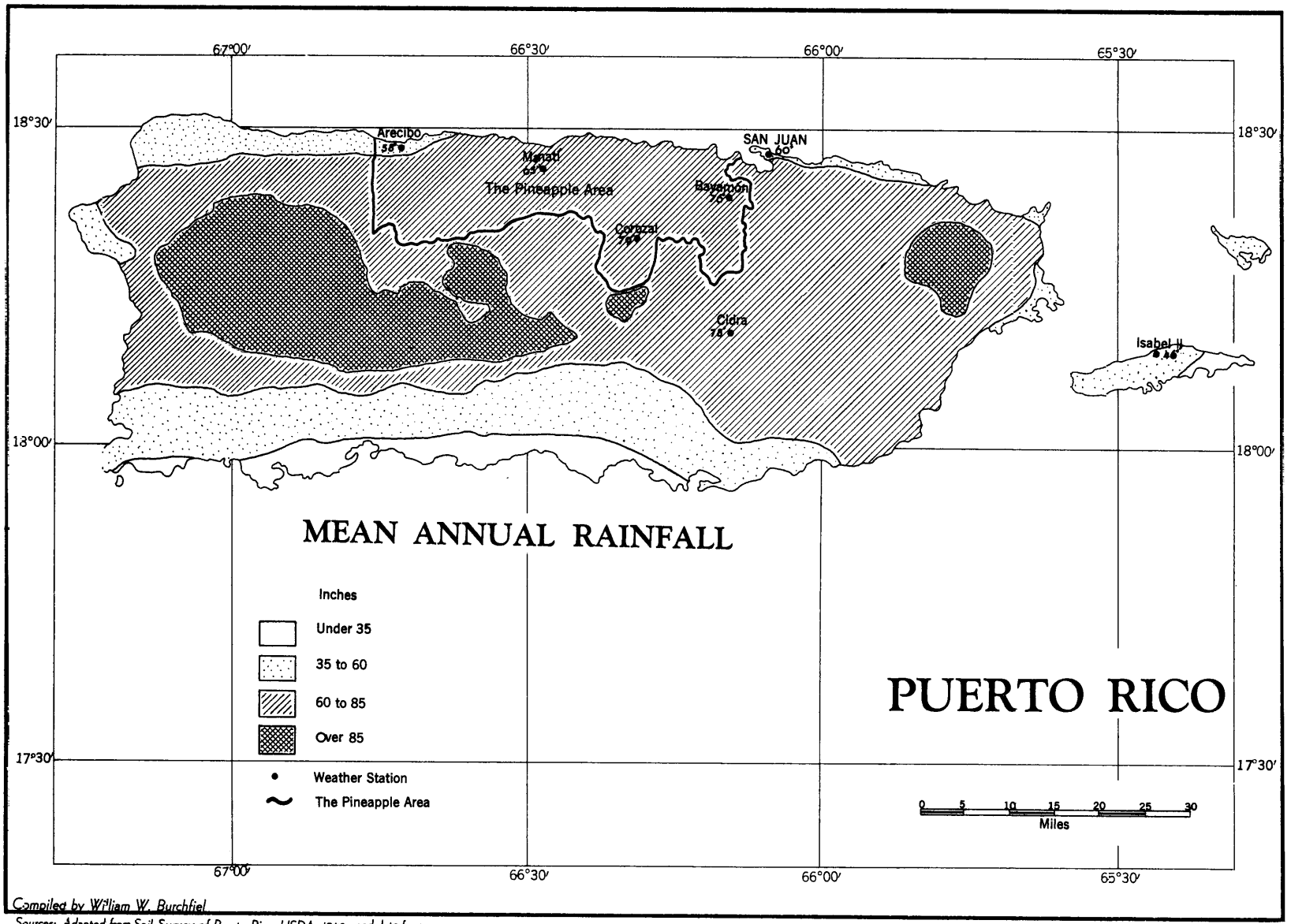
highest, coolest part of the mountains, it seldom falls below 50°F. Frost is unknown at all elevations, and fog occurs only a few days each year in the more sheltered valleys.

Rainfall is of much greater importance in crop distribution than is temperature. The mean annual rainfall for the entire island ranges from less than 30 inches along the southwest coast to nearly 120 inches in a large section of the western highlands (Fig. 2); it is reported that on the loftiest peaks of the Sierra de Luquillo the mean annual rainfall reaches 200 inches. The two areas most deficient in rainfall are: (a) the southern side of the island below elevations of 600 to 1,000 feet and, (b) the northwestern corner. In these areas, the annual rainfall is normally less than 60 inches with wide variability from year to year.

It has been calculated that 65 to 70 inches of rainfall in Puerto Rico is equivalent in crop effectiveness to about 40 inches in the Ohio River Valley.[7] The high rate of evaporation because of uniformally high temperatures and constant winds tend to produce semiarid conditions even where the average rainfall is nearly 60 inches

---

[7] R.C. Roberts, Soil Survey of Puerto Rico, U.S. Department of Agriculture (Washington: Government Printing Office, 1942), p. 53, states that "a rainfall of 30 inches in Puerto Rico is equivalent in effectiveness to about 15 inches in the United States." The author calculated the effectiveness of rainfall in the Ohio Valley as compared to Puerto Rico (San Juan) by the application of Thornthwaite's formula, P-E index.



Compiled by William W. Burchfiel

Sources: Adapted from Soil Survey of Puerto Rico, USDA., 1942, and data from U.S. Weather Bureau, 1951.

Fig. 2 — Mean Annual Rainfall.

per year, as is the case of a small district in the extreme western part of the Pineapple Area.

In the less humid localities, the rate of evaporation exceeds the amount of precipitation during the drier winter months and, as crops grow throughout the year, irrigation is necessary for certain crops even in the few districts within the Pineapple Area that have an annual rainfall of 65 inches. Since pineapples, as well as other tropical crops such as coffee, bananas, and coconuts, require a year-around growing season, a uniform distribution of rainfall throughout the year is an important factor.

Within the Pineapple Area, the mean annual rainfall ranges from about 58 inches along the coast west of the Arecibo river to 85 inches along the south-flanking uplands of Corozal (Fig. 2). Although there are no definite rainy seasons, there is a slightly higher concentration of rainfall from early May to mid-December (Fig. 3 and Table 3).[8] Throughout the winter, however, many showers occur, but torrential downpours normally take place in summer. The amount of rainfall varies greatly within short distances, especially where the topography is uneven. Other factors being equal, the probability of receiving an adequate amount of rainfall for a given year increases pronouncely from north to south and to a lesser degree from west to east within the Pineapple Area.

---

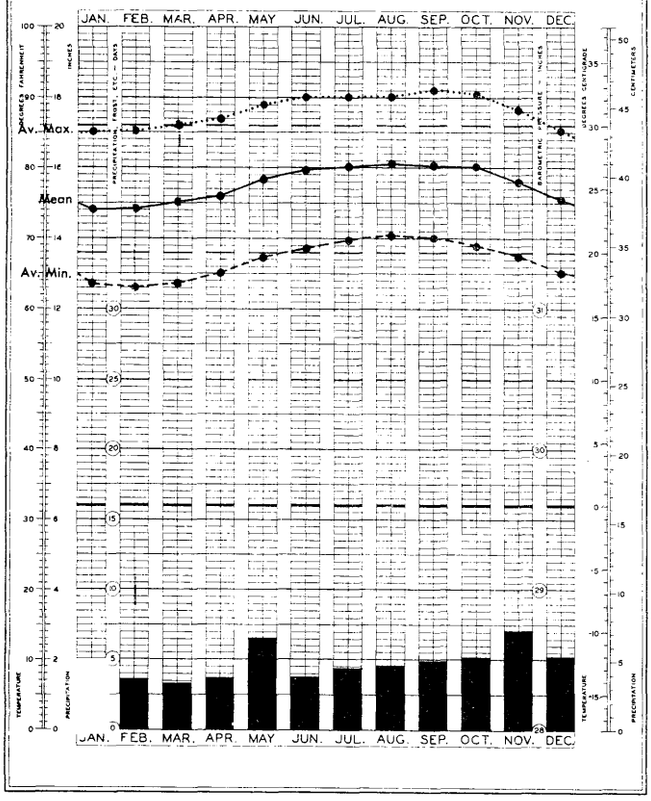
[8]Table 3 is found on page 15.

CLIMATIC CHART No. 70

STATION ARECIBO LATITUDE 18°28'N LONGITUDE 66°42'W ALTITUDE 50 FT.

MEAN ANNUAL PRECIPITATION 37.83 IN. PERIOD 45 years SOURCE U. S. Weather Bureau

TYPE OF CLIMATE

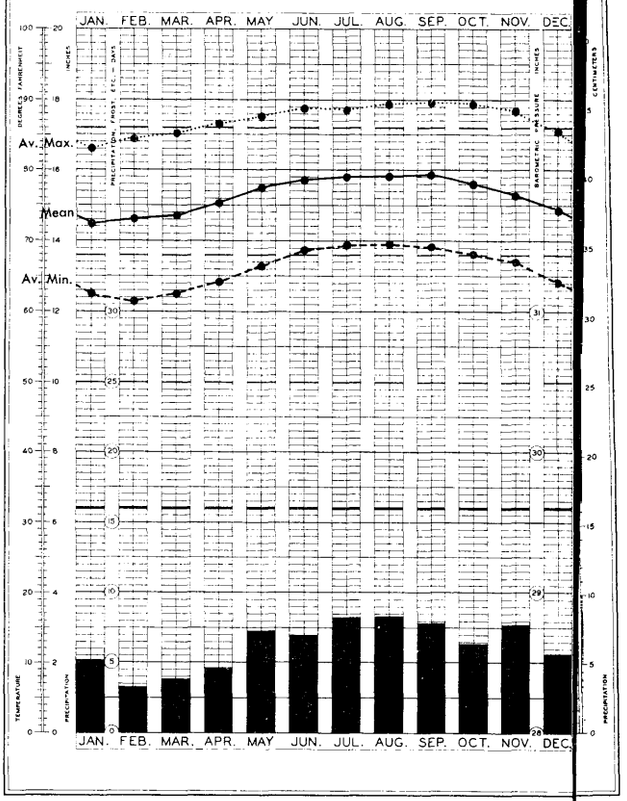


CLIMATIC CHART No. 70

STATION BAYAMÓN LATITUDE 18°24'N LONGITUDE 66°09'W ALTITUDE

MEAN ANNUAL PRECIPITATION 76.16 IN. PERIOD 41 years SOURCE U. S. Weather Bureau

TYPE OF CLIMATE

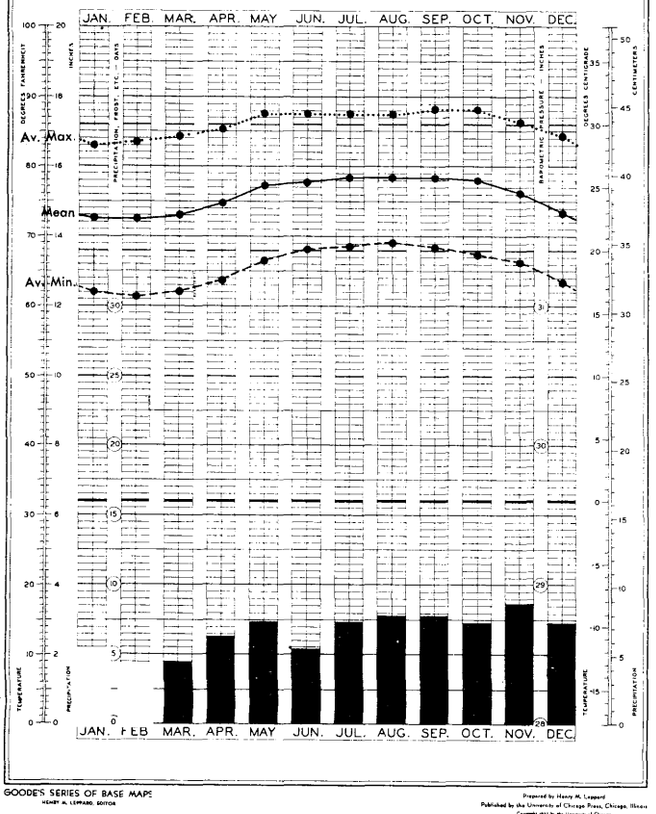


CLIMATIC CHART No. 70

STATION COROZAL LATITUDE 18°20'N LONGITUDE 66°19'W ALTITUDE 400 FT.

MEAN ANNUAL PRECIPITAT ON 75.01 IN. PERIOD 41 years SOURCE U. S. Weather Bureau

TYPE OF CLIMATE



GOODE'S SERIES OF BASE MAPS
HENRY M. LEPPARD, EDITOR

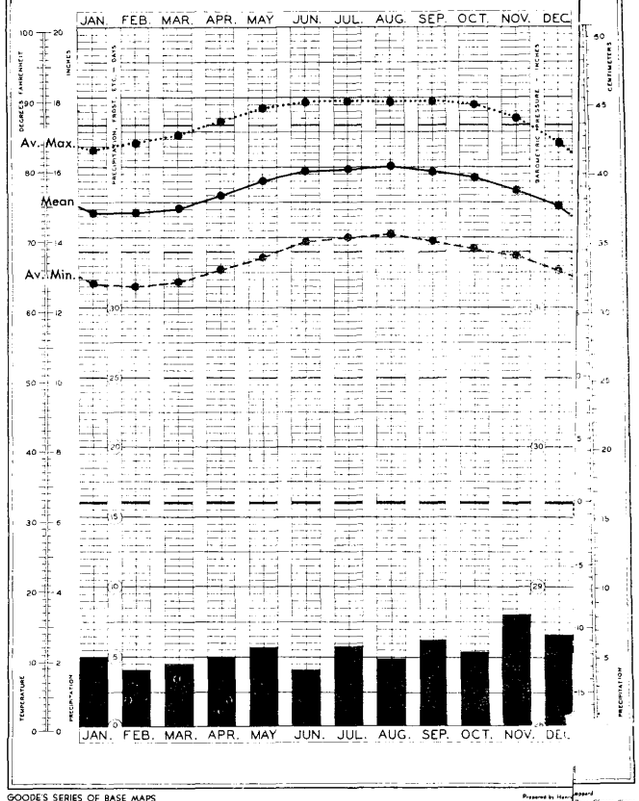
Prepared by Henry M. Leppard
Published by the University of Chicago Press, Chicago, Illinois
Copyright 1937 by the University of Chicago

CLIMATIC CHART No. 70

STATION MANATÍ LATITUDE 18°26'N LONGITUDE 66°29'W ALTITUDE FT.

MEAN ANNUAL PRECIPITATION 64.89 IN. PERIOD 45 years SOURCE U. S. Weather Bureau

TYPE OF CLIMATE



GOODE'S SERIES OF BASE MAPS
HENRY M. LEPPARD, EDITOR

Prepared by Henry M. Leppard
Published by the University of Chicago Press, Chicago, Illinois
Copyright 1937 by the University of Chicago

Compiled by William W. Burchfiel

Fig. 3 - Climatic Data for Selected Stations in the Pineapple Area.

Puerto Rico's greatest climatic risk is the much dreaded hurricane which occasionally devastates large areas during the months from mid-July through October. During the past two centuries there has occurred on the island an average of nearly one hurricane every 4 years (Table 4). These violent tropical storms are characterized by wind velocities ranging from 75 to 100 or more miles per hour accompanied by heavy rains (10 to 25 inches within a few hours) which inundate large areas. Hurricanes that pass within 100 miles or less of the island may also be destructive. Table 4 shows the number of hurricanes by periods that have passed directly across the island or within destructive range during the past two hundred years.

TABLE 4

HURRICANE OCCURRENCE IN PUERTO RICO, 1759-1950*

Period	Number of Hurricanes
1759-1808	18
1809-1858	14
1859-1908	10
1909-1950	8
	50

*Sources: Puerto Rico Department of Agriculture and Commerce, Puerto Rico: A Plan for the Protection of the Agriculture against Hurricanes (Washington: Interdepartmental Committee on Puerto Rico, 1935), p. 81, and from unpublished data obtained from the U.S. Department of Commerce, Weather Bureau, Washington, D.C., 1951.

Hurricanes have occasionally wrought great damage to the island's agricultural economy. Those of 1899, 1928,

and 1932 were particularly destructive. The San Felipe storm in 1928 is remembered by natives as the most severe calamity of this century; it is estimated that financial loss amounted to over $50,000,000 of which the fruit industry suffered a loss of well over $2,000,000; nearly 3,000 lives were lost. The San Ciprian hurricane in 1932 destroyed some $30,000,000 worth of property and crops. Owing to protective measures hurricanes during the past 18 years have been far less destructive both of property and human life.

Following each devastating hurricane, interest rates soar, credit structure becomes fluid and unstable, and yields are greatly reduced. Fortunately, hurricanes occur during the period of the year when most of the pineapple plants are still comparatively small (excluding ratoon crops); therefore, the loss incurred by the growers normally is not nearly as great as it is for other fruits and coffee.

The hurricane menace has proved to be a dominant factor in the virtual decay of the grapefruit industry. In 1930, the total export value of grapefruit amounted to over 3½ million dollars; by 1947, it had decreased to slightly more than one-fourth of a million dollars. Pineapples and sugar cane, unlike such tree crops as grapefruit, oranges, and coffee, are not nearly so susceptible to the effects of strong winds and heavy downpours of rain. This is explained by the fact that pineapples and

sugar cane are low plants and their foliage being more firmly attached to their stalks than are the leaves of tree crops. Furthermore, pineapples recuperate following storms far more quickly than do tree crops. However, it should be pointed out that pineapple growers do suffer along with their fellow tree-crop growers, but normally to a less degree. The greatest pineapple losses, as a result of hurricanes, usually occur when excess runoff of water is permitted to collect in low places in the fields, causing the roots of the plants to rot. Moreover, pineapple growers are often left without packing and grading sheds, factories, and farm equipment as a result of such storms.

5. Soils

Climate, topography, bedrock and mantle rock vary markedly within comparatively short distances in Puerto Rico, and these variations have resulted in the development of an intricate soil pattern. In all, 115 soil series are represented on the island; these series are subdivided into 352 soil types and phases. Even within the Pineapple Area there are 65 different soil types and over 90 soil phases.[9]

Mean annual rainfall varies from less than 30 inches to nearly 200 inches in different parts of the island, and soil differences correspond to a marked degree to climatic and topographic differences. For example,

---

[9] R.C. Roberts, 1942, pp. 180-183.

Cialitos soils are distributed mainly in upland and mountainous regions receiving more than 75 inches of mean annual rainfall and with slopes ranging between 30 and 60 per cent; whereas, Aguadilla soils are distributed mainly in level to undulating sections receiving between 60 and 70 inches of mean annual rainfall and with slopes of less than 15 per cent.

In age, soils range from recent alluvial deposits of the coastal lowlands to very old soils developed on nearly level remnants of ancient plateaus. The parent material has been produced from many different kinds of rock such as limestone, shales, tuff, ash, granites, and andesites, and many types of metamorphic rocks, such as serpentine and quartzite. The processes of weathering have been in the past, as they are at present, very active.

Some of the soil types, such as the Red and Yellow Podzolic soils, Reddish Chestnut soils, and Planosols, have counterparts in southern United States; others, such as the Yellowish-Brown and Reddish-Brown Lateritic soils, are found only in more tropical areas.

The pineapple plant grows best on moderately acid, well-drained, permeable soils that contain considerable organic matter and where aeration is favorable.[10] The plant does not require large quantities of water nor is it deep-rooted. If the soil is too wet, too compact, too

---

[10] R.C. Roberts, 1942, p. 108.

alkaline, or poorly aerated, the plant is likely either to wither or to produce an unmarketable fruit. Such rigid soil requirements for pineapple production are more favorably met within widely scattered districts of the Pineapple Area than in any other section of the island.

The alluvial soils, which more or less fringe the island and lie adjacent to many of the larger stream channels, are considered to be the richest and most productive soils. However, these soils generally are too wet for pineapples and such land is devoted almost exclusively to sugar cane production. Contiguous to the alluvial soils, on slightly higher and better drained land, are discontinuous belts derived from soft to medium-hard limestone. These soils are commonly red, reddish-brown, or grayish-brown in color, friable, deep, moderately fertile, permeable, and slightly to strongly acid in character (Table 5). Here pineapples and sugar cane are the two leading crops.

Almost three-fourths of all soils within the Pineapple Area are derived from limestone. These soils are delineated on the south by a line that extends directly across the Pineapple Area, passing near the towns of Bayamón and Corozal and continuing westward beyond the area under investigation. To the north of the limestone belt, averaging two to four miles in width, is a discontinuous belt of soils composed of Pleistocene and Recent alluvial and eolian deposits. In general, these

TABLE 5

MAJOR SOIL TYPES ON WHICH PINEAPPLES ARE GROWN[a]

Soil Type and Depth of Top Layer (In Feet)	Origin	Elevation and Topography	pH Factor[b]		Surface Soil Characteristics	Subsoil Characteristics
			Soil	Subsoil		
Moca 10 or more	Lower Tertiary limestone and clay.	250-1,000 feet. Gently rolling or nearly level valleylike districts.	5.0	4.5	Moderately acid. 6 to 8 inches of heavy plastic clay, sticky when wet. Grayish-brown or brown color.	Moderately acid, plastic sticky clay. Colors vary between dark gray, red and brown. At depth of 5 feet plastic clays interbedded with round or angular stones and gravel.
Espinosa 8 to 20	Middle Tertiary soft limestone.	100-600 feet. In open valleys or basins slightly undulating.	4.5 to 5.5	4.5	Moderately to strongly acid 6 to 10 inches of very granular, light-brown or grayish-brown clay.	Moderately acid. Fine, sticky clay of pale yellow or yellowish-red color. Upper 2 feet or subsoil stiff and fine cloddy clay.
Vega Alta 15 or more	Same as above.	100-600 feet. Flat or gently rolling in large valleys and broad basins.	4.5 to 5.5	4.0 to 5.0	Moderately to strongly acid. 6 to 8 inches of grayish-brown to yellowish-brown, friable clay; also argillaceous and sandy loam. Heavily leached.	Strongly acid. More speckled than Bayamón and Espinosa. Heavy and plastic clay of a dark red color, at 18 inches becoming more compact.
Bayamón 8 to 20	Middle Tertiary medium hard limestone.	100-600 feet. Open valleys to slightly undulating.	4.0 to 5.5	4.0 to 5.0	Strongly acid. 10 to 12 inches of dark red to medium red color. Large quantities of individual clayey particles, giving soil a loamy or sandy texture.	Strongly acid in top layers. Clay very compact; columnar structure in places. Red or dark red color at depth of 2 feet underlying sandy clay.
Sabana Seca 15 or more	Pleistocene and recent marine deposits mixed with material washed from uplands.	50-500 feet. Level to slightly undulating.	5.0 to 6.0	5.0 to 6.0	Moderately acid. 6 inches of semi-compact clay of dark brown color. Numerous irregularly shaped concretions.	Moderately acid. Upper 3 inches of heavy plastic clay of speckled red, dark gray, and yellow colors, gradually becoming lighter and less compact with depth. Hardpan below 1 foot.
Catalina 10 to 15	Upper Cretaceous fine-grained volcanic igneous rock such as andesitic tuff and ash. Some shale.	100-3,000 feet. Undulating, broken to hilly.	6.0	4.0 to 5.0	Slightly acid. Granular, permeable clay of red or purplish red color. 4 to 12 inches thick, depending on slope.	Strongly acid in top layers. Compact clay of reddish-brown to dark red or purple color. Upper 1 or 2 feet of subsoil friable.

[a]Sources: Adapted from "La Piña en Puerto Rico", Revista de Agricultura de Puerto Rico, Vol. 33, No. 4 (San Juan: Department of Materials, Printing, and Transportation, 1941), p. 525, and R.C. Roberts, Soil Survey of Puerto Rico, U.S. Department of Agriculture (Washington: Government Printing Office, 1942), pp. 183-487.

[b]See Glossary.

soils are ill-suited for pineapple production because they are too wet and too compact. South of the limestone belt, continuing to the southern limits of the Pineapple Area in Corozal and Bayamón, soils are derived from Upper Cretaceous shales, in part calcareous, and from pyroclastic rocks such as andesitic tuffs (Table 5).

From an agricultural standpoint, thoroughly matured soils derived principally from ancient material are, in general, less productive than their younger equivalents, for many of the vital chemical ingredients have been leached out. As previously mentioned, many of the alluvial soils in proximity to the coast are not well suited to pineapple production because they are too compact or too heavy for proper drainage and aeration. These are but two reasons why commercial pineapple production is limited primarily to limestone soils occurring between elevations of 100 and 1,500 feet above sea level.

6. Population Growth, Distribution, and Urban Development

Course of Settlement. When Columbus landed in Puerto Rico in 1493, it is estimated that there were approximately 80,000 Indians living on the island; some 25 years later, this figure had been reduced to perhaps 3,500 to 4,000.[11] This sharp decline of the Indian population resulted mainly through epidemics of imported diseases, starvation,

---

[11] A.G. Price, White Settlers in the Tropics (New York: American Geographic Society of New York, 1939), pp. 79-89.

and forced labor. Immigration, mostly Spanish, came to the new colony in great numbers during the sixteenth, seventeenth, and early decades of the eighteenth centuries. Around the middle of the eighteenth century many potential settlers found "greener pastures" elsewhere in the New World, and the number entering Puerto Rico dwindled to a few thousand per year.

Between 1795 and 1835 (Table 6), there was a sudden upsurge in immigration to the island colony not only from Spain but from other western European countries as well; no doubt they selected Puerto Rico because it was one of the few Spanish possessions in the Western Hemisphere in which the spirit of revolt had not developed. To augment this wave of immigration, African slaves were brought in great numbers to work the plantations.[12]

For short periods during these three hundred and fifty years when Spain was engaged in war and her connections with the island severed, immigration came to a sudden stop, only to resume again once the blockades were lifted. By the turn of the twentieth century immigration on a limited scale came to Puerto Rico from the United States, Cuba, Mexico, and several of the South American countries.

---

[12]African slaves, first introduced in 1518, came in greatest numbers just prior to 1800. Slave trade lasted until 1873. In 1802, Negroes comprised 52 per cent of the total population of the island. In 1845, Puerto Rico enumerated 227,056 Negroes and 216,183 whites, approximately the same ratio as nearly a half century earlier. Price, 1939, p. 79.

TABLE 6

POPULATION OF PUERTO RICO (1765-1950) AND THE PINEAPPLE AREA (1899-1950)*

Census Year	Puerto Rico			Pineapple Area		
	Population	Increase Over Preceding Census		Population	Increase Over Preceding Census	
		Number	Per cent		Number	Per cent
1765	44,883	-----	-----	-----	-----	-----
1775	70,250	25,367	56.5	-----	-----	-----
1800	155,456	85,206	121.2	-----	-----	-----
1815	220,892	65,436	42.1	-----	-----	-----
1832	330,051	109,159	49.4	-----	-----	-----
1846	447,914	117,863	36.7	-----	-----	-----
1860	583,308	135,394	30.2	-----	-----	-----
1877	731,648	148,340	25.4	-----	-----	-----
1887	798,565	66,917	9.1	-----	-----	-----
1899	953,243	154,678	19.4	119,333	-----	-----
1910	1,118,012	164,769	17.3	150,251	31,428	26.3
1920	1,299,809	181,797	16.3	174,422	23,672	14.4
1930	1,543,913	244,104	18.8	204,971	30,549	17.5
1940	1,869,255	325,342	21.1	246,447	41,476	20.2
1950	2,210,703	341,448	18.3	283,770	37,323	15.2

*Sources: Puerto Rico Reconstruction Administration, Census of Puerto Rico: 1935, Population, Number, and Distribution of Inhabitants, Bulletin No. 1 (San Juan: Unpublished Report, 1935), p. 1, Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1942-43 (San Juan: Office of Economic Research, 1945), pp. 2-4, and U.S. Department of Commerce, 1950 Census of Population, Preliminary Counts, Puerto Rico, Series PC-4, No. 5 (Washington: Government Printing Office, 1950), pp. 1-2.

The population of Puerto Rico nearly doubled between 1899 and 1940, and in 1950 had reached 2,210,703, or an 18 per cent increase over the 1940 enumeration, giving it an average density of 646 persons per square mile. By comparison, for the ten-year period, 1940 to 1950, the population of the United States increased by 19,028,086 (14.5%), showing an average density of only 49 persons per square mile. Population density of Puerto Rico, in spite of its few natural resources and lack of space for expansion, is over 13 times that of the United States. The current population of the island is increasing at a phenomenal rate, approximately 34,000 per year. Emigration is roughly 26,000 per year since the end of World War II, mainly to the United States.[13]

The present-day population of the island is a composite of three racial types: the Spanish creole, approximately 65 per cent of the total; the mulatto, estimated at 30 per cent; and the African Negro, comprising the remaining 5 per cent.[14] The mestizo so characteristic

---

[13]Comparatively few women migrate to the United States mainly because of insufficient funds for passage, family ties, language barriers, or other factors. The ratio of migrants is almost 31 to 1 in favor of men. The Insular government is studying ways by which to accelerate the rate of female migration to other countries, especially to the United States. U.S. Department of Commerce. Current Population Reports, Population Estimates, Puerto Rico (Washington: Government Printing Office, 1949), pp. 2-5.

[14]W.N. Harris, "Puerto Rico--Island of Extremes," The Journal of Geography (Chicago: A.J. Nystrom and Co., 1949), p. 288.

in the racial composites of many Latin American countries, is practically nonexistent in Puerto Rico. The ruthless conquistadores proved to be perfectionists in utilizing and exploiting almost the entire Indian labor force. Except for a comparatively few Indians that managed to escape, virtually the entire native population was liquidated as a result of adverse working and living conditions, diseases introduced by the conquerors, and local uprisings against the Spaniards.

There are comparatively few racial prejudices on the island, and color lines are not nearly so marked as they are in the southern part of the United States. Generally speaking, the whites are most prominent in the professional fields and frequently are the larger landholders, while mixtures are common among the general working classes. Exceptions to this are the jibaros. Although Negroes may be seen in any of the island's occupations, the purest Negroid types are to be found among the workers in the larger urban centers.

The total population within the Pineapple Area could not be ascertained prior to 1899 because the complicated methods of enumeration did not adhere to municipality boundaries. Consequently, population data for the Pineapple Area before the twentieth century could not be determined with any degree of reliability.

The population of the Pineapple Area more than doubled between 1899 and 1940 (Table 6), but the greatest percentage of increase occurred before 1910. This

was due largely to the influx of migrants associated with rapid development of the sugar industry on the fertile coastal plain. The need for additional labor grew with the sugar industry. After 1910, however, the introduction of machines, especially in the refineries, had its telling effects on the over-all population increase over and above the normal birth rate. As sugar plantations grew larger and larger and the land tenure system changed, the economic opportunities for employment, other than in the sugar industry, became more and more restricted. In spite of the fact that fertile land became more difficult and more expensive to acquire, other agricultural and small-scale manufacturing industries, requiring large amounts of year-round labor per unit area, were able to become firmly rooted. For these reasons, the rate of population increase in the Pineapple Area since 1920 has been about 2 to 3 per cent less than for the island as a whole.

In 1950, there were nearly 264,000 inhabitants living within the Pineapple Area, three-fourths of which were whites. This ratio is approximately the same as for the island as a whole. The group designated as "nonwhites" (approximately 67,000) consists of Negroes, persons of mixed Negro and white blood, and the small number of persons of other nonwhite races, including Chinese, Indians, Japanese, and Philippinos. No objective differentiation can be made between the racial types, owing to the degree of racial amalgamation. Any method of classification, although expertly done, is largely subjective.

Pattern of Settlement. The distribution of population in Puerto Rico is closely related to the different forms of land use and land tenure. It is noteworthy that the heaviest concentration of rural population occurs along the coast in districts favorable for producing sugar cane, fruits, and truck-farming crops. Moreover, the heaviest concentrations of urban population also are found along the coastal fringe of the island. Even in many sections of the rugged interior where cash crops can be grown and marketed, comparatively heavy concentrations of population occur. No part of the island can be said to be sparsely populated.

Puerto Rico is predominantly a country with a large number of small, private landholders.[15] A large percentage of the small-sized farms are located in the hilly or mountainous regions where poor soil, rugged topography, and inaccessibility combine to hinder strongly nearly all forms of agricultural activities. On the other hand, a large percentage of the middle- and large-size farms

---

[15] In 1950, Puerto Rico had a total of 53,512 farms (according to the latest Census, a farm is defined as having not less than 3 cuerdas, and having some agricultural operations). This was 2,007 (3.8%) fewer farms than was counted in 1940. A change in the definition of a farm accounts for a part of this decrease. By contrast, the number of farms in the Pineapple Area increased from 5,886 in 1940 to 6,050 (2.8%) in 1950. This increase is explained partly by the fact that several of the large estates were broken up into smaller units. U.S. Department of Commerce, Preliminary 1950 Census of Agriculture, Number of Farms by Municipalities, Puerto Rico (Washington: Government Printing Office, 1951), pp. 1-2.

are concentrated in the richer, more level coastal plains where direct communication is facilitated with the larger urban centers. Fortunately, because of the reasons mentioned above, the pineapple industry is gradually shifting out of the hills into the coastal plains, changing the pattern of settlement in its path.

The average size of a farm within the Pineapple Area is roughly 38 cuerdas.[16] In general, the size of farms decrease inland from the coastal lowlands to the foothills and uplands; conversely, the number of farms increase. Of the 54 farms growing pineapples commercially within the Pineapple Area, the average size farm is 225 cuerdas or more than five times as large as the non-pineapple-producing farms. In 1950, 45 of the 54 commercial pineapple growers in the Pineapple Area reported the size of their farms. They were as follows: none less than 10 cuerdas, 7 between 10 and 49, 8 between 50 and 99, 15 between 100 and 249, 8 between 250 and 449, and 7 over 500 cuerdas each.

Within the Pineapple Area population distribution is related to land tenure, land use, and topography. Of the three, land tenure and land use appear to be of greater significance than topography to population distribution and pattern of settlement. This is especially true in

---

[16]This figure was ascertained by dividing the total amount of land in farms by the total number of farms in the Pineapple Area.

the lowlands and along the lower flanks of the foothill region. However, on the inland margins of the foothills, topography takes on added importance with regard to population distribution and pattern of settlement.

With few exceptions, the distribution of population within the Pineapple Area is fairly uniform throughout. Districts of lowest concentration of population are noted in swampy lowlands contiguous to the coast and in widely scattered districts of extremely rugged topography, that is, in general, where agricultural activities are least conducive to the earning of a livelihood. Another exception to the uniformity of population distribution is on the inland side of the marshy and swampy lowlands and along the lower stretches of the floodplains where some of the largest sugar cane estates are located. Here the concentrations of population are noted along the main roads, on the margins of farm boundaries, and on less productive land. There is a slight concentration of population, although not too pronounced, in a belt 3 to 5 miles wide that extends from the town of Bayamón westward to Arecibo via Manatí. However, this population belt is not continuous, for the floodplains that dissect the lowlands afford sites for comparatively few people.

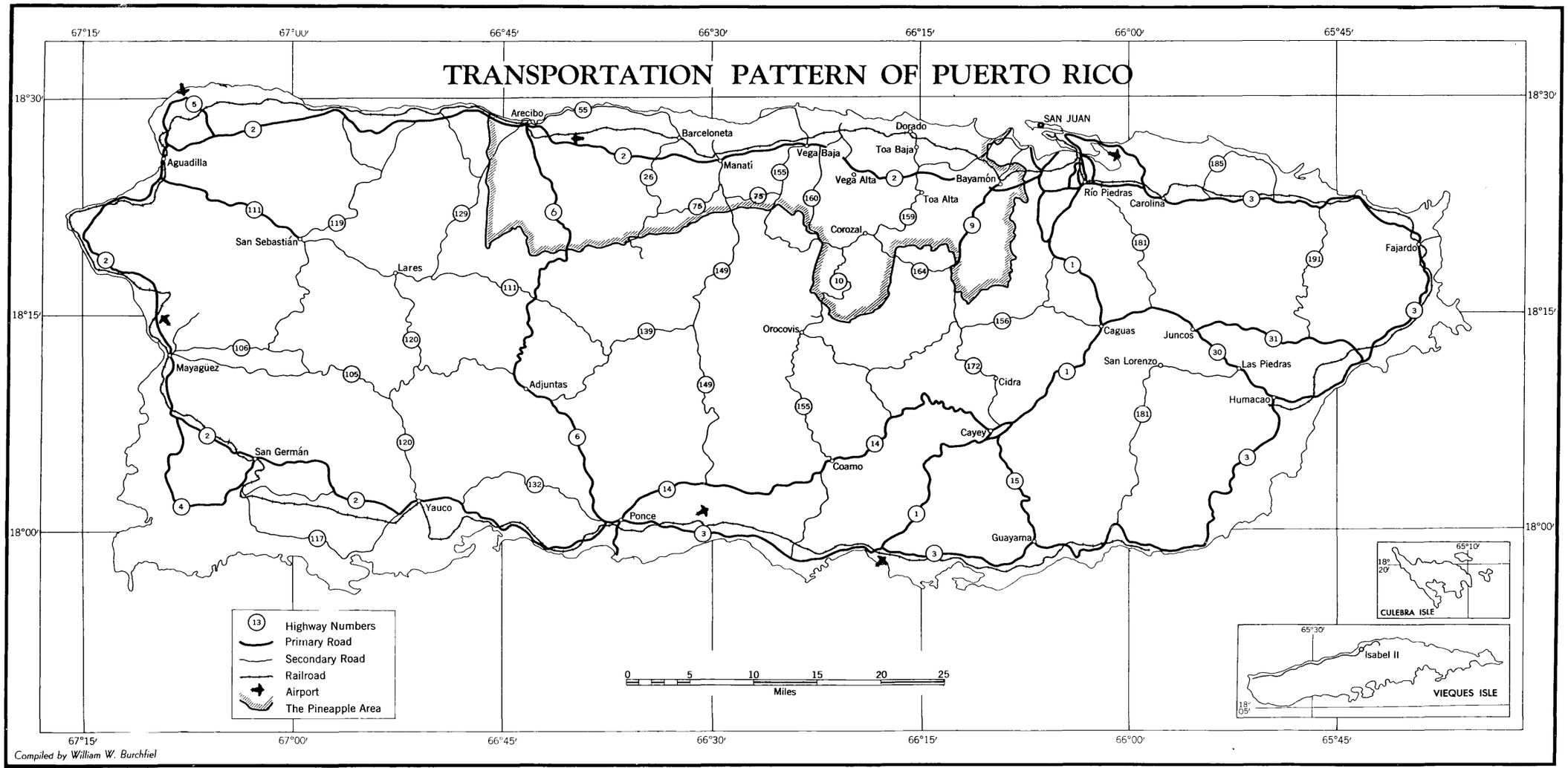
The Pineapple Area, with nearly 284,000 people, contains roughly 15 per cent of the island's total population (Table 6), compared to only 12½ per cent of the

total land area, for an average of 669 persons per square mile. Based on the total of only 158,700 cuerdas or arable land, it can readily be seen that the Pineapple Area, as well as the island as a whole, is greatly over-populated. Moreover, there are only a few resources, other than an abundant supply of labor and agriculture, that hold any great promise in strengthening the island's economy or rapidly improving the general living conditions of the people.

The rural population of the Pineapple Area in 1950 totaled about 207,000 (73%) of the total population of the area, as compared with 1,278,000 (58%) rural population for the entire island. The rural population for the Pineapple Area increased by nearly 22,500 (12%) in the 1940-50 period. During the same period the rural population for the island increased by only 49,500 (4%). The urban population of the Pineapple Area totaled slightly over 77,000 in 1950, as against an urban population of about 930,000 for the island as a whole. Urban population for the Pineapple Area showed an increase of nearly 15,000 (24%) between 1940 and 1950, while the urban population for the entire island showed a 10-year increase of nearly 288,000 (44.9%). The difference in the rate of urban population increase between the Pineapple Area and the island as a whole is explained in part by the unstable conditions, especially in the larger coastal cities of San Juan, Mayagüez, and Ponce, produced as a result of World War II.

There are three urban centers of more than 10,000 population within the Pineapple Area, largest of which is Arecibo with a population of 26,500. The concept "urban center" includes the population of the pueblo; rural population includes the remainder of the population within a municipality. Almost without exception, all sizable urban centers lack planning by American standards. They are closely compact and contain a far greater number of people per unit area than in the United States.

If an urban center bears the same name as the municipality, it is a political center of a civil district, as well as a center for recreational activities, marketing of crops, and purchasing of processed or manufactured items needed on the farm or for household use. There are usually two or more roads radiating from each urban center (Fig. 4). There are some exceptions to this, particularly in the mountainous municipalities where access to urban centers is possible only by tracts or seasonal roads. In general, Puerto Rico has an adequate road net to meet its present needs. Some of the best roads of the island traverse the Pineapple Area, linking the larger towns of the north coast with the metropolitan centers of San Juan and Rio Piedras to the east (Fig. 4).



Source: Puerto Rico Planning Board, 1950.

Fig. 4 - Transportation Pattern of Puerto Rico.

CHAPTER II

PROBLEMS OF GROWING OF PINEAPPLES

1. Introduction

It has been stated that in order to be a successful farmer in China all one has to do is to follow precisely the techniques followed by his nearest neighbor. In Puerto Rico, on the other hand, if a pineapple grower follows the identical techniques of his neighbor, he is apt to fail. The wide variety of soils, varied climatic conditions within short distances, combined with factors of slope, erosion, drainage, productivity, and varied fertilizer requirements, render it nearly impossible to establish standard agricultural techniques and practices even for a small segment of the Pineapple Area.

Methods and techniques of pineapple production in Puerto Rico are constantly changing but not at an accelerated rate or at the same degree of efficiency as that of the sugar industry. Greatest progress in the pineapple industry at the present time seems to be in the selection of better varieties, healthier plants, and conservation practices rather than the introduction of labor-saving devices and equipment. This is partly due to the great reservoir of available labor and to the limited amount of capital. Technologically, there is a wide gap between the agricultural phase of pineapple

production and the processing phase. The former has lagged behind the latter in regard to the degree of mechanization, operating efficiency, as well as in long-range planning. Of the four manual operations in which human skill and judgment are necessary in pineapple production, three are in the agricultural phase.[17]

2. Relief Factors

Within the Pineapple Area, elevations range from sea level along the north coast to approximately 2,500 feet above sea level along the southern margins (Fig. 1). Pineapple production is concentrated almost exclusively between elevations of 100 to 1,500 feet above sea level.[18] Based on the total number of cuerdas planted to commercial pineapples by altitudinal zones are as follows: approximately 100 cuerdas less than 100 feet in elevation above sea level; 1,900 cuerdas between 100 and 500 feet elevation; 1,925 cuerdas between 500 and 1,000 feet elevation,

---

[17] Selecting slips and suckers for a new crop, inserting young plants into the soil, and picking mature fruit. See Section 21, "Degree of Mechanization".

[18] In Hawaii, by mutual consent, sugar cane is grown on land which is below 300 feet above sea level; pineapples are concentrated largely between 300 and 2,300-foot levels. Elevations of 500 to 800 feet are regarded as the optimum for pineapple production under the soil and climatic conditions in the territory. Above 2,000 feet marginal conditions prevail; fruits are smaller in size and less sweet, yields are low; and widespread plant-rot is prevalent due to the presence of a fungus (Phytophera cinnamoni) in the soil.

and the remaining 200 cuerdas more than 1,000 feet elevation. The lower boundary is determined primarily by drainage and porosity of the soil, whereas the upper boundary is determined principally by slope and climatic conditions. In recent years there has been a definite trend toward devoting more and more level or slightly undulating land to pineapple production.[19] This practice reduces the labor requirement and facilitates the use of mechanized equipment. Costs of production are thereby greatly decreased. Furthermore, larger-sized farms suitable for pineapple production under modern techniques are situated nearer the north coast, where the surface is more level.

Communication, although adequate, is not nearly as highly developed in the foothill section as in the alluvial coastal plain. Furthermore, farmers in the more rugged districts of the Pineapple Area are confronted with problems of increased transportation and marketing costs of their crops. The more isolated pineapple growers of the interior have difficulty in competing with growers in the lowlands. The former group is handicapped by increased transportation and marketing costs. Moreover, steep slopes accelerate drainage and lessen leaching; they at the same time increase erosion and render the soil less and less fertile.

---

[19] See Section 7, "Early Growth, Development, and Changing Structure".

3. Climatic Factors

The pineapple is influenced to a large degree by temperature and precipitation. Average temperatures for the coldest months, usually January or February, must not fall below 56°F.; average temperatures for the warmest months, usually August or September, should not exceed 85°F. (Table 2).[20] Pineapples cannot withstand frost and are slow in recuperating following brief periods of near-freezing weather.[21] Unusually high temperatures tend to wither the leaves and produce sunburns in the fruits.[22] This is particularly true when high temperatures are accompanied by parching winds for periods of a week or ten days; these sometimes occur during May and June near the end of the harvesting season.

The amount of rainfall required by pineapples varies according to season, temperature, soil conditions, slope,

---

[20] Optimum conditions prevail in localities where average annual temperatures range between 74° and 80°F., a spread of only 6°.

[21] Occasional cold periods account primarily for the virtual decay of the pineapple industry in Florida.

[22] Experiments in Hawaii reveal that when the mean monthly temperatures exceed 85°F., fruit results in low acidity and is insipid; convergely, when mean monthly temperatures are lower than 62°F., fruits are small and sour. Practically no growth occurs when temperatures fall below 65°F., and it is the consensus of experts that fruit distortion results from unusually cold spells. F.C. Cook and E. Chem, The Pineapple Industry of the Hawaiian Islands, Report No. 32, (Johore: Government Printing Office, 1949), pp. 2-3.

stage of growth, and even to the varieties.[23] Therefore, it is difficult to express actual amounts of water needed in quantitative terms.[24] Mr Arthur S. Mason, formerly technical advisor to Office of Agricultural Experiment Station at Rio Piedras, believes that areas which normally receive less than 60 inches or in excess of 85 inches of annual rainfall are unfavorable for the growing of the Red Spanish variety of pineapples in Puerto Rico.

Significant facts have been determined by the Puerto Rico Agricultural Experiment Station pertaining to rainfall and temperature of the Pineapple Area. Fruit matures much slower at elevations of 1,200 to 1,500 feet than at elevations of 150 to 300 feet, regardless of season. Moreover, pineapple plants in the coastal lowlands grow more

---

[23]On Vieques Island, where climatic conditions are similar to those found in the pineapple-producing areas of Hawaii, the Smooth Cayenne variety is grown in a district receiving about 45 inches of annual rainfall. In Hawaii, optimum conditions prevail where annual rainfall is between 45 and 55 inches with a marked and regular dry season which permits the fruit to ripen prior to harvest. Cook and Chen, 1949, p. 3. By contrast, Puerto Rico proper does not have a marked dry season, which appears to be one of the basic difficulties in obtaining healthier plants, higher yields, and in combatting pests and diseases.

[24]Experiments conducted by the Agricultural Adjustment Administration, Fruit and Vegetable Branch of the Bureau of Agricultural Economics at Santa Isabella in 1933-34, revealed that Red Spanish pineapples could not be grown successfully with less than 35 inches of rainfall without irrigation. The large Cabezona variety, however, can be grown in localities receiving less than 35 inches of rainfall. Mr. Juan Torro, largest Cabezona grower in the Lajas Valley, states that in his experience in growing this variety 45 to 55 inches of annual rainfall is optimum.

slowly and fruit matures more slowly during the winter months than in summer; this is especially noticeable when the rainfall is exceptionally heavy during the cooler months. Thus, it is reasonable to assume from what has been stated that the highest yields are obtained on the inland margins of the coastal lowlands due to favorable temperature and rainfall averages.

Pineapples require a 12-month growing period, as do many other important cash crops grown on the island; the highest yields, however, are obtained in years when the total monthly rainfall does not exceed 3.5 inches during the harvesting season (Table 3 and Fig. 3). During the drier months, normally February and March, when pineapples are reaching a final stage of maturity, average monthly rainfall ranges from 3 to 5 inches. During the wettest months, normally July, August, and September, when the bulk of pineapples are planted, average monthly rainfall varies from 5 to 8 inches. However, the reliability in rainfall is uncertain from year to year and from season to season.[25] Excessive rainfall during the harvesting season or deficient rainfall during the planting season

---

[25]During the main planting period average monthly rainfall for Manatí, in the heart of the Pineapple Area, is 4.01 inches for June, 5.71 inches for July, and 4.90 inches for August (Table 3). In 1950, for the corresponding three months, the total rainfall was 2.75, 5.23, and 1.93 inches, respectively. (Consultation with representatives of the U.S. Weather Bureau, San Juan Station, May 3, 1951.)

almost invariably results in reduced yields and occasionally complete crop failures.[26]

The much feared and dreaded hurricane, usually accompanied by excessive rainfall, commonly occurs near time of general planting. On the average, hurricanes strike some part of Puerto Rico once nearly every four years (Table 4). Since the hurricane season occurs in late summer or early autumn (mid-July through October), most pineapple growers are either planting their first crop or the crop planted the preceeding year is well rooted and, therefore, the strong winds do not normally destroy the crop completely. However, the torrential downpours of rain frequently flood many of the lowlands, requiring the resetting of plants in new fields and straightening up of the one-year old plants.[27]

With the pineapple industry gradually moving out of the foothills onto the coastal lowlands, damage from hurricanes will doubtless become more serious in years to come. The greatest hurricane damage in all of Puerto Rico over the past 75 years has occurred on the north

---

[26]During the 1948-49 crop-year, considered a normal year, yields ranged from 10 to 15 per cent higher than the 1949-50 crop-year which was too wet or the 1950-51 crop-year which was considered too dry.

[27]It is estimated, as a result of the hurricane of September 21, 1949, that 100 cuerdas of pineapples were destroyed, mainly by flooding, that would have yielded in 1950 and 1951.

side of the island between Manatí and Fajardo.[28] In future construction of pineapple canneries, packing sheds, and warehouses, investors in the pineapple industry must weigh carefully the hazards and losses that may be expected to ensue as a result of the hurricane.

4. Soils and Soil Erosion

The soils of the Pineapple Area range from low to high in fertility. However, in general, the poorest soils are found on the steeper and more rugged slopes of the Pineapple Area, owing to the loss of topsoil through erosion, and to constant leaching of the minerals and vegetative matter as a result of heavier rainfall (See Fig. 5).

Table 7 shows the relative productivity of each of the major types of soils on which pineapples are grown. The productivity ratings are based wholly on average pineapple yields for a normal year and under current practices and do not necessarily constitute comparable ratings for other crops grown in the Pineapple Area. In some cases, the low fertility of a given soil type may be overcome by proper application of fertilizers and other scientific farming techniques. For this reason, it is difficult to determine precisely the number of cuerdas within the Pineapple Area that is suitable for pineapple

---

[28] From unpublished records made available to the writer by the U.S. Weather Bureau, San Juan Station, June 5, 1951.)

SOIL EROSION IN THE PINEAPPLE AREA

(Generalized)

66° 45′ | 66° 30′ | 66° 15′

18°30′

18°15′

U
Arecibo
Barceloneta
Manati
Lake Tortuguero
Vega Baja
Vega Alta
Dorado
Toa Baja
Toa Alta
Corozal
Bayamón
SAN JUAN

DEGREE OF SOIL EROSION IN THE PINEAPPLE AREA
(Area delimitation approximate)

- No apparent accelerated erosion: 70,400 cuerdas (25% of total area)
- Slight sheet erosion, 0-25% of top soil removed: 72,325 cuerdas (26% of total area)
- Moderate sheet erosion, 25-75% of top soil removed: 71,000 cuerdas (25% of total area)
- Severe sheet erosion, more than 75% of top soil removed and very slight removal of subsoil: 24,725 cuerdas (9% of total area)
- Severe sheet erosion with occasional gullies, more than 75% of top soil and less than 25% of subsoil removed: 21,950 cuerdas (8% of total area)
- U — Undifferentiated erosion including urban areas, lakes, marshes, floodplains, terraces, etc.: 19,000 cuerdas (7% of total area)

1 cuerda equals 0.9712 acre

0 3 6 9
Miles

Source: Puerto Rico Soil Conservation Service, USDA, 1950
Compiled by William W. Burchfiel

Fig. 5 —Soil Erosion in the Pineapple Area.

TABLE 7

SOILS OF THE PINEAPPLE AREA BEST SUITED TO PINEAPPLE PRODUCTION, BY TYPE, PRODUCTIVITY RATING AREA, AND COMPETING CROPS[a]

Symbol of Soil	Soil Type[b]	Productivity Rating[c]		Total Area (in Cuerdas) (approx.)	Principal Competing Crops
Ah	Aguadilla loamy sand	55[d]	(10)[e]	772	Coconuts, grapefruits.
Ac	Almirante clay	70	(7)	1,845	Cane, subsistence crops.
An	Almirante sandy clay	60	(9)	1,940	o.
Af	Almirante fine sandy loam	50	(11)	641	Grapefruit, subsistence crops.
Bc	Bayamón clay	85	(4)	2,241	Cane, subsistence crops.
Bf	Bayamón fine sandy loam	85	(4)	7,317	o.
Bs	Bayamón sandy clay	90	(3)	2,175	o.
By	Bayamón sandy clay loam	90	(3)	1,384	o.
Cc	Catalina clay	75	(6)	2,317	Coffee, bananas.
Cc	Catalina clay, level phase[f]	85	(4)	515	General crops.
Ec	Espinosa clay	70	(7)	1,450	Cane, subsistence crops.
Ey	Espinosa sandy clay	75	(6)	6,623	o.
Lc	Lares clay	75	(6)	2,575	Coffee, subsistence crops.
Mo	Moca silty clay loam	75	(6)	1,845	Cane.
Sc	Sebana Seca clay	55	(10)	3,914	o.
Vc	Vega Alta clay	70	(7)	395	Cane, subsistence crops.
Vc	Vega Alta clay, heavy subsoil phase	70	(7)	1,450	o.
Vm	Vega Alta sandy clay loam	75	(6)	1,516	o.
Vm	Vega Alta sandy clay loam, heavy subsoil phase	70	(7)	515	o.
Vy	Vega Alta clay loam	75	(6)	1,895	o.
Vy	Vega Alta clay loam, heavy subsoil phase	70	(7)	1,252	o.
	Total			44,397	

[a]Source: Adapted from R.C. Roberts, Soil Survey of Puerto Rico (Washington, Government Printing Office, 1942), pp. 180-183 and 392-407. Slight modifications have been made with regard to productivity rating.

[b]Soil types on which pineapples are seldom grown, soils which yield less than 225 crates per cuerda, and soils in which insufficient area is known to definitely assign a rating are generally omitted.

[c]See Glossary.

[d]A crop yield of 350 crates or over of pineapple per cuerda is equivalent to a base of 90.

[e]Based on a rating of 1 to 11. A rating of 1 represents the most productive soils, and 11 to the least productive.

[f]Phase is that part of a soil type having minor variations in characteristics such as relief, stoniness, or accelerated erosion.

production either with a standard crop rotation plan or with practices in which pineapples are planted year in and year out on the same soils.

Soils of the Rugged Upland. Large portions of the more rugged sections of the Pineapple Area are occupied primarily by Mucara (Mt), Cialitos (Ci), and associated types of brown, red or purplish-red color. These soils are high in permeable clay and low in silt and sand. The silica content is low, but the iron and aluminum content is high. Surface soils are friable, acid, and readily worked. The subsoils, for the most part, are very acid, heavy, and permeable, and are adequately drained. In general, these soils are subject to sheet erosion. Cialitos soils are especially well adapted physically to many crops, but, owing to a deficiency in chemical elements, such as magnesium, phosphorus, and to their rugged relief, and generally to their inaccessible locations, comparatively few important cash crops are grown.[29] For these reasons the Cialitos soils have been omitted as pineapple-producing soils from Fig. 6 and Table 7.

Soils of the Foothills. These soils, such as the Lares (Lo) and Mocc (Mo) series, are typically dark, sticky, plastic, heavy clay surface soils and plastic, deep, heavy subsoil, and they are comparatively difficult

---

[29] R.C. Roberts, 1942, pp. 191-193, 213-214 and 244-245.

SPECIFIC PRODUCTIVITY RATING IN THE PINEAPPLE AREA

(Generalized)

66° 45′ | 66° 30′ | 66° 15′ | 18° 30′ | 18° 15′

Arecibo · Barceloneta · Manatí · Vega Baja · Vega Alta · Dorado · Toa Baja · Toa Alta · Corozal · Bayamón · SAN JUAN · Lake Tortuguero

SPECIFIC PRODUCTIVITY[a] FOR PINEAPPLE-PRODUCING SOILS ONLY

Rating[b]	Average yield per cuerdas
90 or more	350 crates or more
80 to 90	300-349 crates
70 to 80	275-299 crates
60 to 70	250-274 crates
50 to 60	225-249 crates
Under 50	Less than 225 crates omitted

Note: See Table 7 for explanation of individual soil symbols, Area, Productivity Ratings, and Competing Crops.

[a] *Specific productivity means soil productivity in reference to the growing of pineapples exclusively on such soils.*

[b] *A crop yield of 350 crates or over of pineapples per cuerda is equivalent to a base of 90. Numerous, widely scattered soil types of less than 200 cuerdas each are not shown on map.*

1 cuerda equals 0.9712 acre

SOIL TYPES

Ac	Almirante clay	Cz	Corozo fine sand
Af	Almirante fine sandy loam	Dc	Dominguito clay
Ah	Aguadilla loamy sand	Ec	Espinosa clay
An	Almirante sandy clay	Er	Espinosa sandy loam
Av	Algarrobo fine sand	Eo	Espinosa loamy sand
Bc	Bayamón clay	Ey	Espinosa sandy clay
Bf	Bayamón fine sandy loam	Gf	Guayabo fine sand
Bs	Bayamón sandy clay	Iy	Islote sandy loam
By	Bayamón sandy clay loam	Lc	Lares clay
Ca	Catano loamy sand	Ll	Lares clay loam
Cc	Catalina clay	Ly	Lares sandy loam
Cd	Cataño sand	Mc	Moca clay
Cf	Colinas fine sandy loam	Mi	Martín Peña clay
Cg	Camaguey silty clay	Ml	Martín Peña sandy clay loam
Ch	Colinas stony clay loam	Mo	Moca loam
Ci	Cialitos clay	Ms	Moca silty clay loam
Cl	Colinas stony loam	Mt	Mucara silt loam
Cn	Colinas clay loam	Mt	Mucara silty clay loam
Cp	Coloso silty clay	Pc	Pinones clay
Cq	Coloso clay	Ps	Pinones silty clay
Cu	Coloso silty clay loam	Py	Pinones sandy clay loam
Cw	Coloso silt loam	Rc	Río Piedras clay
Cy	Coto sandy clay	Rj	Río Lajas sand
Sc	Sebana Seca clay		
Sk	Soller clay loam		
Sm	Saladar muck		
So	Soller clay		
Su	St. Lucia fine sand		
Sx	Santa Clara clay		
Sy	Sebana Seca sandy clay loam		
Ta	Tanamá stony clay		
Tc	Toa silty clay loam		
Tf	Toa fine sandy loam		
Tl	Toa loam		
Tm	Tiburones muck		
To	Toa silt loam		
Tx	Torres clay		
Vc	Vega Alta clay		
Vf	Vega Alta fine sandy loam		
Vl	Vega Alta loamy fine sand		
Vm	Vega Alta sandy clay loam		
Vy	Vega Alta clay loam		

0 3 6 9 Miles

Sources: *Adapted from Soil Survey of Puerto Rico, USDA 1942, Puerto Rico Planning Board, Santurce, May 1950.* *Compiled by William W. Burchfiel*

Fig. 6—Soil Productivity in the Pineapple Area.

to till. Wherever these soils occur relief ranges from nearly level to undulating. Although fairly good pineapple yields are obtained from both the Lares and Moco series, owing to a high organic matter in the surface soil, much of the smoother relief is devoted to sugar cane.

Along the northern flanks of the Foothills region, including the Bayamón (Bc, Bf, Bs, and By), Espinosa (Ec and Ey), and Vega Alto (Vc, Vm, and Vy) series are derived largely from medium-hard limestone and occur in level or slightly undulating valleys and basins (See Table 5). These soils are heavy, permeable, and acid. Pineapple yields are directly affected by the acidity of the soil. Many soil scientists believe that the most suitable pH unit for pineapple production is in the range of 4.5 to 5.5. Increases over that pH tend to reduce size of fruit in a proportion of about one-half pound per pH unit increased. Since such soils contain a large percentage of clay particles, they are somewhat sticky when wet. In general, below 500 feet elevation, these soils grade into more friable, looser, lighter-textured types, and have deeper surface soils than soils above 500 feet. Some of the highest pineapple yields are obtained from these soils, particularly the Bayamón sandy clay or Bayamón sandy clay loam types. Compare specific productivity ratings in Fig. 6 with highest average pineapple yields in Table 8.

TABLE 8

YIELDS OF PINEAPPLES AND OTHER CROPS PER CUERDA IN PUERTO RICO[a]

Crop	Unit	Lowest Yields[b]	Average Yields[c]	Highest Yields[d]	Locality or Soil Types
Pineapples[e]	Crates[f] Tons	200.00 7.0	300.00 10.50	500.00 17.50	Generally highest yields obtained in municipalities of Barceloneta, Vega Baja.
Sugar	Tons	1.80	3.75	7.80	Highest average for autumn and spring plantings and ratoons in soils of San Anton, Fraternidad, etc.
Tobacco	Cwt.[g]	4.00	7.14	20.00	Yields on Toa and Estacion soils.
Coffee	Cwt.	0.60	1.64	6.00	Yields from "La Carmelita" farm of the Agricultural Extension Service.
Plantain	Thousands	8.00	13.30	18.00	Yields on well-managed plantations in Corozal.

[a]Source: Harvey S. Perloff, Puerto Rico's Economic Future (Chicago: University of Chicago Press, 1950), p. 327.

[b]Crop failures are not considered.

[c]The average yields in 1942 are used as base. Insular Department of Agriculture and Commerce reports 1942 as typical year.

[d]Yields in experimental plots and small-sized plantings not included.

[e]Red Spanish variety only.

[f]Crate is equivalent to 70-pounds net.

[g]Hundredweight.

Soils of the Coastal Lowlands. Occupying widely scattered belts throughout the Coastal Lowlands are such soil series as the Sabana Seca (Sc) and Almirante (Ac and Af). They are fine-textured and, therefore, difficult to cultivate because of their heavy, stiff nearly impermeable subsoils. Subsoil of Sabana Seca, for example, beginning at approximately 1-foot, consists of plastic, stiff sandy clay that forms a "hard-pan". Soil is generally unsuited for plants that have deep root systems. Both the Sabana Seca and Almirante series are costly to cultivate, susceptible to drought, and require heavy applications of fertilizer in order to obtain mediocre returns. Although some pineapples are grown on these soils, the relative productivity is low.

From Fig. 6 and Table 7, it can been seen that approximately 44,400 cuerdas of land,[30] comprising 21 soil types, are best suited to pineapple production within the Pineapple Area. Soil types on which pineapples are seldom grown, soils which have specific productivity ratings of less than 50, and soils in which insufficient area is known to definitely assign a rating are generally omitted. The writer concludes that only about 16 per cent of the total Pineapple Area is suitable for pineapple production.

---

[30] In Fig. 6, the following factors were evaluated: (1) specific productivity rating, (2) soil characteristics, (3) elevation, and (4) annual rainfall.

These discontinuous belts of soils that are best suited to pineapple production extend the entire length (east to west) of the Pineapple Area but are, for the most part, concentrated along a 5-mile strip within the foothill region and the inland margins of the coastal lowlands. The largest and most productive pineapple soil belts are in the municipalities of Arecibo, Barceloneta, Manatí, and Vega Baja.

According to the Insular Division of Soils, the the total area of proven pineapple soils exceeds 200,000 cuerdas. Based on soils listed in Table 7, not more than 60,000 cuerdas on the entire island are well suited to pineapple production. However, it must be pointed out that there are other soil types which are suitable for pineapple production but which are not found in the Pineapple Area and, therefore, are not appraised in this investigation. According to a study (currently in progress) by Dr. J.A. Bonnet, Puerto Rico Department of Soils, it is estimated that there are approximately 125,000 cuerdas of land that are suitable for pineapple production on the entire island, including Vieques. Other investigations of the total cuerdas in Puerto Rico that is suitable for pineapple production show a range from 150,000 to 225,000 cuerdas. The writer views these latter two figures as entirely too high. Many of these figures, however, are based solely upon climate and soils and do not take into account other major factors as slope, erosion, drainage, etc.

The Pineapple Area, like other sections of Puerto Rico, has not escaped continued soil abuses. Specialized farming without adequate provisions for conserving the soil's productive qualities has been the general practice followed, not only in the past fifty years of commercial pineapple production, but also throughout most of the four preceeding centuries. Consequently, sheet erosion has greatly depleted vast areas, especially in the central and southern portions of Corozal and Bayamón (See Fig. 5).

It was noted from field observation that sheet erosion was more serious in central Corozal than in any other part of the Pineapple Area. Although the actual amount of topsoil removed in this section may not be nearly as great as in the more mountainous section to the south, the harm resulting from erosion is more lasting. Erosion is more serious in central Corozal than elsewhere mainly because the rainfall is sufficient to encourage farming of the hillsides. Here numerous, small farms are devoted to clean-till crops, such as tobacco, pigeonpeas, and beans. Along the southern margins of Corozal, where the annual rainfall is considerably higher and the slopes steeper, it would appear that sheet erosion would be the most severe of all, but this is not the case. Here vegetation grows so quickly and densely that the force of runoff is checked and the soil granules are held together by the plant roots.

The Soil Erosion Map of the Pineapple Area (Fig 5) reveals that, whereas less than 25 per cent of the topsoil has been removed from approximately one-half of the Pineapple Area, between 25 and 75 per cent of the topsoil has been removed in the remainder of the island, except for scattered localities. This is a positive indication that the Pineapple Area still contains some of the best agricultural land to be found on the entire island.

Fortunately, there is comparatively little gully erosion in the Pineapple Area. Sheet erosion is most severe in central Corozal. This is perhaps one of the major underlying causes for the gradual shifting of pineapple production northward during the past decade.

According to the Soil Survey of Puerto Rico report on Catalina and related soils, sheet erosion does not reduce the yield of pineapples nearly as much as it does those of other crops competing for the same land. With the application of large quantities of proper fertilizer, "the production of pineapples on soils with a six-inch surface soil is only slightly higher than on soils with a deep subsoil but with little or no surface soil".[31]

In spite of the absence of many sand grains in the more clayey soils, particularly the Catalina (Cc) and similar soils of the Foothill Region, there is comparatively little evidence of serious gully erosion. Compare

---

[31]R.C. Roberts, 1942, p. 113.

Figures 5 and 6. Man-made ditches further facilitate rapid drainage, even on slopes ranging from 45 to 60 per cent. It is a general practice in the more rugged foothills to plant pineapples with the contour of the land, rather than with the slope. (See Plate I). In many fields it would be advantageous if some of the ditches were constructed also along the contour of the land. These ditches would serve to check the runoff following heavy rains before the water has time to gain sufficient speed and force to remove the loose soil particles.

Of all soils found in the Foothill Region, the Moca (Mo) and Lares (Lc) are most vulnerable to gully erosion, as they contain a high ratio of sand particles. On these soils, especially the Moca, gullies two to three feet deep have developed within a period of less than three months. Moca soils, being highly plastic in character, necessitate pineapple beds to be constructed six to twelve inches high, thus facilitating the formation of gullies and accelerated erosion.

5. The Pineapple Plant

The pineapple, Ananas comosus, is a member of the family Bromeliaceae. There are four species of the genus Ananas and one in the closely related genus Pseudananas. "Both genera have collective fruits, which serves to

differentiate them from the other genera of the Bromeliaceae".[32]

The genus Ananas include three species of wild pineapples--bracteatus (Lindl.) Schultes, Ananassoides (Bak.) L.B. Smith, and erectifolius L.B. Smith-- and Comosus (L.) Merr. which comprises the commercially cultivated varieties of pineapple. The Comosus may be differentiated from the three wild species of the genus in the following ways: First, the fruits are mostly seedless. Secondly, the size of the fruit is commonly larger and contains comparatively large amount of palatable flesh. Third, the floral bracts are very inconspicuous in the mature fruit and do not completely cover the apex of the ovary.

In appearance, the culture pineapple resembles the lily, the agave, or even some of the yuccas. Belonging to the bromeliads, the pineapple plant can absorb nutrient constituents through its leaf axils and long-barbed and barbless bayonetlike leaves that protrude from numerous whorls on the main stalk. This biennial plant produces leaves 30 to 40 inches in length and two and one-half inches in width at the base, tapering to a point. The height of the plant ranges from two to six

---

[32] J.L. Collins, "History, Taxonomy and Culture of the Pineapple," Economic Botany, Vol. III (New York: New York Botanical Garden Press, 1949), p. 337.

feet, depending on the fertility of the soil and other factors.

During the first year of growth the plant stores up starch in the thick central axis for the production of the inflorescence.[33] Differentiation commonly occurs in autumn, but the bud is not visible until about 90 days later.[34] The inflorescence is borne at the apex of the plant axis and terminates the vertical growth of the plant. Fruits mature in four or six months after differentiation. The core of the fruit is a continuation of the penduncle, and at the top of the fruit are clustered vegetative shoots known as "crowns".[35]

According to J.L. Collins, it has been proved that a decrease of roughly 10°F. mean night temperature during the cooler season is the primary environmental factor in causing the change from a leaf-producing apical stem meristem to a flow-forming meristem.[36] Seasonal differences

---

[33]Includes general arrangement, mode of development, and disposition of the flowers on the axis. The pineapple belongs to the inflorescent type known as capitulum, or head.

[34]The pineapple emerges from a purple-colored flower near the center of the plant on a short, bright red stalk. Flowering period continues for approximately three weeks in Puerto Rico.

[35]See Glossary.

[36]This is probably the reason pineapple plants at elevations of 1,200 to 1,500 feet develop healthier appearance for a given variety compared to plants at lower elevations, although there is no correlation between the size of the matured fruit with increased elevation.

in length of day in latitudes where pineapples grow seem to have little influence in flower production.

The pineapple fruit is composed of a number of individual berry-like fruitlets, each attached to the central axis core, and fused on all sides to adjacent fruitlets or to the shell itself. The number of fruitlets depend upon the size and variety of the fruit, ranging from 110 to 180 in the larger varieties such as the Smooth Cayenne and Cabezona to less than 100 fruitlets for the Red Spanish. The shell covering the fruit is composed of three thickened fleshy sepals, the fleshy bracts partially covering the sepals of each fruitlet.

In the cultivated varieties of pineapple, seedlessness is due in part to self-incompatibility which is not present in the seed-producing wild varieties. Viable seeds can be obtained in seedless varieties by artificial cross pollination. The hummingbird is believed to be one of the principal means of natural cross pollination. "If these birds are prevalent the cultivated varieties frequently produce seeds, but they rarely do so in countries where this type of bird are not present".[37] Although seeds, on rare occasions, are used for propagation, they render both fresh and canned pineapple unmarketable in the United States.

---

[37] Collins, 1949, pp. 343-345.

6. History of Pineapple

According to Parkinson's "Theatrum Botanicum", published in 1620,[38] the pineapple (Ananas comosus) was first known to European explorers in the early part of the sixteenth century. It was found growing wild along the coast of Santa Cruz, in Brazil. Peter Martyr states that Columbus saw pineapples growing on the island of Guadeloupe in 1493.[39] Early records of pineapple culture are vague and contradictory. Botanists generally agree, however, that pineapple was a native of Central or South America and was carried into the West Indies by either the Carib or Arawak Indians prior to 1500. It was here that Europeans first tasted its delicious fruit. In Brazil it was called by the natives "naña" or "anaña", and by the Spanish and Portuguese "piña". The name piña was given to the pineapple by the Spaniards because it resembled in many respects the pine cone of Spain.

Oviedo y Valdés, a Spanish official, in 1513 wrote what is believed to be the first detail description of pineapples in the New World. This early writer described three types of pineapples and provided Indian names for them. Some were called yayama, others boniana, and still

---

[38] G.W. Johnson, The Pine Apple. Vol. I (Winchester: H. Woolridge Printers, 1847), p. 2.

[39] "Pineapple", Encyclopaedia Britannica. Vol. XVII (Chicago: Encyclopaedia, Inc., 1945), p. 939B.

others yayagua.[40] The latter type was bitter and acrid, but the meat was white and juicy. That which the natives called yayama was somewhat oblong in shape; whereas, the other two types were more rounded in shape. The yayama, according to this Spanish official, was considered to be the best type of all. Its meat had a yellowish color and was very sweet and tender. He noted that in certain localities great numbers of pineapples were seen growing wild, but those grown under cultivated conditions were of a much higher quality. On his return voyage to Spain, Oviedo y Valdés brought along a number of pineapple "cuttings", all of which died or rotted en route. It is conceivable that the commercial varieties of pineapple grown in Puerto Rico today developed from one or more of the early types which Oviedo y Valdés described.

Early use of pineapples was primarily in the treatment of human disorders; it "arouses the appetite". However, long since the days of the conquistadores, many of the native people have gradually ceased to grow this fruit. This is perhaps the primary reason for the obscure and vague history of the areal distribution of pineapple culture for almost four centuries.

By the end of the sixteenth century, pineapple plants had been carried by missionaries and navigators

---

[40] G. F. Oviedo y Valdés, Historia General y Natural de la Indias. Part 2, Book 7, Chapter XIV (Asuncion: Editorial Guaranta, Reprint 1944), pp. 185-186.

into Africa, China, and the East Indies.[41] The early Portuguese explorers appear to have played a dominant role in introducing the pineapple to other parts of the world. Pineapples were planted on the island of St. Helena shortly after 1510, but it was not until nearly two centuries later that the first pineapple plant was introduced into Europe.

According to G. W. Johnson, the pineapple was first introduced into England by a Mr. Bentick in 1690, but merely as a plant worthy of being added to the national botanical collection. By 1712 the pineapple plants numbered nearly 200, but it was not until six years later that a Mr. H. Telende, gardener for Sir Mathew Decker, in Surrey, produced the first fruit under artificial conditions. During the following century the fruit was eaten mainly by members of the royal courts and occasionally served at the king's table on special celebrations. By 1820, pineapples began to be shipped to England as well as to countries of continental Europe in considerable quantities from the West Indies; the

---

[41] This was possible because the pineapple plant with proper care can be removed from the ground for several months and yet grow when transplanted in moist, rich soil. Pineapple plants may be transported great distances provided that they are taken from the ground at the proper stage of growth, protected against salt spray, kept in cool, well ventilated storage, and handled with extreme care in transit. Some ecologists are convinced that this world-wide distribution was incidental to the use of the pineapple as an item of food for the crews on their long voyages. The answer, however, is still obscure.

shortest passage was then six weeks. This greatly lessened their price,[42] and rendered them more common.

It is not definitely known when or how the pineapple first reached Puerto Rico. According to hearsay, the Cabezona variety was first found growing wild at Palmerejo, a small village two miles southwest of Lajas, in the early part of the nineteenth century.[43] The Cabezona is thought to have originated in Venezuela shortly after 1800, although its name does not appear in English literature until 1841, when it was mentioned as a hot-house variety in England. Even though a score or more varieties are grown today, none can be traced further back in history than the Cabezona. This is probably due to the fact that the same variety shows distinct characteristics in the different parts of the island. Furthermore, new types under new names are constantly originating from seeds.

Red Spanish and Smooth Cayenne varieties were introduced into Puerto Rico from Florida in 1905 and 1906, respectively. In turn, the Red Spanish variety was introduced into Florida from Cuba in 1860 by Benjamin

---

[42]Pineapples were sold at fruit stands in London during the summer months for one-half to one crown each, or at two shillings a pound.

[43]U.S. Department of Agriculture, Pineapple Growing in Puerto Rico, Bulletin No. 8 (Washington: Government Printing Office, 1909), p. 24.

Baker. It is not definitely known when and by whom first introduced the Smooth Cayenne into the United States.[44]

7. Early Growth, Development, and Changing Structure

Unlike coffee, sugar, and tobacco growing, commercial pineapple production in Puerto Rico is comparatively new.[45] Prior to the turn of the twentieth century, pineapple production was so insignificant that no official records were maintained with regard to area planted, yields, varieties, returns, etc. Pineapples were grown chiefly in small patches for home consumption. In years of high yield, the farmer would cart a wagon-load to San Juan or Mayagüez in hope that he might market his fruit to some fruit dealer or to a shipping crew stopping long enough to put aboard food supply for a long voyage.

According to Barrett,[46] the first canning of pineapple in Puerto Rico was begun in 1902 in the vicinity of Lajas in the southwestern part of the island. The

---

[44]U.S. Department of Agriculture, Pineapple Culture in Florida. Farm Bulletin No. 1237 (Washington: Government Printing Office, 1937), pp. 3-5.

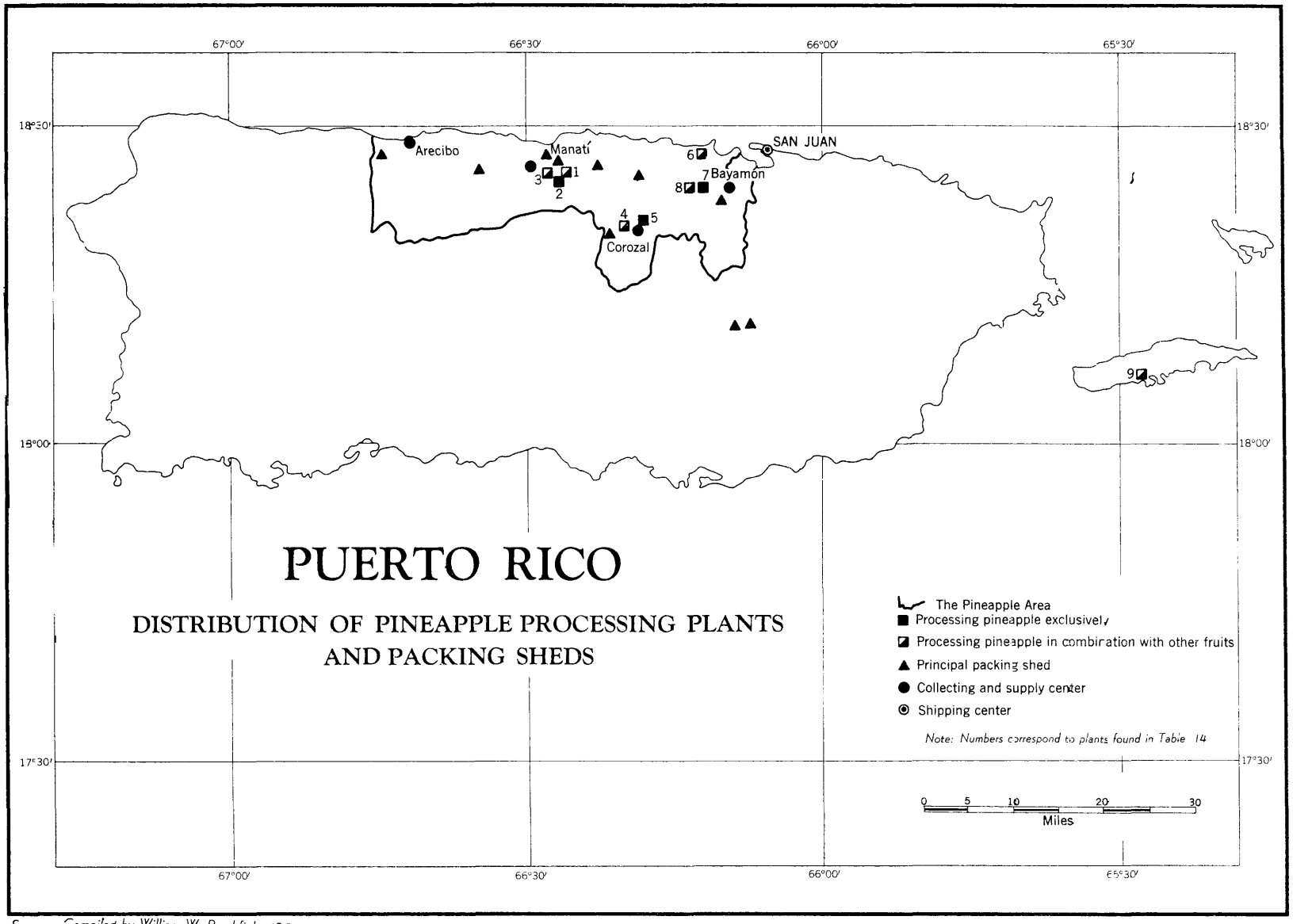
[45]In 1899, There were 6,150 cuerdas devoted to commercial tobacco; 74,160 cuerdas to sugar cane; 202,910 cuerdas to coffee; and 8 cuerdas to pineapples. R. Picó, The Agricultural Problems of Puerto Rico (San Juan: Puerto Rico Reconstruction Administration, 1936), Table 5, Appendix.

[46]O.W. Barrett, "The Food Plants of Puerto Rico," Journal of the Department of Agriculture of Puerto Rico. Vol. IX, No. 2 (Rio Piedras: The Insular Experiment Station, 1939), p. 61.

large Cabezona variety, growing in a semi-wild stage, was used exclusively; but after 10 years of interrupted operation the venture proved unsuccessful. In 1908, the canning of the Red Spanish variety was attempted at Martin Peña and Rio Piedras on the north coast. These canneries proved to be profitable enterprises, and from these two centers the industry was gradually extended westward to its present location (Fig. 7).

Not until 1910 did the pineapple industry enter into the economy of the island. A few growers, on a small scale, began to allocate a portion of their farms for producing pineapples for the commercial market. The market structure and means of transportation and distribution were loosely organized. Each grower was independent of all other growers in respect to harvesting and marketing of his crop. During this decade the pineapple industry grew slowly through trial and error. Never more than a few hundred cuerdas were ever devoted to the crop for a given year.

During the past two decades, especially since World War II, the pineapple industry has made vast progress. Conditions both internal and external have brought about rapid expansion in both the agricultural and processing phase of the industry. The total area devoted to commercial pineapple production has more than tripled during the past 20 years.



Source: Compiled by William W. Burchfiel, 1951.

Fig. 7—Distribution of Pineapple Processing Plants and Packing Sheds.

Another major change in the structure of the pineapple industry is the degree of specialization that has taken place during the past decade. In 1940, there were 91 commercial pineapple growers, of which 46 were in the Pineapple Area;[47] by 1950, the total number had dwindled to 79, of which 54 (68%) were in the Pineapple Area (Table 9). Among the principal reasons offered for this sharp decline in the number of pineapple growers during the 10-year period were increased production costs and larger initial capital investments required. As a result, fewer and fewer growers were financially able to engage in commercial pineapple production.

While the number of farms devoted to commercial pineapple production decreased by 13 per cent between 1940 and 1950, the number of cuerdas harvested by municipalities increased by 27 per cent. In 1940 the average Puerto Rico pineapple grower harvested 32 cuerdas of fruit; in 1950 he harvested an average of 50 cuerdas; and by making the same comparison for the ten-year interval of fruit harvested within the Pineapple Area, the average grower harvested 51 cuerdas in 1940 compared to 66 cuerdas in 1950. From these two comparisons, it is reasonable to assume that the average pineapple grower

---

[47]According to the 1940 Official Census, there were 268 farms in 27 municipalities reported growing pineapples, but roughly two-thirds of the farms were growing fruit only for home consumption.

TABLE 9

COMMERCIAL PINEAPPLE PRODUCTION IN THE PINEAPPLE AREA, BY MUNICIPALITIES[a]
(Fiscal Year 1949-50)

Municipality	Number of Growers	Area Harvested[b] (in Cuerdas)[c]	Total Production (in Crates)[d]	Average Yield Per Cuerda[e] (In Crates)[d]	Total Farm Value (In Dollars)
Arecibo	7	276	62,886	228	63,718
Barceloneta	2	458	128,743	302	187,317
Bayamón	4	169	29,457	198	75,664
Corozal	10	493	120,629	263	170,591
Dorado	2	7	2,200	314	2,926
Manatí	15	1,218	329,286	275	428,817
Toa Alta	2	63	13,028	207	17,325
Toa Baja	2	50	5,943	175	15,902
Vega Alta	2	87	22,514	259	22,990
Vega Baja	8	740	221,629	305	344,489
Totals, Pineapple Area	54	3,561	936,315	274	1,329,739
Totals, entire island	79	3,960	1,031,230	273	1,455,698
Percentage in Pineapple Area	68	89.92	90.79	---	91.34

[a]Source: Bureau of Agricultural Economics, Puerto Rico Department of Agriculture and Commerce (Santurce: unpublished data, 1951).

[b]Figure includes 138 cuerdas that was not harvested owing to flooding, pests and diseases, drought, and experimental purposes.

[c]One cuerda is equivalent to 0.9712 acre.

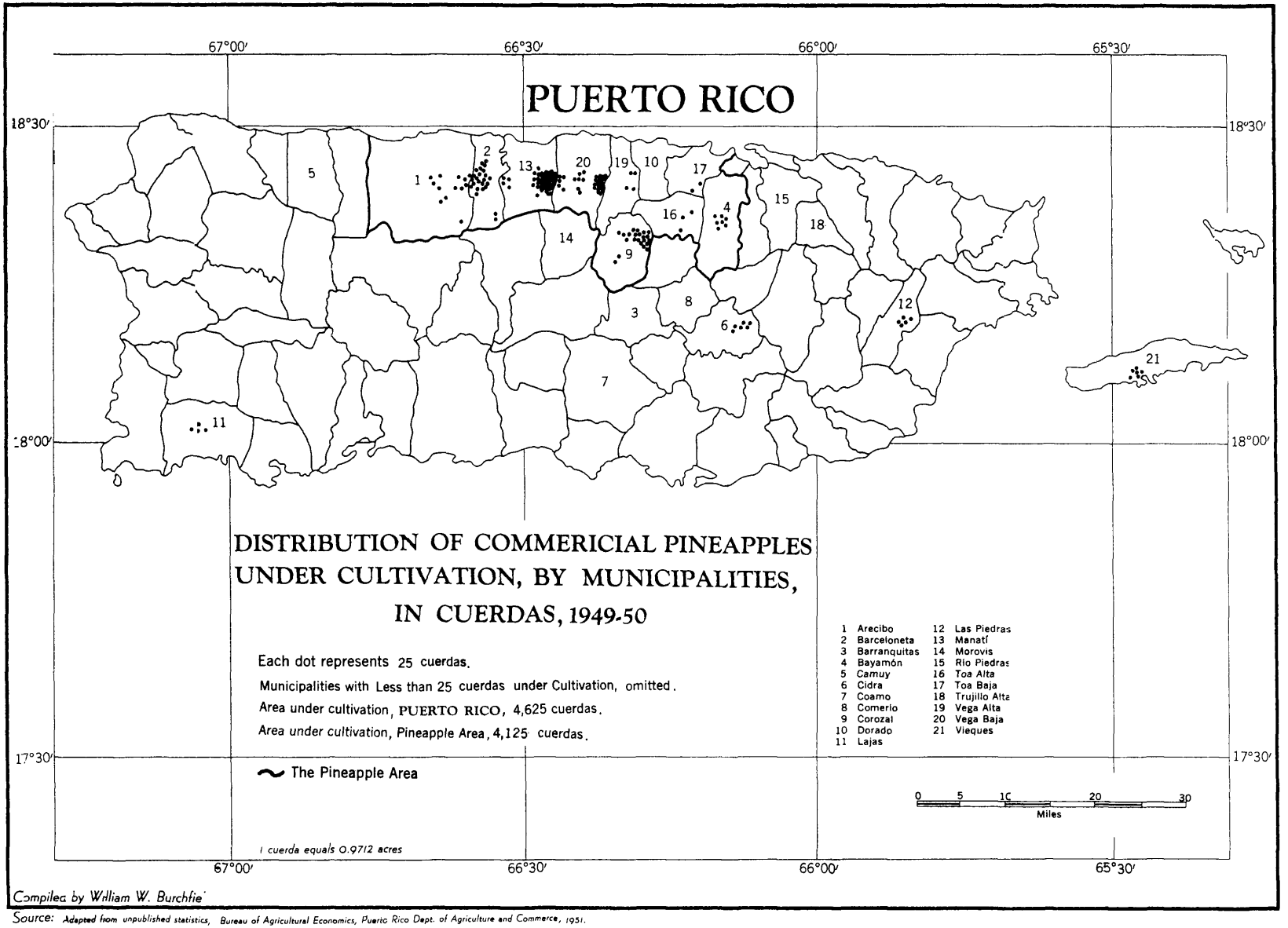
[d]Crate weighs 70-pounds net.

[e]Average yield based on area actually harvested.

within the Pineapple Area produced roughly one-fifth more fruit than his counterpart who lived beyond the limits of the Pineapple Area.

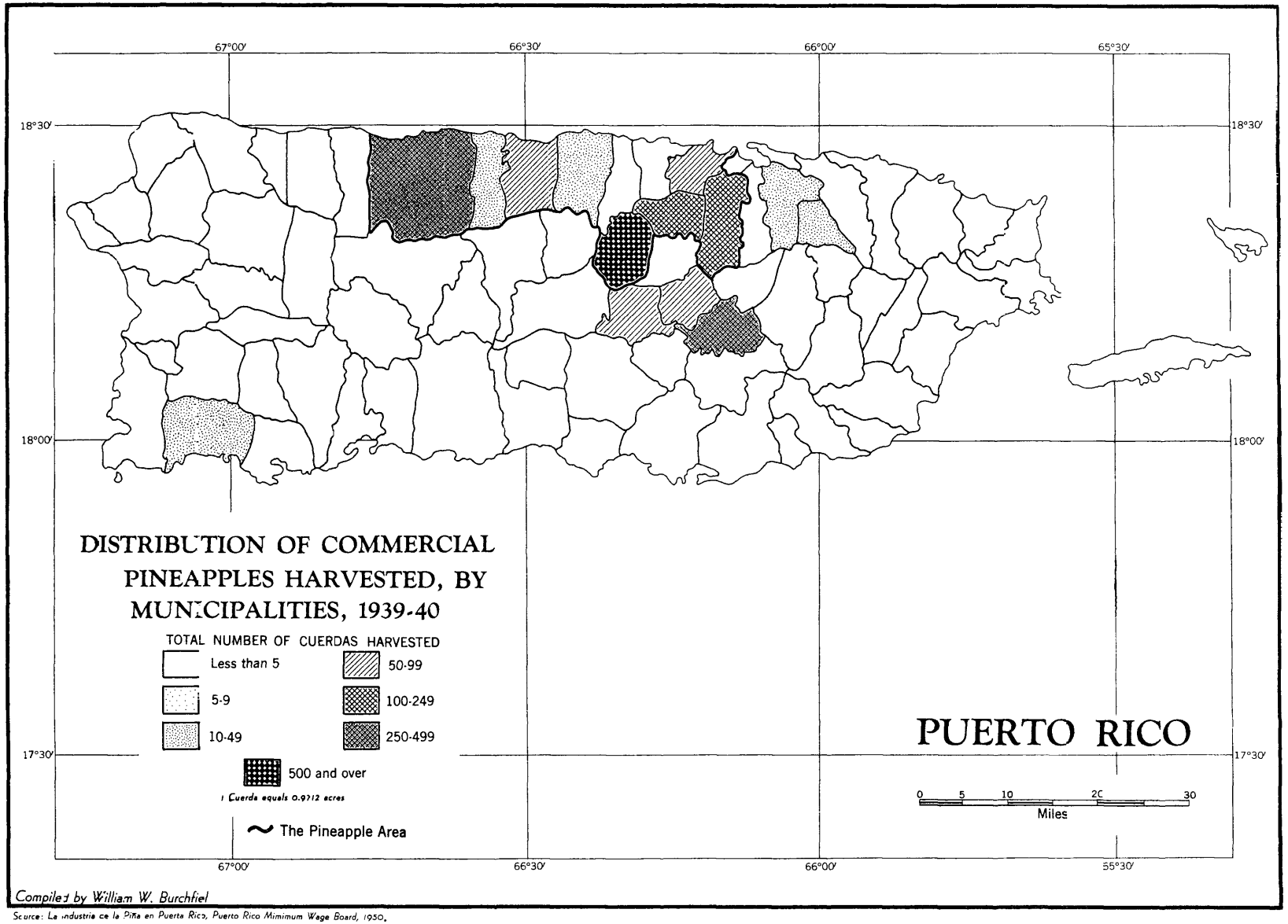
In 1950, there were 4,125 cuerdas of land planted to pineapples in the Pineapple Area (Fig. 8). Approximately 2,600 cuerdas of pineapples were under cultivation within a belt 15 miles long and five miles wide, extending from Vega Baja westward to Arecibo. By far the largest concentration of pineapples under cultivation was in eastern Manatí where some 1,400 cuerdas were planted. Other concentrations of pineapples were in western Barceloneta, eastern Vega Baja, and northern Corozal; elsewhere cultivation of commercial pineapples was widely scattered.

Figures 9 and 10 show the number of cuerdas of commercial pineapples harvested by municipalities during the crop-years of 1939-40 and 1949-50. It is noteworthy that in the former crop-year only Corozal harvested more than 500 cuerdas of pineapples, whereas in the latter crop-year, both the municipalities of Manatí and Barceloneta exceeded 500 cuerdas. Corozal was the only municipality within the Pineapple Area to have a reduction in the number of cuerdas harvested within the ten-year period; all other municipalities either increased the number of cuerdas harvested or remained comparatively stationary. By comparing Figures 9 and 10, it is clearly seen that most of the rugged and



Source: *Adapted from unpublished statistics, Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1951.*

Fig. 8 –Distribution of Commercial Pineapples under Cultivation, by Municipalities, in Cuerdas, 1949-50.



Source: La Industria de la Piña en Puerta Rico, Puerto Rico Minimum Wage Board, 1950.

Fig. 9— Distribution of Commercial Pineapples Harvested, by Cuerdas, 1939-40.

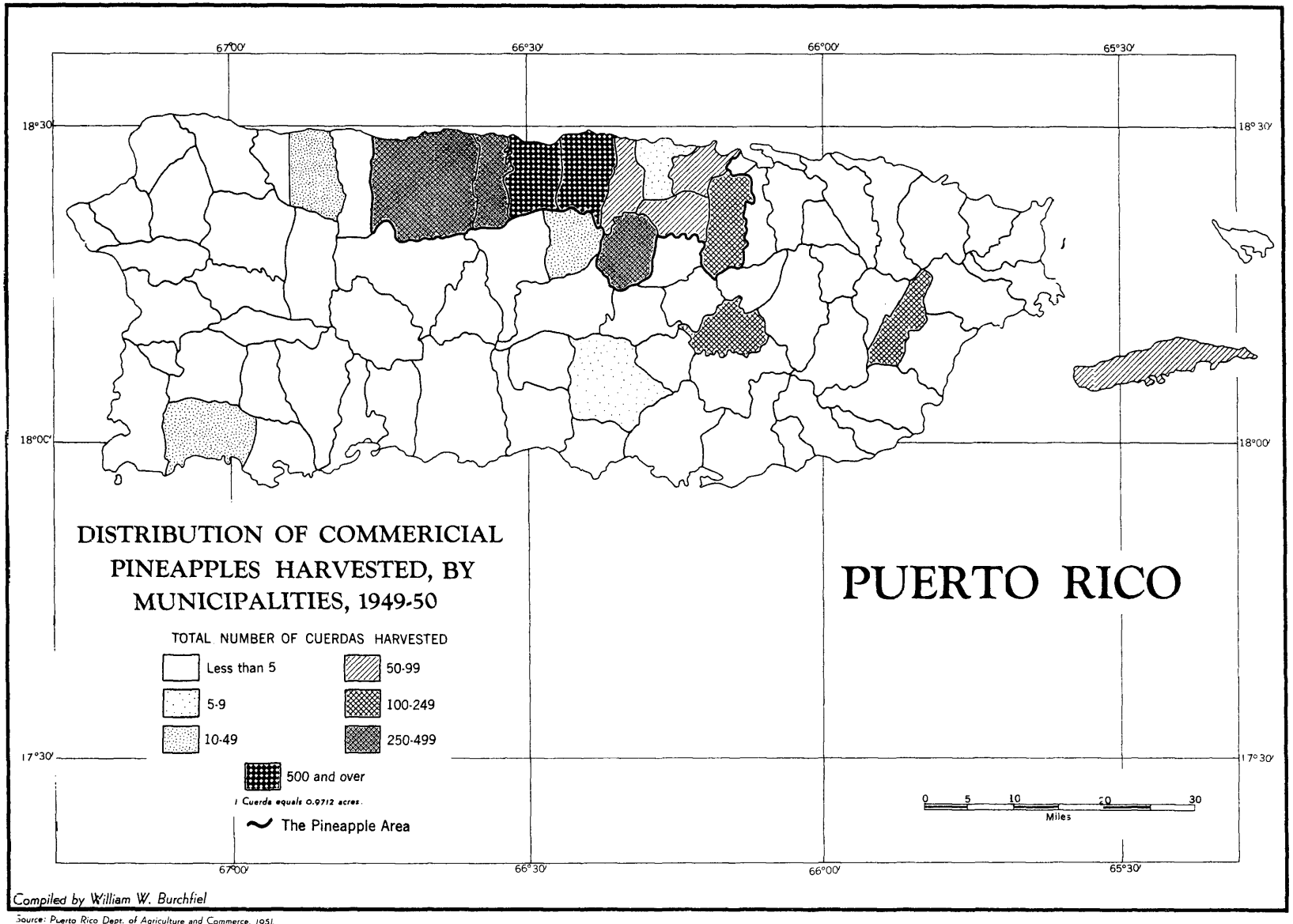


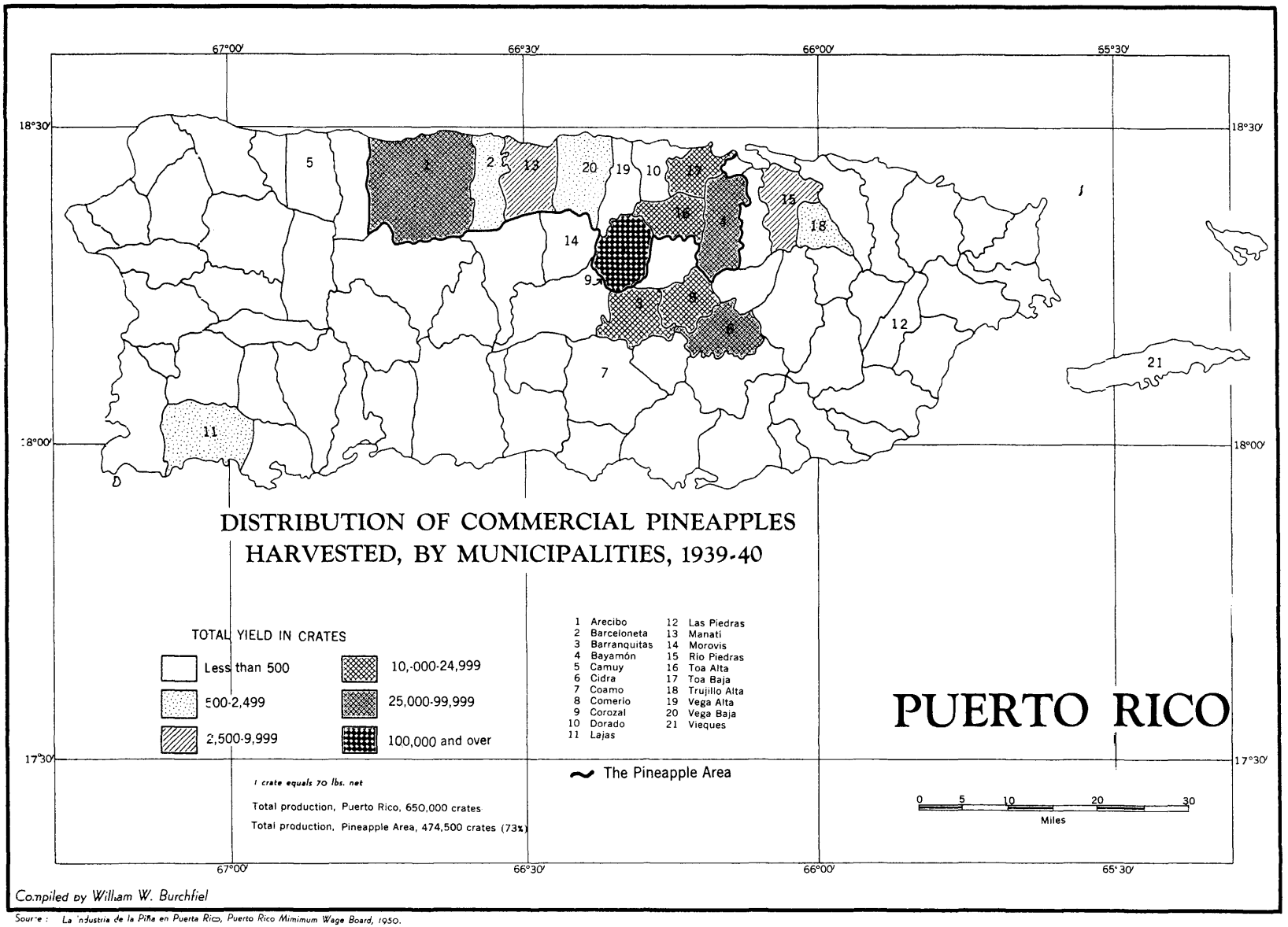
Fig. 10—Distribution of Commercial Pineapples Harvested, by Cuerdas, 1949-50.

mountainous municipalities have become less important pineapple producers during the past decade. The reasons for this decline are discussed below.

By analyzing Figures 11, 12, and 13, showing production in crates by municipalities, the following deductions have been made: (a) The island's total production of commercial pineapples increased 37 per cent, compared to a 51 per cent increase for the Pineapple Area during the same ten-year period; (b) while only one municipality (Corozal) produced 100,000 or more crates of fruit in 1940, four municipalities produced 100,000 or more crates in 1950 (Table 9); production centers today focus on Corozal, Barceloneta, Manatí, and Vega Baja.

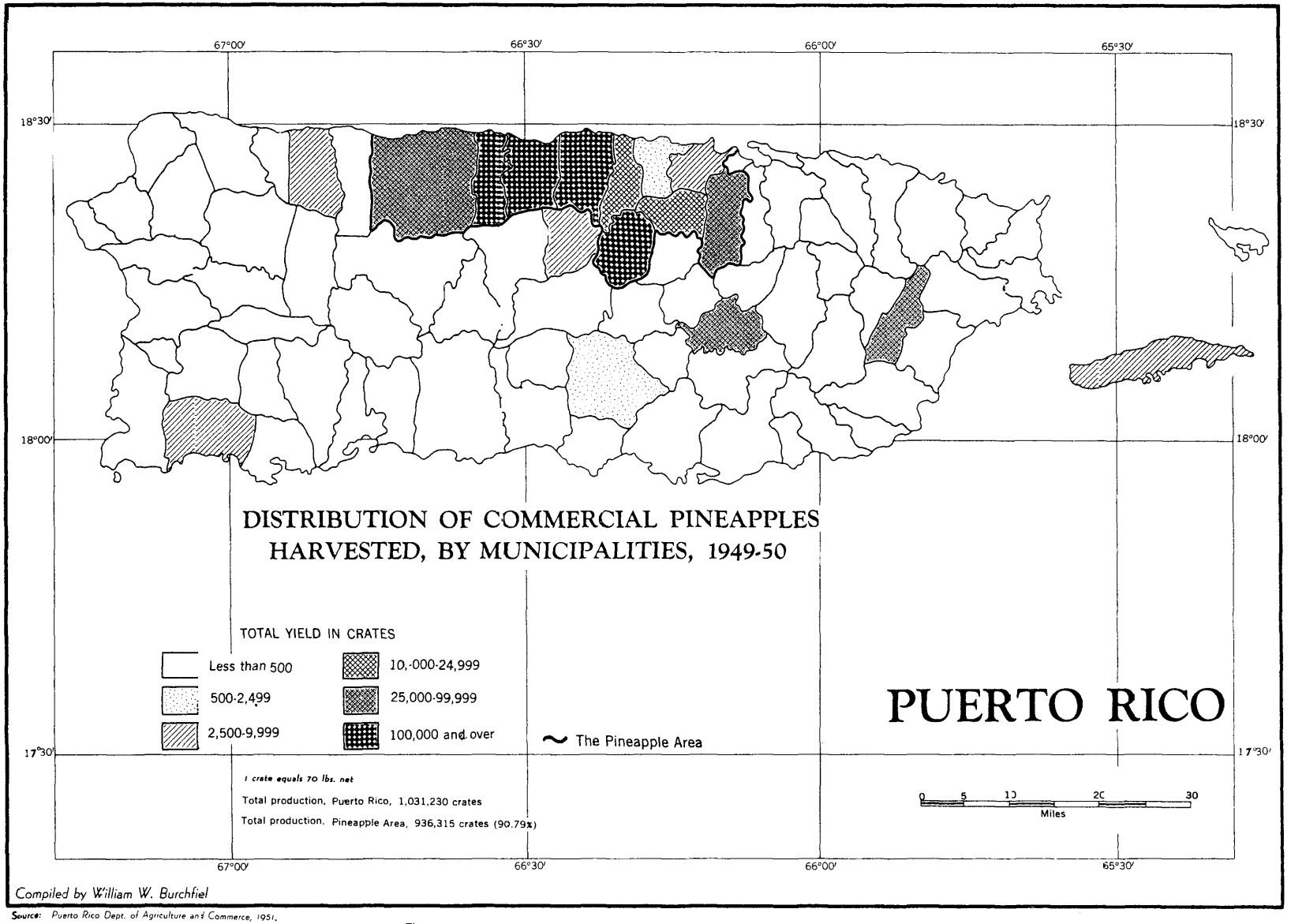
As indicated in Table 9, the combined pineapple production of the municipalities of Manatí and Vega Baja totalled 1,958 cuerdas or one-half of the total commercial harvest for the 1949-50 crop-year. In terms of crates, these two municipalities produced 550,915 crates or 51 per cent of the island's total production.

There are several plausible reasons why pineapple production is becoming more and more concentrated in a few municipalities. Among the reasons are the following: (1) Specialization today favors large-sized farms topographically adapted to increased mechanization. The larger and more suitable pineapple farms are most numerous and most easily acquired intact within the foothills



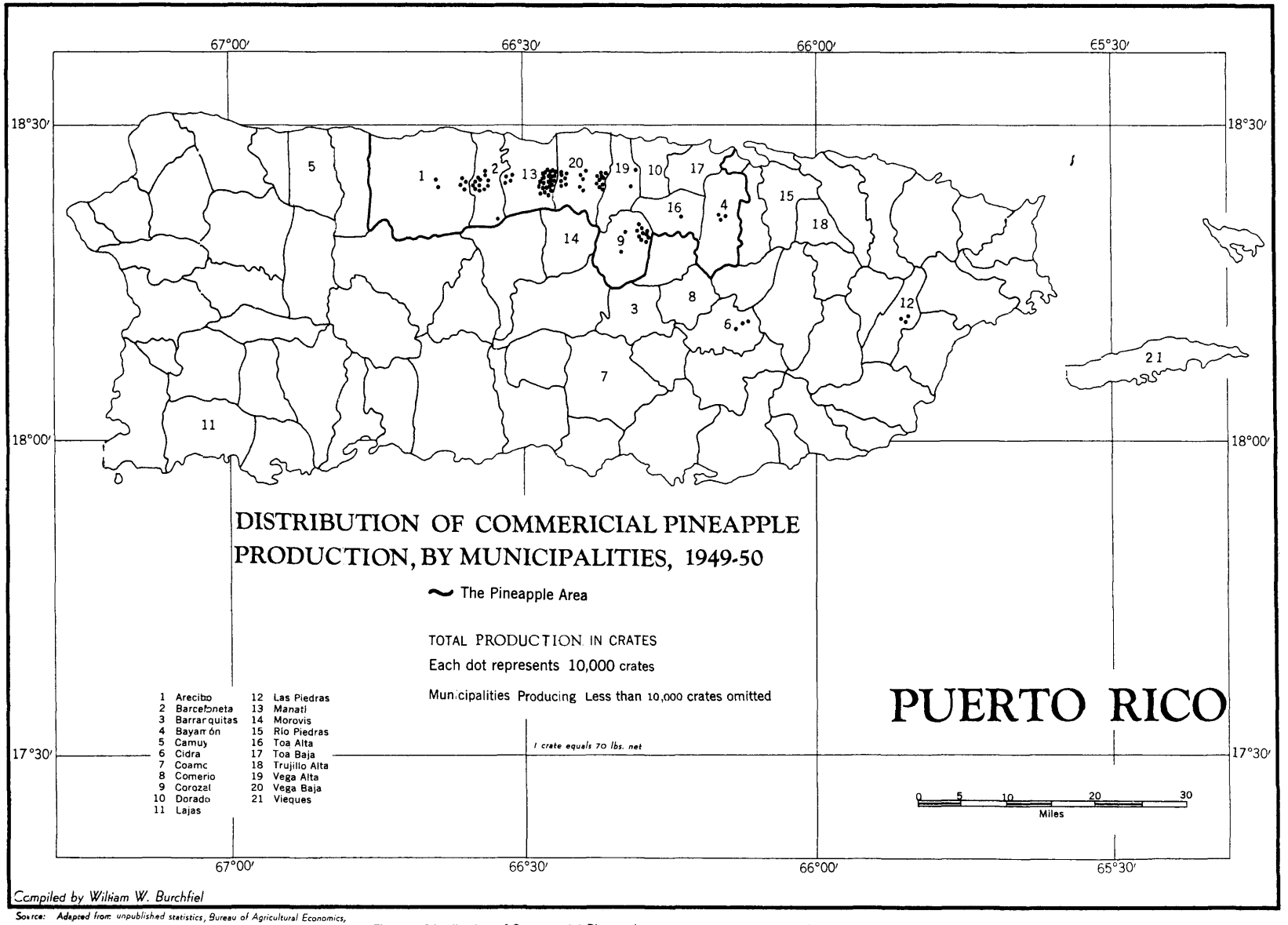
Source: La Industria de la Piña en Puerto Rico, Puerto Rico Minimum Wage Board, 1950.

Fig. 11—Distribution of Commercial Pineapples Harvested, in Crates, 1939-40.



Source: Puerto Rico Dept. of Agriculture and Commerce, 1951.

Fig. 12 —Distribution of Commercial Pineapples Harvested, in Crates, 1949-50.



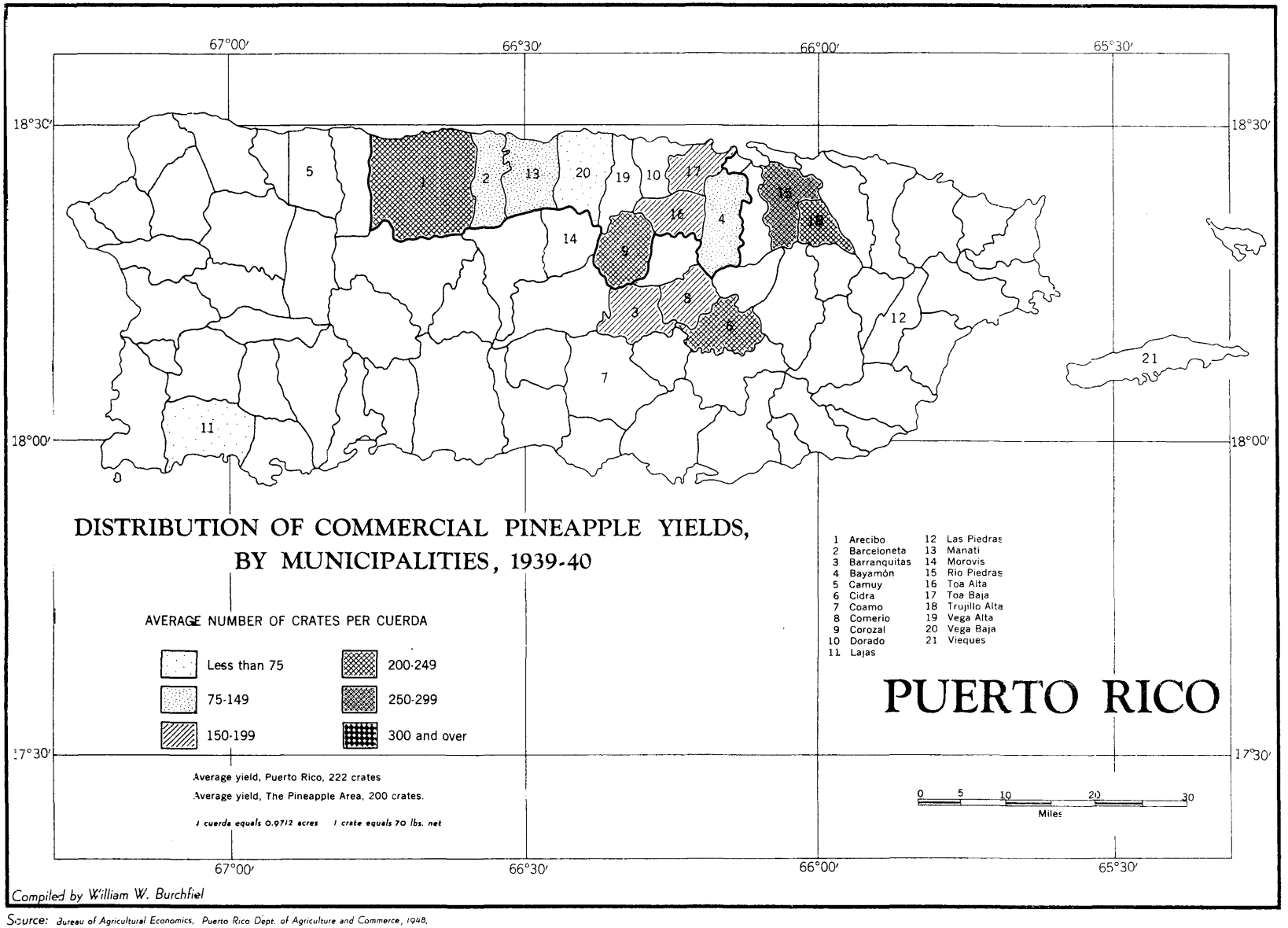
Source: Adapted from unpublished statistics, Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1951.

Fig. 13– Distribution of Commercial Pineapple Production, by Municipalities, in Crates, 1949-50.

and coastal plains districts. (2) Proximity to processing plants and packing sheds tends to attract new pineapple growers. (3) Adequate transportation networks which link pineapple farms with canneries and packing sheds have a direct bearing on production. The writer feels that, other factors being equal, the small and perhaps the middle-sized commercial pineapple growers situated more than 25 miles from packing sheds and more than 20 miles from canneries ultimately will not be able to compete successfully in either the fresh or processed fruit markets.

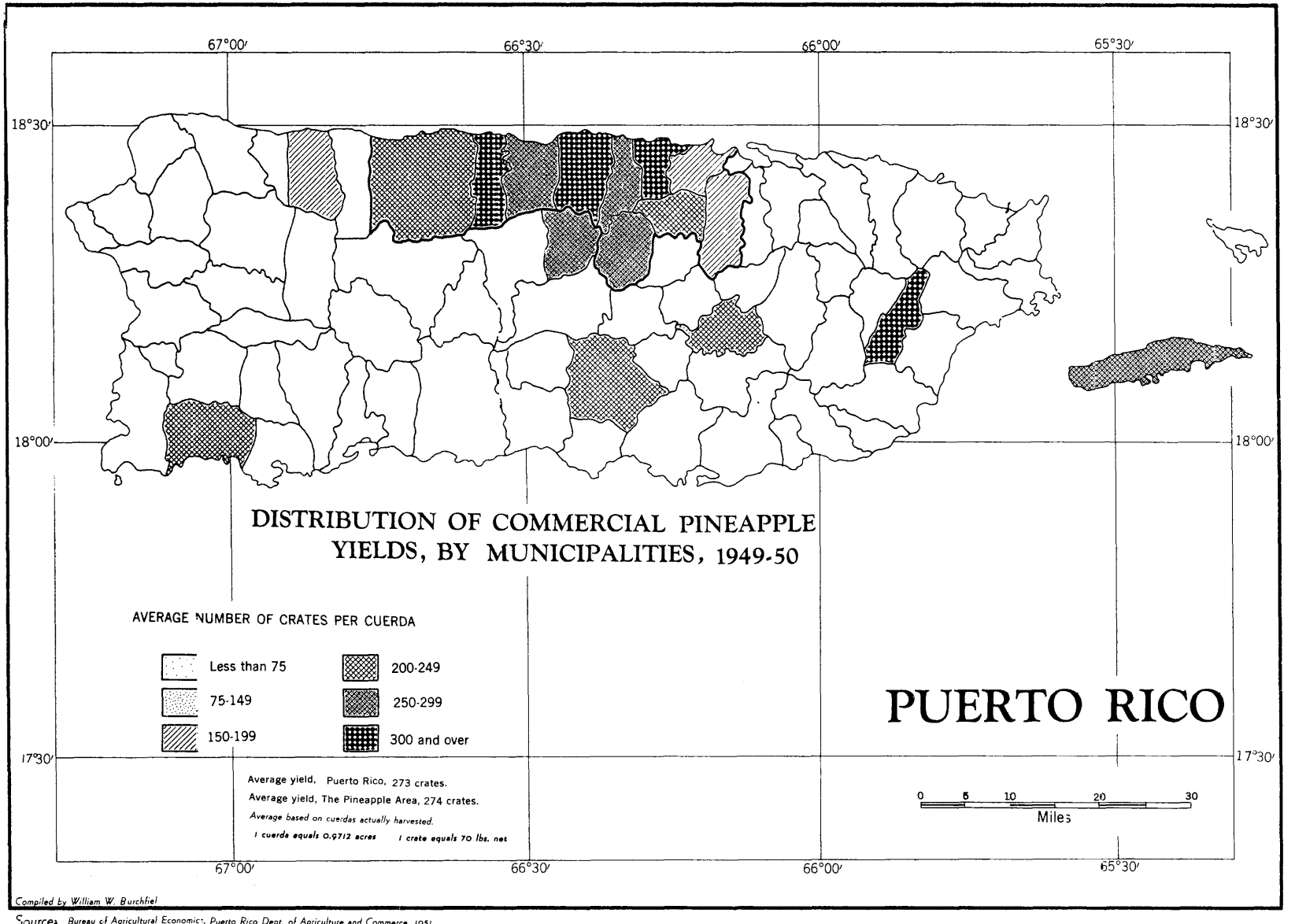
Figures 14 and 15 indicate the increase in yields by municipalities from 1940 to 1950. In the former crop-year the average yield for the whole island was 222 crates per cuerda; by 1950 it had reached 273 crates per cuerda. In 1940, the highest yields per cuerda were obtained outside of the Pineapple Area, while in 1950 most of the highest yields were obtained within the Pineapple Area. It should be pointed out that the 1940 crop-year was considered almost normal, while the 1950 crop-year for pineapple production was considerably below normal because of adverse weather conditions. An average of 300 crates of pineapple per cuerda is considered a normal yield over a long period of time (Table 6).

Based on increased yields, areal distribution, and production trends of the pineapple industry during the



Source: Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1948.

Fig. 14—Distribution of Commercial Pineapple Yields, by Municipalities, 1939-40.



Source: Bureau of Agricultural Economics, Puerto Rico Dept. of Agriculture and Commerce, 1951. Fig. 15—Distribution of Commercial Pineapple Yields, by Municipalities, 1949-50.

past decade, four significant conclusions have been drawn: (1) Average yield per cuerda has been greatly increased. During the last ten-year period yields have been stepped up by 51 crates per cuerda for the island as a whole and by 74 crates per cuerda for the Pineapple Area. There are several plausible reasons for this general increase in yields: (a) Better land-use practices such as application of larger amounts of commercial fertilizer, devoting more fertile land to pineapple production, and increased mechanization. (b) Increased size of pineapple landholdings have proved more efficient. (2) There has been a gradual but steady migration of the pineapple industry from the foothills northward onto the coastal plains. Pineapple growers are beginning to realize that mounting labor costs may be partly offset by converting to mechanization, but mechanization is most efficient on level land. Higher yields normally may be expected on land which receives direct sunlight for a major portion of the day. (3) Total area devoted to pineapple production has been greatly expanded. (4) Since the growing of pineapples is a specialized type of agriculture which depends upon a foreign market almost exclusively for its existence, the number of farms which meet the basic requirements (such as size, location, transportation facilities, proper management, and available capital) are comparatively few. Moreover, present trends appear to indicate that in the future fewer and

fewer growers will be able and willing to devote their farms to the production of pineapples.

8. Actual Land Use and Recommended Land Use

Based on incomplete preliminary data obtained from the Bureau of the Census for 1950, the following statistics for land use within the Pineapple Area were computed: Of the 279,400 cuerdas which comprise the Pineapple Area, 232,515 cuerdas (83%) were in farms. Of the total land in farms, 98,515 cuerdas (42%) were under cultivation. The cultivated land was subdivided as follows: 57,596 cuerdas in sugar cane, 6,148 cuerdas in plantains and bananas, 4,579 cuerdas in coffee, 4,125 cuerdas in pineapples (Fig. 16), 2,823 cuerdas in corn, 2,679 cuerdas in coconuts, 2,304 cuerdas in tobacco, 1,576 in grapefruit, and the remaining 16,685 cuerdas divided among subsistence, truck and minor crops. The non-agricultural land (134,000 cuerdas) was subdivided as follows: 61,531 cuerdas in improved pasture, 19,389 cuerdas in unimproved pasture, 41,064 cuerdas in brush and woodland, and 12,016 cuerdas in idle, waste, and urbanized land.

Based on a recent study conducted by the United States Soil Conservation Service, it was ascertained that approximately 127,275 cuerdas of land is suitable for continuous cultivation within the Pineapple Area (Fig. 17). By comparing actual land use and recommended use for the Pineapple Area, several salient facts are

LAND UTILIZATION IN THE PINEAPPLE AREA 1950-51

(Generalized)

66° 45′ | 66° 30′ | 66° 15′

18° 30′

Arecibo
Barceloneta
Manatí
Vega Baja
Dorado
Toa Baja
SAN JUAN
Vega Alta
Toa Alta
Bayamón
Corozal

U

Land Use in the Pineapple Area
(See Glossary for explanation of terms)

CROPLAND

- Pineapple
- Cane
- Coffee
- Coconut
- Grapefruit
- Bananas and plantain
- Truck crops and minor subsistence crops
- Minor subsistence crops with pasture, brush, or forest
- Corn
- Tobacco

PASTURE, FOREST, AND BRUSHLAND

- In rotation
- Harvested forage
- Improved pasture
- Natural pasture
- Forest and brush

NON-PRODUCTIVE LAND

- Idle or waste land
- U — Urban, military reservation, lagoon, lake

Note: Corozal data based on observation; exact map data lacking.

0 3 6 9
Miles

18° 15′

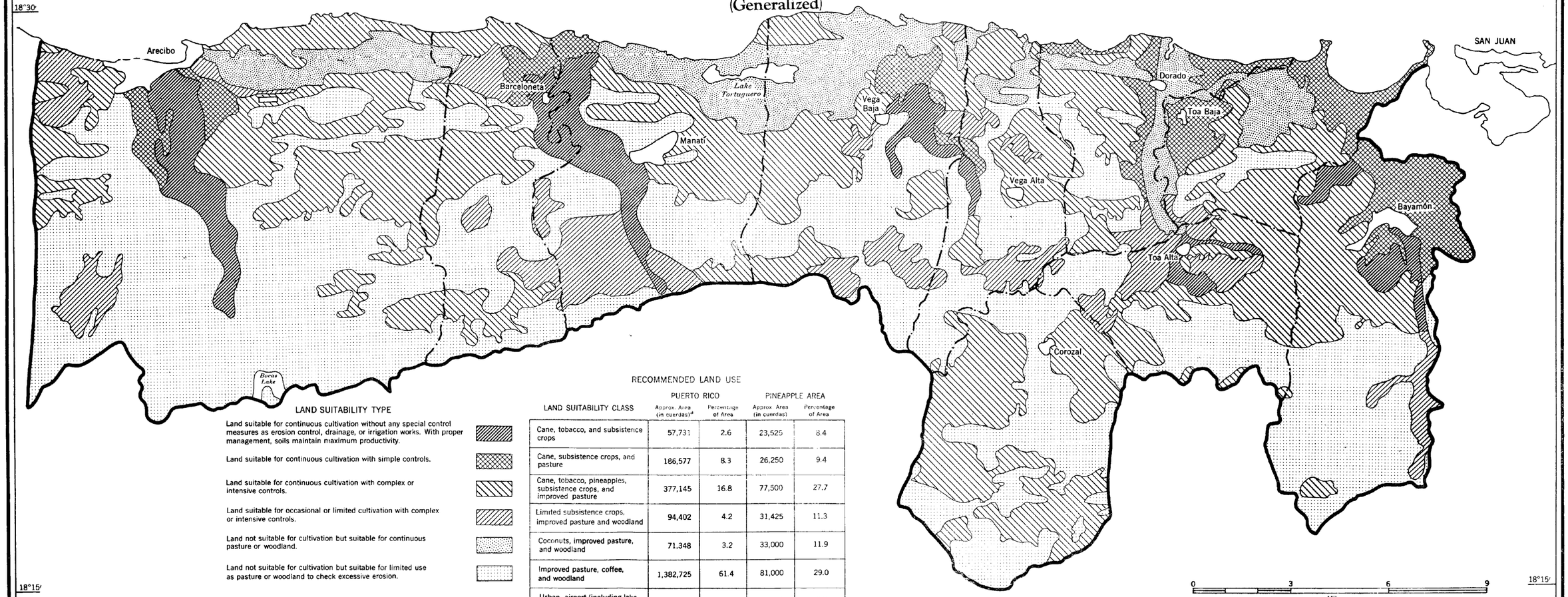
Source: Rural Land Classification Program, Puerto Rico Dept. of Agricultural and Commerce, 1951.
Compiled by William W. Burchfiel

66° 45′ | 66° 30′ | 66° 15′

Fig. 16—Land Utilization in the Pineapple Area, 1950-51.

LAND SUITABILITY AND RECOMMENDED LAND USE IN THE PINEAPPLE AREA

(Generalized)



LAND SUITABILITY TYPE

Land suitable for continuous cultivation without any special control measures as erosion control, drainage, or irrigation works. With proper management, soils maintain maximum productivity.

Land suitable for continuous cultivation with simple controls.

Land suitable for continuous cultivation with complex or intensive controls.

Land suitable for occasional or limited cultivation with complex or intensive controls.

Land not suitable for cultivation but suitable for continuous pasture or woodland.

Land not suitable for cultivation but suitable for limited use as pasture or woodland to check excessive erosion.

Source: Soil Conservation Service, USDA, 1950
Compiled by William W. Burchfiel

RECOMMENDED LAND USE

LAND SUITABILITY CLASS	PUERTO RICO Approx. Area (in cuerdas)[a]	PUERTO RICO Percentage of Area	PINEAPPLE AREA Approx. Area (in cuerdas)	PINEAPPLE AREA Percentage of Area
Cane, tobacco, and subsistence crops	57,731	2.6	23,525	8.4
Cane, subsistence crops, and pasture	186,577	8.3	26,250	9.4
Cane, tobacco, pineapples, subsistence crops, and improved pasture	377,145	16.8	77,500	27.7
Limited subsistence crops, improved pasture and woodland	94,402	4.2	31,425	11.3
Coconuts, improved pasture, and woodland	71,348	3.2	33,000	11.9
Improved pasture, coffee, and woodland	1,382,725	61.4	81,000	29.0
Urban, airport (including lake, lagoon, etc.)	80,485	3.5	6,400	2.3
Total	2,250,413	100.00	279,400	100.00

[a] *1 cuerda equals 0.9712 acre*

Fig. 17 —Land Suitability and Recommended Land Use in the Pineapple Area.

revealed: (1) Some 29,000 cuerdas of land suitable for continuous cropping are not currently under cultivation. (2) Roughly one-half of the total number of cuerdas suitable for sugar cane production is presently devoted to this crop; whereas less than one-tenth of the total number of cuerdas suitable for pineapples is actually in pineapples. (3) Approximately 3,500 cuerdas of land now classed as idle or waste, conceivably could be converted to productive land. (4) About one-half of all land suitable for continuous cropping is in sugar cane. However, it should be pointed out that considerable tracts of land planted to sugar cane should be devoted to pasture and forest. On the other hand, large tracts of land currently in pasture, woodland, and brush should be brought under cultivation. For individual examples of existing conditions, compare Figures 16 and 17.

9. Major Land-Use Patterns

The Pineapple Area, located in the north central part of Puerto Rico, comprises one of the largest and most productive agricultural sections of the island. The various types of farming units, in general, decrease in size and increase in number progressively from the coastal lowlands toward the rugged foothills and uplands of the interior. The larger and richer tracts of land found in the coastal lowlands and along the flood plains farther inland are almost exclusively devoted to sugar

cane production (Fig. 16). Land that is unsuited for cane production is generally devoted to pasture, coconuts, pineapples, citrus fruits, or brushland. The land-use patterns for subsistence crops in the coastal lowlands indicate that the growing of many crops are largely influenced by local population densities, proximity to farm boundaries and roads, and the fertility of the soil. As previously mentioned, concentrations of population in the coastal lowlands occur mainly on the fringes of the large sugar estates on sites which are commonly unfavorable for cane production either because of low fertility or because the local topography is not well adapted to the use of mechanized equipment.

In the foothill region, sugar cane continues to dominate all other crops in regard to the total number of cuerdas under cultivation. However, pineapples, tobacco, coffee, truck crops, and subsistence crops become increasingly important. Unlike the coastal lowlands, farms in the foothills are more irregular in shape and much smaller in size. Another conspicuous feature is that truck farming districts are moderately well concentrated in the eastern half of the Pineapple Area, generally in proximity to roads leading to coastal towns. Small-sized tobacco farms are especially numerous in southern Bayamón and Toa Alta.

Finally, in the rugged uplands, the growing of tobacco, plantains, bananas, and numerous minor subsistence

crops in small fields show a marked contrast against the large sugar cane estates of the coastal lowlands. The larger fields, generally encompassing the steeper slopes and summit areas, are usually planted to tree crops such as coffee, bananas, or plantains. Fields that are not cultivated ultimately revert to natural pasture or to brushland. Pasturelands, improved and unimproved, comprise the largest tracts of any single land-use type in both the foothills and upland regions. In general, the physical factors, such as relief, soils, temperature, and rainfall, as well as to the economic factor of competition with other crops, largely determine what crops are to be grown in a given district.

10. Representative Land-Use Patterns

"Most of the flatlands in Puerto Rico have always been in fairly large estates held originally under royal grants and cultivated by slaves, but the hilly interior (parts of Bayamón and Corozal) was settled to a great extent by squatters and small farmers who carved homesteads for themselves out of the virgin forest."[46]

Farm boundaries within the Pineapple Area, for the most part, are fairly regular. Rectangular-shaped farms are far more conspicuous in the coastal plains than in the foothills where fields are highly irregular in shape,

---

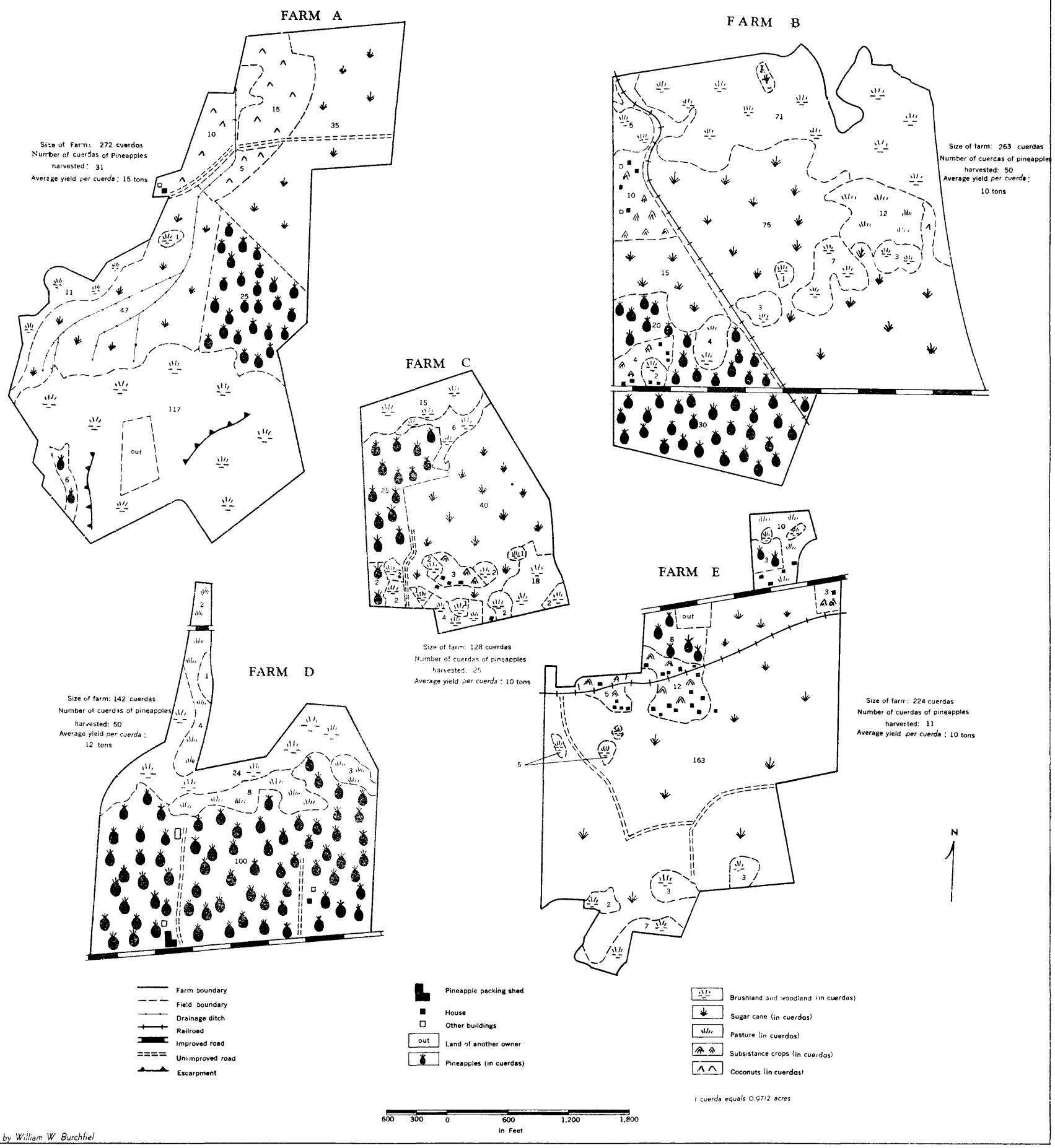
[46]V.S. Clark, Porto Rico and Its Problems (Washington: The Brookings Institution, 1930), p. 196.

because of the topography and soils which vary sharply within short distances. Usually fields are divided by such features as drainage ditches, streams, roads, and brush-covered limestone hills.

A farmer may own and operate several scattered farms, but usually such units are within three miles of the "home farm". On some of the farms visited by the writer, it was noted that all arable land was devoted exclusively to pineapple production, whereas on other farms pineapples, cocoanuts, and sugar cane were grown side by side. In cases of multi-crop farming, it was observed that basic physical factors, including soil type, slope, and drainage, largely dictated what crop should be planted in a given field. The production of pineapples and sugar cane on the same farm prevents the owner from fully utilizing his labor force since the harvest period of the two crops more or less coincide. Farms growing pineapples together with other fruits, especially oranges and grapefruit, are in a much more favorable position to enable the owner to obtain maximum use of his workers throughout the year.

Figure 18 shows five sample farm-patterns of the Pineapple Area. The actual selection of these "typical" farms was based on location, size, physical factors, and the number of different crops grown. These sample farms are in the municipalities of Barceloneta and Manatí, and range in size from 128 to 272 cuerdas each. All farms

SAMPLE LAND USE PATTERNS OF THE PINEAPPLE AREA



Compiled by William W. Burchfiel

Source: Adapted from Puerto Rico Soil Conservation Service Field Office, 1948.

Fig. 18—"Typical" Land-Use Patterns of Selected Pineapple Farms.

are at elevations of less than 750 feet; Farm Unit B, the lowest, has a general elevation of roughly 250 feet above level.

Farm Unit A, largest shown in this sample, has 31 cuerdas of pineapples, 82 cuerdas of sugar cane, 30 cuerdas of coconuts, and 129 cuerdas of brushland and woodland, totaling 272 cuerdas. Pineapples are grown on the best drained soils.

Farm Unit B has 50 cuerdas of pineapples, 91 cuerdas of sugar cane, 14 cuerdas of subsistence crops, 12 cuerdas of pasture, and 96 cuerdas of brushland, totaling 263 cuerdas. This farm represents a cross-section of the topography in the districts producing pineapples. A series of limestone hills, some 200 to 350 feet high, extend across the farm. This farm is separated into three parts by a railroad and an improved road, yet it is operated as a single unit.

Farm Unit C, with a total of 128 cuerdas, is the smallest in this sample. It is comprised of 27 cuerdas of pineapples, 40 cuerdas of sugar cane, three cuerdas of subsistence crops, and 58 cuerdas of woodland and brushland. Unlike all other sample farms shown, this farm does not have access to either an improved or unimproved road.

Farm Unit D is unique in that all arable land (100 cuerdas) is devoted to pineapple production. Although

containing only 142 cuerdas, this farm has access to two improved roads and contains an important pineapple packing shed.

Farm Unit E has 11 cuerdas of pineapples, 163 cuerdas of sugar cane, 20 cuerdas of subsistence crops, ten cuerdas of pasture, and 20 cuerdas of brushland, totaling 224 cuerdas. This farm represents the size of the average pineapple farm in Puerto Rico. It is noted that clustered houses on this farm, similar to Farm B, are located either adjacent to the railroad or the improved road.

From the writer's observations, it was noted that, in general, the smaller the farm the more diversified and self-sufficient was the system of agriculture. Moreover, field observation revealed to the writer that subsistence crops of smaller farms were better cared for than those on larger farms irrespective of equipment employed.

11. Commercial Varieties

To classify the great number of varieties of pineapples found growing in Puerto Rico in such an arrangement that the classification may be of practical value seems an almost hopeless task. The same variety shows different characteristics in various parts of the island, and varieties imported from other Caribbean islands under given names are wholly different from those already grown in Puerto Rico under those names. Moreover, new

types are constantly being introduced from seeds, either naturally or through artificially controlled experimentation.

Mr. Fausto Mariota, Assistant Plant Breeder for the Insular Agricultural Experiment Station, is faced with the task of breeding new varieties of pineapple. The ultimate objective is to breed a variety that possesses or blends the good qualities of both the Red Spanish and Smooth Cayenne. These qualities include the color, size, and shape of the smooth Cayenne, and the aroma, fiber content, root system, and ratooning ability of the Red Spanish. Some positive results thus far have been obtained. A hybrid fruit has been developed that was seven pounds in weight, eight inches long, five inches in diameter, yellow colored and possessed a good aroma, but the fruit had the bad quality of deep eyes. Another hybrid fruit developed weighed nearly eight pounds; was six inches in diameter, seven inches long, juicy and sweet like the Smooth Cayenne and had shallow eyes, but it had a white-colored meat like the Red Spanish. All tests with the Cabezona variety have thus far ended in complete failure. The crossing of the Natal variety from South Africa and other foreign varieties with the Red Spanish is currently being made, but results remain to be determined.

The most widely known varieties include: Red Spanish, Smooth Cayenne, Cabezona, Pan de Azucar, and Negrita.

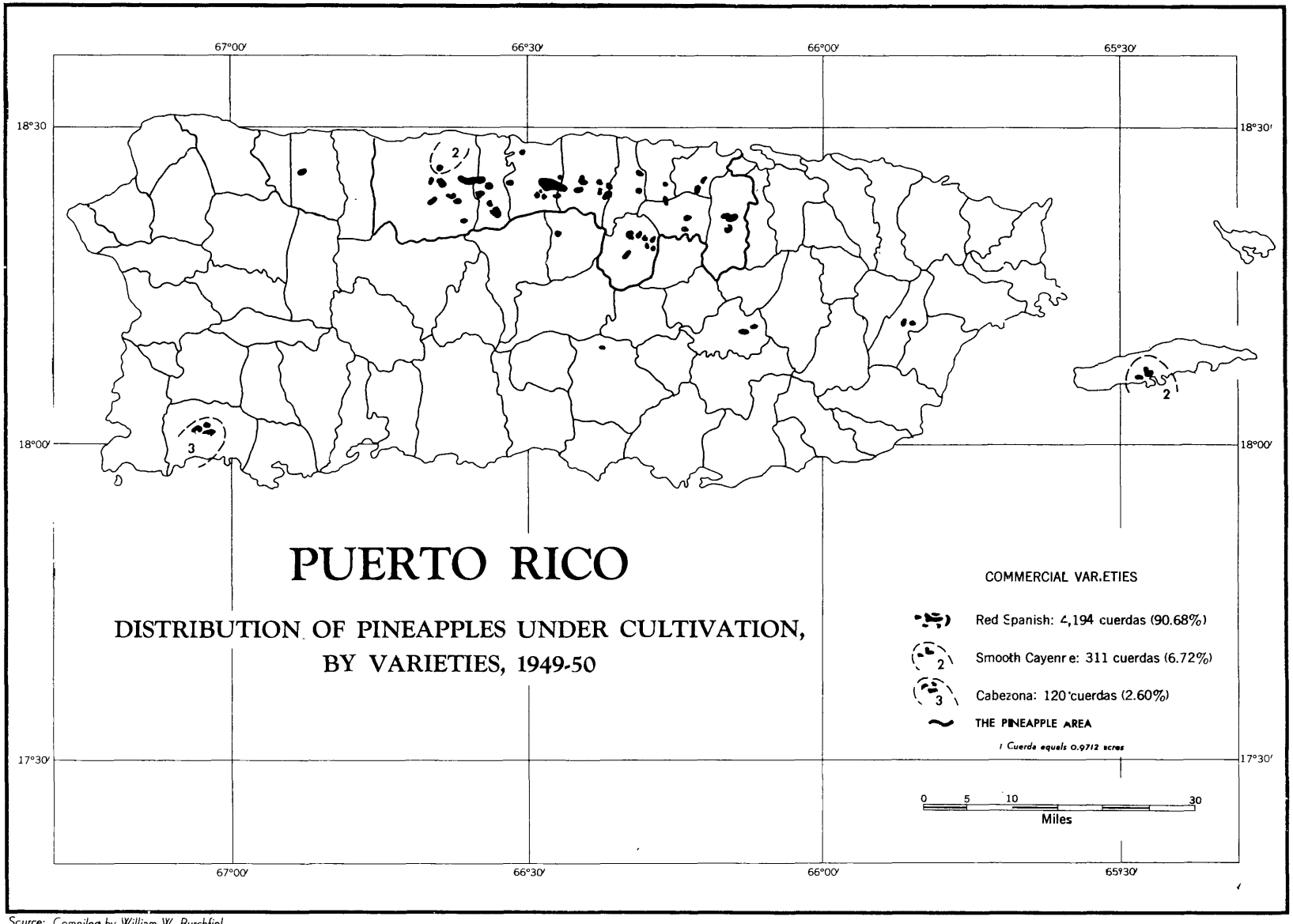
Only the first three varieties are produced commercially (See Fig. 19).[49] Of the three commercial varieties, the Red Spanish and Smooth Cayenne comprise more than 97 per cent of the total area under cultivation. The Pan de Azucar and Negrita varieties are grown exclusively for local consumption and, therefore, do not enter into the international picture.

The Red Spanish variety, due to its large number of strains, differs in characteristics from one locality to another. Changes in variety due to soil, cultivation, and climate are often greater than the strain differences. Red Spanish slips imported from other Caribbean islands, especially from Cuba, further complicate the problem of grouping.

In general, the fruit of the cylindrical-shaped Red Spanish variety has a firm, luxuriant crown (Plate II). Edible portions of the fruit are white, acid, and juicy, but contain less sugar than either the smooth Cayenne or the Cabezona. Average weight of fruits

---

[49] In the 1949-50 crop year, there were 4,625 cuerdas of land devoted to commercial pineapple production in Puerto Rico, divided as follows: 4,194 cuerdas (90.7%) planted to Red Spanish variety; 311 cuerdas (6.7%) to Smooth Cayenne, and 120 cuerdas (2.6%) to the Cabezona variety. By comparison, in 1948, Hawaii had 72,842 cuerdas of pineapples under cultivation---Lanai, 25,000 cuerdas, Oahu, 21,000 cuerdas, and the four other islands, Mokokai, Maui, Kauai, and Hawaii, 26,842 cuerdas between them. Varieties in Hawaii are confined to two, Smooth Cayenne 92 per cent and Hilo nearly eight per cent. The latter is consumed mainly as fresh fruit. Cook and Chem, 1949, pp. 1-12.



Source: Compiled by William W. Burchfiel

Fig. 19—Distribution of Commercial Pineapples under Cultivation, by Varieties, 1949-50.



Plate II.--Comparison of Red Spanish and Cabezona Varieties

Red Spanish on left has a uniform, cylindrical shape and weighs four pounds. The Cabezona on right is quite distorted, as seen by arrangement of the bracts, and weighs 14 pounds. Foot ruler shows comparative size of the two varieties. June 1951.

exported fresh ranges from one and one-half to nearly four pounds (Table 10). The eyes are comparatively large and deep, and when ripe have a clear red color. Having a hard and firm rind, the Red Spanish can withstand rough treatment in shipment.

The vigorous plant of the Red Spanish variety is not as large as the Cabezona. Its leaves, reddish-green at the tips, change to bluish-green at the base; relative to length, they are quite wide and have a

TABLE 10

COMMON SIZES OF FRESH PINEAPPLES EXPORTED FROM PUERTO RICO*
(Red Spanish Variety)

Classification by Size (No. of Fruits per crate)	Range in Diameter (in inches)	Average Weight per Fruit (in lbs.)
18	5 1/8	3.89
24	4 5/8-4 3/4	2.92
30	4 3/8-4 9/16	2.33
36	3 15/16-4 1/8	1.94
42	3 3/4-3 7/8	1.67
48	3 7/16-3 1/2	1.46

*Source: Adapted from Report by William Pennock, "La Piña en Puerto Rico", Revista de Agricultura de Puerto Rico, Vol. 33, No. 4 (San Juan: Department of Materials, Printing, and Transportation, 1941), p. 527.

heavy thick base. Unlike the Cabezona and Smooth Cayenne varieties, the fruit of the Red Spanish breaks off clean and close to the base, and with little danger of being injured. The plant responds to unfavorable growing conditions by turning reddish or losing color and becoming yellow. It is highly responsive to soil conditions and to methods of cultivation and fertilization. The plant produces several slips and thus propagates rapidly. An average of five slips per plant may be expected, and as many as 20 or more slips, suckers, and ratoons have been counted on a single plant. This rapid multiplication, together with other desirable characteristics, makes the Red Spanish the most important commercial variety at the present time, although others surpass it in quality and yield.

The Smooth Cayenne[50] has been grown in Puerto Rico for nearly 45 years. However, due to difficulty that has been encountered in propagation and cultivation, its importance has been secondary until recently. The plant is very delicate and has little resistance to rough handling. The average fruit weighs about five pounds; pulp is yellow, sweet, and juicy. Prior to World War II, the Smooth Cayenne was unable to compete with the Red Spanish in Puerto Rico. However, in the

---

[50]Receives its name for having almost spineless leaves.

last five years some headway has been made, especially on the nearby island of Vieques where some 200 cuerdas are currently under cultivation.[51] Scattered fields of Smooth Cayenne may be found along the northern littoral in the municipality of Arecibo. It is grown almost exclusively for canning purposes and does not play any major role in the fresh fruit market.

Of the less important varieties, Cabezona, Pan de Azucar, and Negrita, the Cabezona is the most widely grown and at intervals during the past four decades has reached the markets of continental United States. The American consumer, in the past, has been reluctant to purchase it either fresh or canned. Its appearance in the foreign market usually causes a drastic drop in the price of other varieties. This is due to the fact that the Cabezona is easily bruised in handling and deteriorates rapidly once it is harvested. The Cabezona variety varies in shape from oblong, tapering, and often irregularly bulging to almost cylindrical with uniform sides (Plate II). The fruit is large, ranging from six to 14 pounds; green fruit turns to a bright

---

[51] Smooth Cayenne, grown the world over, comprises approximately 92 per cent of total production in Hawaii, between 50 and 75 per cent in the Philippines, Australia, and South Africa, roughly 25 per cent in Mexico, and less than 15 per cent in Cuba and Puerto Rico. There is an upward trend of this variety, especially in the Caribbean-producing areas.

yellow when ripe. The pulp is somewhat fibrous, yellowish, sweet, and juicy.

The Pan de Azucar and Negrita varieties, produced in small patches throughout the island, are consumed at home or carted to local markets. These two varieties yield large edible fruit but are often seedy, spotted, and subject to bruising when transported even for short distances.

12. Propagation

The principal material of propagation consists of slips, suckers, or crowns (See Glossary). The vast majority of the growers have a certain preference for the well-developed slip which yields large fruit. It is reported that approximately 90 per cent of the new fields of pineapple are planted with slips because they yield roughly three tons more to the cuerda than do fields planted to suckers (Table 11 and Plate III). The writer, on the basis of personal observation, believes that this percentage is somewhat too high for an average year. A ratio of 80 per cent slips to 20 per cent suckers for new plantings would be more accurate over a period of several years.

A plant bears but one fruit, and the succeeding crop must be produced from a new plant. Although there are several different parts of a pineapple plant that may be used for propagation, they are all quite different. Each of the small plants is known under different

TABLE 11

AREA AND YIELDS OF PINEAPPLE HARVESTED IN PUERTO RICO, CROP YEARS, 1948-49 AND 1949-50*

Type of Plant	Cuerdas Harvested		Average Yield Per Cuerda		Total Production	
	1948-49	1949-50	1948-49	1949-50	1948-49	1949-50
			(in tons)		(in tons)	
Slips	1,724.98	1,320.65	12.70	10.45	21,978.85	13,795.35
Suckers	156.50	222.40	9.77	10.06	1,998.40	2,227.50
Second Crop (ratoon)	1,127.50	2,035.85	9.29	8.45	12,247.70	17,215.96
Third Crop (ratoon)	113.50	346.80	8.52	7.51	995.50	2,206.48
Fourth Crop (ratoon)	----	34.00	----	7.12	----	242.08
Totals	3,122.48	3,959.70	Av.11.86	9.12	37,020.45	36,090.37

*Source: Unpublished statistics obtained by writer from the Bureau of Agricultural Economics, Puerto Rico Department of Agriculture and Commerce, San Juan, May 1951.

182682



Plate III.--Pineapple Suckers Ready for Planting

Suckers pulled from the base of the mother plant a few days earlier are ready for planting. These suckers will yield fruit about one year later. Suckers normally comprise between 15 and 25 per cent of all new plantings by acreage. May 1951.

names, according to the position in which it is found on the mother plant. Buds that develop below the surface are called ratoons; those in the leaf axils of the main stalk, suckers and slips (the latter being just below the fruit); and those clustered around the fruit, crowns or crown slips (See Glossary).

Sucker and ratoon, if unattended, will develop root systems of their own. The ratoon develops directly in the soil, and will eventually be independent of the mother plant and can be left to produce another crop. The sucker, if left on the mother plant, although

not in direct contact with the soil, will throw out roots. The roots develop partly around the roots of the new plant and partly in the leaf axils of the mother plant. In that position the sucker will grow and bear fruit exactly as if the roots were taking up nourishment from the soil. The practical importance of this is that where the plants are close enough together to prevent the suckers from being blown over they can be depended upon to bear a crop of fruit. Both the ratoon and sucker can be severed from the mother plant at any time and used for planting.

13. Methods and Time of Planting

In Puerto Rico, the two- and three-row system of planting is used almost exclusively, with the exception of a few smaller growers that still employ one-, four-, or five-row systems. The two-row system is the most common method of planting in the extreme southern portion of the Pineapple Area and on the island of Vieques where the Smooth Cayenne variety is grown. The single-row system is used largely with the Cabezona variety in Lajas; elsewhere the three-row system prevails. Advantages of the two- and three-row systems are: First, maximum use of land as paths between series of rows will form ridges for the following planting; secondly, greater than three-row system complicates the problems of tilth, weeding, and harvesting as

applied in Puerto Rico; thirdly, use of a four or more row system, especially in loam or clay soils, affects ground aeration, water collecting following rains, and replanting. In the three-row system the distance between rows and individual plants is about 18 inches (Plate IV). A space or path of five feet is left between each series of three rows. In this system about 33,000 plants per hectare (2.47 acres) or 13,250 plants per cuerda can be planted (Table 12).[52]

The planting of both slips and suckers generally is conducted during the wettest season, mainly between mid-May and mid-September (Table 13).[53] Suckers are easier to plant, as they may be inserted in the ground

---

[52]Standard planting practice in Hawaii differs radically with that used in Puerto Rico. In Hawaii, fields are laid out geometrically in blocks. In brief, the planting system is as follows: Number of beds per block 21, distance between beds three feet; number of rows per bed two; distance between plant rows two feet; plant intervals in rows one-foot; and number of plants per acre 17,450. At higher altitudes, slightly closer planting is permissable. With plant intervals of ten inches, some 18,000 plants may be set per acre. This system has several advantages which warrant careful consideration by Puerto Rican growers: (1) Closely spaced plants produce a more uniformly shaped fruit and of standard dimensions which is highly significant in view of peeling and coring; (2) closely spaced plants provide better weed-control by shading the ground; and (3) higher yields are obtained per acre. Cook and Chem, 1949, pp. 16-17.

[53]As in Puerto Rico, pineapples in Hawaii may be planted at any time of the year, but in the latter locality, owing to the incidence of seasonal drought, rains, and cold weather, the results differ. Hawaiian growers plant the bulk of their crop during September, October, and November.



Plate IV.--Three-Row System of Cultivation

Ten-months-old plants are healthy and growing vigorously despite deficient rainfall during early spring. Weed growth is difficult to control after the first year owing to the criss-crossing of leaves. Farm leased by Puerto Rico Agricultural Company, Arecibo. May 1951.

at almost any depth; whereas slips and crowns must not be planted deeper than two inches. As a general rule, the more permeable the soil the shallower should be the bed. Both slips and suckers may be pulled from the mother plant several days before planting and still maintain their vitality and healthy condition.

14. Cultivation

Cultivation of pineapples requires intensive

TABLE 12

APPROXIMATE NUMBER OF PINEAPPLE PLANTS PLANTED PER CUERDA[a]

System of Planting	Distance between rows (in inches)	Distance apart of plants in rows (in inches)	Distance between centers of banks (in feet)					
			5 feet	6 feet	7 feet	8 feet	9 feet	11 feet
Single row	18"	12 - 18"	8,700[b]	7,075	6,050	5,300	4,725	3,850
			5,750	4,700	4,025	3,525	3,125	2,550
Double row	18 - 24"	12 - 16"	12,550	10,950	9,675	8,700	7,900	6,675
			9,400	8,200	7,225	6,500	5,900	5,000
Triple row	18 - 20"	16 - 18"	13,250	11,650	10,400	9,375	8,500	7,200
			11,800	10,350	9,250	8,350	7,550	6,400
Quadruple row	18 - 20"	16 - 18"	13,000	11,825	10,775	9,975	9,250	8,075
			11,550	10,525	9,600	8,875	8,225	7,175

[a]Source: Compilations based on data provided by William Pennock, Puerto Rico Agricultural Experiment Station, Rio Piedras, 1951.

[b]Approximate number of plants calculated to the nearest 25.

TABLE 13

CALENDAR OF AGRICULTURAL ACTIVITIES ON PINEAPPLE FARMS COMPARED WITH [illegible]ER CROPS COMPETING FOR LAND IN PINEAPPLE AREA*

Month	Pineapples	Sugar cane (ratoon)	Oranges	Corn
Jan.	Plowing. Weeding. Fertilizing. Preparing for new crop.	Harvesting. Preparing terraces.	Harvesting. Grafting. Spraying.	--------
Feb.	Weeding. Plowing land for new crop. Begin harvesting from suckers.	Harvesting. Preparing terraces.	Harvesting. Grafting. Spraying.	[illegible]reparation of land. [illegible]arvesting.
Mar.	Weeding. Plowing land for new crop. Harvesting fruit.	Harvesting. Preparing terraces.	Grafting. Spraying.	[illegible]reparing of land. [illegible]estroying of insects.
Apr.	Weeding. Plowing land for new crop. Harvesting fruit. Cutting and planting suckers.	Harvesting. Preparing terraces.	Transplanting. Fertilizing. Spraying.	[illegible]lanting. Weeding. [illegible]reparing of land.
May	Weeding. Fertilizing shoots for 2nd crop. Planting suckers. Harvesting fruit.	Harvesting. Preparing terraces.	Transplanting. Fertilizing. Spraying.	[illegible]lanting. Cultivating.
June	Fertilizing. Planting suckers and slips. Weeding. Harvesting.	Harvesting. Preparing terraces.	Planting. Harvesting.	[illegible]eeding. Destroying insects.
July	Planting slips. Fertilizing earlier plantings. Weeding. Destroying plants in abandoned fields.	Cultivation.	Cultivation. Planting. Harvesting.	Harvesting.
Aug.	Planting slips. Weeding. Treating fields with carbide.	Cultivation.	Harvesting. Planting.	Preparing of land. Harvesting. Planting.
Sept.	Weeding. Finish up planting of slips. Carbide treatment.	Cultivation.	Harvesting. Planting.	Preparing of land. Harvesting. Planting.
Oct.	Weeding. Fertilizing. Carbide treatment.	-------	Harvesting. Spraying.	----------
Nov.	Weeding. Fertilizing. Completing carbide treatment.	-------	Pruning. Spraying.	Weeding. Destroying insects.
Dec.	Weeding. Minimum activity on pineapple farm.	-------	Spraying. Fertilizing.	Weeding. Destroying insects.

*Sources: Adapted from Dr. D.S. Campbell's thesis, The Geography of the Cof[illegible]e Industry of Puerto Rico (Chicago: University of Chicago Press, 1947), pp. 114-115. Conference with [illegible]r. Francisco Vazquez, Puerto Rico's largest pineapple grower, May 17, 1951; Letter from Mr. John E. Ray[illegible]r, pineapple grower for 26 years, June 24, 1951.

farming techniques combined with considerable patience.[54] Pineapples require from 12 to 22 months of cultivation before the first harvest. During this period weeds must be fought vigorously and incessantly,[55] and the soil must be maintained in excellent tilth. (See Table 13).[56]

On account of the shallow root system and closely spaced planting, pineapple cultivation is confined almost entirely to hand labor in Puerto Rico. Regardless of the row-system employed after the first year leaves interlace between the rows and it becomes difficult to till the soil even with a scuttle hoe. The ordinary hoe, however, is commonly used because of the heavier soil, and the more abundant growth of weeds. Because

---

[54] Based on a survey made in Puerto Rico in 1947-48 by the Insular Labor and Minimum Wage Board, 68 man-days work was required to cultivate a single cuerda of pineapples out of a total of 114 man-days work required for all operations from time of planting through harvesting.

[55] A few progressive farmers are turning to more economical and efficient chemical weed sprays. These include various combinations of oil and emulsifying compounds. Two of the best known chemical weed sprays are 2-4-D (2.4 dichlor phenoxy acetic acid) and 2-4-5-T, but they are so extremely toxic to pineapple plants that they frequently cannot be used. In Hawaii, these two compounds are used to collapse and destroy worn-out ratoon crops before replanting.

[56] John E. Raymer, pineapple grower of 26 years experience, estimates that weed control constitutes 65 per cent of the total cost of cultivation.

the most difficult and expensive operation in pineapple culture is cultivation, great efforts have been made to alleviate the problem of hand labor. A recent promising technique is the use of mulch paper (Plate V).



Plate V.--Use of Mulch Paper

Mulch paper in the pineapple industry conserves moisture, prevents excessive leaching of fertilizer, retards weed growth, activates nitrifying bacteria, and accelerates plant growth by increasing the soil temperature. No date. (Courtesy of Martinez Rogers, Fotografo, Santurce.)

Mulch paper, obtained in rolls 24 to 36 inches wide, is impregnated with asphalt on one side to prevent leakage. The paper is unrolled between rows of plants shortly after planting. Soil must be rolled along both sides

of the paper in order to be most effective and to anchor it securely against winds. The paper decays and disintegrates in 12 to 14 months, by which time the pineapple plants are sufficiently large to shade the ground, thus reducing weed growth.

Mulch paper, as used in Hawaii,[57] serves at least five major functions or benefits. First, and perhaps foremost, is a reduction in weed growth, as weeds cannot live without sunlight. The saving in weed eradication costs thus effected has been considered sufficient to justify the added cost of the paper. Second, mulch paper increases soil temperature.[58] Third, the paper tends to retard moisture evaporation from the soil surface. Fourth, a higher nitrate content has been found in mulched soils regardless of type or amount of fertilizer. Finally, a quick start and early development of new plantings, brings about a higher percentage of plants in relation to fruit.[59]

---

[57] The pineapple industry uses about 250,000 rolls of mulch paper annually at an estimated cost of $3,500,000.

[58] In the summer, mulch paper increases soil temperature from 12° to 15°F. during the day time and from 4° to 5°F. at night. During the winter months these temperatures range from 5° to 8°F. and 2° to 4°F. day and night, respectively. Collins, 1949, pp. 349-350.

[59] A Hawaiian Research Field Station on an experimental plot obtained a 20 per cent increase in yield by mulching. Mulched plants grew a foot higher than adjacent unmulched plants of similar age.

In Puerto Rico to date, only one mulch paper-laying machine has been used. It has not met expectations for three reasons: First, it is not necessary to raise the temperature of the soil during the growing period in Puerto Rico; second, the effectiveness of the paper in combatting weeds seldom exceeds one year; and third, increased cost of the paper discourages wide use.

15. Methods of Regulating Fruit Maturity

During the past 25 years there have been developed three successful processes by which pineapple maturity can be regulated or controlled. These include the carbide process, smoking process, and use of hormones.

The carbide process, a pre-war development (1939), is employed primarily to hasten fruit maturity. A vast majority of the growers treat a portion of their crop in order to extend the harvesting season because if left to the elements of nature, fruit maturity is concentrated in the month of May, whereas with carbide the harvesting period may be staggered over a period of several months. In 1950, an estimated 90 per cent of growers used the carbide treatment to some extent.

The application of carbide is commonly made between late August and mid-November to plants that are approximately one year old, as well as to shoots of old plants that are bearing a second crop. The bloom appears in about six weeks after the application of carbide

solution, and the fruit matures some four months following the flowering period.[60]

There are three advantages in using carbide. First, it reduces the harvesting costs, since fewer workers are required; second, it hastens crop maturity by about two or three months, thus enabling those growers participating in the fresh fruit market to command higher prices for their crop during the off season; and third, the carbide process is considerably cheaper than the obsolete "smoking process",[61] because it is equal to it and possibly more effective because a windy night could easily nullify the smoke treatment.

The use of a hormone, known as ANA (Alpha Naphethalene Acetic acid), a post-war discovery, appears to be the most promising of all methods thus far known to regulate or control fruit maturity. It must be applied in extremely low concentrations (about three parts per million of water) by boom sprayers or by airplane, for

---

[60] Treatment consists of pouring one-fourth cup (30 cc) of solution by hand into top of each pineapple shoot. A solution of 11 ounces of calcium carbide in 30 gallons of water is sufficient to treat one cuerda, costing roughly $10.00. (Adapted from letter received from John E. Raymer, Arecibo, January 29, 1951.)

[61] Smoking process, first employed by accident in the Azore Islands in 1925, was introduced into Puerto Rico shortly after 1930. This process consists of burning wood for several hours beneath a canvas covering several rows of pineapple. This process, no longer used, had the disadvantage of costing about $25.00 per cuerda, almost complete loss of slips for propagation, and additional work required in erecting and maintaining equipment. R.C. Roberts, 1942, pp. 113-114.

it is nearly impossible to get the proper amount of this solution onto each plant by use of hand sprays.[62] The solution is applied just prior to bud formation and it forces the backward flowers to spring forth so that all fruit develops and ripens simultaneously.

By using the hormone ANA, the entire structure of the plant is changed. Plant nutrients are drawn from all parts of the plant to encourage fruiting at the expense of vegetative growth, and, as a consequence, sucker development is drastically reduced and basel slips fail to form. The failure to produce slips is the primary reason why this hormone is not normally applied to the plant crop. Since the ratoon crops mature with less regularity than the plant crop and as slips and suckers for future planting have been removed before spraying, the use of the hormone is ideally suited for ratoon crops. However, a second hormone, described as BNA (Beta Naphathalene Acetic acid), is at present being developed to strengthen the stem, enlarge, the fruit, and give it a firm texture. The future of BNA, as well as other hormones under investigation, may completely alter methods of pineapple cultivation.

---

[62]The writer observed devastating results to a 20 acre field that had been sprayed by hand with too high a concentrate. Healthy plants withered away and died within two weeks.

16. Harvesting

Some pineapples are harvested in Puerto Rico during the entire year, although maximum production occurs during the period between mid-March and mid-June (See Section 15, "Methods of Regulating Fruit Maturity"). Fruits from suckers normally mature from 12 to 16 months following planting; fruits from slips between 16 and 20 months; and fruits from crowns between 20 and 22 months. Pineapples are harvested during either one of two stages of maturity. If the crop is destined to the continental fresh fruit market, the fruit is picked from two to three weeks before becoming fully ripened in order to allow time for grading, packing, shipping, and other time-consuming operations before reaching the consumer. If, on the other hand, the fruit is contracted to the cannery, it will not be harvested until fully ripe. Therefore, it is obvious that radically different techniques in harvesting are required. (See Frontispiece).

Fruit, not fully ripened, is gathered by crews of well-trained workers. Workers engaged in this operation first remove the fruit in the rows from both sides of the path. Behind these skillful cutters are carriers with special baskets with which to carry the fruit to the edge of the field where the fruit is assembled with crown head-down, and is exposed to the sun for three or four hours (Plates VI and VII). At this point,



Plate VI.--Sole Method of Transportating Fruit from Field to Road.

Fruit bearers "tote" pineapples on their heads as their fathers did a generation ago. Baskets filled with fruit weigh from 40 to 60 pounds. Aprons protect workers against the barblike leaves which overlap the paths. One cutter and two carriers can harvest about 3,600 pineapples in a ten-hour day. April 1942. (Courtesy of Revista de Agricultura de Puerto Rico).



Plate VII.--Treating Pineapples for Fresh Fruit Market

The pineapples are first stripped of basal bracts and small slips and neatly arranged in rows with their crowns down. Their butts are exposed to the sun for three to four hours, and then the fruits are treated against "black rot" before being transported to packing shed for grading and crating. April 1942. (Courtesy of Revista de Agricultura de Puerto Rico.)

pineapples are treated against "black rot" (See Section 18, "Diseases and Pests"). Later the fruit is collected and transported to the nearest packing shed (Fig. 7), where it is graded, inspected, crated (Plate VIII), and labeled before being trucked to San Juan for overseas shipment.



Plate VIII.—Typical Packing Shed Used in Grading, Sizing, and Crating Fruit

Pineapples are mechanically channelled to wooden bins on right according to diameter. They are then carted to the grading tables on left of belt. After the fruits are carefully graded, they are carried along the conveyor belt to waiting crates seen in foreground. No date. (Courtesy of Revista de Agricultura de Puerto Rico.)

Harvesting fully ripened fruit contracted to the cannery does not require nearly the degree of skill as harvesting that destined to the fresh-fruit market; this is reflected in the daily wage-scale. (See Chapter IV, Section 6, "Income and Wage Contributions".) Workers engaged in this operation are provided with sharp machetes and cut the fruit of the rows from both sides of the path. The fully ripened fruit must

be more carefully handled than in the case of pre-ripened fruit for it is highly susceptible to bruises. The fruit is removed from the field in baskets and placed in piles at the edge of the field convenient to loading onto waiting trucks. It is common practice to remove the crowns before transporting the fruit to the cannery.

As pineapples in a given field do not ripen uniformly under natural conditions regardless of their ultimate destination, several collections, from three to ten days apart, are necessary. After the second or third collection when the fruits become thinned out, the working crews who remove the fruits from the plants may also carry them in canvas bags to waiting trucks, thus eliminating a considerable number of "basket toters" so important at the peak of production.

Since each step in the harvesting operation must be closely timed in relation to all other tasks, close coordination and supervision is essential. However, there appears to be little correlation between the size of farms and harvesting costs in terms of man-days required per cuerda. As hand labor is used almost exclusively in harvesting pineapples, human skill and judgment become increasingly more important. The harvesting expert, usually the owner or manager, must know the degree or state of ripeness of the fruit at all times. He is able to determine this by a combination

of conditions such as color, size of eyes, and shape of bracts. If a field of pineapples has been infected by a desease known as "gummosis" (See Section 18, "Diseases and Pests"), the normal period of harvest is delayed ten days or two weeks as a slow rate of ripening is one of the results of this disease. Immediately prior to harvest, weather forecasts are closely watched because fruit gathered during rainy spells are subject to rot. However, in spite of all these variable factors affecting the actual harvest, the grower always harvests his crop with great assurance.

17. Yields

Pineapple yields in Puerto Rico vary considerably from one year to another, as is true in most other major producing areas the world over. Primary factors which determine total yields of the industry as a whole for a given year are the prospective market outlook, climatic conditions, total acreage in first-year harvest, and availability of capital for investment. Major factors influencing the average yield per cuerda of a given grower include proper management, availability of healthy slips for planting, and favorable weather conditions.

The fact that total or average pineapple yields cannot be predicted with any degree of accuracy has a direct effect in securing needed capital for investment.

Moreover, constantly changing conditions throughout the long growing season which tend to increase or decrease prospective yields frequently disrupt or alter the processing and marketing structure of the entire industry long before harvest. For example, the occurrence of a hurricane or a period of excessive rainfall several months prior to harvest result in unstable economic conditions all along the line. Any adverse weather conditions, during the cultivating and harvesting periods which tend to affect yields are reverberated throughout the industry.

In an unfavorable year when there is a deficiency of rainfall at planting time or excess of rainfall at harvesting time, average yields decline (only 274 crates per cuerda in 1950). During such low productive years, growers become disheartened and frequently shift from pineapple production to sugar cane; canners also become discouraged and sometimes either cease to operate or, when equipment permits, shift production to other fruits that are more profitable.

However, several encouraging trends are reflected in or associated with increased yields. First, during the last decade there has been a definite increase of pineapple yields per cuerda, as is evident in Figures 14 and 15, even though the 1950 crop-year was much below normal. During normal years, roughly 300 crates

of pineapples per cuerda can be expected.[63] In exceptionally favorable years, such as 1949, when an average of 330 crates per cuerda were harvested, the entire industry surged forward with increased acreage, new processing facilities, and new equipment which tended to add stability to the industry. Table 14 lists the names and dates of establishment of new processing plants.

As mentioned earlier and pointed out in Table 11, yields obtained from slips and suckers for the first or plant-crop range from 28 to 86 crates more than from the second or third crop. Most growers feel that if a ratoon crop does not yield as much as 200 crates per cuerda a new crop should be planted. The gross yield for a full four- or five-year cycle for individual fields varies between 35 and 45 tons of fruit per cuerda, but for the total planted acreage under pineapples in Puerto Rico, the over-all annual yield is between nine and 12 tons.

In Hawaii, the gross yield for a four- or five-year cycle ranges from 40 to 70 tons per acre, divided as follows: plant crop between 20 and 35 tons per acre; second or first ratoon crop between 20 and 25 tons; third or second ratoon crop from less than one

---

[63] See Table 8 for average highest and lowest yields.

TABLE 14

FACTORIES PROCESSING PINEAPPLES IN PUERTO RICO[a]

Name	Date Established	Location By Municipality	1948-49 Pack		1949-50 Pack	
			Cases[a]	Per Cent	Cases[a]	Per Cent
1. Companie Agricola Industrial[b]	1950	Manatí	102,909	9.8	84,570	12.0
2. Francisco Vazquez, Inc.[c]	1949	Manatí	273,047	26.1	231,016	33.0
3. Manatí Packing Company[b]	1945	Manatí	129,611	12.4	In hands of receiver	
4. Valiente y Compania	1939	Corozal	53,489	5.1	28,902	4.1
5. Corozal Canning Company[c]	1937	Corozal	293,957	28.0	257,354	36.7
6. Isabela Grove Company[b]	1919	Toa Baja	29,464	2.8	15,960	2.3
7. Norman E. Parkhurst Company[d]	1931	Bayamón	159,208	15.2	70,816	10.1
8. Del Frutal Canning Company	1949	Toa Baja	6,815	0.6	3,840	0.6
9. Puerto Rico Agricultural Co.	1949	Vieques Isle	----	---	8,290	1.2
Totals			1,048,500	100.00	700,748	100.0

[a]Sources: Data for the 1948-49 pack was obtained from Insular Department of Agriculture and Commerce; the 1949-50 pack was obtained from individual canners by writer. Cases have been converted to number 2-sized cans (24 cans per case).

[b]Plants not canning pineapple during 1951 season.

[c]Plants processing pineapple exclusively. All other plants process pineapple along with other fruits such as grapefruit, guava, guanabana, papaya, etc.

[d]The Parkhurst Company currently has two factories. The new plant, established in 1950, is devoted exclusively to processing frozen concentrates. The old plant is expected to continue operation on a limited capacity.

ton to 15 tons. This amazing difference in yields between the two islands is due, in part, to the different varieties of fruit grown. The Smooth Cayenne pineapple weighs on an average about one pound more than the Red Spanish. In 1948, Mexico reported an over-all average yield of 303 crates (10.6 tons) or approximately the same as Puerto Rico.[64] There was no information available to the writer on Cuba's average yield.

18. Diseases and Pests

The pineapple plant is attacked by comparatively few diseases and pests (Table 15). It is almost axiomatic that failure with pineapples is a direct indication of poor management or farming techniques.

"Black rot", (Thielaviopsis paradoxa) prior to 1940 was one of the most deadly diseases confronting pineapple growers. In some localities its incidence was as high as 25 per cent, but the average expectance was less than five per cent for a given year.[65] Today, cause and nature of this disease are well known. The disease is caused by a fungus which is especially destructive if the fruit is harvested immediately

---

[64](Adapted from an unpublished table provided by Ana M. Gomez, Economic Assistant, American Embassy, Mexico City, November 24, 1950.)

[65]U.S. Department of Agriculture, Control of Black Rot of Pineapples in Transit. Circular No. 511 (Washington: Government Printing Office, 1939), p. 1.

TABLE 15

PINEAPPLE DISEASES AND PESTS IN PUERTO RICO*

Disease or Pest	Cause	Effect on Pineapple	Remedy or Control
1. Black rot	Thielaviopsis paradoxa (fungus)	Core of fruit becomes infected, leaves become spotted, and the fruit rots.	Paint butts of fruit with benzoic acid, titanium oxide, or boric acid in solution.
2. Gummosis	Insect injuries	Gummy substance oozes from around the eyes of the fruit.	Spray with insecticides.
3. Mealybug wilt	Pseudococcus brevipes (insect)	Insect bores holes in fruit, causing decay. Also attacks roots and leaves.	Introduce parasites. Spray oil emulsions and compounds of cyanide.
4. Club root	Heterodera marioni (nematodes)	Worm destroys roots of plants and produces warts on roots.	Fumigate with: (a) Chloropicrin (tear gas), (b) Methyl dibromide, (c) D.D. compound.
5. Chlorosis wilt	Iron deficiency in soil	Leaves wither and loss of color.	Spray iron sulfate solution on leaves.

*Source: Consultation with Dr. Luis A. Alvarez, Plant Pathologist, University of Puerto Rico, June 1951.

following or during prolonged rainy periods. Black rot begins at the stem of the fruit with an oozing of a gummy substance. If unattended, the decay progresses rapidly and will rot the entire fruit in three or four days.

Recent experiments have revealed that the incidence of black rot is higher in the larger size fruit and also that the juice from diseased fruits is more acid. The factor of size may prove to be highly significant, with increased emphasis being placed on the production of Smooth Cayenne and other large varieties. Today, the average expectancy of black rot is normally less than two per cent, thanks to scientific research.

The use of boric acid, titanium oxide, and especially benzoic acid have proved effective in reducing the incidence of black rot. Treatments are conducted after pineapples are removed from plants and carried to the edge of the field and there arranged so that the bases of the fruits are exposed to the sun (See Plate VII). With the cut stem thus exposed, application of the solution commonly is made with the use of a paint brush. Some growers use a two per cent boric acid solution; others use a benzoic treatment that consists of grain alcohol of 95 per cent strength, denatured by the addition of 10½ ounces of benzoic acid per gallon. It has been calculated that the benzoic treatment costs roughly $1.35 for materials and labor to treat 10,000

fruits, or one-half per cent crate of average size pineapples.[66]

Gummosis is another disease that warrants mentioning. It is thought to result from a physiological break-down of the fruit due to irregular water supply and insect injury. The occurrence of heavy rainfall during the later stages of fruit maturity tends to accelerate the spread of this disease. Commonly the first visual evidence of gummosis is an oozing of a liquid substance from the eyes, beginning near the base of the fruit. This is followed by a discoloring (brownish-yellow) of vascular tissues. There is no known control of this disease, although a liberal application of potash is thought to reduce its incidence in the case of physiological breakdown. If it is a question of insect injury, as some pathologists strongly hold, spraying with insectisides appears to be the most promising means of control. Some growers have found that gummosis is more prevalent in fields that were fertilized late. In any event, if the pineapple does not break down within a month before harvesting, there is little likelihood it will do so. However, the fruit is susceptible to gummosis

---

[66](Conference with Dr. Luis A. Alvarez, Plant Pathologist, Puerto Rico Agricultural Experiment Station, Rio Piedras, May 21, 1952.)

at any time during its growth (See Plate IX).[67]

The mealybug (Pseudococcus brevipes Ckll.) is the most serious insect pest affecting pineapple production in Puerto Rico. It is a small helpless, louselike creature which must be constantly attended by ants which protect the mealybug from its natural enemies and move it from plant to plant. It not only attacks pineapples but other crops as well, and is found in all parts of the island. Although this insect may attack all parts of a pineapple plant, it is most destructive to the fruit and leaves. It attacks the underside of a leaf, pierces the epidermis, sucks out the juices and injects a toxin brought from an adjacent diseased plant. The toxin results in a wilted, flaccid appearance of the leaves. Wherever mealybugs occur in great numbers, widespread crop failure is certain to result.[68] The Red Spanish variety of pineapple is not nearly as susceptible to the attacks of the mealybug as the Smooth Cayenne.

The Puerto Rico Agricultural Experiment Station has been actively engaged in combatting the mealybug

---

[67] Gummosis disease causes losses estimated at $500,000 annually. (Letter from Dr. Rafael Picó, Chairman, Puerto Rico Planning, Urbanizing, and Zoning Board, July 19, 1951.)

[68] No information was available to the writer with regard to reduction of yields in Puerto Rico as a result of the mealybug, but in Hawaii yields have been reduced from about 30 tons per acre to only three tons.



Plate IX.--Pineapple Pests and Diseases

Fruit "A" has been attacked by rodents; "B" is a perfect fruit; and "C" is infected by gummosis as shown by dark spots near base of fruit. Weight of fruits range from 3½ to 5½ pounds. June 1951.

for a number of years. Among its most successful results in combating this pest has been the introduction of two parasites (Anagyrus coccidivorus and Hambletonia pseudococcoina), first one from Brazil and the second one from Hawaii. Early indication reveals that in due time the mealybug in pineapple production can be controlled biologically.

Club root is caused by nematodes (Heterodera marioni), soil-harbored eelworms. These obnoxious organisms burrow into the root and the pineapple plant and cause gall-like swellings which strangle the plant

and result in low-quality fruit.[69] Under tropical conditions eelworms persist in the soil indefinitely. A practical method of control consists of crop rotation with grasses which are non-susceptible, so as to reduce the pests by starvation. The chemical method of control consists in soil fumigation with D.D. compound (not DDT),[70] a by-product of petroleum refining, which is most economical. Other fumigants are as effective but costs are prohibitive or applications are more difficult.

Another less important disease (Chlorosis) which appears from time to time is described in Table 15. In general, this disease may be due to soil conditions, improper fertilizer, and/or crop rotation practices.

It should be pointed out also that the much dreaded fruitfly, thanks to the vigilance of the Puerto Rico government, has not been introduced into the island. The three fruitflies now so well entrenched through the pineapple-producing areas of Hawaii "still head the list

---

[69]The common name, "Club root", is used to describe the appearance of the warty roots produced by these eelworms.

[70]D.D. Compound is a chemical mixture of unsaturated chlorinated hydrocarbons. It costs about 18 cents per gallon and the amount per application varies from 50 to 100 gallons per cuerda. Chloropicrin (tear gas) has been tried but its costs were prohibitive and it proved to be too volatile and unpleasant to use.

of agricultural pests for which satisfactory controls have not been found".[71]

19. Fertilizers

No general rule can be rigidly drawn as to the proportions of the various chemicals which comprise the fertilizers used. Some growers prefer amounts of nitrogen, phospherus, and potassium, in the ratio of 12-6-8; other growers employ a more concentrated fertilizer in the proportion of 12-6-10. Table 16 shows the time and numbers of applications and proportions per cuerda based on these two formulas.

Many pineapple growers apply a small amount of cottonseed meal or tankage immediately after setting the slips or suckers in a new field. This serves the purpose of preventing the young plants from being choked with sand and also of furnishing ammonia. The nitrogen is applied almost exclusively in the form of ammonium sulfate. It is reported that nitrate of sodium produces fruit of a pale color. Nitrogen may be present in the soil or in commercial fertilizers in the form of nitrates, that is, in the form of nitric acid in combination with some base, usually sodium, potassium, or calcium. Ammonium sulfate as a source of nitrogen is

---

[71] U.S. Department of the Interior, Annual Report of the Governor of Hawaii to the Secretary of the Interior, Fiscal Year Ending June 30, 1949 (Washington: Government Printing Office, 1950), p. 7.

TABLE 16

APPLICATION OF FERTILIZER TO PINEAPPLE FIELDS[a]
(Amount per Cuerda in Pounds)

Number of Applications	Time of Application	Amount per Application (12-6-8 to 12-6-10)	Nitrogen $N H_3$	Phosphate $P_2 O_3$	Potash $K_2 O$	Filler
First	At planting.	500-700	60-60	30-30	40-70	370-540
Second	4 to 5 months later.	500-700	60-60	30-30	40-70	370-540
Third	8 to 9 months after planting.	500-700	60-60	30-30	40-70	370-540
Fourth	12 to 14 months after planting.	500-700	60-60	30-30	40-70	370-540
Fifth (ratoon crop)	20 to 22 months after planting.	500-700	60-60	30-30	40-70	370-540
Sixth (ratoon crop)	24 to 26 months after planting.	500-700	60-60	30-30	40-70	370-540
	TOTAL	3,000-4,200	360-360	180-180	240-420	2,200-3,240

[a]Source: Conference with Mr. William Pennock, Puerto Rico Agricultural Experiment Station, May 1951.

much superior to ammonium nitrate, seemingly because of the sulfuric acid it contains. Although the reason has not been determined definitely, it is thought to be due to the influence that the ammonium sulfate has on the acidity of the soil. Potassium, when used as a fertilizer, is always in combination with some acid, usually sulfuric or muriatic. The pineapple plant requires very little phosphate. One study reveals that a pineapple plant, entirely devoid of nitrogen and potassium, needs about one-third ounce each of ammonium sulfate and potassium sulfate.[72] Following heavy rainfall, leaching of plant nutrients is inevitable. The rate of leaching varies with different soils, slope, and crop cover because some land is much more retentive than others. Under such conditions, nitrates are leached out to a greater extent than are the ammoniates and potash salts.

Because pineapple plants usually are not fertilized until after being set, commercial fertilizer cannot be scattered broadcast without some of it lodging on the plant. Therefore, the general practice is to apply it with a spoon attached to a wooden handle. A spoonful, containing roughly 30 grams of fertilizer, is spread between the plants and later it is dispersed and well mixed into the loose soil by use of a hoe. This

---

[72] H.C. Hendricksen, Some Pineapple Problems. Report No. 15 (Puerto Rico Agricultural Experiment Station, 1935), p. 5.

method is costly and tedious. As indicated in Table 16, there are a total of six applications of fertilizer, ranging from four to eight months apart. The fifth and and sixth applications are used wholly to increase the yield of the first ratoon crop. If a third (or second ratoon) crop is anticipated, although rarely the case in Puerto Rico, a seventh application of fertilizer may be applied in the same proportion as the preceeding ones. The average pineapple grower, based on Table 16, would apply approximately one and one-half to two tons of fertilizer per cuerda.[73] Next to the cost of weeding, the fertilizing operation ranks second among all cultivating expenses.

In 1951, commercial fertilizer in the ratios of 12-6-8 and 12-6-10 cost between $56.00 and $58.00 per ton f.o.b. San Juan. In 1947, the Insular Experiment Station began conducting investigations with filter-press cake (See Glossary) as a possible inexpensive and readily available source of fertilizer (Plate X). It is calculated that roughly 75,000 tons of (dry) filter-press cake from sugar mills is available each year to

---

[73] Prof. Sanchez states that the Mexican pineapple growers commonly use about 3,100 lbs. of commercial fertilizer per hectare (2.47 acres) in the following proportions: potash 800 lbs., superphosphate of calcium 600 lbs., calcium sulfate 1,600 lbs., and iron sulfate 100 lbs. C.G. Sanchez, Cultivo de la Piña (Mexico City: Bartolome Trucco Publishing Co., 1947), pp. 34-35.



Plate X.--Scientific Experimentation to Increase Yields

Red Spanish slips, approximately one year old, are being studied to determine the effects of the filter-press cake as means of increasing yields. Puerto Rico Agricultural Experiment Station, Rio Piedras, May 1951.

pineapple growers. It is recommended that between 20 and 30 tons be applied per cuerda; this material costs about $1.25 per ton. The Insular government is currently reimbursing pineapple growers at the rate of $1.00 per ton for commercial fertilizer spread on the farm. The filter-press cake should be applied at time of planting in a single application by mixing thoroughly with top-soil. In experimental plots, with filter-cake treatment, yields increased from 3.2 to 3.8 tons per cuerda on

first-year crop.[74] Some commercial pineapple growers are not using this new form of fertilizer but results will not be available until the 1952 crop is harvested.

Even with the proper form and amount of fertilizer, a soil may become unsuited for pineapple production because the physical conditions of the soil change to such an extent that aeration is impeded. It also may be that the reaction changes and the colloidal matter becomes deflocculated, but usually it is the combination of all the factors mentioned. The pH and deflocculation are never serious problems, for they can be remedied by correcting or altering fertilization (See Tables 5 and 16); by subsoiling where soil conditions and slope are favorable, and when it can be done without undue expense; and also by the application of sulphur. Sulphur in amounts of 1,000 to 2,000 pounds per cuerda has been found to be most practical material to use for correcting alkalinity and deflocculation.

20. Crop Rotation Practices

As previously mentioned, the desired crop rotation plan would be based on a five-year cycle. A farmer with 250 cuerdas of productive land would be encouraged to establish this plan: 50 cuerdas producing the plant

---

[74](Conference with Mr. Ernesto Hernández, Agricultural Experiment Station, Río Piedras, May 1951.)

(first-year) crop, 50 cuerdas producing the second-year crop, 50 cuerdas being prepared for planting, and the remaining 100 cuerdas in cover crops, preferably Crotalaria (Crotalaria juncea) grass. However, because of the wide range in size of commercial pineapple farms, varying degrees of specialization by individual growers, and different farming practices and techniques employed, it is virtually impossible to establish a standard uniform crop rotation plan for a few growers, much less the entire industry. Practices used are as varied as the growers themselves.

In Puerto Rico, there are two schools of thought concerning the problem or question of rotating pineapples with other crops.[75] The first group, mostly agricultural specialists of various types, strongly hold to the theory that pineapples should not be planted in a rotation plan with such crops as cane, tobacco, and corn which sap the soil of basic plant nutrients. Their arguments include the following: (1) Sugar cane and tobacco should not be used because of the insect pests that remain in the soil; and (2) land suitable for cane will yield from five to seven cuttings (two to three years), and therefore, does not fit into a four- or five-year rotation policy.

---

[75](Conference with Arthur S. Mason, formerly Technical Advisor, Office of Puerto Rico Agricultural Experiment Station, April 1951.)

The second group, composed mainly of middle-and-large size farmers, follow the school of thought that pineapples can be rotated successfully with sugar cane. Their chief argument is that cane destroys most weeds and alleviates the weeding problem, the single most expensive cultivating operation, when replanted to pineapples. Furthermore, they claim that insect pests are not as destructive when pineapples follow cane. However, both groups agree that in any crop rotation plan, the land should lie fallow for at least one year. Crotalaria grass is presently thought to be the best cover crop to restore the natural fertility of the land. In addition to restoring nitrogen to the soil, Crotalaria grass will produce upward of 14 tons per cuerda in a single year. Sword beans and pigeonpeas, sometimes recommended as cover crops, will yield only two tons per cuerda. Cover crops recommended make their heaviest growth and serve their purposes best when planted in spring or early summer. If pigeonpeas or jack beans are used as a cover crop, it has been found that both are harmful if planted before the last crop of pineapples has been harvested.[76]

---

[76] C.F. Kinman, Cover Crops for Porto Rico. Bulletin No. 19 (Washington: Government Printing Office, 1916), pp. 31-32.

21. Degree of Mechanization

Of the manual operations in the pineapple industry where human judgment and skill are still absolutely necessary, three are in the agricultural phase of production. These hand operations include the picking of fully ripened fruit, selection of young plants for a new crop, and the insertion of them into the soil for a fresh start.

It can be stated safely that the degree of mechanization in the agricultural phase of the pineapple industry in Puerto Rico has not kept pace with the processing phase. Furthermore, the degree of mechanization for both phases in Puerto Rico is far behind the methods and techniques employed in Hawaii. This has been, in part, due to two factors, namely the large reservoir of cheap labor that is readily available and accessible at the time of harvest in Puerto Rico and the lack of sufficient capital with which to purchase expensive farm implements. Unlike Hawaii, where increased mechanization of pineapple culture has also encouraged large-scale farming, for only a large farm can afford expensive machinery, Puerto Rico, a country of comparatively few and small pineapple growers, cannot hope to compete on equal basis with her largest rival.

Puerto Rican pineapple growers have farms, averaging about 225 cuerdas each, with seldom more than 75 cuerdas planted to pineapples at any one time. They are,

with few exceptions, either owner-operated or owner-managed;[77] capital for all improvements must be earned from receipts of crops on a year to year basis. In Hawaii, where corporative-formed structure permits plantations of several thousand acres each, capital for investment, experimentation, and labor-saving equipment is always available, regardless of yields or fluctuation in prices for a given year.

The effective mechanization of pineapple production in Puerto Rico has been handicapped and somewhat delayed in comparison with sugar cane and other crops for several reasons. First of all, slope of land on which most pineapples are grown is generally not conducive to intensive mechanization. Slightly less than 40,000 cuerdas in the Pineapple Area, most suitable for pineapple production or may prove suitable in the future, have slopes of less than seven per cent where mechanized equipment may be employed freely. Another 10,000 cuerdas suitable for pineapple production have slopes between seven and 15 per cent where mechanized equipment may be used only with difficulty. The remaining 230,000 cuerdas within the Pineapple Area are not suitable for pineapple production and/or have slopes

---

[77] (Conferences with Mr. Jose F. Ferrer, Vice-President of the Royal Bank of Canada, and with Mr. L. Velez of the National City Bank, San Juan, May 3-4, 1951.)

exceeding 15 per cent, which prevent the use of such equipment except locally. Secondly, soils suitable for pineapple culture are often difficult to work. This problem is further increased if the tough, fibrous plant material is left scattered over the field from the old planting. Thirdly, the use of mulch paper complicates the task of fertilizing and cultivating the crop during the first year.

No machine has yet been built to differentiate a ripe pineapple from a green one, hence the task of removing the fruit from the plant must be done exclusively by hand. Then too, a field of pineapples does not ripen uniformly under natural conditions; consequently, two or more pickings are necessary. Finally, the total combined area throughout the world planted to pineapples has been small in comparison to many other crops. As a result, manufacturers of farm equipment have been reluctant to build equipment designed especially for use on pineapple plantations. Because of this, mechanization of pineapple production has had to depend largely on the resourcefulness and ingenuity of the processors and growers.

Perhaps the greatest single invention to the pineapple grower, comparable to the Ginaca machine in the processing phase, (See Chapter III, Section 3, "Processing

Stages"), is the harvester.[78] Although this machine has been used successfully in Hawaii for nearly ten years, it has not been introduced into Puerto Rico thus far because of the comparatively steep slopes on which pineapples sometimes are planted. Other factors include the initial cost of the machine and the abundant cheap labor supply.

22. Research and Experimentation

At the present time, Puerto Rico, through its two major agricultural research organizations, Agricultural Experiment Station at Mayagüez and the Agricultural Experiment Station of the University of Puerto Rico at Rio Piedras, is devoting much time and effort to ways and means by which the pineapple industry may be improved. These two organizations, although comparatively small in size, fully cooperate with and depend upon each other as well as upon many of the other Federal and Insular government agencies when investigating any major

---

[78] A truck-carrying conveyor that moves along the path parallel to the rows, while the conveyor extends at a right angle across 20 or more rows. This permits workers to walk between rows and remove the fruit and place it on the moving belt. Fruit from the conveyor drops automatically into a waiting truck. The specially designed truck, when loaded, proceeds to the cannery where, by setting into motion the moving bed, the driver can discharge his entire cargo onto the storage conveyor at the cannery. This operation eliminates the back-straining, box handling in both loading and unloading. Moreover, it reduces the loss due to bruising of fruit in handling.

problem. To cite but one example, there is a close tie between the Soils Department of the Puerto Rico Agricultural Experiment Station and the Bureau of Agricultural Economics of Puerto Rico. The former is concerned with soil characteristics and soil productivity, while the latter maintains records of yields, acreage, farm value, and land tenure.

These and other research groups are, as far as the pineapple industry is concerned, concentrating their efforts largely on the agricultural phase of production. The vast majority of the members of these groups with whom the writer conferred feel that the present difficulties and bottlenecks in production lie in the farming stage rather than in the processing stage. As a result of this broad policy, in which the writer concurs, practically all of the most promising avenues of investigation have been along lines relating to the agricultural phases.

Among the most promising results thus far obtained in the pineapple industry may be included: (1) Partial control of black rot disease as well as progress in combatting other diseases and pests;[79] (2) improved fertilizer mixtures and search for new and cheaper sources more readily available (Plate X);[80] (3) attempts to

---

[79]See Section 15, "Diseases and Pests".

[80]See Section 19, "Fertilizers".

develop new varieties of plants that will blend the desirable qualities of the Red Spanish and Smooth Cayenne;[81] and (4) means of increasing yields through soil productivity studies.[82]

23. Summary

From what has been stated in Chapter II, the problems of growing pineapples commercially in the Pineapple Area of Puerto Rico are varied and complex. As a result of many of these problems, the growth and expansion of the pineapple industry has been slow and erratic when compared with other major pineapple-producing countries. Because of numerous physical and cultural limitations which tend to impede possible expansion of the pineapple industry on the island, Puerto Rico can never hope to seriously challenge Hawaii in the number of cuerdas that might be devoted to pineapple production. In spite of relief, climatic, and soil restrictions or limitations, pineapple production within the Pineapple Area could conceivably be expanded to encompass approximately 45,000 cuerdas, or roughly ten times the present acreage devoted to this crop (Table 7).

There are many inherent problems associated with the production of pineapples commercially which cannot

---

[81] See Section 11, "Commercial Varieties".

[82] See Section 4, "Soils and Soil Erosion".

be solved without major land reforms, government cooperation, and available capital for investment. Some of the problems are: The comparatively small size of the average commercial pineapple farm (approximately 225 cuerdas); the fact that an average grower cannot afford to purchase expensive labor-saving equipment, cannot operate his farm for a period of nearly two years before receiving any returns on his original investment, nor cannot devote all his arable land to a cash crop that is as unstable as pineapple production under the present structure.

There are relatively few large farms in the Pineapple Area not presently planted to pineapples that could conceivably be converted to this crop. This is owing to the fact that there are very few potential pineapple farms that can meet the basic requirements so essential to large-scale production. These rigid requirements include favorable relief and types of soils, available capital investment by owners, farm units of 250 or more cuerdas each, and the necessary technical knowledge for efficient management of such farms.

The actual growing of pineapples requires considerable investment and operating capital, technical knowledge, and a large amount of labor per unit area. It is estimated that roughly $800 ($400 for capital investment and $400 for operating investment) is

required to grow one cuerda of pineapples. Comparatively few landholders on the island can meet even this prerequisite. Technical knowledge and practical experience are essential in selecting planting material, preparing land for cultivation, planting of slips and suckers, applying the proper amount of fertilizer, and maintaining the soil in excellent tilth, combatting diseases and pests, and finally, harvesting the crop at peak of maturity. It can safely be stated that the growing of pineapples require more careful attention than that of any other major export crop grown on the island, so that the operating costs are high and the net income is, therefore, not so large as its gross income might indicate.

Although hand labor is used almost exclusively in the planting, cultivating, and harvesting operations, there is a definite trend toward greater use of mechanized equipment where relief is favorable and the size of the farm warrants the use of labor-saving machinery. The writer predicts that hand labor will continue to play a dominant role in the growing of pineapples for many years to come, unless growers are encouraged to increase their landholdings to a point where mechanized equipment can be fully utilized.

One of the most widespread problems among the growers on medium- and small-sized pineapple farms is that of securing an adequate number of healthy and

vigorous plants for a new crop. The owners of larger farms, usually with contacts in Cuba, are able to obtain needed planting material when there are no surplus slips available locally. The owners of small farms, on the other hand, must depend almost exclusively on their neighbors to sell them additional planting material when available. During years that are unusually wet or dry surplus slips are at a premium. The larger growers can more readily acquire all surplus plants and thus force smaller growers in need of new planting material to give up pineapple production altogether. This is one of the fundamental problems of pineapple growing that must be overcome before the pineapple industry can hope to make the adjustments necessary for a uniform and dependable flow of fruit from farm to cannery.

CHAPTER III

PROCESSING AND MARKETING

A. Processing

1. Introduction

Puerto Rican pineapple is consumed both as a fresh fruit and as a processed fruit. It is processed primarily to reduce its perishability, to stabilize the supply, and to increase its export value. In addition, there are far fewer problems associated with marketing of processed pineapple than with fresh pineapple.

Throughout this Chapter the writer has made numerous direct comparisons of methods and techniques employed in the processing and marketing of pineapples between Puerto Rico and Hawaii for two major reasons: First, to point out a few of the advancements and progressive steps that have taken place in Hawaii, the acknowledged leader in the pineapple processing and marketing field; and second, to indicate possible ways by which Puerto Rico may improve pineapple processing.

2. Processing Facilities

Pineapple processing in Puerto Rico ranges from the use of obsolete and labor-consuming equipment to modern mechanized equipment. Existing processing facilities are more than sufficient to meet the needs of present production. A recent study sponsored by the

Insular Department of Agriculture and Commerce revealed that if all the pineapple processing plants were operating at maximum capacity, the canneries could be geared to handle approximately 115,000 tons of pineapples annually, or four times the present rate of production. Daily pack for the largest canneries ranges from 2,500 to 3,500 cases, whereas in Hawaii canneries are capable of packing as much as 150,000 cases in a single day.[83] Hawaii cans roughly 55 per cent of the total world pack, whereas Puerto Rico packs only 2.2 per cent. By comparison, the former packs more fruit in ten days than the latter does in an entire year. The largest Puerto Rican canneries currently are processing only 10 to 15 tons of fruit per hour, whereas Hawaiian plants are handling as many as 250 tons during the same period.[84]

In 1951 only six pineapple canneries were operating in Puerto Rico. Three years earlier there were fourteen pineapple canneries operating in Cuba, eight in Mexico, and eight in Hawaii. However, it should be remembered that there is no direct correlation between the number of canneries and the volume of pack. For instance, one

---

[83]U.S. Department of Labor, Public Hearing before Special Industry Committee No. 5 for the Purpose of Receiving Evidence to be Considered in Recommending Wage Rates for Employees in the Fruit and Canning Industry in Puerto Rico, (San Juan: Unpublished Report, August 8, 1947), pp. 53-58.

[84]Cook and Chem, 1949, pp. 34-35.

Hawaiian plant processes several times as much pineapple as the factories of Puerto Rico, Cuba, and Mexico combined.

Mechanization in Puerto Rico, both in the processing and production phases, has never kept pace with other major pineapple-producing countries of the world. For instance, the degree of mechanization in the Puerto Rico processing phase is roughly 40 per cent compared to about 95 per cent for Hawaii. This percentage was derived by dividing the total number of factory workers into the total pack on a five-year average for the two countries. The ratio per worker was 1,650 cases in Hawaii compared to 715 cases per worker in Puerto Rico. This difference between the respective countries is attributed to the lack of sufficient working capital, lack of technical knowledge, and poorly organized production and marketing structure within Puerto Rico's pineapple industry.

Although the processing of pineapple in Puerto Rico began in 1902 (see Chapter II, Section 7, "Early Growth, Development, and Changing Structure"), it did not play any major role in the island's economy until 1944 (Table 17). The canning industry developed as an offshoot of the growing of fresh pineapples, as canning was commonly done in order to salvage: (1) That portion of the fresh fruits which could not otherwise be marketed owing to low prices, (2) the over-ripe fruit, and (3) the fruits

TABLE 17

VALUE OF PINEAPPLE EXPORTS FROM PUERTO RICO, FISCAL YEARS 1920-21 TO 1949-50[a]
(Value in dollars)

Fiscal Year	Fresh Fruit	Average Price per Crate	Prepared or Preserved Fruit	Average Price per Pound	Grand Total
1920-21	574,640	- - -[b]	48,146	- - -[b]	622,786
1921-22	600,514	- - -	71,228	- - -	671,742
1922-23	726,091	- - -	70,275	- - -	796,366
1923-24	811,925	- - -	162,493	- - -	974,418
1924-25	1,046,503	- - -	153,574	- - -	1,200,077
1925-26	1,534,173	- - -	162,099	- - -	1,696,272
1926-27	1,791,109	2.99	128,183	0.09	1,919,292
1927-28	1,654,108	3.01	142,268	.07	1,796,376
1928-29	1,727,063	3.27	241,799	.10	1,968,862
1929-30	1,743,862	3.48	359,447	.08	2,103,309
1930-31	2,278,449	3.24	123,316	.07	2,401,765
1931-32	1,896,728	3.08	135,403	.06	2,032,131
1932-33	1,225,225	2.96	13,292	.05	1,238,517
1933-34	1,056,673	2.49	62,817	.06	1,119,490
1934-35	911,219	2.30	131,861	.07	1,043,080
1935-36	1,183,424	2.27	123,381	.06	1,306,805
1936-37	1,213,978	2.32	266,352	.06	1,480,330
1937-38	939,451	1.94	166,447	.06	1,105,898
1938-39	862,423	1.86	142,721	.06	1,005,144
1939-40	842,801	1.98	229,442	.06	1,072,243
1940-41	901,735	1.99	223,229	.06	1,124,964
1941-42[c]	483,454	1.99	323,797	.10	807,251
1942-43[c]	- - - -[d]	- -	472,677	.11	472,677
1943-44[c]	40	5.00	1,308,099	.11	1,308,139
1944-45[c]	54,309	4.41	1,733,804	.13	1,788,113
1945-46	499,596	4.06	2,036,142	.14	2,535,738
1946-47	549,697	4.09	2,530,385	.13	3,080,082
1947-48	710,458	4.00	4,103,363	.15	4,813,821
1948-49	1,164,039	4.01	2,550,370	.14	3,714,409
1949-50	1,057,967	4.17	2,597,294	.11	3,655,261

[a]Sources: U.S. Department of Commerce, Monthly Summaries of Foreign Commerce (monthly and annual reports 1935 to 1949), San Juan, Customs District of Puerto Rico, and unpublished data from Citrus and Deciduous Fruit and Vegetable Branch, Production and Marketing Administration, U.S. Department of Agriculture, 1951.

[b]Figures not available.

[c]Shipments to the United States only.

[d]No shipments owing to war-time shipping facilities.

unmarketable because of poor quality or undesirable size.

By far the greatest stride in pineapple processing in any single period since its beginning has been achieved since the end of World War II. New factories have been established (Table 14), modern equipment secured, technical advisors employed, and standards of products improved. Each of these factors has contributed immeasurably to increased production or improved quality. General improvements and tried and proven techniques are being shared by some of the canners; meetings are frequently held to discuss common problems and means of solving them. This is a positive step in the right direction.

3. Processing Stages

It is not the purpose or aim of the writer to discuss in detail each intricate operation in the actual processing of pineapples in Puerto Rico nor to compare operations of one canner with that of another. It is, however, within the scope of this investigation to familiarize the reader with the major stages of processing and to make broad comparisons with those that have been employed successfully elsewhere as to the degree of mechanization, continuous flow of work, and the maximum use of labor force. Each plant employs different makes of equipment, requiring different techniques, and produces a wide range of products (Table 18). The writer

TABLE 18

OUTPUT OF PROCESSED PINEAPPLE IN PERCENTAGE OF TOTAL PINEAPPLE PRODUCTION IN PUERTO RICO AND HAWAII[a]

Style	Puerto Rican Production (Fiscal Year, 1948-49)		Puerto Rican Production (Fiscal Year, 1949-50)		Hawaiian Production (Fiscal Year, 1947-48)	
	No. 2-Sized Cases	Percentage Total	No. 2-Sized Cases	Percentage Total	No. 2-Sized Cases (in 1,000's)	Percentage Total
Crushed (sweetened)[b]	347,143	33.11	302,542	43.16	3,232	13.9
Crushed (unsweetened)	303,550	28.95	--------[c]	-----[c]	759	3.3
Tidbits	42,759	4.07	9,485	1.36	1,520	6.5
Chunks	8,724	0.83	2,135	0.31	1,755	7.5
Sliced	115,832	11.05	122,657	17.49	6,024	26.6
Cubes	7,531	0.73	25,191	3.62	-----[d]	----[d]
Fingers	-------[d]	-----[d]	2,584	0.37	-----[d]	----[d]
Juice	222,961	21.26	236,154	33.69	9,869	42.2
Total	1,048,500	100.00	700,748	100.00	23,159	100.0

[a]Sources: Adapted from an unpublished letter from the Insular Bureau of Agricultural Economics, Department of Agriculture and Commerce to Office of Territories, United States Department of Interior, Washington, August 9, 1951, and data obtained from the Statistical and Historical Research Branch, Bureau of Agricultural Economics, United States Department of Agriculture, June 1951.

[b]See Glossary for definition of style or cut of pineapple.

[c]No differentiation made between sweetened and unsweetened crushed pineapple packed in 1949-50.

[d]None packed.

has combined the best techniques used by all canners in Puerto Rico. This treatment, it is believed, will best aid future planners and builders of pineapple processing factories.

There are four separate and distinct stages in the processing of pineapples: (1) Fruit preparation, (2) packing, (3) canning, and (4) warehousing.

(1) Fruit preparation. Fruit is commonly packed in wooden boxes in the field and hauled by truck to the factory topping shed where it is unloaded by manual labor. At the topping shed the first task consists of removing the crown and butt of the fruit. This is done by the use of a sharp knife, called a machete. The fruit is then placed on a moving belt and delivered to the grading bin. Fruits are generally, but not always, washed prior to grading for size. Washing the fruit at this point serves to remove dust and vegetable fragments and to assist the movement of pineapples along the production line.

The fruit-grading machine in its simplest form consists of a moving belt and a series of sorting rollers at various distances above the belt. The rollers, set at an angle of about 45-degree from the longitudinal axis of the belt, force the fruit off the belt into bins. The largest fruits are forced from the endless belt first; the second roller being a fraction of an

inch lower or nearer the belt beneath carrying the fruit forces off the next largest size, and so on, until three or four grades of fruit have been separated. The three recognized grades of fruit are based normally on the diameter of the standard cans used to pack cut-slices: Number 1 fruit, over 5 inches in diameter; Number 2 fruit, 3 7/8 to 5 inches; and Number 3 fruit, 2 3/4 to 3 7/8 inches. If a Number 4 fruit size is desired, it is processed mainly into juice and crushed pineapple.

Peeling and coring of the fruit is perhaps the most important single operation in the entire processing phase because the method of removing the skin or shell and the core determines largely the grade and style of pack as well as the percentage of waste incurred. The "complete" Ginaca machine, invented by Henry Ginaca in Hawaii, removes the shell and core in a single operation (Plate XI). The cylinder of fruit coming from the Ginaca drops down a chute and passes in one continuous stream into the next department for further processing. The fruit shells, which fall away from the peeler and corer, as well as the cores and cut-away portions of fruit fragments, are carried by belt to a juice extraction machine which separates the remaining portion of the edible fruit from the inedible portions. The inedible portions are later converted into livestock feed.

(2) Packing. The cut-fruit cylinders coming from the Ginaca pass along a rubber belt to the trimming tables

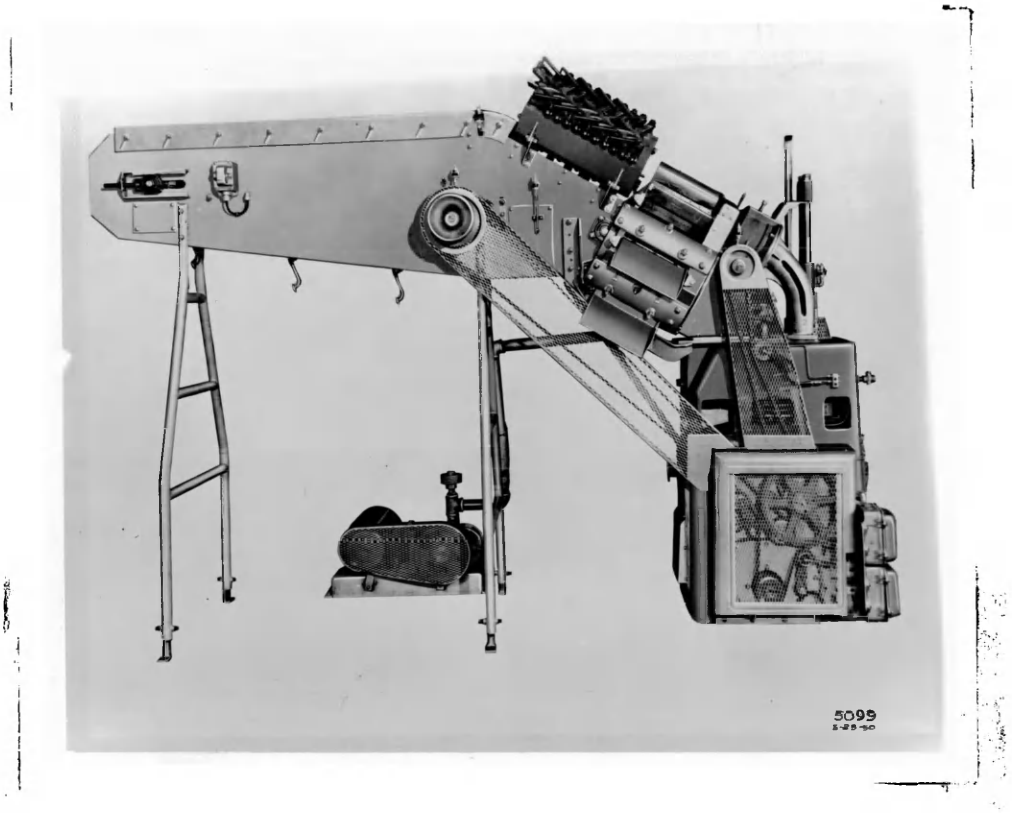


Plate XI.--"Complete" Ginaca, a Labor-Saving Device

This complicated machine, costing $16,700, peels and cores a maximum of 65 pineapples per minute. May 1950. (Courtesy of Food Machinery and Chemical Corporation.)

where women with rubber gloves remove blemishes with special knives (Plate XII). These workers are responsible for cutting out deep eyes, ragged edges, bruised marks, and green spots not removed by the peeler and coring machine or the Ginaca. The trimmed cylinders are then placed on a stainless steel link belt, fitted with lugs, which carry the fruit to the slicing machine.

The mechanical slicer is simple and efficient and yields (except for the two ends) exactly uniform clean-cut slices. Slices are cut in two thicknesses, one inch and one-half inch. The former are for subsequent conversion into chunks, the latter are packed as slices, tidbits, or other styles. The slicer consists of a series of vertical, razor-sharp, steel blades, so that the blades pass through slots in a horizontal stainless steel tube through which the fruit cylinders are forced in continuous pulsating procession with a regular pause to allow the knife to slice through the line of the fruit. An integral part of the machine is a spray washer which removes, before the fruit is sliced, any adhering particles or fragments left by the trimmers.

The sliced fruit emerges from the slicer and is carried by means of a rubber belt to stainless steel packing tables. Sorting and grading is determined largely by texture, color, defects, and physical uniformity. Women at the head of the table select the more perfect slices for the "fancy" pack and replace the rejects on



Plate XII.—Hand Labor in Processing Pineapples

Fruit blemishes and the "eyes" are removed exclusively by hand. This is one of the most expensive operations in the entire processing phase. Caps, uniforms, and gloves are provided by all canneries. No date. (Courtesy of Revista de Agricultura de Puerto Rico.)

the moving belt.[85] Other members of the team remove the remaining whole slices from the rejects for the "choice" pack, and allow the broken, thin, or irregularly cut slices to pass to the last group of women, who pick segments or broken rings for "standard" pack, leaving broken fragments and thin edges to be carted away to the crushing machine. The chunk, cube, and tidbit cutters operate on the same principal as the sliced fruit and grading is conducted in similar fashion. Cylinders of fruit destined to be packed as "fingers", however, are cut by a special machine and are not sliced, but grading and sorting is standard procedure regardless of the style.

In order to insure uniformity of sorting and grading irrespective of weather conditions (i.e., sunny or overcast), standard conditions of lighting are provided in the modern factories. One factory visited by the writer had a line of flourescent lamps, above each trimming, grading, and packing table, that provided brilliant daylight conditions.

Cans used in packing fancy cuts are usually delivered to the packing tables in wooden boxes or trays. Trays generally contain from 12 to 24 cans each, depending upon the size of the cans. This is one of the most

---

[85] Such technical terms as "fancy", "choice", "standard", "chunks", "cubes", "tidbits", and "fingers" are defined in the Glossary.

tedious operations and one of the most likely points for disruption of continuity in the entire processing phase. Confusion of grade may be avoided by use of identifying letters, numbers, or colors on each tray or individual can prior to its delivery to the packing table. Containers must be conspicuously marked so that each grader, cart-operator, and closing-machine operator is well aware of the various grades as they are carted away to be canned.

(3) Canning. In the larger factories, there are a number of flow lines in operation simultaneously. Trays of filled cans are carted to the appropriate reception point. The fruit is then given a final inspection to see that the proper amount of fruit is in each can; the can is examined also for imperfections that might cause the fruit to spoil at a later date. Sugar, in the form of syrup, may be added by a separate mechanical operation before the cans are sealed.

Of the two common methods employed in sealing cans, vacuum and exhaust, only the latter method is employed in Puerto Rico.[86] In the exhaust process, after syrup is added to the fruit the open can is preheated in a continuous steam exhauster or hot box for a period of

---

[86]Both methods are used in Hawaii. The chief advantage of the vacuum method is that it reduces the over-all time for the canning stage by roughly one half (eight to nine minutes).

five to six minutes, or more according to size of can. Cans are then passed through the closing-machine, which seals the lids. Finally, the canned fruit is placed in a continuous agitating cooker at 190° to 195°F. for a period of 12 minutes, or more for larger cans. The over-all canning time by the exhaust process is roughly 17 minutes. The exhaust process serves a three-fold purpose: It preheats the contents of the can to a temperature near boiling point, thus reducing the time the can must be in the cooker; secondly, it expands the contents of the can so that after the lid is securely fastened, a vacuum is created; and thirdly, it forces the air from the intercellular spaces and thereby deepens the color of the fruit.

After the cans have been removed from the cooker, they are placed in a vat of cold water for four to six minutes. The temperature is sharply reduced, so that any overcooking of fruit is avoided. If, however, water-cooling is unduly prolonged the cans may not dry properly and are apt to rust in storage. It is generally agreed that the emerging cans should not be cooler than 90°F.

A new product called "aersol" has been used successfully by Dole Packing Company in Hawaii to reduce the surface tension of the water so that it will run off the emerging cans as they roll off the runways. The use of this product serves three purposes: First, to reduce

the number of handlings of cans; second, to reduce storage space; and third, to provide a continuous flow of work.

(4) Warehousing. After the filled cans arrive from the coolers, it is the general practice in Puerto Rico to stack the cans on the floor of warehouses for several days before labeling or boxing for temporary storage. Unlike Hawaii, most of this work is done by hand. In Hawaii, however, the canners use wooden palettes on which they place their cans for drying. On these palettes are trays, each holding two dozen cans, they are automatically loaded and stacked by machine.

In Puerto Rico, after the cans have been fully dried, they are usually cased or stored until labeled, sometimes days or weeks later, varying with individual canner and the degree of pressure to fill backlog of orders.

4. Materials and Equipment

Perhaps the most striking feature in the Puerto Rican canneries constructed since World War II is the lavish use of stainless steel which has replaced copper, galvanized iron, wood, brass, and to a lesser extent aluminum. Although stainless steel is extremely expensive compared to many of the other metals mentioned above, it is thought, in the long run, to be the cheapest and most satisfactory material known.

The writer was informed that grading and packing tables covered with galvanized iron lasted, at most, only through one canning season, while stainless steel will last at least ten, and perhaps 15 years. This light-weight metal, in addition to being the most acid-resistant material known, has one major advantage over rubber, the most satisfactory substitute, for use in contact with cut fruit or juice; it is more easily washed and rendered sterile. Some of the more important items of equipment containing stainless steel that are essential in pineapple canning include: slicers, pasteurizers, storage tanks, table tops, knives, and buckets.

Rubber, generally considered to be the only other satisfactory alternative, also has varied uses. It is used for conveyor belts, aprons and gloves, steam and water hoses, and for other purposes. Other materials used in considerable quantities include corrugated iron, steel, paint, copper, and glass.

In summary, it can be stated that practically all of the power-driven machinery and tools and much of the other materials necessary for continued operation of the Puerto Rican pineapple canneries are imported from the United States. This factor in itself greatly increases the over-all operating costs and tends to lower production efficiency. Any changes in the processing

flow lines, small as they may be, require careful planning and perfect timing months in advance of the harvesting season. Several of the canners cannot afford to purchase large stocks of spare parts needed in the event of a sudden break-down. Temporary interruptions in pineapple canneries during the harvesting period often results in serious losses. Factories with old and worn equipment generally suffer the greatest losses in the case of a prolonged break-down, especially when substitute materials and repair shops are available only in San Juan. The problem of materials and equipment essential in canning pineapple is further complicated by the fact that there is little exchange of spare parts among canners once the harvesting season begins. Spare parts and substitute materials, purchased mainly during the off-season, are the only assurance that the canner has that his contracted fruit will be packed. The writer views this unsolved problem as one that can be removed in a unified corporate structure for the canning industry (see Chapter V, Section 3, "Recommended Steps").

5. Subsidiary Industries and By-Products

Although pineapple juice has, in the past, been considered a subsidiary industry of secondary importance in Puerto Rico, it can no longer be classified as a true subsidiary industry because roughly one-third to one-half of the total pack is produced and sold in this form.

By 1952, one Puerto Rican canner was expected to be devoting his entire factory to the processing of frozen fruit concentrate. This ultra-modern factory has an annual capacity of 500,000 gallons of juice. Although actual operations did not commence until mid-1950, it appears to be one of the most promising outlets for pineapple juice and may be the key to future success of the entire industry.

Other methods of preserving pineapple in its various forms, in addition to canning, are drying and preserving in sugar. To the knowledge of the writer, no dried or candied pineapple has thus far been exported from the island. It is recommended strongly by the writer that each of these methods of preserving be explored with the purpose of finding new and more profitable outlets for pineapple products.

Preserving of pineapple, as done in Hawaii, is accomplished by boiling and soaking chunks or slices of fruit in a succession of hot syrups of gradually increasing concentration, starting at approximately 30 Brix and finishing at about 72 Brix.[87] Candied or crystalline pineapple is obtained if the chunks of fruit are finally immersed in hot super-saturated sugar solutions, and allowed to drain on a steel grill until comparatively dry.

---

[87] See Glossary.

6. Possible Utilization of Pineapple Waste

Cut fruit is the economic backbone of the canning industry, and the yield of sliced pineapple in Puerto Rico is approximately 10 per cent of the total weight of the whole fruit; in Hawaii the yield of cut-fruit slices is approximately 16 per cent.[88] The difference in yields of cut fruit between the respective countries is due in part to the variety of fruit grown. The Smooth Cayenne variety of Hawaii averages about a pound more per fruit than the Red Spanish of Puerto Rico. Moreover, the Smooth Cayenne, in contrast to the Red Spanish, has shallow eyes and an almost cylindrical shape. Both depth of eyes and shape of fruit have a direct bearing on the percentage of the weight of the fruit that can be utilized.

It is extremely difficult to determine precisely the total weight of the whole fruit that can be utilized in any given year. The exact per cent depends on quality, size and shape of fruit, variety, style of cut (i.e., slices, chunks, fingers, tidbits, etc.), and even the efficiency of cutting. The residue (shells, tops, tails, cores, etc.) of the fruit, formerly regarded as waste, constitutes between an estimated 60 and 70 per cent of the total weight.

---

[88]Cook and Chem, 1949, pp. 39-40.

With the introduction of the fruit eradicator in 1947, it was possible to increase the yield of canned or preserved products in Puerto Rico to about 50 per cent of the total weight of the fruit, mainly because the eradicator salvages pineapple flesh much closer to the outer shell. The green (outer) skin of the fruit, constituting 25 to 35 per cent by weight, presented an extremely difficult problem. Juices extracted were bitter and rank and apparently of little use; and the skins were too wet and soggy to dry economically for boiler fuel. These skins when fed to livestock, save for small amounts, invariably resulted in diarrhea and other disorders. However, recent experiments in Hawaii have proved that by removing certain acids and alcohol compounds from the residue, pineapple skins can be converted into a silage or rough feed for dairy cattle. This is accomplished through the use of a fruit dehydrator.

The first dehydrators are currently being tested in Puerto Rico. No concrete results were available to the writer during period of field work. Although there are two processes by which pineapple skins may be converted into livestock feed, the writer will describe briefly only one method. Pineapple skins are first pulverized in a vertical shredder and twice pressed to extract as much bitter juice as possible. The resulting meal still contains considerable amount of moisture.

This moisture is driven off by passing the ground meal through a rotating tubular drier heated by a flame from an oil burner. The resulting product, called pineapple bran, is crisp and sweet, and enthusiastically devoured by livestock.

It has long been known that alcohol and vinegar can be processed from the bitter skin juices, but as both of these common products can be more easily and cheaply obtained from other sources, no great importance was attached to solving this problem until recently. Once again the Hawaiian pineapple research staff discovered ways of utilizing these bitter juices. Pineapple juices normally contain between 10 and 14 per cent sugar and can be converted into solutions containing from 4 to 5 per cent ethyl alcohol. This alcohol can be concentrated in a fractionating still to the desired strength. It may be converted into vinegar in either of two ways: First, by permitting the alcohol solution to stand for several days in wooden barrels in contact with beech shavings; secondly, by a complicated redistillation process. Thus far, to the knowledge of the writer, no attempts have been made in Puerto Rico to process either vinegar or alcohol from pineapple juice.

Pineapple tops (crowns) in Puerto Rico are little utilized; they are either left in the field to rot or are carted away from the cannery and dumped in some

out-of-way place. In Hawaii, however, they are chaffed and fine-chopped. Whenever fed to dairy cattle, these green or fermented tops, are reported to produce higher yields of milk than Napier grass.[89]

Because pineapple tops constitute about 7 per cent of the total weight of the fruit, it is estimated that the total available supply of tops in Puerto Rico is roughly 3,500 tons annually. The writer was informed that the average milk cow would consume an estimated one ton of tops per month, so that the pineapple tops in Puerto Rico would form a rough feed for a herd of 300 cows if available sources were collected.

There are numerous other possible uses of pineapple waste which thus far have not been exploited in Puerto Rico; of these, the writer will mention only three. Immediate steps should be taken to study the possibilities of extracting fiber from pineapple leaves. It has long been known that the fiber from the sterile pineapple plant is suitable for making fine cloth, but it is not known whether the Red Spanish variety would be best for this purpose. Piña cloth, woven from the fiber obtained from the pineapple leaf, is soft, strong, flexible, and transparent. It is particularly suitable for scarfs,

---

[89]D.L. Crawford, Hawaii's Crop Parade (Honolulu: Advertiser Publishing Co., 1937), pp. 200-204, and Cook and Chem, 1949, p. 66.

handkerchiefs, embroidery, etc. Since Puerto Rico is noted for its needlework (in 1949-50 exported nearly 43 million dollars worth of woven fabrics, or 18 per cent of her total exports), it seems that this new avenue of research may prove to be important in the future.

Next, experiments should be conducted to determine the possible use of pineapple bran in combination with other feeds for livestock because additional feed is urgently needed under the present expanding livestock industry of the island. A third possible use of pineapple waste is for the extraction of bromelin, a proteolytic enzyme similar to papain. It is obtainable from pineapple juice and the latex of the leaves and stalk. The methods of obtaining bromelin, although at present uneconomical, involve two complicated distillation processes which are necessary to separate this enzyme from the alcohol equivalent of the sugar. Experiments reveal that bromelin is about as effective as papain in tenderizing meat, yet possessing a pleasant odor. In the future bromelin may prove to be of major importance in both industry and medicine.[90]

---

[90]U.S. Department of Agriculture, Protein-Digesting Enzymes of Papaya and Pineapple. Circular No. 631 (Washington: Government Printing Office, 1941), p. 9.

B. Marketing

1. Introduction

Approximately 95 per cent of Puerto Rico's total pineapple production normally is sold abroad; the remainder is marketed locally. Whereas the local market is dominated by domestic pineapple products, in the overseas markets, Puerto Rico must compete with a large number of other pineapple-producing countries (Table 19). The principal competition for the fresh fruit market in the United States is provided mainly by Cuba and Mexico, and for the processed fruit market, Hawaii and Cuba. Since the problems and characteristics of fresh and processed fruit marketing differ so radically in structure, they are discussed separately.

2. Marketing Problems

The marketing of pineapples is the most difficult and the most uncertain of all the major cash crops, excluding perhaps coffee, grown in Puerto Rico. There are various reasons for this fact. Because pineapples are considered a luxury food, their consumption the world over fluctuates from year to year and from one season to another. In time of depression, the pineapple industry is one of the first to feel the effects. On the other hand, during prosperous periods the demand for pineapples frequently cannot be met. This situation

TABLE 19

ANNUAL PRODUCTION OF CANNED PINEAPPLE IN ACTUAL CASES FOR LEADING COUNTRIES OF THE WORLD, 1948-1950, INCLUSIVE[a]
(In Thousands of Cases, Solid Pack)[b]

Year	Hawaii[c]	Cuba[c]	Mexico[c]	Puerto Rico[c]	Other Countries[d]	Total Known World Pack
1938	12,203	167	f	112	5,137	17,639
1939	10,521	150	f	93	4,282	15,046
1940	10,999	300	f	93	5,466	16,858
1941	10,056	300	f	85	5,817	16,258
1942	10,515	530	15	111	800	11,971
1943	11,230	735	56	222	454	12,697
1944	11,126	435	95	255	196	12,097
1945	10,164	390	110	385	134	11,183
1946	9,051	960	214	404	218	10,847
1947	10,237	1,000	500	527	121	12,385
1948	11,492	1,229	327	519	837	14,404
1949[e]	13,696	784	246	527	767	16,020
1950[e]	14,372	261	308	500	f	15,441

[a]Sources: J.L. Collins, "History, Taxonomy and Culture of the Pineapple", Economic Botany, Vol. 3, No. 4 (New York: New York Botanical Garden Press, 1949), p. 356, and U.S. Department of the Interior, Annual Report of the Governor of Hawaii to Secretary of the Interior (Fiscal Year Ending June 30, 1950) (Washington: Unpublished Report, 1950), p. 110.

[b]"Solid pack" includes all canned pineapple except juice.

[c]Based on 36 pounds per case. Weights in "other countries" range from 25 to 45 pounds per case.

[d]"Other countries" include British Malaya, South Africa, Australia, Formosa, and the Philippine Islands.

[e]Statistics for 1949 and 1950 obtained from the Production and Marketing Administration, U.S. Department of Agriculture, Washington, 1951.

[f]Data not available.

existed in 1951 while this dissertation was being prepared.[91]

Another major defect of Puerto Rico's pineapple marketing structure is that production has never been geared to distribution. It has been more or less a hit-and-miss proposition for both producers and distributors. Nearly two years are required from the time pineapple slips are planted until the fruit is ready for market. In spite of this lapse of time between planting and harvesting, there are many so-called "fair-weather growers", who commonly plant large areas in pineapples when prices are high and the demand great, and plant few or no pineapples when prices are low or the demand weak. As a consequence, a favorable relation between supply and demand at time of harvest is more or less coincidental. This practice causes a highly irregular flow of fruit from farm to market and entails considerable loss when the market is glutted, especially in the fresh market.

Records reveal that growers who devote a fairly constant amount of land to pineapple production year

---

[91]Representatives of John G. Paton Company state that 50 per cent more Puerto Rican pineapples could be sold than will be canned in 1951. George H. Kendall, agent for Simens and French Company Inc., reports that 33 per cent more fresh fruit could be marketed fresh than will be received during 1951, provided the market is not glutted during any one week. Maximum weekly requirements range from 8,000 to 15,000 crates. (From conferences held with these two New York pineapple distributors in March 1951.)

in and year out receive the highest returns on their investments in the long run. The stability of the pineapple market, like that of most other cash crops, is directly influenced by the laws of supply and demand. As mentioned above, the factor of demand is far more difficult to regulate than the factor of supply; therefore, it would seem logical to attack the supply problem where comparatively few interests are involved. The supply of pineapple, both fresh and processed, could be quickly and effectively controlled by the establishment of an Insular or a Federal quota or allotment system similar to that currently enjoyed by the cane and tobacco growers. (See Chapter V, Section 3, "Recommended Steps".) Ways must also be found to insure a more stable marketing structure. One possible way would be to devise a form of crop insurance which would serve to stabilize earnings of the growers.

3. Foreign Market

Fresh Fruit. The United States constitutes almost the exclusive "foreign" market for Puerto Rico's fresh pineapple. Since pineapple production within the continental limits is negligible, the United States must look abroad for supply to meet her needs. Furthermore, Puerto Rico does not have any regular and dependable steamship service or marketing outlets to any other major country except to the United States. Fortunately,

Puerto Rico's fresh pineapples can compete favorably in price and quality with that of Cuba and Mexico in the New York market. Puerto Rican pineapples normally average from $0.75 to $1.00 more per crate for a given size than either Cuban or Mexican fruit at auction sales (Table 20). One of the principal reasons for this price differentiation is the fact that Puerto Rican growers grade their fruit more carefully than do growers in Cuba and Mexico.

Approximately 95 per cent of the fresh fruit from Puerto Rico is distributed through one concern,[92] the remainder by large chain stores. New York is the only port of entry for Puerto Rican fresh pineapple. This is because a single steamship line (Bull Lines Inc.), holding a franchise between San Juan and New York, provides the only regular and dependable service.

Cuba supplies approximately 36 per cent and Mexico 10 per cent of the total sales in the New York market,[93] the bulk being channeled through South Atlantic and Gulf ports where distances, freight rates, and competition are

---

[92] Simons and French Co. Inc., New York City, representing 25 of the Island's largest growers, handled roughly 255,000 crates during 1950 (Table 21).

[93] Of the total number of crates of pineapples entering the New York market in 1948, Puerto Rico supplied 178,000 crates; Cuba, 116,000 crates; and Mexico, 31,500 crates. U.S. Department of Agriculture, Production and Marketing Administration (unpublished statistics), July 1951.

TABLE 20

PUERTO RICAN AND CUBAN PINEAPPLES SALES AT NEW YORK AUCTION[a]
(Week of April 17, 1951)

Puerto Rico Sales (Value in Dollars)

Brand	Number of Crates	Number of Fruits per Crate,[b] by Size						Average Price Received
		18	24	30	36	42	48	
Lotus	874	5.81	6.46	5.76	4.70	----	----	5.95
Marquis	248	5.22	5.55	4.85	4.25	3.55	----	5.23
Cidra Farms	265	5.75	5.85	5.30	4.45	3.90	3.19	4.82
Caribbean	108	4.55	4.10	3.60	----	3.40	----	3.86
Blue Diamond	1,322	7.35	7.30	6.15	5.20	4.10	----	6.18
Gloria	541	7.20	7.10	6.32	5.08	4.13	----	6.44
Boriquen	700	7.80	7.95	6.51	5.31	4.29	----	5.84
Santana	258	----	6.10	5.17	4.67	----	----	5.03
Rainbow	148	5.25	6.25	4.92	----	----	----	5.67
Starlight	103	----	5.75	5.20	4.70	3.90	3.40	4.28
Bonita	1,180	7.70	7.60	6.55	5.09	4.09	3.55	6.08
Walcott	238	6.05	6.36	5.40	----	----	----	5.93
Blue Diamond No.8	430	7.45	7.25	5.69	4.60	4.15	----	5.66
Amapola	1,587	5.47	6.30	5.62	4.72	4.15	----	5.51
Linda	95	----	6.90	5.95	5.00	4.20	----	5.43
White Star	139	----	5.40	5.02	4.32	4.05	3.35	4.69
Total	8,236							5.76

Cuban Sales (Value in Dollars)

		Number of Fruits per Crate,[b] by Size						
		7	8	9	12	15	18	
Ferro	961	----	----	2.51	2.56	2.40	----	2.51
Blue Goose	322	----	----	2.20	2.15	2.10	----	2.12
Las Canas	104	----	2.25	----	----	2.35	----	2.31
El Morro B.S.	700	----	----	----	2.85	2.45	----	2.62
El Morro Canas	659	2.35	2.55	2.80	2.80	----	----	2.64
C.P.F.	501	----	----	----	2.40	2.15	----	2.19
Total	3,247							2.47

[a]Source: Consultation with representatives of Simons and French Co. Inc., importers and exporters of fresh fruits, 99 Hudson Street, New York City. June 1951.

[b]Puerto Rican growers ship their fruit in a standard wooden crate with a 70-Pound net capacity, whereas Cuban growers use a one-half size, wire-bound crate with a 35-Pound net capacity.

TABLE 21

PINEAPPLE PRODUCTION AND FRESH EXPORTS FROM PUERTO RICO[a]
(Crop Years 1928 to 1951)

Crop Year	Production (in crates)[b]	Number of Crates Exported Fresh[c]	Percentage of Crop Exported Fresh
1928	800,000	549,280	68.66
1929	775,000	528,522	68.20
1930	750,000	501,058	64.65
1931	1,000,000	703,280	73.33
1932	875,000	614,058	70.18
1933	625,000	409,868	65.58
1934	650,000	413,336	63.59
1935	657,000	395,613	60.22
1936	776,000	521,016	67.14
1937	810,000	523,140	64.59
1938	703,000	484,734	68.95
1939	725,000	463,860	63.98
1940	650,000	425,022	65.39
1941	480,000	451,095	93.98
1942	500,000	242,700	48.54
1943	450,000	----	---
1944	450,000	8	.0017
1945	550,000	12,304	2.24
1946	618,000	123,072	19.91
1947	1,000,000	134,317	13.43
1948	1,100,000	177,684	16.15
1949	1,234,000	290,436	23.54
1950	1,031,000	269,872	26.18
1951	1,060,000[d]	275,000[d]	26.04

[a] Sources: Frank Zorrilla, La Industria de la Piña en Puerto Rico (San Juan: Unpublished Report to the Governor of Puerto Rico; 1950), p. 7.

[b] Crate equals 70-pounds net.

[c] Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-50 (San Juan: Office of Economic Research, 1951), p. 378.

[d] Estimates prepared by Bureau of Agricultural Economics, Puerto Rico Department of Agriculture and Commerce, March 1951.

not so great.[94] Moreover, Cuban and Mexican shippers are required to pay a tariff of three-fourths of a cent per pound on all fruit entering the United States proper since they do not enjoy the tariff protection that is provided territories and possessions of the United States. This cost differentiation, however, in the case of Cuba, is approximately offset by lower freight rates. Cuba's freight rates, based on a hundred-weight, amount to roughly 25 cents per crate from Habana to Tampa, whereas, Puerto Rico's rates, based on unit weights of 77 cents per crate from San Juan to New York, are about three times as great.

Cuban pineapple growers ship their fresh fruit to the mainland in wire-bound crates, holding about 35 pounds each (Table 20), or one-half as large as the standard Puerto Rican crate (see crate dimensions in Glossary). The reasons for the difference lies in the fact that wire-bound crates of standard Puerto Rican size will not protect the fruit adequately. Cuba's fruit is handled only three times between packer and wholesaler compared to eight times for Puerto Rico's

---

[94] In 1950, the total annual imports of fresh pineapples into the United States amounted to approximately 2,113,000 crates divided as follows: Cuba, 932,583 crates (44.1%); Hawaii, 475,000 crates (22.5%); Mexico, 439,881 crates (20.8%); Puerto Rico, 262,886 crates (12.5%), and from all other countries 2,749 crates (0.01%). U.S. Department of Agriculture, Production and Marketing Administration (unpublished statistics), July 1951.

fruit. In addition, Cuba's shipping costs are based on gross weight, whereas Puerto Rico's freight rates are established on unit weights.

In 1951, the average over-all cost per crate of pineapples shipped from San Juan to New York market amounted to $1.86. Costs are divided as follows: handling fee per crate in San Juan, 2 cents; freight, 77 cents; insurance, 2 cents; handling fee in New York, 65 cents; reconditioning fee, 10 cents; and auction fee based on 6 per cent of sale value ($5.00), 30 cents.[95] The writer concludes that this is one of the basic difficulties with the fresh fruit market, and that far greater efficiency in marketing practices can be accomplished. (See Chapter V, Section 3, "Recommended Steps".)

All fresh fruit shipments from Puerto Rico are administered by the Pineapple Growers' Cooperative Association, which was established in 1939 for this purpose. The principal functions of the Association include arranging for boat space, providing information to individual growers regarding ship sailings, prices of previous sales, and condition of fruit on arrival, and supervising actual loading of ships. The Association has 41 members, including all of the larger fresh fruit

---

95(Based on data obtained from representatives of John G. Paton Co., and Simons and French Co., Inc., New York, 1951.)

growers and canners. In order to maintain this Association, each member is assessed 2 cents per crate on fresh fruit exported and 30 cents per ton on fresh fruit sold locally.

Weather permitting, the pineapple grower, working independently of all other growers, normally harvests and grades his fruit on Monday or Tuesday and transports it by truck to San Juan not later than Wednesday night. The steamship departs on Thursday and arrives in New York harbor early Monday morning, or approximately three and one-half days later. The fruit reaches the auction block on Tuesday. Each lot maintains its identity until sold. From the proceeds of each sale are subtracted transportation costs, handling and reconditioning fees, etc., with payment of balance being made directly to the grower.

Fresh fruit in transit is carefully tended. While aboard ship, crates must be securely lashed in the compartment so that there is no appreciable movement, a major task during stormy weather. Optimum temperatures in the compartments range from 55° to 60°F., with ample ventilation but not refrigeration. Fruit that is chilled will not ripen uniformly. Moreover, chilled fruit during the summer months is subject to sweating on being exposed to normal air temperatures and decay immediately sets in, and considerably more handling is required for refrigerated fruit than nonrefrigerated fruit, thus

increasing the cost and the percentage of bruises and rot per crate.

At present, less than one per cent of all fruit shipments from Puerto Rico are made by use of refrigeration. At irregular intervals when the fruit is harvested too late or prices exceedingly high, refrigeration is utilized. The so-called cold-storage form of shipment costs $1.03, or 26 cents more per crate than the conventional ventilated storage.

After the fruit is sold to wholesaler representatives at the auction block, it normally requires an additional two or three days for it to be trucked or railed to the retail stores. On arrival at the retail stores, the fruit is expected to remain in good condition for another seven to ten days before being sold to the consumer. In total, the pineapple grower must harvest his crop from 17 to 20 days before it reaches its peak of ripeness in order to allow for transportation, handling, and other delays. Even though the marketing structure is so synchronized through each operating stage, from packer to retailer, it is still considered to be an extremely risky enterprise. However, when the demand for fresh pineapples is strong, nearly one-half of all Puerto Rico's commercial growers are willing to engage in this speculative form of marketing.

The foreign fresh-fruit market of Puerto Rico is almost exclusively confined to the Red Spanish variety

of pineapples. This is due primarily to the fact that the Red Spanish is the only variety thus far produced commercially that can withstand rough handling in shipment. Moreover, the Red Spanish, after being harvested, ripens more slowly and more uniformly than any other known variety.

The sporadic appearance of Cabezonas and Smooth Cayennes in the Eastern market is indicative of abnormally high prices, as was the case during the early part of 1951. During March and April of that year, Cabezonas averaged roughly $8.00 per crate at auction; the few Smooth Cayennes brought about $5.50 per crate, and the Red Spanish averaged between $5.00 and $6.00 per crate (Table 20). The volume of Cabezonas and Smooth Cayennes sold at auction during a normal year is not very great. For instance, only 1,500 crates, or less than one-half of one per cent of the total 1950 auction sales, were of the Cabezona variety, all of which were exported from Puerto Rico. However, the 1951 sale of Cabezonas is expected to reach 2,500 to 3,500 crates if prices remain high. The volume of Smooth Cayennes that is sold at the New York auction normally is about one-half to one-third of that of the Cabezonas.

Whenever these two varieties of pineapples reach the Eastern market in considerable volume, based on past experience, the entire economic structure of the fresh fruit market is adversely affected, resulting in sharp

sales decline. This is explained, in part, by the fact that the Cabezonas and Smooth Cayennes become soft and mushy far more quickly than do Red Spanish pineapples, regardless of the precautions taken in shipping and handling. Moreover, it is claimed by some wholesale distributors that the meat of the Cabezonas is not of uniform color, and occasionally contain seeds. Each of these undesirable qualities seriously effect volume of sales of the entire fresh fruit market.

If the demand for fresh pineapples continues strong throughout the remainder of 1951 and 1952, pineapple plantings in Puerto Rico will be greatly expanded. At prevailing prices, it is more profitable for the average grower to market his fruit fresh than to sell part, if not all, of his crop to the local cannery. In any event, the writer predicts that the period of prosperity currently being enjoyed by those engaged in the fresh fruit market will be short-lived, as have other prosperous but brief periods during the past 20 years.

An examination of Table 21 (Pineapple Production and Fresh Exports from Puerto Rico) reveals several definite trends. First of all, over the past two decades, except for the war years of 1943, 1944, and 1945, there has been a gradual downward trend of fresh fruit exports. In 1930, there was nearly twice as much fruit exported as in 1950. Moreover, the percentage of the total crop sold fresh decreased from 64.7 per cent to

26.2 per cent during the corresponding years, in spite of the fact that production has increased by more than a quarter of a million crates.

The marketing outlook is further darkened by a gradual reduction of fresh pineapple sales in the Eastern United States. Prior to 1940, some 60 per cent of all fresh fruit from Puerto Rico was marketed outside of metropolitan New York; ten years later less than 45 per cent was purchased by out-of-town accounts.[96] Among the reasons presented for the decline in fresh pineapple sales are the high freight rates, as reflected in retail selling prices.[97] Increased competition between Cuba and Mexico has further reduced the demand for Puerto Rican pineapples, especially in the South and Mid-West. Perhaps the single most important reason for this decline is the fact that many of the large chain stores purchase fruit directly from Cuban and Mexican growers, thus eliminating most of the middlemen. As a result, Cuban pineapples today are found in retail stores from Portland, Maine, to Denver, and

---

[96] (Consultation with representatives of Simons and French Co., Inc., New York, 1951.)

[97] In July and early August 1951, the writer made a limited survey of retail prices of Red Spanish pineapples in Washington, Baltimore, and Richmond. The results were as follows: Retail prices ranged from 10 to 16 cents per pound ($7.00 to $11.20 per crate); sizes 18 to 24 were in greatest demand, in spite of higher cost per pound (Table 20); fruit of nonuniform color, oblong shape, and conspicuous defects was difficult to sell, regardless of the price.

from New Orleans to Minneapolis, whereas Puerto Rican fruit seldom finds its way south of Richmond, west of Chicago, or north of Boston. Mexican fruit is sold largely in the Southwest, Mid-West, and on the West Coast, competing strongly with Cuban fruit in the first two regions and with Hawaiian fruit in the latter region. In 1947, Hawaii shipped nearly 477,000 crates of fresh pineapples into the United States, or nearly one-fourth of her total requirements (Fig. 20). Los Angeles, San Francisco, and Seattle serve as ports of entry.

There are no agreements, either written or unwritten, between Puerto Rican, Cuban, Mexican, or Hawaiian growers, associations, or their representatives in the United States as to the markets or sections of the country each will serve. Each of these four widely separated pineapple-producing countries invades the continental markets as time and conditions permit. Of the four countries, however, Puerto Rico, because of its single port of entry, is the least flexible of all.

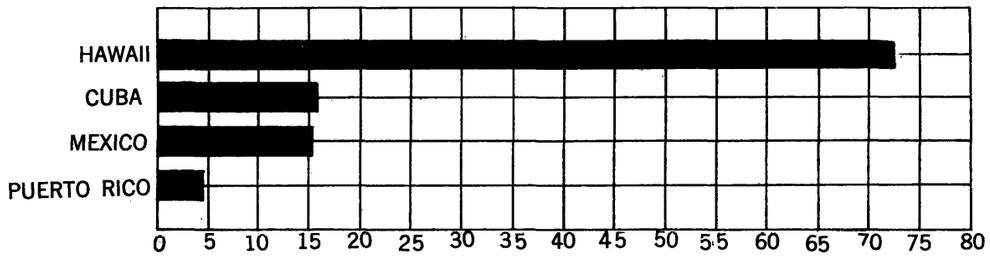
Processed Fruit. Prior to 1944 the principal outlet for Puerto Rican pineapple was the fresh fruit market, which, owing to war conditions for a period of three years, became virtually non-existent because of the lack of shipping facilities; the resulting effect

PRINCIPAL PINEAPPLE-PRODUCING COUNTRIES

SERVING THE UNITED STATES MARKET, 1950

LAND DEVOTED TO PINEAPPLE PRODUCTION BY COUNTRY, 1950

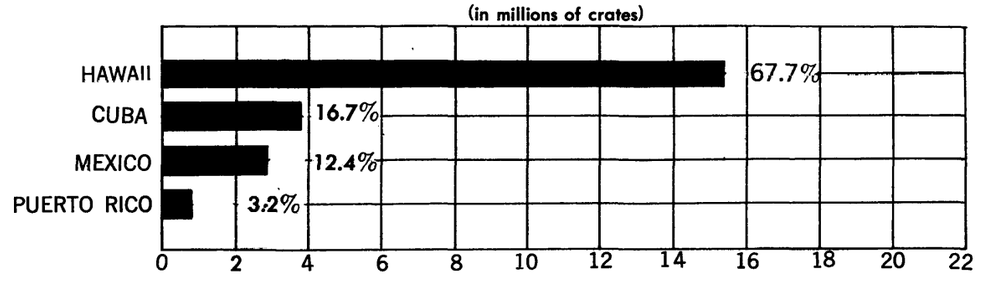
(in thousands of cuerdas)



PINEAPPLE PRODUCTION BY COUNTRY

(10 year average, 1941-50, inclusive)

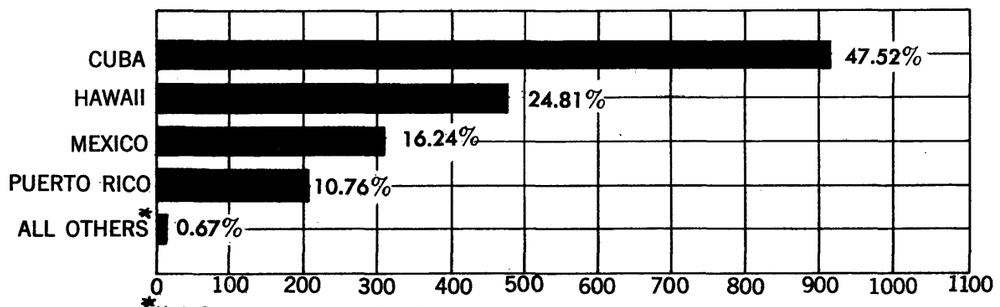
(in millions of crates)



PINEAPPLE IMPORTS INTO THE UNITED STATES, 1947

FRESH PINEAPPLES

(in thousands of crates)

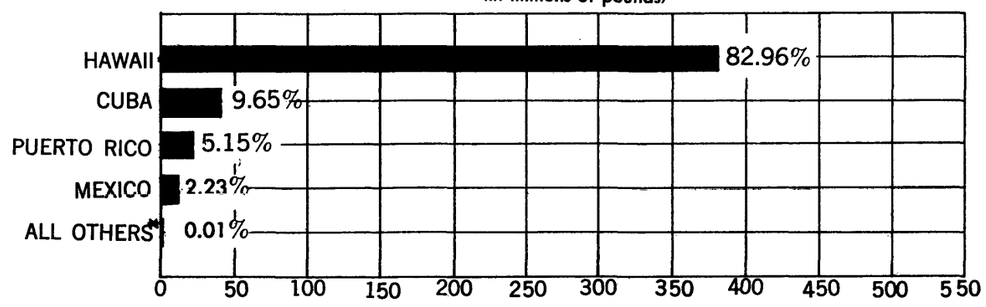


*Haiti, Dominican Republic, and Costa Rico

PINEAPPLE IMPORTS INTO THE UNITED STATES, 1947

PROCESSED OR PRESERVED PINEAPPLES

(in millions of pounds)



*Philippine Islands, Australia, Formosa.

Sources: U.S.D.A. Foreign Crops and Agriculture, Vol. 57, No. 16, Wash. D.C., and unpublished statistics after 1948 from U.S.D.A. Production and Marketing Administration, 1951.

1 cuerda equals 0.9712 acres 1 crate equals 70 lbs. net

Compiled by William W. Burchfiel

Fig. 20—Principal Pineapple-Producing Countries Serving the United States' Market.

has been a rapid transfer of the principal market into the canning industry. Before World War II all processed fruit was prepared and sold in the form of either crushed pineapple or juice, never aggregating more than four and one-half million pounds nor attaining an export value of over one-half million dollars for any single year (Table 22).[98] By 1950, the export value of processed pineapple had risen to more than twice that of fresh exports (Table 17).

As previously mentioned, the United States consumes practically all of Puerto Rico's exported processed pineapple. In the 1950 fiscal year the island exported more than four times the amount it had exported seven years earlier. Throughout the postwar period of rapid expansion, one distributor handled the entire annual pack for the various canners. This system of distribution continued uninterrupted through 1950. However, the sale of the 1951 pack was divided between two continental distributors. John G. Paton Co., the older firm, retained roughly 90 per cent of sales, and the newcomer, Donald Reed Co., the remainder. Both companies have their main offices in New York City.

---

[98] In 1949-50, of the 19,539,250 pounds of canned pineapple exported to all countries, 19,520,000 pounds (99.9%) was sold in the United States. Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-50 (San Juan: Puerto Rico Office of Economic Research, 1951), p. 379.

TABLE 22

EXPORTATION OF CANNED PINEAPPLE FROM PUERTO RICO*
(At 5-Year Intervals, 1927 to 1948)

Fiscal Year	Total Exportation		Average Value per Exported Pound (in cents)
	Pounds	Dollars	
1927-28	2,121,576	142,268	0.067
1932-33	287,793	13,292	0.046
1937-38	2,882,462	166,447	0.057
1942-43	4,427,235	472,677	0.106
1947-48	26,704,724	4,103,363	0.153

* Sources: Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-50, (San Juan: Office of Economic Research, 1951) p. 375, and U.S. Department of Agriculture, Fruit, United States Foreign Trade Related to Production 1910-1949, Foreign Agriculture Report No. 60 (Washington: Office of Foreign Agriculture Relations, 1951), p. 46.

Unlike fresh pineapples marketed in the United States, Puerto Rico's processed fruit up to the present time has not been able to compete favorably in quality or quantity with its chief rival, Hawaii (Fig. 20); the former, however, has been able to compete successfully in price owing largely to low cost of labor. During an average crop-year (1948-49, for example), Puerto Rico exports roughly one million cases of solid pack and juice, while Hawaii can be expected to export from 20 to 25 times as much (Table 18). The volume of Puerto Rican processed fruit that can be sold in the United States is directly influenced by the volume and distribution of the Hawaiian pack.

The United States, world's largest pineapple-importing country, consumes an estimated 435,500,000 pounds of processed cut fruit annually.[99] This is equivalent to roughly 56 per cent of the total world production of commercial pineapples. Annual civilian consumption of pineapples in the United States increased from an estimated 311,520,000 pounds in 1945 to 426,463,000 pounds in 1950, or 37 per cent increase. This increased consumption has been due largely to the sharp rise in family income, especially since 1947.

---

[99]All estimates of pineapple consumption in the United States are based on unpublished data obtained from the U.S. Department of Agriculture, Production and Marketing Administration, Statistical and Historical Branch, July 1951.

Puerto Rico supplies only 5.2 per cent of the total requirements of processed fruit, whereas Hawaii provides 83 per cent (Fig. 20).

In 1951, it was estimated that civilian consumption of canned pineapple in the United States was roughly 428 million pounds. The military rate of consumption, based on 2.4 pounds per capita for 1944-45, amounts to 7.5 million pounds. Civilian per capita annual consumption of canned pineapple was 2.4 pounds in 1945; by 1951, it had risen to nearly 2.9 pounds per capita. For the same period, annual consumption of pineapple juice had increased from 1.1 pounds per capita to 2.1 pounds, or 90 per cent.

Prior to the outbreak of World War II, there were only four canneries operating in Puerto Rico (Table 14). At that time a common remark was, "Let Hawaii have the lucrative processed pineapple market, but leave us (Puerto Rico) the fresh fruit market." Today this remark is no longer heard, for the future of the pineapple industry appears to rest with the processed fruit rather than the fresh fruit outlet. Since 1945 vigorous measures have been taken to expand production and to increase sales of processed fruit. Distributors have been particularly aggressive in expanding the marketing area.

New York distributors, representing the pineapple industry of Puerto Rico, have accounts in 50 of the

principal cities of the United States, extending as far west as Denver and as far south as Lubbock, Texas. Wide distribution is made possible through increased sales of processed fruit to large chain stores. Since chain stores generally prefer to use their own brand names on the labels, consumer education through advertising is reduced to a minimum.

Since neither canners, distributors, or wholesalers have ever invested any capital directly in advertising Puerto Rico's pineapple products, increased sale is dependent solely upon buyer's demand. Perhaps this failure to introduce canned products directly to the consumer through advertising is one of the most serious defects, if not the most serious defect in the entire marketing structure. (See Chapter V, Section 3, "Recommended Steps".)

Since 1947 export value of Puerto Rico's processed pineapple has increased from $2,500,000 to well over $4,000,000, yet not a cent has been allocated directly to advertising its products. By comparison, the Hawaiian pineapple industry in 1909, three years before it reached an annual capacity of one million cases, spent a sum of $50,000 in magazine advertising, using the slogan "picked ripe, canned ripe". The results of this investment were amazing, for all surplus stocks were sold immediately. Four to six years later, 1913-1915, a second advertising campaign was launched, costing

$100,000, although the average annual pack was less than two million cases. Once again all surplus stocks were quickly moved.

Package labelling may, of course, be considered a form of advertising, but even here advertising is deficient in Puerto Rico. Roughly one-half of all the island's processed pineapple is sold unlabelled. There are several valid reasons for this method of marketing. From 40 to 60 per cent of the total annual pack is "crushed" and the ice cream and confectionery industries are by far the larger users of this style of pineapple (Table 16). Such industries utilize from 80,000 to 100,000 cases or equivalent of processed pineapple annually, or roughly 15 to 20 per cent of the total pack. These industries buy in large quantities. The additional expense of costly labels for the cans would not be justified. As previously pointed out, several large independent and chain-store wholesalers purchase considerable amounts of Puerto Rico's pineapple unlabelled in order to use their own special brand names, most of which do not even carry the words "canned in Puerto Rico". Thus, by adding the total industrial sales and those of many wholesalers, perhaps not more than one-half of all Puerto Rico's processed pineapple sales indicate where it is packed.

Since the remainder of the island's processed pineapple is marketed under no less than a dozen

different brand names, and because of the limited scale of production, no one canner can afford to conduct an intensive advertising campaign even for a single large city. However, if all of the island's pineapple products were shipped under a single brand name, as strongly recommended by the writer, a small regional advertising campaign could be established immediately.

As previously pointed out, all processed pineapple sales in the United States are handled through distributors. When a field representative secures an order for Puerto Rican pineapple, the order is cabled or air-mailed to the Secretary of the Pineapple Growers' Cooperative Association in San Juan. Normally, orders are filled and deliveries made within 15 to 30 days, depending upon port of entry, time of transit, and even the season of the year. Regular weekly sailings are made to New York, with occasional sailings to Baltimore, Charleston, Savannah, Jacksonville, Mobile, and New Orleans. Approximately four days are required to the Atlantic ports and seven days to Gulf ports.

Wholesale price lists are subject to change without notice and new prices are printed every month or so. These lists are circulated among the 34 subbrokers and to regular wholesale customers. Prices quoted for processed fruit are f.a.s. (free alongside ship). This implies that the purchaser must bear all handling

charges, freight and insurance, and the 6 per cent tariff, amounting to about 66 cents per case (based on No. 2-sized cans) of fancy sliced pineapple. The distributor receives 5 or 6 per cent commission, but his fee, borne by the canner and not directly by the purchaser, is concealed in the list price (Table 23).

4. Domestic Market

Domestic consumption of both fresh and processed pineapple is estimated at approximately 1,100 tons annually, or at the rate of about one pound per capita. Civilian consumption of fresh pineapple in Puerto Rico is estimated at roughly 950 tons per year; processed fruit canned locally, about 100 tons; and imported canned fruit, at 47 tons.[100] Although the annual rate of consumption per capita is only about one-third that of the United States, the island consumes considerably more pineapple than any of the neighboring islands except possibly Cuba.

For the most part, small farms provide the largest share of the fresh fruit consumed locally. Table 24 indicates that the farm price obtained from fresh fruit shipped abroad was from $30.00 to $32.00 higher per ton than fruit marketed locally. The writer concludes that

---

[100]Fresh pineapple consumption based on data obtained from the Insular Bureau of Agricultural Economics and processed fruit consumption based on data obtained from the U.S. Department of Agriculture, Production and Marketing Administration, Citrus and Deciduous Fruit and Vegetable Branch, July 1951.

TABLE 23

AVERAGE ALLOCATION OF PRODUCTION COST PER CASE IN CANNING CRUSHED PINEAPPLE, 1948[a]

Items	Cost of Processing	
Estimated cost of fresh fruit per case[b]		$2.02
Cost of equipment, maintenance, and depreciation	0.085	
Fuel and other materials	0.045	
Cans, including rejects	0.780	
Labels	0.070	
Insurance	0.070	
Taxes and interest	0.015	
Sugar	0.360	
Canning labor	0.340	
Salaries	0.110	
Truckage to San Juan	0.250	
Brokerage and discounts	0.250	
Trade discounts	0.100	
Miscellaneous expense	0.065	
Total Factory Cost	$2.330	$2.33
Total Production Cost		$4.35

[a]Based on several estimates.

[b]One ton of fresh pineapple is equivalent to approximately 24 cases (No. 2-sized cans) of crushed fruit. The price paid growers by canners during the 1948 crop year averages $57.20 per ton, according to the Puerto Rico Canners' Association. By the 1950 crop year, the average farm price paid per ton of fresh pineapple had declined to $33.84, equivalent to $1.41 (cost of fruit per case). Assuming that all other costs remain stationary between 1948 and 1950, the average production cost per case in canning crushed pineapple was $3.74.

TABLE 24

DISPOSITION AND FARM PRICE OF PINEAPPLES HARVESTED IN PUERTO RICO, 1948-49 AND 1949-50[a]

Disposition	Crop Year 1948-49		Crop Year 1949-50	
	Tons	Average Price per Ton	Tons	Average Price per Ton
Export (fresh)	7,577.50	$76.82	8,535.20	$70.68
Local Sales (fresh)	146.95	55.00	774.50	38.26
Sold to Canneries	28.909.00	38.27	24,315.91	33.84
Total sales	36,633.45	-----	33,625.61	-----
Others[b]	387.00	-----	2,465.06	-----
Total crop	37,020.45		36,090.67	

[a]Source: Bureau of Agricultural Economics, Puerto Rico Department of Agriculture and Commerce (San Juan: Unpublished data, 1951).

[b]Pineapples disposed of in such forms as animal feed, domestic use, experimentation, etc.

the larger growers with contacts, packing sheds and other equipment, and an established brand name cater almost exclusively to the continental market where prices are considerably higher and the demand more suitable.

Approximately three-fourths of all the unprocessed fruit is handled through middlemen, located chiefly in the larger urban centers. The middlemen distribute the fruit to retail stores, push-cart peddlers, hotels, and restaurants. Retail prices of fresh pineapples range from five to ten cents per pound, varying with the season, supply and demand, and even with the stage of ripeness of the fruit itself.

The canned pineapple market is dominated largely by two Puerto Rican canners. The canner normally markets his products through a wholesaler, but occasionally sales are made directly to the retailer, thus eliminating one middleman. Imported canned pineapple, largely from Hawaii via the United States, amounts to less than one-half of that which is canned and sold locally. As imported fruit commands a slightly higher price, it is found in the better-stocked stores, especially in the larger cities and towns.

The domestic market is less affected by the existing transportation net than is the export fruit market. By comparing Figures 4 and 7, it is noted that most of the packing sheds within the Pineapple Area are located

on or within short distances of improved roads. Pineapples should be grown in relatively close proximity to processing plants and packing shed, owing to the fact that the fruit is apt to be bruised and followed by rapid deterioration if subjected to rough handling in transit. Improved roads facilitate the movement of fruit, especially fully ripened fruit, thus greatly reducing the chance of damage between the fields and the processing plants. The "Military Highway" (highway No. 2, shown in Figure 4) constitutes the primary artery for movement of both fresh and processed fruit across the Pineapple Area to the larger urban centers, particularly San Juan and Rio Piedras.

Comparatively few concrete facts can be presented with regard to the movement of fresh pineapples within the domestic marketing system. By and large, the fresh fruit market is dominated by many small, independent pineapple growers; many of whom do not harvest more than a few hundred fruits in a course of a full year. Such growers commonly transport their entire crop by truck or station wagon in a single trip to one of the larger towns and either peddle their fruit on the street or as a mobile roadside market. As a result of this method of marketing, the writer has been led to believe that a considerable portion of the domestic fresh fruit sold in San Juan and neighboring towns is grown in small, scattered patches in the southeastern portion of the Pineapple Area.

5. Future Outlook

Known world production of commercial pineapples increased from 18,742,000 crates in 1945 to an estimated 36,901,000 crates in 1950 (Table 25), or almost a 100 per cent increase for that five-year period. The total pineapple production was subdivided as follows: Hawaii produced an estimated 19.9 million crates (53.9%); Cuba, 4.5 million crates (12.2%); Mexico, 4.5 million crates (12.2%); Puerto Rico, 1.0 million crates (2.8%); and all other countries, 7.0 million crates (18.9%).[101]

The United States today consumes more than one-half of the world's processed pineapple and about a tenth of the total fresh fruit. It is anticipated that the demand for processed pineapple will increase slightly in the immediate future as a result of stock-piling of foodstuffs for the Armed Forces.

Using generous estimates of demand and cautious estimates of supply, it appears that a world shortage of processed pineapple may develop. If the supply is greater than is now calculated, and if the demand does not reach expectations, a small surplus of processed pineapple may continue to exist. In either case, pineapple prices are expected to remain at or above the

---

[101] Based on preliminary estimates obtained from the U.S. Department of Agriculture, Production and Marketing Administration, Citrus and Deciduous Fruit and Vegetable Branch, Washington, March 1951.

TABLE 25

KNOWN WORLD PRODUCTION OF COMMERCIAL PINEAPPLES, 1940-50[a]
(in 1,000's crates)

Country	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Hawaii	17,727	25,101	13,202	11,133	7,123	7,403	16,522	17,737	16,613	19,579[c]	19,878[c]
Cuba	2,377	2,456	2,440	3,186	2,676	3,086	5,114	5,296	5,457	3,929	4,500[c]
Mexico	1,267	1,591	1,823	1,913	1,797	2,429	3,166	3,716	4,094	3,149	4,486
Puerto Rico	650	480	500	450	450	550	618	1,000	1,100	1,234	1,031
United States[d]	8	12	5	3	15	10	20	4	5	5	6
All others[e]	13,783	10,582	8,681	7,964	5,676	5,264	5,305	6,161	6,500[c]	6,000[c]	7,000[c]
Totals	35,312	40,222	26,551	24,649	17,737	18,742	30,745	33,914	33,769	33,896	36,901

[a]Sources: U.S. Department of Agriculture, Foreign Crops and Markets, Vol. 57, No. 16 (Washington: Government Printing Office, 1948), p. 302, and unpublished data since 1947 obtained from Citrus and Deciduous Fruit and Vegetable Branch, Production and Marketing Administration, U.S. Department of Agriculture, Washington, March 1951.

[b]Crate weights 70-pounds net.

[c]Based on preliminary estimates.

[d]Commercial pineapple production in the United States proper is confined almost exclusively to the state of Florida.

[e]Philippine Islands, Australia, Formosa, South Africa, British Malaya, Brazil, Haiti, Dominican Republic, and Costa Rico.

1951 level. The principal factors in predicting prices for future pineapple sales hinge on world conditions, especially economic conditions in the United States, and weather conditions in the major pineapple-producing countries. The production, marketing, and consumption outlook for the years following 1953 remains obscure.

CHAPTER IV

THE PINEAPPLE INDUSTRY IN THE ISLAND'S ECONOMY

1. Introduction

Scientific literature on the pineapple industry firmly convinces the writer that the structure of the Puerto Rican pineapple economy is radically different, for example, from that of the pineapple-producing districts of Hawaii, but is similar in broad outline to that of other Latin American pineapple-producing countries. In this chapter, it is not the primary purpose of the writer to compare the various aspects of the Puerto Rican pineapple industry with that of other important pineapple-producing countries, but rather to present some of the basic geographic-economic factors and problems that confront the pineapple industry in the island's economy. However, in presenting the units dealing with labor, income, and wages, some comparisons are made between the pineapple industries of Puerto Rico and Hawaii. In this manner, it is hoped that subsequent investigations may be conducted along these lines.

2. Relative Importance of The Pineapple Industry

2. Relative Importance of The Pineapple Industry

The pineapple products, including both fresh and processed, overshadow all other fruit industries in

export value (Table 26). Since 1947, these products have accounted for not less than 85 per cent of the total value of all fruits exported from the island. In the fiscal year 1949-50, pineapple exports from Puerto Rico were valued at $3,655,000 (Table 17), or 1.5 per cent of her total exports. On the surface this appears to be a relatively small percentage, but by comparing the land under cultivation, labor force, and export value of pineapple and pineapple products with that of sugar cane, the true picture of the pineapple industry in the island's economy comes into focus. For every cuerda of land devoted to pineapple production, there are 84 cuerdas devoted to sugar cane; for every laborer employed in the pineapple industry, there are 43 laborers in the sugar cane industry; for every dollar value of exported pineapple, there are 44 dollars of exported sugar cane or cane products. If it were actually possible to reverse the relative positions of pineapple and sugar cane, and other factors remaining constant, the pineapple industry, with 388,000 cuerdas under cultivation, would have an export value of over $300,000,000, or almost twice that of sugar cane, and would provide employment for over 275,000 persons, or more than double that currently employed in the cane industry.[102]

---

[102]Comparisons based on statistics from the following sources: Perloff, 1950, pp. 88 and 401, and Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-50, 1951 pp. 363, 365, 366, 375, and 386.

TABLE 26

VALUE OF FRESH AND PRESERVED FRUITS EXPORTED FROM PUERTO RICO, FISCAL YEARS 1940-1950[a]

Fiscal year	Pineapples	Grapefruit	Citrons	All others[b]	Total	Pineapples (percentage of total)
1940-41	$1,124,964	$170,418	$139,880	$ 16,161	$1,451,423	77.51
1941-42	807,251	168,426	366,335	16,680	1,358,692	59.41
1942-43	472,677	-----	471,174	2,489	946,340	49.95
1943-44	1,308,139	-----	349,805	127,426	1,785,370	73.27
1944-45	1,788,113	99,910	687,335	100,896	2,676,254	66.81
1945-46	2,535,738	271,025	927,868	36,788	3,771,419	67.23
1946-47	3,080,082	124,405	335,684	22,244	3,562,415	86.46
1947-48	4,813,821	96,963	153,741	63,952	5,127,977	93.87
1948-49	3,714,409	63,081	201,359	108,481	4,087,330	90.87
1949-50	3,655,261	137,908	321,914	39,333	4,154,416	87.98

[a]Source: Puerto Rico Department of Agriculture and Commerce, Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-50 (San Juan: Puerto Rico Office of Economic Research, 1951), P. 375.

[b]Oranges, bananas, and guavas.

In reality, it can be safely stated that the Puerto Rican pineapple industry does play an important role in the island's economy despite the fact that it is overshadowed by the cane, tobacco, and coffee industries in the number of persons gainfully employed as well as the total number of cuerdas under cultivation. However, in export value, the pineapple industry is outranked only by the sugar cane and tobacco industries.

In order for the pineapple industry to expand appreciably in the near future, land needs and capital requirements must be met, financial structure must be consolidated and stabilized, banking and credit facilities further expanded, income and wages greatly increased, labor more thoroughly trained and specialized, and a more adequate food supply must be readily available, both in volume and variety, to meet the growing needs of the island.

3. Land Needs and Capital Requirements

Even with all of the latest methods and techniques of modern agriculture, Puerto Rican growers can expect to obtain only two, rarely three, crops of pineapples from one planting before having to return this land to cover crops or to begin a new planting of pineapples. For a grower to obtain 100 cuerdas of bearing pineapples each year, he should have allocated for this purpose a minimum of 250 cuerdas, excluding land for

gardens, buildings, orchards, etc. Under such a plan, 50 cuerdas would be producing the first crop, 50 cuerdas producing the second (first ratoon) crop, 50 cuerdas being prepared for planting, and 100 cuerdas in cover crops. A closely followed crop-rotation plan is of special importance in soil conservation and increased yields.

Figure 17 shows the latest estimated arable land in Puerto Rico, based on its capability to produce certain crops, to be only 715,855 cuerdas or 0.32 cuerda per person. The total arable land in the Pineapple Area is about 158,700 cuerdas or roughly 0.59 cuerda per person, or 0.27 cuerda greater than for the island as a whole.[103] Population pressure on the land is rapidly approaching a breaking point.

Because of its scarcity in Puerto Rico, arable land has increased greatly in value. For example, in 1937, average pineapple-producing land sold for about $150 per cuerda. By 1951, the value of arable land had more than doubled or tripled. This sudden land "boom" resulted from several factors, including inflationary spiral, increased population pressure, war-time profits invested in land, government policies, and shifting of

---

[103](From conference with representatives of the U.S. Soil Conservation Service, Field Office, Santurce, May 1951.)

population. Arable land in Manatí and Barceloneta commanded a price between $350 and $400 per cuerda; in Corozal, between $300 and $400; and in Bayamón, from $400 to $600. Proximity to improved transportation lines and urban centers, and the size of the farm all have had a direct effect on the selling price of a given farm, in addition to the accepted factors of slope, natural fertility, degree of soil erosion, drainage, and workability of land. In general, farms in excess of 200 cuerdas can be purchased, whenever available, for $25 to $50 less per cuerda than those of smaller sizes. This is attributed to the fact that the number of prospective buyers for the larger farms are comparatively few.[104]

Based on the total number of commercial pineapple farms, averaging roughly 225 cuerdas each, with present value of all land (including both arable and non-arable) at an estimated $200 per cuerda, the industry represents a total land investment of between $3,500,000 and $4,000,000. The writer assumes that the average pineapple farm contains an equal amount of arable and non-arable land and that the arable land has a value of $400 per cuerda and the non-arable land is worthless;

---

[104](Conference with Mr. Jose F. Ferrer, Vice President, Royal Bank of Canada, San Juan, May 8, 1951.)

this is generally the case. Based on data shown in Fig. 17, almost one-half (46%) of the entire Pineapple Area is classed as arable.

The total land investment of the 54 growers in the Pineapple Area is about $2,430,000 or roughly 70 per cent of all land held by the island's commercial pineapple growers; pineapple processing plants and other equipment amounts to nearly $3,000,000, or 92 per cent of the island's total investment. The grand total investment of the island's pineapple industry is approximately $6,750,000.

Pineapple growers, operating on a large scale, should have a minimum of 250 cuerdas of arable land allocated for this purpose. In order to purchase a farm of this size, based on present day values of land, the initial capital outlay of more than $90,000 would be required. If the cost of machinery and equipment, planting material and fertilizer, labor and other expenses, were included, large-scale operations for the first crop would require upward of $180,000 investment. Based on the present day landholdings, less than a dozen commercial pineapple growers can qualify as large-scale operators.

According to H.C. Henricksen, it costs nearly $1,000 a cuerda to produce a crop of pineapples. This includes cost of slips, planting, cultivation, fertilizing, harvesting, packing, transportation, selling

commission, taxes, working capital, interest on land, and other expenses.[105] This figure also includes costs incurred in growing and harvesting one or two ratoon crops. The writer feels, based on consultation with several growers, that this figure is approximately one-fifth too high. Moreover, a cost of $1,000 per cuerda to produce a crop of pineapples would make it too costly for the average grower to engage in this agricultural pursuit. The writer concludes, based on 1950 price level, that if the total cost of production per cuerda exceeds $1,000, little or no profit will be realized. On the other hand, if production costs can be kept at or near $800 per cuerda reasonable returns on investments are possible.

4. Financial Structure

Since the end of World War II, the pineapple industry has been quite remunerative to both growers and processers alike. Prices for fruit in 1948 and 1949 brought abnormally high returns on investment (Table 17). Weather conditions during these two years were especially favorable and new production records were established (Table 21). Profits were channeled into purchasing of expensive canning equipment, erecting

---

[105] R.C. Roberts, 1942, p. 117.

new factories, [106] and additional farm equipment with which to expand the pineapple industry all along the line. Most of the post-war profits were quickly invested in stabilizing and expanding production. By the middle of 1949, it looked as though Puerto Rico was at last destined to take its place among the other large Latin American pineapple-producing countries.

By late 1949, the price of processed fruit suddenly decreased from 14 to 11 cents per pound (Table 17). Growers became more and more reluctant to purchase expensive slips for a new crop. Canners could not guarantee the growers a predetermined price per ton for fruit delivered to the factories. Distributors were having difficulty selling Puerto Rican pineapple in the United States, even at a reduced price. This meant the unsold pack in the warehouses could not be converted to badly needed capital for the following canning season. Many canners asked, "Why pack more fruit when we cannot sell what is on hand?" Growers, canners, and distributors were all discouraged. To augment their troubles, 1950 proved to be one of the wettest years on record. Moreover, two hurricanes passed near the island and affected the entire economic structure of the industry. Interest rates soared; loans were difficult or impossible

---

[106] Three new canning factories were established in 1949 and an additional one in 1950 (Table 14).

to secure, and the industry was on the verge of collapse.

The Insular government, realizing the precarious situation of the faltering pineapple industry, took immediate steps. Efforts were made to incorporate all pineapple growers and processers into a single, unified organization. These efforts met immediate opposition. A few months later, after realizing that there was no chance of organizing the growers, an attempt was made to amalgamate all canners under a single corporation, but this plan also failed to materialize, and finally was voted down in April 1951. Major differences are reported to be ironed-out and continued conferences are currently taking place.

The principal advantages of the proposed corporate structure for canners are the following: (1) It would permit marketing a pineapple product under a single brand of a higher quality; (2) it would enable canners to possibly benefit under the Insular income and property tax exemption clause for a period of ten years; (3) it would assist financially the smaller canners who need new equipment and ready capital; (4) it would eliminate local competition and develop an improved market for all pineapple products; (5) it would enable canners to pool their technical knowledge and best techniques; (6) finally, it would enable all canners to operate more efficiently during the peak canning season.

There also are disadvantages of the proposed corporate structure for the pineapple canning industry: (1) Large canners believe that income and property tax exemptions most likely could be obtained through individual efforts rather than by joint or group action. (2) The larger canners argue that the smaller ones would have more to gain under such an arrangement. (3) Some canners who have been fortunate in collecting a high per cent of products sold abroad are reluctant to include as assets approximately one-half million dollars worth of goods outstanding. These unpaid notes are held mainly by the older firms, a percentage of which can never be collected. (4) Canners with new processing facilities are confronted with the problem of equitably appraising and evaluating the older and outmoded equipment held largely by smaller canners.

Increasing stress on production, as a result of the national preparedness program, perhaps has been the most significant factor in delaying or postponing the amalgamation of Puerto Rico's pineapple canning industry into a single organization. By the spring of 1951, stock-piling by both the Armed Services and large wholesalers suddenly liquidated all surplus stock. An estimated 75 per cent of the 1951 pack was sold before the harvesting season began. Moreover, the distributors stated that 50 per cent more processed pineapple could have been sold than was possible to pack in 1951. Also,

the demand for fresh fruit rose to a point where growers could not meet the demand. Growers and canners alike were earning large returns on their investments. Practically all debts incurred during the industry's brief expansion period in 1948 and 1949 were liquidated, and plans were being made for further expansion.

5. Mortgage Indebtedness and Credit Structure

There is a direct relation between the mortgage indebtedness of a pineapple farm and the volume of pineapple produced. The greater the mortgage indebtedness (a fixed operating cost), the less liquid capital the grower has for operating his farm. Many operators of small-sized farms have meager financial resources. Often they are unable to secure items necessary for proper operation of their farms, and find it difficult to survive in years of reduced yields or low prices. During such years, many are forced to mortgage their property. Operators of middle- and large-sized farms, on the other hand, generally have sufficient resources to buy proper equipment and to see them through years with unfavorable conditions. Several large growers own or have interest in canning factories; a few own urban real estate or have interests completely divorced from the pineapple industry. In 1951 more than one-half of the pineapples harvested were grown on land either owned or leased by the pineapple canners themselves.

The same relation between mortgage indebtedness and operating capital holds for processing plants, with the attendant effects on volume. Only one or two of the smaller canneries are believed to be mortgaged, however.[107] This belief is substantiated by the fact that during the past decade only one cannery has gone into the hands of a receiver, and even in this instance factors other than indebtedness and credit needs were responsible.

Since the bulk of pineapples are produced by large, independent growers who have few credit problems, it is difficult to obtain the credit requirements of individual growers. On rare occasions when the large grower needs a short-term loan, he is considered a far better risk if his crop is contracted to the canning industry rather than destined to the fresh fruit market, where the time factor and constant fluctuation in price make the enterprise risky. However, on the other hand, the small pineapple growers, generally outside the limits of the Pineapple Area, do have financial difficulties from time to time.

---

[107] The extent to which pineapple canneries are mortgaged, owing to such a small number of canners, could not be ascertained. However, conferences with members of the Royal Bank of Canada, Banco Popular de Puerto Rico, National City Bank, Bank of Nova Scotia, and the Production Credit Administration of the U.S. Department of Agriculture led the writer to believe that not more than two canneries are mortgaged.

Banking and credit facilities in Puerto Rico have expanded at a phenomenal rate during the past five years. This expansion has had a profound effect on increased production and strengthening the island's economy. The pineapple industry also has profited greatly by the banking and credit facilities. The pineapple grower has access to numerous credit sources such as the Farmers Home Administration (U.S. Department of Agriculture), commercial houses, private banks, and private individuals. Even with all these credit sources available, the pineapple grower frequently has difficulty in securing his capital requirements at a reasonable rate of interest. Both long- and short-term loans on farms, crops, buildings, and equipment carry an interest rate, ranging from 5 to 10 per cent. Many of the loaning agencies, especially the private ones, channel their loans into the sugar and tobacco industries, which are considered sounder enterprises than pineapples. Sugar and tobacco growers are rigidly controlled by established allotments as to area planted. As one banker stated, "Buyers from the mainland come to Puerto Rico and purchase sugar and tobacco in the field, whereas pineapples and coffee must be transported to the mainland in search of their markets." During the past two years speculation in the pineapple industry has resulted in losses due mainly to adverse weather conditions. Reluctance of

leaning agencies to provide credit will probably continue until at least 1954.

6. Income and Wage Contributions

Only a rough approximation of the income received by the pineapple growers within the Pineapple Area can be ascertained from various postwar studies. For example, it was shown in 1950 that of the 54 growers engaged in commercial pineapple production in the Pineapple Area, only 45 reported their gross income from pineapple sales.[108] Of these 45 growers, 6 (13%) had a gross income of less than $2,000; 9 growers (20%) between $2,000 and $5,000; 7 growers (15%) between $5,000 and $10,000; 15 growers (34%) between $10,000 and $50,000; and 8 growers (18%) over $50,000.

The total farm value of the 1949-50 pineapple crop amounted to $1,455,698, of which $1,329,739 (91.3%) was earned in the Pineapple Area (Table 9). Total farm value of the 1947-48 pineapple crop within the Pineapple Area was $2,037,300, or $707,561 greater than in 1949-50.

Zorilla reports that the annual payroll in the agricultural phase of the pineapple industry of Puerto Rico in 1948 was $560,000 as against $400,000 for the processing phase. Based on the 1948 figures, the annual

---

[108] Unpublished data from the Bureau of Agricultural Economics, Puerto Rico Department of Agriculture and Commerce, June 1951.

payroll of the agricultural phase of the Pineapple Area was about $510,000 as against $375,000 for the processing phase.

Wages paid pineapple workers, especially those working on the *fincas*, have fluctuated widely from year to year in response to demand and supply. In general, factory wages have been somewhat more stable and dependable than those on the farm. However, during the recent decade, with a gradual migration of the *agregados* to the urban centers, the canning labor force has been more unsettled.

Table 27 shows that in 1947-48 the average wage-earner in the agricultural phase of the pineapple industry worked 38 weeks each year and had a weekly income of $6.25, or an estimated annual income of $237.50.[109] He worked an average of 27 hours per week and received 23 cents per hour. Based on a four-day work week, he received $1.56 per day. In 1948 his counterpart on the sugar plantation received daily wages from 50 cents to $2.00; the coffee picker earned from $1.25 to $1.30 daily. Eleven years earlier, in 1937, according to the Pineapple Producers' Association, the average farm worker earned 60 cents for an eight-hour day or $4.00

---

[109] Total income from all sources, including earnings of all members of the household, was estimated to be $527.00. F. Zorrilla, *La Industria de la Piña en Puerto Rico* (San Juan: Unpublished Report to the Governor of Puerto Rico, 1950), p. 29.

TABLE 27

AVERAGE NUMBER WEEKS OF WORK PER YEAR, AVERAGE WEEKLY INCOME, AND ESTIMATED ANNUAL INCOME OF 346 WORKERS EMPLOYED IN THE AGRICULTURAL PHASE OF THE PINEAPPLE INDUSTRY, PUERTO RICO, 1947-48[a]

Farming Operations	Average Weeks of Work per Year	Total Weekly Income	Estimated Annual Income[b]
Cultivation	34.8	$6.27	$218.20
Harvesting	41.3	6.13	253.17
Packing	39.1	2.98	116.52
Others	43.7	7.88	344.36
Average per worker for all operations	38.0	$6.25	$237.50

[a]Source: Frank Zorrilla, La Industria de la Piña en Puerto Rico (San Juan: Unpublished Report to the Governor of Puerto Rico, 1950), pp. 20 and 29.

[b]Estimated annual income is earnings obtained from the pineapple industry only.

a week. This was more or less standard pay regardless of the industry.

Since July 1950, thanks to the Puerto Rico Minimum Wage Board, the wage scale of all agricultural workers in the pineapple industry has been gradually increased, but still wages have not kept pace with the rising cost of living.[110] Minimum Wage Decree, No. 17, shown in Table 28, indicates that wages per day range from $1.70 to $4.00, depending upon the degree of skill required and the zone in which the work is performed. Daily wages paid workers employed in the sugar-cane industry are considerably higher ($2.61 to $4.37 per day) than those paid the pineapple laborers.

It is interesting to note that laborers employed to do the simplest menial tasks such as carrying water, making crates, and working as general field hands in the Puerto Rican pineapple industry earn from 21 to 27

---

[110] Insular Bureau of Statistics revealed that the cost of living has almost doubled between 1940 and 1950. In December 1949, the Bureau ascertained that a minimum adequate budget of expenses for an average pineapple worker's family of six members should be $1,526 per year (food $975, clothing $111, shelter $45, furniture $44, heat $47, housekeeping $37, medical care $25, personal care $51, entertainment $36, transportation $35, education $20, and other expenses $100). (Consultation with members of the Insular Bureau of Statistics, Puerto Rico Department of Labor, June 1951.)

TABLE 28

DAILY WAGES PAID FARM WORKERS IN PUERTO RICO AND HAWAII[a]

Task	Puerto Rico				Hawaiian
	Pineapple Industry		Sugar Cane		Pineapple Industry
	Zone 1[b]	Zone 2[c]	Zone 1	Zone 2	
Water carrier, field hand, crate maker, cane cutter	$1.70	$1.95	$2.61	$2.92	$15.70 to $16.20
Fruit sorter, crate maker, fruit filler, weeder, ripe fruit picker.	1.80	2.05	2.31	2.53	16.20 to 18.00
Fresh fruit picker, packer, slip setter, carbide sprayer, cane loader.	1.90	2.15	2.61	2.83	17.20 to 19.00
Truck driver, tractor driver, special crafts worker.	3.20	4.00	4.06	4.37	23.20 to 28.00

[a]Sources: Data obtained from Puerto Rico Minimum Wage Board, San Juan, May 1951. Wages established by Minimum Wage Decree, No. 17, July 1950, for pineapple and sugar cane workers of Puerto Rico. Wages paid farm workers in the Hawaiian pineapple industry was adapted from F.C. Cook and E. Chem, The Pineapple Industry of the Hawaiian Islands, No. 32 (Johore: Federation of Malaya Printing Office, 1949), pp. 30-31.

[b]Zone 1 includes all farms growing sugar cane and pineapples within the municipalities of Aguadilla, Cidra, Corozal, Lajas, Las Piedras, Mayagüez, Morovis, Naranjito, San German, Toa Alta, and the barrios south of highway No. 2 and west of highway No. 9 within the municipality and any other municipality on the mountainous region of Puerto Rico, or of the west coast. (See Fig. 4.)

[c]Zone 2 includes all other pineapple and sugar cane farms not covered by Zone 1.

cents per hour,[111] whereas workers doing identical work, in the Hawaiian pineapple industry earn between $1.96 and $2.05 per hour. Comparisons of wage scale requiring higher degrees of skill between the two areas reveal that the Hawaiian pineapple industry pay its workers from seven to eight times as much as does the Puerto Rican industry for the same types of work. No statistics are available to indicate the amount of work performed per worker during similar periods of time. However, it is reasonable to assume that the degree of mechanization in the Hawaiian industry more than offsets the higher cost of labor.

In 1929 the Hawaiian industry operated under a minimum wage of 34 cents per hour. Increased mechanization has resulted in a 6.1 reduction in labor. One Hawaiian grower stated that he could (1949) spend $4,000 in capital expenditure to eliminate one laborer, and considered it economical to introduce machines whenever wages in excess of 50 cents per hour were required, particularly whenever individual output was inadequate or quality of work was erratic or not of a high standard.[112]

---

[111] In the Cuban pineapple industry the minimum legal wage for agricultural and industrial workers is, respectively, 20 and 25 cents per hour for an eight-hour day, plus 9.09 per cent in lieu of vacation. (Letter from Guy W. Bush, Agricultural Attaché, American Embassy, Habana, Cuba, August 7, 1951.)

[112] Cook and Chem, 1949, pp. 31-32.

In 1948 the average Puerto Rican laborer employed in the processing phase of the pineapple industry earned $10.43 per week (24 cents per hour) during the period of maximum activity.[113] The weekly wage scale ranged from $8.66 for peelers (mostly women) to $22.69 for overseerers. No information on wages was available to the writer for the processing phase of the Hawaiian industry.

In late 1950, the Federal Wage-Hour Administrator recommended a new minimum wage of 30 cents per hour in all vegetable and fruit processing factories. This would increase weekly wages of the lowest paid workers by approximately $3.90, or one-third above the 1948 wage-scale level. Under this decree, the lowest paid workers in the pineapple processing phase would receive an hourly increase of about nine cents.

After closely examining the wage scale of unskilled and semiskilled workers employed in both the agricultural and processing phases of the pineapple industry, one can better realize the deplorable economic and social conditions existing not only in the Pineapple Area but throughout the entire island as well. As pointed out in various footnotes, this subsistence-wage scale is

---

[113] Weekly wage, $12.54 for men and $9.10 for women, is based on a 43-hour week. The period of maximum activity normally is of approximately 16 weeks' duration, but volume of crop, price of fresh fruit, weather conditions, etc., directly affect the length of the processing period.

not confined exclusively to the pineapple industry; persons employed in the cane, tobacco, and citrus fruit industries have, at best, slightly higher incomes.

Actually the agregado who lives on the pineapple finca, although receiving somewhat less cash income than his counterpart on the sugar-cane plantation, may be better off financially, provided he has farm privileges which entitle him to a small plot of ground on which he can grow much of his food (Fig. 18).

The writer observed that the larger pineapple farms containing the most fertile land in the coastal lowlands had fewer subsistence crops, fewer poultry and livestock, and far more closely compact houses than the smaller pineapple farms in the foothills section. The writer views such unhealthy living conditions of the worker as one of the greatest evils in the shifting of the pineapple industry from the foothills section to that of the coastal lowlands. (See Chapter V, Section 3, "Recommended Steps".)

7. Labor Contribution

The Pineapple Area has an abundant supply of unskilled and semiskilled labor which constitutes an important element underlying both agricultural and industrial development. In appraising this labor force one encounters nebulous elements which defy measurement in tangible units. The agricultural phase

of pineapple production does not require the degree of skill essential in the processing phase (a fact reflected in the hourly wages earned by each group). Technological changes in the processing phase, especially since World War II, when new pineapple slicing and cutting machines were introduced, have increased operational and maintenance requirements.

In 1949 the pineapple industry employed approximately 3,200 heads of families. Families averaged about six persons for the island as a whole, and presumably some 19,000 persons depended on this industry, in part or exclusively, for their livelihood. Of the 3,200 family heads, 1,800 were engaged in the agricultural phase and 1,400 in the processing phase. A further break-down of these statistics revealed twice as many men as women were employed. Men comprised 98 per cent of the farm-working force but only 30 per cent in the processing phase. In canneries where large numbers of workers are essential in peeling, sizing, grading, and packing fruit, women have proved to be more adept than men.

In the Pineapple Area, there were approximately 2,880 persons engaged in both the agricultural and processing phases: 1,600 on the farms and 1,280 in the factories. The ratio of men to women was approximately the same as for the island as a whole.

In 1948 it was ascertained that 114 man-days of work were required to grow one cuerda of pineapples, considering both large and small growers (Table 29). It normally requires from 18 to 24 months from time of preparation of soil to harvesting of crop; work is fairly uniformly distributed throughout the year. The cultivating operation, which includes plowing, fertilizing, and weeding, commonly requires more than one-half of the total man-days of work. Thus in this stage of operation, large growers with labor-saving equipment are able to reduce the number of man-days of work per cuerda by 20 (Table 29).

The average farm laborer in 1948 was employed for a period of 38 weeks per year (Table 27). In preparing soil and setting slips, the laborer averaged only 35 work-weeks per year; but in plowing, weeding, fertilizing, and harvesting operations, he averaged slightly more than 41 work-weeks. His counterpart in the canning phase was offered a maximum of only 23½ work-weeks per year, which indicates that the processing phase of the pineapple industry, as in the case of the sugar industry, is more seasonal in nature. It is unfortunate for labor that the period of maximum activity in the pineapple industry more or less coincides with the period of maximum activity in the cane industry.

Within the designated pineapple-producing area, sugar cane, tobacco, citrus fruits, corn, and some

TABLE 29

AVERAGE NUMBER OF MAN-DAYS REQUIRED TO PRODUCE ONE CUERDA OF PINEAPPLES IN PUERTO RICO, 1947-48[a]

Operation	Number of Man-Days per Cuerda		
	Large Growers[b]	Small Growers[c]	Total
Soil preparation, planting and replanting	13.2	15.9	13.4
Cultivation	66.3	85.8	67.7
Harvesting and packing	29.3	27.2	29.2
Transportation	3.7	5.0	3.7
Total	112.5	133.9	114.0

[a]Source: Frank Zorrilla, La Industria de la Piña en Puerto Rico (San Juan: Unpublished Report to the Governor of Puerto Rico, 1950), p. 36.

[b]Large growers harvested 50 or more cuerdas of pineapples.

[c]Small growers harvested less than 50 cuerdas of pineapples.

coffee are grown also. Each of these crops competes with pineapples for the need of additional labor, particularly during periods of harvest; hence, there is considerable labor migration, generally seasonal in nature, within the Pineapple Area. As previously pointed out, the population of the Pineapple Area is rapidly increasing, especially in the urban centers fringing the north coast. There is a seasonal exodus of workers from these centers to the pineapple, cane, and coffee-producing districts. Because of its size, labor requirements in the cane industry overshadow the other two. Between December and early July migratory labor moves into the cane-producing sections in search of employment. Those not finding employment by mid-March often turn toward the pineapple or tobacco industries, though relatively few actually secure work in any single locality. The pineapple industry affords maximum employment for migratory workers during the harvesting period between mid-March and early July, varying somewhat with the seasons. As coffee is harvested between October and January, and the demand for labor is not very great during the remainder of the year, the sugar-cane industry attracts the _jibaros_ from the interior hills and uplands. By mid-July, the pineapples and sugar cane are harvested, the migratory labor force slowly drifts homeward, and unemployment rolls increase sharply. Normally, the sugar-cane industry affords

somewhat higher wages than any of the other named industries;[114] this is another reason why migrant laborers seek work in the cane industry first; if they fail, they turn to other industries.

For a period of 20 years prior to 1940 there was a slow rate of migration from the rural interior to the coastal urban centers. Then, World War II was a powerful stimulus to rural-to-urban movement. With the induction of young men into the Armed Forces and the construction of military bases and other installations, people not only from the Pineapple Area, but from other parts of the island as well, migrated to the cities in great numbers.

This permanent migratory movement is still continuing today. The movement is due in part to the desire of the migrants to participate in the greater range of social activities incidental to urban life. Those jibaros finding suitable employment in the city have been able to eke out a subsistence for themselves and their families despite the rising cost of living; many of those failing to find adequate employment eventually have settled in city slums and depend upon

---

[114] Unlike the cane industry, there are no organized labor unions in either the agricultural or processing phases of the pineapple industry, but recent attempts have been made to form a union among workers employed in various canneries. The writer feels that it will be only a matter of time until both phases will be completely unionized.

unemployment benefits for their main existence. There are few indications that these war and postwar migrants desire to return to the farm. The growing slums are far more deplorable than the living conditions existing in the rural sections, and constitute one of the major problems facing the Puerto Rican government.

The Land Authority, an agency of the Puerto Rican government, was established in 1941 to better the economic status and living conditions of low income families. Land is procured by enforcing the 500-Acre Law, which has long had a harmful effect upon land tenure in Puerto Rico. The Land Authority by May 1948 had provided some 15,000 plots, ranging from one-fourth to three cuerdas each, to landless farm workers. Other purposes of this agency are to assist farmers with experience and training to secure plots of land, varying from 5 to 25 cuerdas each. Proportional-benefit farms of 100 to 500 cuerdas each have been set aside to assist farm workers. All laborers on these farms are paid wages at current rates, and at the end of the year they receive an additional share in the profits. In each of these plans, the primary purpose is to encourage workers to remain on the farm where they can grow a portion, if not all, of their food requirements.

8. Available Food Supply and Growing Needs

The present emphasis in the Pineapple Area, as in many other regions of the island, is on producing export

crops that will yield relatively large cash returns per cuerda. For this reason, among others, Puerto Rico produces only about two-thirds by weight of her total food supply,[115] the remaining third is imported almost exclusively from the United States. Approximately 58 per cent by volume and 46 per cent by value of the foodstuffs consumed locally are grown on the island.[116] The Pineapple Area does not produce even this percentage of its own food requirements. Current estimates based on several different sources indicate that roughly 55 per cent by volume and 44 per cent by value of the foodstuffs consumed locally are produced in the Pineapple Area.

Available food supply is not only insufficient in volume but is also lacking in variety. Local food consumption is highly concentrated on starchy fruits and vegetables such as sweet potatoes, plantains, bananas, and breadfruit. There is a serious deficiency in green and leafy vegetables, especially cabbage, onions, peppers, and snap beans. Other serious deficiencies exist in

---

[115] According to Perloff in the fiscal year 1945-46, roughly 1,211 pounds of food was available per capita annually; 1.8 billion pounds was grown locally and 1.1 billion pounds imported. It is calculated that a minimum of 1,400 pounds of food per capita is essential to maintain a healthy diet, or an over-all increase of some 15 per cent in volume to reach minimum health requirements. For comparative purposes, it is interesting to note that the average annual consumption in the United States during the depression years was 1,440 pounds per capita. Perloff, 1950, pp. 313-314.

[116] Perloff, 1950, p. 312.

available milk, fats, and oils, and in meat and egg products. Fortunately, fresh fruits are available in abundant quantities, almost enough if properly distributed and marketed to meet the local requirements. In 1945-46, 93 per cent of the volume of fruit consumed was grown locally (176 million pounds compared with 13 million pounds imported). Of the total volume of fruit available, pineapples constituted less than one per cent.[117]

There is a growing need in Puerto Rico for land which can be planted to food crops. The use of pineapple-producing land for additional food crops is frequently presented as the solution to an ever-growing population problem. The writer is diametrically opposed to this concept. If all land now devoted to pineapple production were converted to other food crops, the total available land for the entire island would be increased by only 0.65 per cent. In reality, land currently in pineapples would not grow a sufficient quantity of food to make any substantial contribution to the food supply for the people now depending upon it.

9. Local Pineapple Consumption

Although pineapples are grown commercially in 21 widely scattered municipalities (Fig. 13), the average Puerto Rican does not consume much pineapple. According

---

[117] Perloff, 1950, pp. 315-317.

to Descartes, the average per capita consumption of pineapples in Puerto Rico in 1939 was 0.4 pineapple, equivalent to one pound.[118] This would indicate that the entire island consumed roughly 1,880,000 pounds, or 940 tons. The writer estimates that in 1950, based on local sales of 775 tons (Table 14), an additional 175 tons sold or given to persons for which no records are available, 100 tons processed locally, and nearly 50 tons (canned) imported, approximately 1,100 tons or 2,300,000 pounds of pineapple were consumed for an average of about one pound per person per year. By comparison, civilian consumption of pineapple in the United States during 1950 amounted to over 426,000,000 pounds, or nearly three times that consumed per person in Puerto Rico.[119]

There are several reasons why Puerto Ricans do not consume much pineapple: (1) The farm price obtained from pineapples sold in the fresh fruit market abroad is roughly 50 to 100 per cent higher than that which is sold locally (Table 24). Inadequate distribution and marketing facilities are major factors for this price differentiation. (2) Retail price of fresh pineapples

---

[118] S.L. Descartes and Associates, Food Consumption Studies in Puerto Rico. Bulletin No. 59 (Rio Piedras: Puerto Rico Agricultural Experiment Station, 1941), pp. 28 and 62.

[119] (Consultation with Dr. B.H. Pubols, U.S. Department of Agriculture, Bureau of Agricultural Economics, July 1951.)

sold locally ranges from five to ten cents per pound, varying considerably from season to season and from one year to another. These figures are based on retail prices at stores, corner fruit stands, and open-air markets in San Juan, Rio Piedras, Caguas, and Mayagüez in 1951. The bulk of the population throughout the island cannot afford to pay such prices, especially when other fruits are readily available at a fraction of this cost. (3) With increased production costs, larger initial capital investments, and scientific farming techniques and methods required, fewer and fewer growers are willing to engage in pineapple production for the local market. Production and sales must be geared to meet competition in the markets of the United States. (4) Pineapples are objectionable as a staple food because locally they are thought to produce ill effects when eaten with other foods. According to a survay conducted by Roberts and Stefani in 1946-47 among 1,000 rural and urban families, approximately one-fourth of all those polled objected to pineapples as a staple food. The consensus was that pineapples eaten with fish, mamey, or milk are harmful.

It is a striking commentary on the state of local food consumption that the growing of pineapples, which is so important from the standpoint of dietary requirements, is at present so haphazard and their distribution so inadequate that they do not furnish an ample year-

round local supply. Ironically enough, canned pineapple bearing a Hawaiian label is found on the shelfs of practically every large Puerto Rican store. This is explained, in part, by the fact that the wealthier people, most of whom dwell in the larger cities, are able and willing to pay higher prices for fruit of recognized quality.

The National Resources Planning Board conducted an investigation in 1940 with regard to the amount of land that would be necessary to produce enough pineapples each year to meet the minimum dietary requirements of Puerto Rico. Their findings disclosed that 1,432 cuerdas of land would be required.[120] Based on their findings, in 1950, it would require 1,690 cuerdas of land to meet the minimum needs of the population, or over one-third the amount of land presently devoted to the production of this fruit, assuming that the total production would be consumed locally.

---

[120] U.S. National Resources Planning Board, Minimum Decent Living Standards for Puerto Rico: Food, Clothing, and Shelter. (San Juan: Unpublished, 1942), pp. 32-33.

CHAPTER V

PROBLEMS FACING THE ISLAND'S PINEAPPLE INDUSTRY AND RECOMMENDED STEPS IN SOLVING THEM

1. Inherent Problems, Adjustments, and Long-Range Considerations

The problems that face the Pineapple Area are varied and complex. The Pineapple Area is greatly overpopulated; the present population is increasing at a rate of nearly 3,000 persons annually. In addition, there are few resources other than abundant labor, most of which is unskilled. Owing to the scarcity of forest, mineral, and fuel resources, among other reasons, the Pineapple Area cannot hope to develop a balanced economy through greater industrialization aimed at increasing producers' goods. It can, however, increase its potentialities in industrial output through a high degree of food-processing, providing the agricultural resources are exploited to the fullest extent. Agricultural resources, few as they are, must be utilized more thoroughly and developed more intensively.

Overshadowing all these and other problems in the Pineapple Area is a food supply inadequate to meet the minimum needs of the population. Based on Perloff's study, it is calculated that a minimum of 1,400 pounds of food per capita annually is essential to maintain a healthy diet. This would require an over-all increase

of some 15 per cent in volume to reach the minimum health requirements. In the past, the Pineapple Area has not been able to produce sufficient food locally nor has it been able to make up this deficiency by cash exports. The Pineapple Area, with roughly 15 per cent of the island's total population, produces somewhat less than 275,000,000 pounds of its annual food requirements. Ways must be found to step up the volume of food grown locally to about 325,000,000 pounds. If local food production could be increased by 50,000,000 pounds annually, less than 100,000,000 pounds of food would have to be imported.

The much discussed question is, which is better, in the long run, to concentrate efforts on expanding production in the light of domestic consumption, or to continue to produce commercial crops that are marketable in foreign countries with the hope of obtaining sufficient income with which to purchase the necessary foodstuffs to balance the needs of the island?

Among the most plausible solutions to the problem of food supply are the following: (1) Expand commercial agriculture for domestic consumption into districts where at present land lies idle; (2) encourage subsistence farming, either voluntary or insular-controlled; (3) introduce new commercial crops that have a high-cuerda value; and (4) increase production of existing

commercial crops for sale in the overseas market. At the present time, the writer feels that the greatest hope lies in a judicious combination of all these methods. The writer believes that foreign experts, in general, tend to favor the last two methods, while in Puerto Rico the first two methods find wider support.

At present there is a definite trend in the Pineapple Area toward increased specialization in a few commercial crops that can be marketed in the United States. There are certain well-known dangers involved in too high a degree of specialization. Further expansion of commercial crops that are marketed abroad will directly reduce the amount of land presently available for domestic food requirements. Ways must be found to increase production of those crops that are well adapted to the natural conditions and fulfill the basic needs of the growing population. There are comparatively few crops that can meet the basic requirements of a large amount of labor per cuerda, high yield per unit area, and invulnerability or resistance to hurricanes. The few crops produced in the Pineapple Area which meet these fundamental requirements best are pineapples, sugar cane, and a limited number of truck-farming crops (corn, tomatoes, peppers, carrots, eggplants, cucumbers, and beans).

Long before any efforts are made to expand Puerto Rico's pineapple industry, several considerations should

be examined minutely. Among these considerations include the problem of fruit processing. As previously described in Chapter III, processed pineapple must pass through several stages before it ultimately reaches the consumer. Each of these varied and complex stages require much labor. It has been calculated that 50 cents is lost to the island's economy in every crate of pineapples exported fresh rather than processed.[121]

Of all major cash crops of the island, pineapple production has shown the greatest rate of increase in cuerdas during the past two decades. This rapid rate of increase has been due largely to higher yields and improved methods of processing. While the export value of fresh fruit has declined erratically during this period (from 2.3 million dollars in 1930-31 to 1.1 million dollars in 1949-50), the processed fruit export value has increased more than twentyfold (0.1 million dollars in 1930-31 to 2.6 in 1949-50). The writer is confident that the future success of the industry depends more upon expanding processed pineapple outlets rather than the fresh-fruit market for the following reasons: (1) During the past decade, especially since World War II, the average housewife in

---

[121]U.S. Department of Labor, Public Hearing before Special Industry Committee No. 5 for the Purpose of Receiving Evidence to be Considered in Recommending Wage Rates for Employees in the Fruit and Canning Industry in Puerto Rico (San Juan: Unpublished Report, 1947), pp. 53-58.

the United States has radically changed her buying habits when is comes to the purchasing of pineapples. Canned pineapple requires less work, is more easily served, and is normally less expensive. (2) Those pineapple growers engaged exclusively in marketing their fruit through canners do not face so many financial risks as those catering to the fresh fruit market. (3) Processed fruit, unlike fresh fruit, can be marketed during every month of the year in quantities to meet the demand in any part of the world.

Two other major problems that are closely interwoven with future expansion of the pineapple industry are the questions of capital available for operation and a change in the land tenure system. The production of pineapples requires considerable amount of capital for large-scale operations. (See Chapter IV, Section 3, "Land Needs and Capital Requirements".) The pineapple industry cannot hope to thrive and prosper with a land tenure system based on farms of 15 to 25 cuerdas each. Based on Zorrilla's report, pineapple farms most economically and efficiently operated are those with 250 or more cuerdas each. Modern techniques and equipment so necessary for expansion in the long run rule out the small-scale operators. Under the present economic structure, most small operators cannot raise sufficient capital or afford to wait nearly two years to obtain the first returns on their investments.

Large operators, on the other hand, with necessary capital can afford to wait until the first crop is harvested for their first returns. Moreover, large operators can secure the services of experts to assist them in handling their problems. An increase in the size of pineapple farms would seem a desirable objective for the industry.

An exhaustive survey should be made of the mainland market and the uncertainties involved in the marketing of fruit. To cite one example, there has never been a broad and comprehensive study made in the United States to determine the characteristics of pineapple most desired by the consumer. Since pineapple usually begins to deteriorate within a period of 12 to 24 months following canning, the fruit should be marketed as rapidly as possible. Deterioration of canned fruit is due, in part, to the effects the acids have upon the can itself. In order to minimize this problem both canners and distributors should strive more closely to coordinate their efforts in order to elevate any prolonged periods of storage. This is one of the most difficult problems for the pineapple industry to solve because there is a wide variation in seasonal as well as yearly demand for the fruit. The maximum demand for "solid" fruit normally is between November and March; for juice, the demand is greatest during the summer months. Variations of seasonal demand for pineapple products in the United

States are due, in part, to consumers' buying habits, to weather conditions, and even to the occurrence of special holidays. The demand for any so-called "luxury food", such as pineapples, is directly affected by the purchasing power of the consumer at any given time.

2. Summary and Conclusions

1. The commercial pineapple-producing area of Puerto Rico is concentrated primarily on the north coastal lowlands and contiguous foothills between Bayamón and Arecibo. In the 1950 crop year, 89.9 per cent of all commercial pineapples harvested and 91.3 per cent of the total farm value were derived from the Pineapple Area.

2. From an agronomic standpoint, sufficient suitable land is available in the Pineapple Area to expand the commercial pineapple industry to a maximum of about 45,000 cuerdas, or nearly ten times its present acreage.

3. By area, approximately 91 per cent of the total commercial crop is of the Red Spanish variety; 7 per cent, of Smooth Cayenne; and the remaining 2 per cent, Cabezonas.

4. Pineapple production requires a high per-cuerda investment, ranging from $700 to $1,000. The first returns on such investments are not possible until the first crop is harvested, or a waiting period of upward to two years.

5. Average pineapple yields per cuerda (about 300 crates) are approximately the same for nearly all large

operators who specialize in pineapples exclusively. Although it is difficult to substantiate, the writer concludes that the large operators receive slightly higher yields (five to ten crates per cuerda) than small operators.

6. Average pineapple yields for all commercial growers, regardless of size of landholdings, have increased almost 50 crates per cuerda during the past decade.

7. The inadequacy of local pineapple slip production seriously hinders possible expansion of the industry. Cuban slips, although frequently difficult to secure, are always in great demand because they are reputed to be healthier and more productive than most slips grown locally.

8. Ranking first after sugar cane and tobacco in export value of cash crops, pineapple exports have more than tripled during the past ten years.

9. The fresh fruit market is greatly limited since New York is the only port of entry. A glutted market invariably results when more than 15,000 crates are placed on the auction block in any single week.

10. Processed fruit of high quality is in great demand and maintains a fairly stable price level, in contrast to fruit of low quality.

11. The processed fruit market is strongly influenced by Hawaiian production of recognized high quality.

Successful competition in the high-quality market and possible expansion of the industry are dependent to a considerable degree on maintaining and possibly improving the present standards.

12. Existing canning facilities are available in Puerto Rico to process an estimated 115,000 tons of pineapple annually; the actual total processed fruit (based on a five-year average) amounts to less than 26,500 tons, or roughly one-fourth of maximum operating capacity. This is one instance where long-range planning and careful foresight can strengthen the entire pineapple industry.

13. Recent establishment of a frozen-concentrate plant is providing a new channel for distribution and is beginning to have its effect in stimulating production.

14. The 1951 demand for Puerto Rico's pineapple exceeded actual production from 33 to 50 per cent.

15. Because of shipping problems, limited market, and a gradual decreasing demand for fresh pineapples, future expansion of the island's pineapple industry appears to rest with the processed fruit outlets.

3. Recommended Steps

The following recommendations refer to the pineapple industry as a whole, and are not to be construed as being directed toward either individual growers or canners. They are based upon field work, varied sources of published material, unpublished surveys, experiments,

and studies made available to the writer by individuals and groups who have devoted many years of intensive research to the pineapple problems of Puerto Rico. During the course of over three years the writer held no less than 400 conferences and discussions with individuals who are or have been directly or indirectly connected with the pineapple industry. Recommendations and suggestions as to ways and means of improving and expanding the pineapple industry were obtained from the grower and canner, the shipper, the distributor, the wholesaler and retailer, and finally, the housewife. The writer has eliminated the recommendations that he feels to be least sound and has incorporated only those which merit further investigation and study toward a partial solution of the industry's problems.

Agricultural Phase. 1. The foremost problem in the minds of the commercial pineapple growers in Puerto Rico is that of how to increase yields without increasing cost of production. The writer feels that this can best be accomplished through Insular or Federal aid. Under such a proposal, a government agency would be established for the purpose of improving the pineapple industry as a whole. This so-called "Pineapple Research Institute" would integrate and coordinate all of the research work that is currently being done. It would plan, direct, and conduct all scientific experiments and investigations dealing with pineapple production, processing, and marketing.

Among the major tasks with which the institute would be fronted include breeding new varieties of plants and procuring a sufficient number of plants for new crops, improving fertilizer mixtures and search for new and cheaper sources more readily available, controlling and possibly eliminating pests and diseases, and investigating conditions under which hormones and chemical weed-killers can best be used. Furthermore, facilities would be available for testing and developing new labor-saving devices and equipment. The institute would report periodically all of its findings in the form of a bulletin, which would have wide circulation.

2. Most pineapple growers, over the course of every few years, are required to purchase expensive slips in order to plant a new crop. Under present conditions, they are at a tremendous disadvantage working independently of each other. Some growers secure pineapple slips from Cuban growers, whereas others scout about Puerto Rico in hopes of finding other growers who have surpluses of slips and are willing to sell them at a reasonable price. Moreover, in the past, especially in years too wet or too dry, there were no surplus slips available. This is one of the basic reasons why pineapple production has fluctuated so widely during the past 15 years.

The writer recommends that the Insular Government immediately take steps to insure all growers an adequate

number of slips each year. This may be accomplished in one of three ways: (1) Rent or lease land on the island for this purpose; any fruit produced would be incidental to the primary objective of propagating slips. (2) Seek a clearly defined trade agreement with the Cuban or Mexican government, preferably through the United States Departments of State and Commerce, to provide a specific number of slips, at a given time for a specific price. The Federal government could render the island's pineapple industry an invaluable service by using the weight of its influence to assist the industry secure the necessary planting material. (3) Purchase slips directly from Cuban and Mexican growers, with full approval of their respective governments. The writer views the second approach to the problem as being the soundest and the one most likely to produce immediate results.

3. In long-range planning, with present emphasis on processed fruit rather than fresh fruit, the industry eventually will be forced to shift from the Red Spanish variety to the Smooth Cayenne (currently very successful in Hawaii) or to some hybrid yet to be developed. If such a shift is attempted suddenly, however, under the present economic structure, the industry might be destroyed completely. Such a change would have to come gradually in order not to disrupt the processing techniques and marketing structure of the industry.

4. With all the advantages that the Smooth Cayenne possesses over the Red Spanish, one major problem has yet to be solved; to determine the reason or reasons why the Smooth Cayenne will not produce fruit (ratoon) successfully in Puerto Rico. The writer feels that the Smooth Cayenne slips imported thus far from Hawaii via Cuba have degenerated to such an extent that they have lost their vitality to reproduce. The writer suggests the theory that the ratooning problem may be due either to climate or soil factors, or a combination of the two. This hypothesis could be easily proved or disproved by securing healthy pineapple slips and soil samples from Hawaii and experimenting with them under Puerto Rico's climatic conditions, and by shipping local slips and soil samples to Hawaii for the counterpart of the experiment.

5. The Insular Government, through the Agricultural Experiment Station, should sponsor the work of a team of experts to go to Hawaii and make a thorough investigation of the pineapple industry somewhat similar but on a much broader scale than the one conducted there in 1946 by the Federation of Malaya Government. Such a scientific group should be composed of agricultural economists, soil scientists, plant pathologists, climatologists, mechanical engineers, and geographers. In this manner, a coordinated investigation might be studied with the purpose of utilizing those findings that are applicable to Puerto

Rico's industry. It has been suggested to the writer that the Hawaiian pineapple industry would be reluctant to accept such a group of scientists on the premise of competitive factors. If the proper approach is made, the writer feels confident that the Hawaiian Government as well as the pineapple industry itself would be more than willing to cooperate in such an undertaking.[122] Moreover, the cooperation extended to the representatives of the Federation of Malaya Government mentioned above is sufficient proof that such a project is plausible.

6. Should the Puerto Rican Government decide to take a more active part in the island's pineapple industry and provide increased subsidies, secure more productive planting material, expand research facilities to combat diseases and pests, and encourage new growers to engage in pineapple production, it should establish rigid quotas and allotments. Such controls would not be aimed at restricting production, but would serve to coordinate the time of planting in order to insure a uniform flow of fruit during the harvesting season, thus eliminating the common complaint of small growers who have difficulty in placing fruit for processing during periods of peak production. Furthermore, under such a system, growers would be encouraged to devote their best land to pineapple

---

122"My personal and unofficial views would be as follows: (1) In general, I believe I could say that any group from Puerto Rico who might come to Hawaii would be welcome." (Quoted from a letter received from Dr. R.L. Cushing, Director, Pineapple Research Institute of Hawaii, January 29, 1953.)

production, and insular subsidies would be closely knitted into a subsistence crop structure as a means of increasing domestic food requirements. Under such a plan, there would be closer relationships between growers, canners, and research groups. Each would be free to call upon the other for advice and assistance.

Processing Phase. 1. Perhaps the single most important problem facing the island's pineapple canners is that of processing a product that will meet high standards, that is in constant demand, and that at the same time can be packed and sold at a profit. Such standards are currently being established under the direction of the United States Department of Agriculture at the request of the Puerto Rican government. Tremendous progress is being made along this line, for all fruit is being more thoroughly graded, more carefully packed and inspected, and distributed under fewer brands. The canners are beginning to realize that high-quality products command high prices and increased demand, thus increasing profits. This is one of the most hopeful and most progressive steps thus far taken to earn the reputation of fruit production of a recognized quality.

2. The writer recommends that immediate steps be taken to incorporate all canners under a single, unified structure. The principal advantages and disadvantages of such a plan are enumerated in Chapter IV. It must be added that the advantages of a corporate structure by

far outweigh the disadvantages. Under such a proposed unified organization many of the present difficulties between canners and growers, and between canners and distributors could easily be eliminated. No single recommendation is more likely to increase the stability of the pineapple industry at this time. If such a unity should materialize, it is not to be expected that the growers could be brought into the corporation immediately; such a union will require time and patience. Once the processing difficulties have been ironed out, growers will cease to oppose the plan and will join willingly.

3. It has often been stated that the pineapple industry is in dire need of a large amount of capital, ranging from five to ten million dollars, in order to improve means of production and distribution, and consequently attain its rightly earned place in the competitive market. Under some proposed plans the capital would be proportioned out in lump sums among the individual growers and canners alike. The writer does not agree with this school of thought. He feels that financial aid must be applied to the industry as a whole, not to individual growers and canners. The establishment of a so-called "Pineapple Research Institute" or the expansion of the Insular Agricultural Experiment Station would provide a more far-sighted investment, for a strong and healthy industry can develop only through education, experimentation, research, and

improved techniques and methods. These are the most promising avenues in which Insular or Federal Government aid should be channeled.

4. In any long-range planning there must be a close balance between production and processing of pineapples; such does not exist today. Canning facilities are available today to handle four times the amount of fruit that is actually being processed, if operated at maximum efficiency. In brief, pineapple production could be increased many times over without overtaxing or even reaching the maximum operating capacity of the factories.

The writer is strongly convinced that three or four well-equipped, properly managed, and centrally located canneries could process all fruit produced on land presently suitable for pineapple production in the Pineapple Area. If as many as 35,000 cuerdas of land were devoted exclusively to the growing of pineapples, four large canneries, operating at full capacity, would be capable of processing the entire harvest. These streamlined factories properly managed could reduce operating costs by perhaps 10 to 15 per cent. If these factory owners and operators pooled their technical knowledge, labor force, mechanical equipment, and purchasing costs, this would not only add stability and strength to the pineapple industry but would provide greater returns on capital investment than are at present enjoyed.

Marketing Phase. 1. Findings of this research project suggest that there is much to be done in the field of pineapple marketing which may have far-reaching effects when applied to the complex problems of Puerto Rico. If, for example, a competent and aggressive pineapple-marketing research program were to be undertaken, suggested avenues of exploration might well include a broad and comprehensive examination of pineapple-consumer taste and buying habits in the United States. Another research project might well include the marketing methods so successfully employed by the Hawaiian pineapple industry. Still another program might be launched to explore the marketing possibilities of Western Europe, where war and subsequent Marshall Plan loans and Mutual Security Program loans have wrought drastic changes in buying habits. Numerous other research programs, in addition to those mentioned above, might enable the pineapple industry to double its volume of output within another six years, as it did during the past six years.

2. The writer concludes that there are several major functions of the present marketing structure that should be strengthened, among the most important of which are transportation to the fresh fruit market and advertising in the processed fruit market. If the pineapple industry plans to continue devoting its efforts to an erratic and unstable fresh fruit market,

immediate steps should be taken to develop greater efficiency at lower cost in the movement of fruit from source to consumer. Tariff barriers mean absolutely nothing if freight and handling charges more than offset the embargoes imposed on Cuban and Mexican fruit entering the mainland market. The problem of infrequent shipping service may continue to impede the fresh fruit industry unless the volume increases several times its present size or competition from other steamship lines bring about greatly improved conditions. Although at present air freight costs are prohibitive, the time may come when air service may be practical.

Puerto Rico's pineapple industry has yet to realize and to capitalize on advertising. The Hawaiian pineapple industry discovered nearly a half century ago that a well-planned and conducted advertising campaign was a "secret weapon" to dispose of unsold stocks, to increase demand, and to create new outlets, resulting in greater output and greater demand. The writer is confident that advertising, even on a small scale, would more than compensate for the cost involved, especially for high-quality cut fruit. Moreover, properly selected channels of advertising might alleviate the problems connected with prolonged storage and tied-up capital investment.

In conclusion, the future expansion of the pineapple industry in Puerto Rico is closely interwoven with

the economic trends in the United States. There is a rapidly growing demand for pineapple products in this country, and there is little doubt but that the rate of consumption will increase in the forseeable future. The outlook for pineapple products the world over appears particularly bright, in all countries where standards of living are improving, diets and buying habits are changing. This opens new horizons for the so-called "luxury foods", one of which is pineapples. Pineapple-producing countries that are willing to pack products that the consumer desires, convince the consumer that their products are best, and at the same time expand production facilities and marketing outlets, will ultimately win out.

If Puerto Rico's pineapple industry can weld its three major phases---agriculture, processing, and marketing, into a single, efficiently operated organization within the next three to five years, it has great possibilities of becoming one of the major pineapple-producing countries of the world. On the other hand, if friction, disunity, and lack of long-range planning continues, the industry can hope for no more than to retain its 2.8 per cent of the total world production.

GLOSSARY

AGREGADO— A landless laborer commonly found in the interior parts of the island, who lives on a farm, in turn, works for landowner when needed.

ARROYO— A watercourse usually dry for a portion of the year.

BARRIO— Minor civil district, a component unit of the municipio.

BRIX— A scale for expressing the specific gravity of processed pineapple when tested with a Brix hydrometer calibrated at 68°F.

BROMELIN— A digestive enzyme which has the property of speeding up a certain chemical reaction. This substance found in pineapples holds great promise in the fields of medicine, industry, and possibly household use.

CASSAVA (Manihot esculenta)— A starchy root crop forming an important item in the Puerto Rican diet; also called manioc, mandioca, or yuca.

CENOTE— Sinkhole or water hole.

CENTRAL— Large sugar mill.

CERRO— Hill or knob.

CHOICE— U.S. grade "B" quality of sliced, tidbit, chunk, cube, finger, or crushed pineapple that possesses a reasonably good color; is free from defects; possesses good flavor and odor; and is of such quality as to score not less than 80 points and not more than 90 points by U.S. standards.

CHUNKS— Irregular pieces of processed pineapple, varying in size and thickness.

CORDILLERA— Major mountain range.

CRATE— A wooden box divided into two compartments, with outside dimensions of 11 by 13 by 36 inches, weighing approximately 11 pounds empty and used in shipping fresh pineapples to market (See Plate VIII).

CROPLAND— Land from which crops, grown individually or in combination, are harvested.

CROWN SLIP— Rosette of leaves on apex of the pineapple fruit; if planted will produce another fruit.

CRUSHED-- Pineapple that has been cut or shredded into very small pieces. If sugar is added, it is sold under the label of "sweetened".

CUBES (Diced)-- Small cubical sections of processed pineapple that match in size and thickness.

CUERDA-- A Spanish land measure equivalent to 0.9712 acres or 43,305 square feet.

FANCY-- U.S. grade "A" includes all fancy styles of pineapple that meet the standards established by the United States Department of Agriculture and shall not score less than 90 points based on color, flavor, uniformity of size and shape, etc.

FILTER PRESS CAKE-- A solid residue remaining after sugar-cane juice has been pressed and refined. It holds great promise as an inexpensive fertilizer in the pineapple industry.

FINCA-- Spanish term for farm.

FINGERS (Vertical cuts)-- Longitudinal sections cut from the prepared cylinder of pineapple.

FOREST AND BRUSH-- Forests include natural woods, planted trees, and brush areas. Forests which are grazed by animals are classed as pasturelands.

HARVESTED FORAGE-- Land devoted to the production of grasses which are cut for stock feeding (Merker, Elephant, Guatemala, Para, Carib, Indian Corn, and Sorghum).

IDLE LAND-- Farmland, not currently used, but which shows evidence of previous use or uses. Included (1) farmland from which no crop was harvested because of crop failure, destruction, and usual wet or dry season so that the crop was not planted, and (2) farmland in fallow for soil improvement and not used for pasture.

IMPROVED PASTURE-- Pastureland which shows evidence of maintenance by seeding, fertilizing, or mowing, and constitutes the major land use.

JIBARO-- A peasant or countryman.

LATERITE-- A group of soils having a high content of hydrous alumina or iron oxide, or both, and low in silica; usually deep-red in color. Such soils develop best under hot, moist, tropical rainforest conditions.

MACHETE— A sharp knife commonly used in harvesting pineapples.

MUNICIPIO— Civil district in Puerto Rico similar to a township in the United States. The island is divided into 77 municipios, the largest of which is Utuado (124 sq. mi.) and the smallest, Cataño (7 sq. mi.). The average size municipio is about 44 square miles.

NATURAL PASTURE— Pastureland of volunteer grasses showing no evidence of seeding, fertilizing, or mowing. These grasses include either mat or bunch grasses, or both in combination. (Bermuda, Horquetilla, Matojo, and St. Augustine).

NON-PRODUCTIVE LAND— Land having no current use for agricultural purposes is classes in this category.

PAPAIN— A proteolytic enzyme in the juice of the green fruit of the papaya which may prove to be of considerable importance as a meat tenderizer.

PASTURE— Land used for the grazing of animals.

pH FACTOR— Degree of acidity or alkalinity of a given soil type.

PIÑA— Spanish name for pineapple.

PUERTO RICO— In Spanish means "rich port". In 1891, the U.S. Board on Geographic Names adopted the spelling Puerto Rico instead of "Porto Rico". However, the latter spelling continued to appear in English literature until 1932, when final approval of spelling Puerto Rico was passed by Congress and signed by President Roosevelt.

RATOON— A pineapple cion that grows at the base of the main stalk in contact with the soil

RATOON CROP— All crops of pineapples harvested from original planting following the first or plant crop.

ROTATION PASTURE— Land showing evidence of cultivation, or belonging in an existing crop sequence, but currently in pasture either planted or natural.

SIERRA— Mountain range commonly connoting subdivision of a cordillera (See Cordillera).

SLICED— Processed pineapple that has been cut into slices approximately at right angles to the vertical axis of the fruit.

SLIP— A cion of a pineapple plant growing below the fruit that is generally used, when available, in new plantings.

SOIL PRODUCTIVITY RATING— An arbitrary rating based on the capability of a soil for producing a specific plant or sequences of plants under a given set of conditions, including such factors as management, relief, soil, and climate.

SPECIFIC SOIL PRODUCTIVITY— Connotes soil productivity in reference to the growing of pineapples exclusively on such soils.

STANDARD— U.S. grade "C" processed pineapple must not score less than 70 points nor over 80 points, or it is "choice". The scoring is based on color, freedom of defects, odor, and uniformity of size and shape as established by the U.S. Department of Agriculture

SUCKER— A shoot of the pineapple plant which emerges from the leaf axil of the mother plant and is used for propagation.

TERTIARY— A geologic period of the early Cenozoic Era represented by relatively young rocks.

TIDBITS— Small, wedge-shaped sections of processed pineapple cut from slices or portions of slices.

WASTE LAND— Land possessing little or no potential productiveness, including areas of marsh, severe erosion, excessive stoniness, and barren rock outcrops.

SELECTED BIBLIOGRAPHY

Abad, Iñigo.
1866. Historia Geográfica, Civil y Natural de la Isla de Puerto Rico. San Juan: Imprenta y Librería de Acosta, pp. 265.

App, Frank.
1930. Report of the Fact Finding Survey of Puerto Rican Citrus and Pineapple Distribution for the Fruit Growers' Improvements Committee. San Juan: Fruit Growers Improvement Committee, pp. 33.

Barrett, Otis W.
1925. "The Food Plants of Puerto Rico," Journal of the Department of Agriculture of Puerto Rico. Vol. IX, No. 2. Río Piedras: The Insular Experiment Station, pp. 61-196.

Bartlett, Kenneth A.
1939. "Introduction and Colonization of Two Parasites of the Pineapple Mealybug in Puerto Rico," The Journal of Agriculture of the University of Puerto Rico. Vol. XXIII, No. 2. Río Piedras: Puerto Rico Agricultural Experiment Station, pp. 67-72.

Blanshard, Paul.
1947. Democracy and Empire in the Caribbean. New York: The Macmillan Co., pp. 379.

Brau, Salvador.
1930. La Colonización de Puerto Rico. San Juan: Centero Fernández et Co., pp. 511.

Campbell, David S.
1947. The Geography of the Coffee Industry of Puerto Rico. Chicago: University of Chicago Press, pp. 140.

Clark, Marjorie.
1944. "What Puerto Rico Wants," New Republic Magazine. Vol. CX, No. 17. New York: Editorial Publications, Inc., pp. 556-557.

Clark, Victor S.
1930. Porto Rico and Its Problems. Washington: The Brookings Institution, pp. 205.

Collins, J.L.
1949. "History, Taxonomy, and Culture of the Pineapple," Economic Botany. Vol. III, No. 4. New York: New York Botanical Garden Press, pp. 335-359.

Colón-Torres, R.
1941. Soils of Puerto Rico Classified by Geological Formations, Series, Types, and Phases, with Productivity Ratings of Each Based on Inherent Qualities of the Land, Area, and Per Cent of Total Area. Rio Piedras: University of Puerto Rico Agricultural Experiment Station, (no page number).

Cook, Frank C., and Chem, E.
1949. The Pineapple Industry of the Hawaiian Islands. Report No. 32. Department of Agriculture, Federation of Malaya, Johore: Government Printing Office, pp. 118.

Crawford, David L.
1937. Hawaii's Crop Parade. Honolulu: Advertiser Publishing Co., pp. 299.

Crist, Raymond E.
1948. "Sugar Cane and Coffee in Puerto Rico," The American Journal of Economics and Sociology. Vol. VII, No's. 2, 3 and 4. New York: Robert Schalkenbach Foundation, pp. 173-184, 321-337, 469-474.

Crist, Raymond E., and Chardon, E.
1947. "Intercultural Colonial Policies in the Americas: Iberians and Britons in the New World," The American Journal of Economics and Sociology. Vol. VI, No. 3. New York: Robert Schalkenbach Foundation, pp. 371-385.

Davis, Kingsley.
1948. "Puerto Rico's Population Problem: Research and Policy," International Approaches to Problems of Undeveloped Areas. New York: Milbank Memorial Foundation, pp. 60-68.

Descartes, Sol L.
1946. Basic Statistics on Puerto Rico. Washington: Office of Puerto Rico, pp. 103.

Descartes, Sol L., and Associates.
1941. Food Consumption Studies in Puerto Rico. Bulletin No. 59. Rio Piedras: Puerto Rico Agricultural Experiment Station, pp. 76.

Fernández y García, E., and Associates.
1923. The Book of Puerto Rico. San Juan: El Libro Azul Publishing Co., pp. 1188.

Fewkes, William J.
1907. Twenty-Fifth Annual Report of the Bureau of American Ethnology. (Special Bulletin), Washington: U.S. Government Printing Office, pp. 30.

Galvin, Hector G.
1945. "La Importancia del Cultivo de la Piña", Revista de Economia. Vol. VIII, No. 1. Mexico City: Venustiano Carranza, pp. 8-10.

Hall, Arthur D.
1898. Porto Rico, Its History, Products, and Possibilities. New York: Street and Smith Publishers, pp. 171.

Harris, William N.
1949. "Puerto Rico--Island of Extremes," The Journal of Geography. Vol. XLVIII, No. 7, Chicago: A.J. Nystrom and Co., pp. 283-293.

Hendricksen, Henrick C.
1935. Some Pineapple Problems. Report No. 15. Mayaguez: Puerto Rico Agricultural Experiment Station, pp. 9.

Hibben, Thomas, and Picó, Rafael.
1948. Industrial Development of Puerto Rico and the Virgin Islands. (Report of the United States Section, Caribbean Commission). San Juan: (no publisher), pp. 320.

Hill, Elton B., and Descartes, Sol L.
1939. An Economic Background for Agricultural Research in Puerto Rico. Bulletin No. 51. Rio Piedras: Puerto Rico Agricultural Experiment Station, pp. 61.

Hill, Elton B., and Noguera, J.R.
1940. The Food Supply of Puerto Rico. Bulletin No. 55. Rio Piedras: Puerto Rico Agricultural Experiment Station, pp. 32.

Johnson, George W.
1847. The Pine Apple. Vol. I-II. Winchester, England: H. Woolridge Printers, pp. 266.

Julián, José.
1806. Historic Geographic, Civil y Natural de la Isla de Puerto Rico. Madrid: Imprenta y Libraria de Acosta, pp. 506.

Kelly, Walter P.
1912. Hawaii Agricultural Experiment Station Annual Report, 1909-1911. Press Bulletin No. 29. Honolulu: Hawaiian Department of Agriculture, pp. 54.

Killian, John A.
1934. The Nutritional Value of Canned Pineapple. San Francisco: Pineapple Producers' Cooperative Association, Limited, pp. 34.

Kinman, Charles F.
1916. Cover Crops for Porto Rico. Bulletin No. 19. Washington: Government Printing Office, pp. 32.

Lobeck, Armin K.
1922. "The Physiography of Porto Rico," Scientific Survey of Porto Rico and the Virgin Islands. Vol. I, Part 4. New York: New York Academy of Science, pp. 301-379.

Loew, Oscar.
1913. Studies on Acid Soils of Porto Rico Bulletin No. 13. Mayagüez: Insular Agricultural Experiment Station, pp. 23.

Ludlow, William H.
1946. La Zonificación en Puerto Rico. Informe Téonico No. 3. San Juan: Junta de Planificación, Urbanización y Zonificación de Puerto Rico, pp. 71.

Meyerhoff, Howard A.
1927. "Tertiary Physiographic Development of Porto Rico and the Virgin Islands." Bulletin of the Geological Society of America. Vol.XXXVIII, No. 4. New York: Published by the Society, pp. 557-575.

_____
1933. Geology of Puerto Rico, Monograph of The University of Puerto Rico. Series B, No. 1. Rio Piedras: University of Puerto Rico Press, pp. 281.

Miller, Paul G.
1922. History of Puerto Rico. Chicago: Rand, McNally and Co., pp. 549.

Minneman, Paul G.
1942. The Agriculture of Cuba. Foreign Agriculture Bulletin No. 2. Washington: Government Printing Office, pp. 144.

Nolla, José. A.B.
1941. Annual Report for the Fiscal Year, 1940-1941. Rio Piedras: University of Puerto Rico Agricultural Experiment Station, pp. 70.

———. 1941. La Conservación del Suelo en Puerto Rico. Washington: Government Printing Office, pp. 30.

Otero, Pablo M., and Associates.
1938. Health and Socio-Economic Studies in Puerto Rico. San Juan: Health Division, Puerto Rico Reconstruction Administration and the School of Tropical Medicine, pp. 201-289.

Oviedo y Valdés, Gonzalo F.
Reprint 1944. Historia General y Natural de la Indias. Part 2, Book 7, Chapter XIV. Asuncion, Paraguay: Editorial Guaranta, pp. 185-192.

Pennock, William.
1941. "La Piña en Puerto Rico," Revista de Agricultura de Puerto Rico. Vol. XXXIII, No. 4. San Juan: Puerto Rico Department of Agriculture and Commerce, pp. 521-532.

———. 1947. Puerto Rico Industrial and Commercial. San Juan: Service Office of the Government of Puerto Rico Printing Division, pp. 59.

Perloff, Harvey S.
1950. Puerto Rico's Economic Future. Chicago: University of Chicago Press, pp. 435.

Picó, Rafael.
1939. "Land Tenure in the Leading Types of Farming of Puerto Rico," Economic Geography. Vol. XV, No. 2. Worcester: Clark University Press, pp. 135-152.

———. 1936. The Agricultural Problems of Puerto Rico. San Juan: Puerto Rico Reconstruction Administration, (Unpublished Report), pp. 35.

———. 1950. The Geographic Regions of Puerto Rico. Rio Piedras: University of Puerto Rico Press, pp. 256.

Platt, Robert S.
1942. Latin America. New York: McGraw-Hill Book Co., Inc., pp. 564.

Price, Archibald G.
1939. White Settlers in the Tropics. American Geographical Society, Special Bulletin No. 23. New York: American Geographical Society of New York, pp. 299.

Puerto Rico: A Bulletin of the Office of the Government of
1950. Puerto Rico. Vol. VI, No. 2. Washington: (Publisher not given), pp. 4.

Puerto Rico Agricultural Company Special Report.
1947. San Juan: Division of Information and Public Relations for Puerto Rico Agricultural Company, pp. 25.

Puerto Rico: A Guide to the Island of Boriquen.
1940. New York: The University Society, Inc., pp. 402.

Puerto Rico: A Plan for the Protection of the Agriculture of
1935. Puerto Rico against Hurricanes. Washington: Interdepartmental Committee on Puerto Rico, pp. 83.

Puerto Rico Department of Agriculture and Commerce.
1941. Informe de la Estación Experimental de Puerto Rico. Mayagüez: University of Puerto Rico Press, pp. 154.

_____. 1945. Annual Book on Statistics of Puerto Rico, Fiscal Year 1942-1943. San Juan: Puerto Rico Office of Economic Research, pp. 205.

_____. 1951. Annual Book of Statistics of Puerto Rico, Fiscal Year 1949-1950. San Juan: Puerto Rico Office of Economic Research, pp. 489.

_____. 1947. Puerto Rico, Industrial and Commercial. San Juan: Service Office of the Government of Puerto Rico, pp. 58.

Puerto Rico Department of Agriculture and Labor.
1920. Citrus and Pineapple Fruit Rot. Bulletin No. 24. San Juan: Puerto Rico Bureau of Supplies, Printing, and Transportation, pp. 38.

Puerto Rico Handbook.
1947. San Juan: Office of Information for Puerto Rico, pp. 45.

Puerto Rico Industrial Development Company.
1948. (Annual Report for the Year Ending June 30, 1948), New York: Aldus Printers, Inc., pp. 36.

Puerto Rico Monthly Statistical Report.
1949. (Prepared for Office of the Governor of Puerto Rico), Santurce: Puerto Rico Bureau of the Budget, pp. 43.

"Puerto Rico's Pineapple Crop,"
1949. Caribbean Commission Monthly Bulletin. Vol. II, No. 8. Port-of-Spain, Trinidad: Information Section, Central Secretariat, pp. 180-191.

Puerto Rico Planning, Urbanizing, and Zoning Board.
1944. A Development Plan for Puerto Rico. Technical Paper No. 1. Santurce: Insular Procurement Office, Printing Division, pp. 66.

_____.
1950. Seventh Six-year Financial Program for the Years 1950-51 to 1955-56. Santurce: Puerto Rico Planning Board, pp. 68.

Roberts, R.C.
1942. Soil Survey of Puerto Rico. Series 1936, No. 8. U.S. Department of Agriculture, Washington: Government Printing Office, pp. 503.

Roberts, Lydia J., and Stefani, Rosa L.
1949. Patterns of Living in Puerto Rican Families. Rio Piedras: University of Puerto Rico Press, pp. 411.

Rosario, José C.
1935. The Development of the Puerto Rican Jibaro and His Present Attitude Towards Society. San Juan: University of Puerto Rico Press, pp. 116.

Sanchez, Carlos G.
1947. Cultivo de la Piña. Mexico City: Bartolome Trucco Publishing Co., pp. 152.

Schappelle, Newell A.
1941. A Physiological Study of the Effects of Waxing Pineapples of Different Stages of Maturity. Research Bulletin No. 3. Rio Piedras: Puerto Rican Agricultural Experiment Station, pp. 28.

Shriver, J. Alexis.
1915. Pineapple Canning of the World. U.S. Department of Agriculture, Bulletin No. 91. Washington: Government Printing Office, pp. 43.

Simpich, Frederick.
1949. "Because It Rains on Hawaii," National Geographic Magazine. Vol. XCVI, No. 5. Washington: National Geographic Society, pp. 571-602.

Tannehill, Ivan R.
1945. Hurricanes: Their Nature and History. Sixth Edition, Princeton: Princeton University Press, pp. 270.

Tugwell, Rexford G.
1947. The Stricken Land. New York: Doubleday and Co., Inc., pp. 704.

U.S. Department of Agriculture.

1926. Climatological Data for the West Indian Islands. Washington: Government Printing Office, pp. 17.

1939. Control of Black Rot of Pineapples in Transit. Circular No. 511. Washington: Government Printing Office, pp. 12.

1951. Cuban Trade in Principal Agricultural Products. Statistical Bulletin No. 96. Washington: Government Printing Office, pp. 34.

1948. Foreign Crops and Markets. Vol. LVII, No. 16. Washington: Office of Foreign Agricultural Relations, pp. 295-310.

1951. Fruit - United States Foreign Trade Related to Production. Foreign Agriculture Report No. 60. Washington: Office of Foreign Agricultural Relations, pp. 68.

1937. Pineapple Culture in Florida. Farm Bulletin No. 1237. Washington: Government Printing Office, pp. 34.

1909. Pineapple Growing in Puerto Rico. Bulletin No. 8. Washington: Government Printing Office, pp. 42.

1941. Protein-Digesting Enzymes of Papaya and Pineapple. Circular No. 631. Washington: Government Printing Office, pp. 9.

———. 1903. Soil Survey from Arecibo to Ponce, Puerto Rico. Bulletin No. 3. Washington: Government Printing Office, pp. 53.

———. 1919. Summary of the Climatological Data for the United States, by Sections. Washington: Government Printing Office, pp. 49.

———. 1943. Tentative United States Standards for Grades of Canned Pineapples. Washington: U.S. Food Distribution Administration, pp. 8.

———. 1950. The Caribbean Forester. Vol. XI, No. 1. Rio Piedras: Puerto Rico Tropical Forest Experiment Station, pp. 56.

———. 1950. United States Foreign Trade in Agricultural Products, Fiscal Year 1949-50 with Comparisons. Washington: Office of Foreign Agricultural Relations, pp. 46.

———. 1945. United States Standards for Grades of Frozen Pineapple. (CFR 7, Section 52.568), Washington: Production and Marketing Administration, pp. 11.

U.S. Department of Commerce. Bureau of the Census.

———. 1942. Agriculture: Farms, Farm Property, Livestock, and Crops, Puerto Rico. Washington: Government Printing Office, pp. 84.

———. 1951. Census of Manufacturers (1949), Puerto Rico. No. MP-1. Washington: Government Printing Office, pp. 61.

———. 1949. Current Population Reports, Population Estimates, Puerto Rico. Series P-25, No. 29. Washington: Government Printing Office, pp. 5.

———. 1950. 1950 Census of Population, Preliminary Counts, Puerto Rico. Series PC-4, No. 5. Washington: Government Printing Office, pp. 2.

———. 1951. 1950 Census of Population, Preliminary Reports, Puerto Rico. Series PC-6, No. 12. Washington: Government Printing Office, pp. 8.

———. 1943. Housing: General Characteristics, Puerto Rico. Washington: Government Printing Office, pp. 121.

———. 1943. Population: Occupations and Other Characteristics by Age, Puerto Rico, 1940. Bulletin No. 3. Washington: Government Printing Office, pp. 106.

———. 1951. Preliminary 1950 Census of Agriculture, Number of Farms by Municipalities, Puerto Rico. Series AC 50-2. Washington: Government Printing Office, pp. 2.

U.S. Department of Commerce. Weather Bureau.

———. 1930. Climatic Summary of the United States. Section 106. Washington: Government Printing Office, pp. 18.

———. 1949. Monthly Climatic Data for the World. Vol. XI, No. 8. Washington: Division of Climatological and Hydrologic Services, pp. 27.

———. 1950. Local Climatological Summary, Honolulu. Hawaiian Section. Washington: Government Printing Office, pp. 8.

U.S. Department of Commerce. Tariff Commission.

———. 1940-1949. Reports of the United States Tariff Commission, Puerto Rico, 1940-1949. Washington: Government Printing Office.

———. 1946. The Economy of Puerto Rico. Washington: Government Printing Office, pp. 67.

U.S. Department of the Interior.

———. 1950. Annual Report of the Governor of Hawaii to the Secretary of the Interior, Fiscal Year Ending June 30, 1949. Washington: Government Printing Office, pp. 55.

———. 1948. Information on Puerto Rico Transmitted by the United States to the Secretary-General of the United Nations Pursuant to Article 73 (e) of the Charter. Washington: Insular Government of Puerto Rico in Cooperation with the Department of Interior, pp. 125.

———. 1941. Investigation into Administrative Responsibilities under the Five-Hundred Acre Limitation on Land Holdings in the Organic Act for Puerto Rico. San Juan: Insular Bureau of Supplies, Printing, and Transportation, pp. 50.

———. 1949. Report of the Commissioner of Agriculture and Commerce for the Fiscal Year 1947-1949. Washington: Division of Territories and Island Possessions, pp. 130.

U.S. Department of Labor.

———. 1947. Brief of the Government of Puerto Rico. (To be presented before the Committee for Reciprocity Information), Washington: (Unpublished), pp. 69.

———. 1937. Brief Submitted to the Committee for Reciprocity Information. San Juan: The Pineapple Producers' Association, pp. 50.

———. 1947. Public Hearing before Special Industry Committee No. 5 for the Purpose of Receiving Evidence to be Considered in Recommending Wage Rates for Employees in the Fruit and Canning Industry in Puerto Rico. San Juan: (Unpublished), pp. 75.

U.S. National Resources Planning Board.
1942. Minimum Decent Living Standards for Puerto Rico: Food, Clothing, and Shelter. San Juan: (Unpublished), pp. 39.

Van Middeldyk, Rudolph A.
1903. The History of Puerto Rico: From the Spanish Discovery to the American Occupation. New York: D. Appleton and Co., pp. 318.

White, Trumbull.
1938. Puerto Rico and Its People. New York: Frederick A. Stokes Co., pp. 376.

Wilson, James N.
1949. "Pineapple Industry in Hawaii," Economic Geography. Vol. XXIV, No. 4. Worcester: Clark University Press, pp. 251-262.

Wright, Meadow.
1946. "Puerto Rico--Land of Pineapples," American Fruit Grower. Vol. LXVI, No. 6. Cleveland: American Fruit Grower Publishing Co., pp. 11-26.

Wylie, Kathryn H.
1947. "Rivers of Puerto Rico," Agriculture in the Americas. Vol. VII, No. 2. Washington: Office of Foreign Agricultural Relations, pp. 37-41.

Zimmerman, Erich W.
1940. Staff Report of the Interdepartmental Committee on Puerto Rico. Washington: (Unpublished), pp. 280.

Zorrilla, Frank.
1950. La Industria de la Piña en Puerto Rico. (Report to the Governor of Puerto Rico), San Juan: (Unpublished), pp. 99.

VITA

Name in Full: William Wesley Burchfiel Jr.

Permanent Address: Marshall Heights, Sevierville, Tennessee

Degree to be Conferred; Date: Doctor of Philosophy, June 1953

Date of Birth: February 22, 1918

Place of Birth: Jefferson County, Tennessee

Secondary Education: Sevier County High School
Sevierville, Tennessee

Collegiate Institutions Attended: Dates Degree Date of Degree

University of Tennessee,	1936-40	B.S.	June 1940
University of Tennessee,	1940-41	M.S.	June 1941
University of North Carolina,	1944-46		
University of Maryland,	1947-53		

Publications: "Our Tropical Outpost in Venezuela," Journal of Geography, May 1945, and "Land of the Smokies," Journal of Geography, November 1946.

Experience: Construction Geologist, Tennessee Valley Authority, 1941-43.
Instructor, Department of Geography, University of Tennessee, 1943.
Officer, U.S. Navy Air Force, World War II, 1943-46.
Military Intelligence Specialist, U.S. Army General Staff, Washington, D.C., 1947-51.
Air Intelligence Specialist, Headquarters, U.S.A.F., Washington, D.C., 1951-Present.