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LAND USE ANALYSIS OF PUERTO RICO

Prepared For

ONVENT. RESEARCH

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sitted December 20, 1979

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LAND USE ANALYSIS OF PUERTO RICO

Prepared vor

iit UPR CENTER FOR EXFECY AND CMVTRON

BIOMASS EEERCY PROGRAY,

By

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Winter Park, Florida 32792

Submitted Decesber 20, 1975

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LAND-USE ANALYSIS OF PUERTO RICO

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LAND-USE ANALYSIS 9° PUERTO RICO

George Samuels, Ph.D.

COER-UPR Biomass Pnergy Program

University of Puerto Rico

ABSTRACT

Puerto Rico has an area of 2,189,026 acres with 901,484 available for agriculture, a population of 3.47 million people, and 0.26 acres of arable Land per person, With these dimensions to consider, every acre of Land becoues importunt, for its use directly or indirectly affects everyone, be the land chosen for food crops, energy crops, forest, industrial plants or coerce. The outstanding feature of the landscape is its rugged topography with only about 20% of che tots! area having a slope of 5 degrees or less. The Cat lowlands ere the creas of comercial agricultural production, the nountain lands areas cf forest and gubsistence agriculture, and the rolling intermediate. The soils have been thorovght

recent soil surveys (1965-80) available for

Agricultural policy and planning for Puerto Rico for about 75 years has been one of lack of continuity, Its agriculture hes not becone modern, nor efficient despite costly injections of funds via subsidies and prograns. Agriculture has lost out to industrialization and urban growth decreasing agricultural acreage. A nedern agricultural progran developed by the Puerto Rican Department of Agriculture has as its major thesis to produce most of the food it ow iaports, improve ite econoay by stimsisting domestic agricul ture production, and provide enployment. New vice, beans, and vegetable enterprises vill be established on conpietely nechanizable land. The cattle industry will be expanded, Tobacco will disappear ané sugar production will

be downgraded. Commercial forssts will be developed. Choices are needed between snall ond large size farm units.

Biomass, plant material to be used as fermentable or combustible solids for recoverable enersy, is a new crop that must be considered in land-use planning for Puerto Rico which imports over 98% of its energy. Sugarcane ith both combustible and fermentable solids is the most efficient energy crop with tropical grasses (Napier & Sordan 70A) ané silviculture "energy plantations? offering viable energy sources. Because of limited land area, balance must be achieved between food and energy cropping. Suggested ?examples of possible biouass land uses coupatible with a modern agriculture program are given.

A/ Research Consultant

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Puerto Rico has a

ited area vith Large dinands placed upon it by a

growing population for food ana energy crepes

fing space, indwatry and

comerce. If is the obsective of +

paper £0 give an analysis of past and

present lend uses

tion to food crops and guidance in developing Puerto

Rico's biomass energy c-opping.

There ave sinple geographic factors which must govern @ land-use analysis

of Puerto Rico.

Scale ~ Its extent is 35 miles by 100 rites with an area of 3,435 square

miles.

Insularity ~ its frontaer is the sea,

Density - There are 3.47 millicn people, 14

10 per square mile with 0.26

of an arcble acre per capita,

Physiography - 80% of its curface consists of hills and mountains; 20%

has to be shared by agriculture, manufacturing, highways,

airports, resreational areas, and cities.

With these dimensions to consider, every acre of land in Puerto Rico

decomes important, for its use directly or indivectly affects everyone, be

land chosen for food crops, energy crops, forests, industrial plants,

housing, or comnerce.

THE LAND

1. Physiographic and Geologie Festus

Puerto Rico aay be divided roughly into three principal physiographic

divisions (Pig. 1) according to Roberts (1). They are the complex mountain

---Page Break---

Which are the aoat extensive, the coastal plains, and the play 2 <beach)

plains

?An east-west mountain range divides Puerto Rico into a northern and southern part, Its crest (about 3,000 feet) is far to the south of a latitudinal Line passing through the center of the Island, To the south of the crest, the

relief is rugged and is characterized by many steep-walled rock cliffs,

abrupt high waterfalls, and jagged peaks. On the north side of the crest and

?extending to the coastal plain, the relief gradually becones less rough.

?The coastal plains parallel nearly the entire coastline. They range in width fron a maxinun of 13 miles at Lares to nil at several points along the eastern and west coasts. ost of the coastal plsine are confined to areas that are covered by a thick deposit of Limestone that several fluctuations in sea level in tires past have caused the landscape to have a belted appearance. Erosion has produced numerous hills and valleys.

The playa pl

8 include the level alluvial plains, lagoon deposits,

and elevated beach sands. The flat alluvial plains occupy the largest area

and conpromige the sost valuable agriculture Land. They occur along all the

streams, but are most extensive near the mouths of

we large rivers.

Betnroth (2) uses Mitchell's seven physiolgraphic regions to cescrive

the physiography of the Island in more detail.

2. Landform and Topography

?The Limitations and potentials of agricultural development are largely

determined by the Island's physical characteristics. The outstanding feature

of its landscape is its rugged topography. Only about 20% of the total area

has a slope of 5 degrees or less. The land area by percent slope is given

in Table 1.

---Page Break---

mae

Young (4) identified 12 different lendform areas based on local relief,

Percentage of steep siope, und percentage of flat land. The three mejor land=

form clesses ciefined vere lovlands, hill lands and mountain lands, In percent~

age of total area they are as follows:

Lowland - 19%

\ lowlange = 11

Rolling Lovlands with some flat land - 22

3, Holling lowlands - &

Nili-tands = 37%

Ae Rol

ing hi21 Land with some flat Land ~ 4%

Boling hi

land ~ 22%

3. Rough hill Land = 42

4, Bugged hit land with some flat land ~ less than 1%

5+ Rugged hii Land ~ 62

Yountain Langs ~ 47

1, Rolling mountain Land ~ 6%

2. Rough sountain land ~ 15%

3. Rugged mountain land - 23%

A description of these landform areas is given by Fields (3, pp. 99-101). Fields superinposed 11 rainfall regions on Young's 12 landform regions to sive seven landform-clinatic regions for the Island that is meaningful from the standpoint of agriculture (Fig. 2).

At the risk of over generalization, the flat lovlands may be characterized

as the area of comercial agricultural productions the mountain lands as t!

area of for

's and subsistence farming: and the rolling lovlands and hill

---Page Break---

lands as intermediate betwen the two, characterized by mixed, small-scale commercial agriculture ard subsistence farming.

Land area in Puerto Rico distributed by altitude is as follows (3):

Feat at level of Land area

352

sos. 999 a

1000 + 2%

?Though 55% of $s Lond area, 1.2 million acres, is under 500 feet in

elevation, the percentage of flat land is substantially less vith only 400,000

ven

acres having slopes of

acreage in subject to constraints

in cultivation as 4 result of such factors as erosion, éxainage, and clinat

icance of the let lant Lies fa its suitability for mechanized agricul

The soils of Puerto Rico have been thoroughly classified. The first detailed survey of the Island vas completed by R. C. Roberts and party in 1936 by the Division of Soil Survey, Bureau of Plant Industry, USOA (1). Thie soil survey is good, covering both crope and sofls. Tt still serves as a handy reference for anyone wishing to know Puerto Rican agricultural status before 1936.

?The Robert's soil survey was updated by the Soil Conservation Service (SCS), USDA beginning in 1965 with a survey of the Lajas Valley area. since then additional soil conservation districts have been covered with the 1 Arecibo, to be published in 1980. The districts covered and their acreages

---Page Break---

Diserier

Arecibo

unacco (6) 470,202

Lajas (7) 102,609

Yayencer (6) 460,836

Fonce: Sur (8) 171,790 acvas

Caribe (10) 123,613 acres 305, 402

San Juan (11) 447,279

TOTAL. sere 2,274,094

The recent

105-80) soil survey is quite comprehensive, and it provides

fore thaa a mere classificaticn of soils, Tha make-up of the soil survey for

4 concervation district conta:

3s General nature of the arsa and climate.

2. General sofi nap for broad land-use planning with mop unit descrip

tions and soft associations.

3, Description of the soils describing each soil series in detail, and

then briefly, for the layman use, each mapping unit in that series.

4, Use and sanagesent of the soils, This sec!

ya costaing an explain

tion of the systen of cupability grouping used by the SCS. Eetimated yields for

the principal crops anz pasture grasses under two luvels of management (local

and improved) are given. Yanagenent of the soile for woodland is also discusse:

Information and Limitations that affect engineering practices and recreation

uses are presented in tables.

the information and classification of the soils as to major factors

of soil formation are given vith the definition of the systen currently used

for classifying soils by the six higher categories of order, suborder, great

---Page Break---

?e0uPy suagroUP, family, und series. A table ie included of the classification

she series giving tie ?amily, sudsroes, and orver for each series.

G. The cLinate of the area is ceverihed with tables for ceaperature and

vointail, and sonstines nota evaporation :ares,

7. A guide to sepping unite which conta:

the capabiticy unit for non

inrageted and irrigated soils of each mapping unit as well as its woodland

euitabinsey

8. Sheet aazs of ths soils wit theic mapping units are inposed on

aerial photographs (scale 1:20,000).

che Fonce survey, race up of two publications, the Sur (9) and Caribe (10)

conta: ouly tables on the roi! properties and limita

at Gotect engineering and recreation wses and lend capability,

erodibility, cud hydrological classification. The tajas Valley aurvey does

Rot contain # table on recreat

?The soil enginsering tables presented in the soil survey have potential

velue fu Land-use clausification provid'ng suen needed data on soil provercies

ae pit, seasons?

Aish water table levels, depth to bedrock, texture, per

Beability, available water capacity, drainage for exons and pasture, irrigation,

and suitability for verraces, diversions, and pond reservoir areas,

The new

onoaic Syston us

sd by the USDA-SCS classified 9 Orders, 22

Suborders, 37 Great Croups, 106 Subgroups, 54 Families, and 164 Series for the

tat

4 G2, p. 19). A briet deccriotion of the nine Orders of Puerto Rican soils, co aid the reader in the use of tables and naps, is given in Table 2. 4m excellent review and explanation of the saxononic classification of the soils of Puerto Rico has been prepared by Lugo-L6pex and Rivera in 1974 (13) with an update for 1977 (14). An inwentory of Puerto Rican soils calculated on @ Percsutege Sesto for each of the nine Ordere for the six soil survey areas is given in Table 5,

---Page Break---

-a-

4. Land Gapabs tier Slaysificacion

?The copabitity classiticatios used by che SCS 1s a srouping that shows

in a gencret way, how suitable soils sre for moet cypes of farming. It ie a

practical grouping based ov limitations of t'w sails, the

ick of damage when

shey ace used, and the way cher

spout to treatment.

In this system, all of the soils are grouped at three levels: the

capability class, subclass, and vn:

In the broadest groupicg are the eight

capability classes

fgnated by Komax numerals T through VIII. ta clase

are the coils that have Cov limitations, the videsc range of use, and the

Yeast risk of Jonage when they are usec. The soils in the other classes have

progressively greater natural Limitations, In class VIII are aofls and land=

forms so rough, sallow, ov otherwise linited that they do not produce vorth-

wai

ields of erops, forage or wood products.

The subclasses indicate major kindy of

ration within the classes.

They are (e) erosion, (4) water a

poor drainage, (s) shallow, droushty, or

stony, and (c) climate too dry.

?The capadis

¥ classificstion unit for each coil is Listed in the ?cuide

Fe Mapping Units" and at the end of the mapping unit description in the section,

?scription of So

's" in the Soil Surveys of Puerte Rice (6-21).

?The soils of Puerto Rico were grouped by Vicente-Chandler (5) in 1978 in

accordance with their agricultural potentiel. The grouping is staple and

usable within the framework of the soil navping units of the land capability

ol

ification of the SCS. The soils are divided into five groups (Table 4).

This grouping has served as the basis for the modern agriculture! program now being carried on by the Conmonseaith Departnent of Agriculture, It is a very ?sseful grouping that can be used as @ base for land-use assignments of crops,

silviculture, and other agricultural enterprises including energy crops.

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ievowiedge of the status of the land-use iuvencory 5f Puerco Rico ts

of botp tas

ours planning. Tie Departuert of Natural Resources made a land=

vse invencory of the IsLané iaventozy was sade from aerial

Photogearhs and teo cosmutor proctams which aliowce deterainationof the laud

use to a detail of 62 acres, hey obeoined ageicuteural acreagex of 1,176,816

and forest 102,278.

The acreage of agricu

yeai laud sulcabie for echanization te an

ingottant factor in ?aicause decisions. Vicente-Chandler (5) estivated

337,000 total acres (276,000 availabi« acres allowing 20% off for coads, housing,

ete.) of Land that ean Se used for fuit mechanization, This i prinarily class T

Land and ne derigation oF adegu nfalt available, Sonnet (22) stated

that sone 523,191 ucres, nhout 244 of Pusrto Rigo's totel eof urea, are

suitohte for mechanized slontiny of sugarcane, whether for sugar or for total

biomass (Table 5). This includes ?tosses

TI, ond some 21 Lunda wita

slopes 20% or less.

te

5. eologicat

?The Puerto Rican scosystens are extrenely important, because they form a

Substantial coaponeat of tho Life-suspert system for over three milion people.

Evel and Whitmore (16) mapped the ecolopical Life zones for Puerto Rico

eccording co the Holdridge system, They identifind six distinct Life zones
Which are also widely represented in Central ant South America, Detailed

emphasis was given to ecological zone fcatures, water balance, ané biotenper-
avure theory, 90 that research cone in fuerte Rico, Central Anerica and South

America vill be mutually beneficial.

---Page Break---

?The aroce occupied by the wcologicat Life ones in Suerte Rico ara (15)!

Subtropical Ary forest 300,578 er

Subtropical noise forest 1,315,105 *

Subtropical wet forest 325,087"

Subtropical rain forest 3.262"

Subtropical lower montane wes forest 26,959"

Subtropical lower montane rain foree

3,939

?She suberopica? mot

and wet forest zones sceupy $57 of the total Land

aves in Puerto Rico.

More churough study has been given vo

stems of Puerto Rico and

the Ww

gin Islané:

han 40 nose other cropical regicns, vhe ecological studias

rade of Puerto Rico prior to 1900 vere summarized hy Wiesvorth (17) én 1950,

Morphy (18) was one of the First to provide detailed &

viptions of Puerto

Rico's forest in 1916. A clases

éeseription of the Isiand?s plant communi

eas published by Cock and Gleason (29) in 1926, which till serves as a standard

Feference work, Ip 1965 Tanseresu (20) published phyoiognentc aud floristic

descriptions of more thar 100 vegetation types in Puerts i

Ne dosignacee

six principal vere

ive rones conditioned primarily by cLinate

secondarily

by either physiography or plant sacerial. Publications with aecoapanying maps

of vegetation were insued by Little ant Wadsworth (21) ia 1964, by Wilfams

(22) in 1967, ond by Odum and co-vorkers (23) in 1970.

6. chivas

A neaningful land-use analysis of

ferto Rico should include a brief

Siscussion of ics climate, for its clirate, p!

ily as related to vainfall

and evaporation, i

juences a great deat of the agricultural usage of the land.

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J, wndfora, oceanic elinase, and om

arly ideot

& heavy precipitation over most of che area. The highest

peaks and the northern snd eastern cides of the acuntain ronges receive the

ts

jot rainfall (Pig. 3). The southern aide, northivesteru corn.

shoreline en! the interior vallsye ceceive the least.

The average annval rainfall regen from

1s than 30 never in ehe south

escorn part of the ?stand to nearly 209 inches on the highest peas in

Sierra de Luguilic (ig. 4). There are no definite seasons, but rather a reiny

period fron ?lay to Novenbur and a dey period the othe: 6 menshs. Throughoct

the winter, hoxaver, mauy showers occur,

the heaviest torrential rains take

place in the sumer.

The high evaporation rate combined with hign teaperatures, Low relative

humidity and constant winds tends to couse samiarid conditions even where the

average annus? raicfall is 45 inches. A cain

11 of 39 inches in Puerto Rico

is equivalent in effectiveness to about 15 inches ia the United States. Many

Of the agricultural sress ou the southern coastal plain have evaporation rates

uch higher in comparison te their rainfall during the dry weather

mat

?other seasons, and irrigation is necess:

?even in aveas Saving aa average

ammual raiatal of 65 inches (Fig. 5).

The voter available from dane, welts, and rivers must face competition

with domestic ond industrial consumption, thas depicting supplies available for

ieeigation, A vater bolance for the seniarid southern repion reveals an

average 5 million gatton per day deficit (Table 6).

?The mesa month: han 5°F trom susmer to winter

temperatures range no more

with a yearly mean average tenperature of 77-79°F on the coastal plains to

71-74" im the mountains. The tenperature seldom tisos higher than 90 and even

---Page Break---

in the highest, coolest parte of the

id, it seldep fal1s below 50°F.

Sunshine occurs daily over uost of Lie Island wits the exception of a fev days each year.

Temperature ané sunlight are not Linicing factors for agricultural produe-ton in Puctrs Rico. Rainfall is Lisiting in some areas of the south and southwest coasts during the winter moaths, but {rrigacion, when available,

compensates for this water deficit.

L.O-USE POTE

Ns Agetouteuran

Puerto Rico's past was cents

2 in ageieulture, Since the days when the

Istand was first setcle? by the Spanish, the people hove been concerned vith Producing agricultural croys. Up untii the twentieth century, the ageicuiture in Puerto Rico, a3 in nost of the Caribbean, was based on large farm of

Plantations, owed by a few, growing sugereane, tobacco, cotton, and fruits for

export, Domestic food was grovn on smal plots by the fam Laborers.

1m 1900, vhen Puerto Rico become = U.S. possession, Congress passed a law Mniting land holdings to no core than 500 acres by any individual or corpora~ Mon, The Jaw was not enforced, and Large land holdings continued. Some of che agricultural policies of the U.S, government in the early 1900's were

applied to the Island, with soit an! varer conserve!

?ion prograns beginning in 1923, the WPA prograns in the 1930's, ond the Farm and Howe Adsinistration Program of fanily faras of 30 to 40 acres in 1948.

?The change of political clinate in che early 1940's, with the beginning

Of the Popular Denocratic Party of Muioz-Marfn, marked the start of the local

Puerto Rican agricultural policy. tn 2961, the Teland's lepistature passed

the land law (Ley de Tierras). Tt reafimmed the 5O0-acre Limitation law.

---Page Break---

At this time, eugarcane occupied over 70% of che crop acreage vith the major

part being contcot!

ed Dy companies wore sharsholée ce were nor in Puerto Rico,

?The 1941 Land iow established Lis Land Authority of Puerto Rico, « seni-

fon, part of the

forte Rice Department of Agriculture.

5 task was to end taree

porate Tout holaixgs, ?elp small farwers, ecourage

pew farmers snd make Seat use of the Lands for public good under efficient and

sconemie production, The Land Authority handled the éisposal of the large

ny Proportional Zenefir

rae (Title IV) consisting of

large connercial faree aud suger ni!ls crgauized and ren by the Authority

devoted mainly to sugarcane; smal! plots (1-7 ceres) were distributed to love income families (Title V): and fanily tons of up to 25 acres were sold to farmers (Title VE.

as

* the creation of the Land Authority in 1941, the laland's agriculture was subjected to neny plans, proyrans, and reports evo'ved to help formulate # sound and dyncuic agricultural poiiey. High points identified by year, are summarized as follows:

1953 = "A Conprehensive Ageiculturel Progean for Puerto %

" drawn up by Dr.

Ns Koening, USDA, with the cooperation of

This study was ncot thorough in its ex

ination of soil eroeion, water use and

control, reclanition, forest and grassland rescurces, as vell as ita analyses

of agricultural credit, marketing probtens, fam size, uneaployncnt in rural

sand the problem of Land use and taxation. Many of the technical findings

and conclusions recomended renain user

and valid today. Nevertheless, the

study's usefulness as a guide to the formulation of a development strategy for

ae

vulture war weakened, because it incorrectly assessed the impact of factors

external to agriculture, aainly industrialization, Wrong conclusions vere

Gram, because it divorced agricultural planning ftom the mainstream of develop

ment decision for the Island as a whole.

---Page Break---

ure ot Puseto Ri

1966 = "the kgete

fom and Possibilities" (25)

prosentad by thy Se:

yoof age/tactuve Me ts

nicz-Agreste in collaboration

with vazives loco! scientists. Tha vepurt mace voromendacione concerning

agriculeural policy ard

utlnad a congran of setter for devel!

pment of many

aspects of

Teore Snstuting ?emang of

Tunds, conservation of water,

soils, and foresce, drainuge pruects, and ine:sariag the agcicultural budget.

Parts of che peoprum were pie Jat

jon, bur not with unified Long-range

Planaing.

period, varinuy ageiculcural seccetaries have given

impulse te distics! yarte of

s program dn acensa wich hie criteria ané the

uations of hg tine {2 off/ce.

Agricultural Land #9 Suet. leo", = study by

the Lelsod Manning Soa.? ané Agricultecat Senet).

?The repores was dawn up to examine the probtens affecting sgt iculture? Land

ownersh{p and t9 recone! ype

te uearures 8 to x0aing oF aon-eoning

laws for ice prose

me A prodectiviyy Inger wan developed te serve an a

basis cor farm classifieution. Tine nermitied che study to envelop only

tex for 1963 date with dotntle for the Yaysguee area. The report contains

8 good generat descrinsisn of crome and taney

phy {Sy pp LOI-LSt) and a ceview

of soit ares characteristics (3, Anpexcix 4

No oni

?ent action was taken

fon this report by governronte? authorit-es despite the Jive need for a clear

policy on zoning to preserve the good agricultural Lands of Puerto Rico.

2 Agriculture

Te appears that the agricultural policy and vlaaning for Puerto Sico for

?about 75 years has Leen one of lack of coutinulzy. The past policies were

Limited to responding to a successioa of crisis fn different sectors rather

than any long-range planning. The tatoad's agriculture hy

not become modern,

---Page Break---

nor efficient. deapére co

y avjactions of funda vis cube:

hase qusrter Uf rhs cwontieth ce:

into botonce var os

A corpvekensive rev

Psogeics Sor a Yodern

Agriculeare dn wert Teo" (5° was developed by J. Vecente-Grandier with the

and of rainly ?oon. cevantints and subei*ted to the Comonwoal ch Department

Agrieat!

46 guide dn Ceveloping 2 complete long-range plan for agricul

tare. The ndor ?heeds of the 9

4 that Puerto Mico roquires a modern

progesa to fulay 6 88

water, and year round

5 of the food it now imports, smorove its econony by

stinulocing domestic agefculty: cl eduction, und srovide employment, but not

the price of -asing

oote.

does on

The repo wely on generalities, Ti presents definite recon

mendations a5 to croy and f

needs, econamis demands,

farm exployment, snd a tire-fyane for development by 1688

tive ig to octulate food prodsetion and minimize 4

product:

fh goals based ov modern Fare vith agronomic supervision to bring the

oder technetugler Wizectty to the tamer.

The plan has designat

sd sone drastic changes in land use, as the modern

agriculture develops over the next 19 years (iebte 7), The area in sugarcane

Will be markedty reduced and vill be Limited to completely nechanizable Lands

The new rice, vegetables axé bean enterprises wili de established on completely

mochanizable land.

Sneapple and hay productton wS11 be expanded on the

mechanizable lands where they are ney concentrated. Tne production of pigeon

peas and starchy vegetables vill be transferred from sloping lands to

---Page Break---

- ee

nechanizable 36)

atthe industry Will expand, The tehasco

dustry

WALL dicavpesr. The procuction of coffee, cittrs, sananss, and plantains

will be cenceutracct on moderately steep so:

wit industry will

be developed on soit,

?5 land fm the semiarid egien, the production of

voultry, digs, and crnaventals will cpand nustly en soils with moderate

slopes in che ne

4 vegion enJ on nechaaizaste but very sendy soils. Com

Bercia? forests will bo developed mscly of steep, deep soils which are at

present largely at

erdoaei, Aquaculture witi be develcnes in appropriate areas

ang the very atuey

Y shalinw soils wili be hep: cn satural woodlands

tn Table A, che total acreage for eacts one!

?clsurat enterprise, the

production fools proie.tev For 1988, and the farm values exe presenzed. Total

vatue of sgriculturs' production at the farm ?eval

is projected to increase

from $421.3 miLiion in 1576 to $793 milton in 1988. The pian presents yearly

production costs of Labor, materials and wther itexs for the 4ifterent agricul

tural enterprises in 1928 (5, Table (43). They point out thet enterprises

with high tebor costs hay

2 greater inpact on the e:

?ory of the Ysland than

0 those whose costs are mainty for meverials, ?hey estinate that every

doliar in farm weges hos a 1.8 muleiplier effect on the Tvianés seuss product,

and thac each jo in age:

ture creates another opportenity for exployment

in other phases of the economy. Attention has been given in the plan as to

the needs of the farner for credit, ¢

fect incentives, services and materials,

arketing and food conservation ané processing.

As one reads the modern agricultural plan, the thought cones to ind,

"IE only this had been Zone years ago". in

context of normal tines, this

agricultural plan appears to provide a definite plan with proper regard to

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-ue

Jan4 use and the peoote, both coumcry and urban, Possibly two obscacles may

be dificult to overcome in the rear future, dexpite the recogniticn and

aMowances nace by the plasnere. Thuy are a shortage of vater for full

serfeuteural potentiat and 9 vsed for nore hishiy urained, rotivated, and

disciplined farmers and farm Laborers

Vafertunately, we are not in « context of rornal times. An enersy crisis affects all of our planzing. Thus, the modern agriculture most try and bring the present ani future energy needs of the Tsland into ite concepts, plan, and propran. this #

tant matter Witt receive further attention in the

Bionass part of the report.

(2) Human Resou Puerto Rico's hunan rear

cos conprised a poulation

9f 3.47 million in 1979, prujected to aa estinates 3.58 million in 1986 (5). Tes lond area is 3,435 61, miles and will not geow any larger. This gives a

Population of 1,010 pecpte yer sq.

Le, giving it a population density greater

than Japan and about the sane as Taivan. Tt becomes impossible co make any decisions in land use for agricutture without consideration of this avsone population density.

An average of 47,000 out of 718,000 persons expt

in agricutture, The eaierity of the

over 44 years old and have an average of 4 years of schooling. On the other hhand, nore chan half the population of the IeLand és tess than 19 years old and ore than 400,000 workers are high school graduates.

?The modern agricultural program in 1958 will exploy a? reasonable salaries bout 47,000 persons throughout the year (Table §) including farm workers,

farmers, and farm managers. An additions! 40,000 jobs will be generated {roe

this agriculture giving a cota! of 88,000 jobs.

---Page Break---

The medors agracet fe Puerto Bice Sas the necessary

tesourses En divas

st en effective aoe consimuovs effort is

reeuited

In bse requivad die chills. Ae pointed

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resents an obstacte to

© rated for fn the praweaa.

(9) Fem

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past, tae bess tots wore Zormed into Large teltinge with onal? fare being

im total acroage. Variiss auministesticns have tried

vom. Anege versus seat? fens she

ngs. The government via

yeed Jo create geali faens usin, ?stir ¥ ané VE grants.

AL present, £200 iy the covered

see of che coucr industry, che government

Recpent ince heer.

?The faim sises for tne sland im 197e are given in Thole 2. over 86t of

the ferms were belov 30 acres, tut this represented only 24% cf the total fara

acreage, There vere °72 fame (2.9% of tora) cumber of fares) over 260 acres

Sony ropeesanted 50% of the estal fara sereare, tater=

eetinniy, comvared co 1950, the number and acres

of quai! size foems are

decreasing and tne iasrr-size fams increasing.

Modern agvicuitere vequt

fos large-size farme for certain crops (sugarcane,

rice) ans suall~size {cvms con do veil in intensive and specialized crops and

enterorises (consnentals, poultcy). The redern aericultura? plan appears to

be wearching £

a he:

Of various fara sizes suited to th

stop of enterprise

The political advantage of saall-size farms must Sew

fghed against the

practical reality of che skitis of the farmer, his resources, and che viability

of the agricuitura! asrvet he must deal in.

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as

The forests of Poorts Kica have played an ipportant rele in protecting

Sleods, rousing the amount of soil

eof} and water resoureas by sini

paterial Jest wo! protenging runoff into periods of

dey woachor, Wher che Leland wae colonived in the eacly 1550", it wes com

for farms was oon begun. By

ty covered with forest, but clearing Tan

1930, nnat 9? the ror-ccs laid bee cut. Sure of these areas were abandoned and

were taken over Sy ?n"erior velustece species.

About 1. million acres of Land ore available for forest cover in Puerto

Rico OD. 1 ory (13) showed fine wood growth at

682,000 rattered crown 32,065 acres, sclié crowm cover 264,493

acca cud public Forests 125,67 acvee. Commercisl and non-cosmerciul forests

inctuding the Cacibbean tacfoaal and Comonwealth forests requires about 50%

cimber stond Iuproveaent or reforestati:

Woodtané-cuinabie groups have boer compited ay the

9 their soil surveys

for Puerto Rico to ausist in planning the use of the soils for Koud crops.

Woodland management taplus include euch specific data as voodiand suitability,

soil group anc sap symbols potential productivity efving suitable trees and

avorago yearly growth per acre in board feet un! the hazards and Limitations

that effect managenenc, including seed sortality, erosion nazard and equipment

Linitation, Using the zoils for forests Javelves ware in changing of some

natural non-connercial forests to comere:

1, the protection ef other aon-com

uercial forests in their natural state, and the planting of nonmforested areas.

About $250 million worth of woos prod

ce arw inported yearly; yet, there

is no local wood industry. The sodern aceicultural program reconends that

220,000 acres of the 280,000 acres of the mountaneous steep, deep soils be

established in convereis! ?orests over the next years. Forestry experts have

---Page Break---

recomenied thet Honduras sine @:) a3 dest for

coumorcial growth in guecce Rice. thes: dorests will produce wood with a fae

value of $63 eillion yearty and will ereute 4,000 Jobs im the Fielé

srowass

1. Intowuseion

lp untii the 1979" any land-use enalyeie study of Puerto Rico would

concern itself wish acreapas of food exens, pastures, and forests for its verious

Soils. The worid enersy crinty Sas clad 2 nev dimension co any planning, be

ft political, economy. or agricul:

crops, a new vord has

been added: ?Siomasy, Biomaes can be defined a0 plone nareriai which hae the

adeiisy co convert

reviact energy of ?he eum to chenical cuerey and to

store this enecgy i recoversbie forus (fermentable and coubust:ble solids).

Thus, Goness ss 21 agricuteura! crop pives man 2 tanevuble energy source to replace dvinéling supplier of fossil fvele.

Thore are tee orincipal groups of bichase: aerbaceous anual species and

woody perennial species. The herbaceous group inclules the majo: part of our

agricultural crops och as sugarcane, forages, graing, veretables, ond starciiy

Foot crops. The perenniri group incluJes such crops as coffee and citrus, but

most woody plants are forestry (or silviculture) species.

Bionass becores available for energy sources by burning its combustible

solids as a boiler fust, conversing its fermentable solids to alcohol based

fuels, use of pyrolitie methods to ~

luce gas and Liquid fvels, and developeent

of chemical conversion cf cellulose and hesicellulose complexes to alcohot oF

chemical feedstocks. Thue, age:

tural planning in Puerto Rico must consider

such crore as cucarcane, tropicel yranten, and sfiviculture, not only for their

conventional uses, but for their energy potentials.

---Page Break---

Puerto Rico inports over 96% of its energy reyuirenents az oil. With

the world energy cricis acnding ofl prices soaring, Che expenditure for of2

in 2976 was 1.4 hiLiton (iS). Food oxpendicuras foe imports amounted to $500 million fer the cane perio. Mouever, off praces ara rising at a more rapid rete then food crop rrices. As a country whick does not have the cesources to produce both its &

1 eueray and food crop requirments, choices vill have to be mide. Any adequate iane-use analysis for Puerte Rico must give serious consideration to bicnass as part of ice presentation.

Biomass Energy Se

The consider:

traditional crops as Memass energy sources requires

thar eradics

fat agrouonic wcactices be replaced by teu serononte practices

seek to obtsin highest yields por ait area ef exergy-porencial saterials,

rather than beac

eva) uses as food, Fiber. or cunstracticn material. For

example, cconoxic

in not possible with conventional

yields of 30 tons of aitiasle cane per

sre, but biomass managed cane yieldicg

90 toms per acce reac? ee eccuonic feasibility, Nontraditional energy crooping

includes non-inten

fve bionass crops on marginal iands with miniaum eillage and

use of weeds ard grass clippings as enerzy sources.

With each crop presented in the folloving secvion, an eatinate is given of

the maximum pows

te ucreage and oi! regional 1ecation available within Limits

ef sound agronomic practices including ecosion and water control. The suggested

acreage allocation (Tabie 10) does not imply chat totat bionase conversion of

Yuerto Rican agriculture is recoumenced; rather, they secve as guides to the

reader for possible use in planning studies, Nor does the acreage given mean

that all of it is su:

wble for che mechanization needed in planting, harvesting,

drying, and transporting the Siorass crop. Where possible, the dry-natter

---Page Break---

bonies production pey acce and totals WEI be given, ay vel? as porencia?

mots oquiviliuts of the sacerte! prod

A Mebie Mo a compe is made to

Bive divect scononic cvaiusticns, ay it ?54s bevced the seape of thie report.

G8,20), say

©) Suge~ ne ie the

cslalzacion of vonnage wes

4 Increase over the averane

use of cone tope and Leaves

contribute atous 30% nore buonasy than just mitieble cone stalks. The fiber

content fo" befter See twa shout ut anw varietion cay o?ve higher fiber

Weluow, The fementable solide can be used for aleoto! production directly

08 the ceae juice or fron wvlagens, Thus every 169 tone of erwen sidlable

becenes 130 tons of Bicmags cane (30% od fre Leaves ane tops)

Which gives 22 dry roa of biomase casabie 9 189 sion TU

equivetent to 36,000 iM of elecericit; lus abast 1,600 gallons of ateoho! from

cone Juiea oF enriched molasses, sufficsent to reptace 1,600 selions of gasoline.

(®) Tropi Tropical wrasen, other c

Promise as meximem bisnass producers. Napier gears ¢

Deen shoim by Alexinier to be capable of producing actually sore biowuss

tonnage than sugarcane in x G-sorth harvest dsterva: (31). Te can be desiguated

ss an intomedinte rotation crop auited in areas not appropriate to sugarcane,

because of Length of growitg season available or other growing conditions such

a5 rainfall.

A crop appropriate for a short rotation Se the hybrid forage, erase,

Sordan 70A, crces between avect sozgivue and sudan gra

Alexande> (31) bas

obtained an averexe of 3.4 tons per acre projected oveneéry biomass in 2-nonth

---Page Break---

-3e

harvest intervals and 4.3 cons in @ domonth harvest interval. Serdan 7CA is

weransile {0 ith shore cronping period to fit inca retations with many food crops.

"Wild Sacchazom clones (US 67-22-2 and SHS £51) and Jetingan grass (Sorzhus Yalegenae) have Seen stugeated fur wininuntittage can/idates for marginal soil where Lack of water is predominant (30). They can produce noderate

she barest siaimus of production inputs.

ict potential for Puerto Rico's crests have never

been realized whos menage? ag ?energy plantations", However, Whitmore and

Lexmiter (42) foresee ancy dimension and civallange in che production of ota?

Gey master for energy conversion rather

1p tumber. 4 pilct rescarch project

hax een sutnicked £9 the USUOE, Fuels from Biomass Systems Srench. Potential

¢ projecnions of 18 tons dry natter/acre/year for tops

rain foxes

1 forests have been suggested (33). Species thought

Certain soecies of the genera Euphorbia, Salotrovis, Ceyptensowin, and

Zarthenium might aiso Se grom on marginal lands becouse of their high contents

of plant hiydcocarbons (32) rather than as a bofier f

3. A Bay

snes Food and Energy Cropping

agricultural planners

Puerto Rico must weigh carefully the merite of

energy planting vereus food planting for the Tsland's availaste land resources.

?There are about 270,000 acres of level, aechanizab}e land for either cropping

system or a combination of both. This is the best land and 3s capable of

---Page Break---

=m

producing the highest yields of food or energy crops. Yet compromise can

prevail to yive a rational combination of both,

Sone suggested exanples of possible biomass Laad uses compatable with a

modern agriculture program aret

1. The proposes 70,000 acres &

sugarcane in the nodern agricuiture

plan can produce, instead of sugar st a Joss, boiler fuel (sagasse) and oxriched

molasses sufficiest to supply all the needs of the Puerto Rico rum industry,

with an apprecial

surplus which ean be converted to alcohol for gasohol, saving

fon imports of both molasses and motor fuel.

2. The use of tropical grasses such as Napier on the hunid, deep coils

with 20-25% slope could provide more BTU's of enezay as a boiler fuel chan al

of che 522,000 acres of coits that could be planted to suparcane (Table 10)

Including the best

feapes for mechanization. Of course all

the 554,000

acres of the huni, doep soile with 20-25% elope can not be used for Napiers

but aside from slope, the soils and clinate are good for Nepier grass production.

3. The use of Sordan 70A, not only in the semiarid gentle rolling hills

for three crops per year, but in any cropping area where there is fallow of

2:3 months before planting the next crop (auch as for vegetables).

4, The use of silviculture to produce boiler fuel instead of Lumber.

?There are ahout the sane number of BTU"s available on these non-food croplands as on those available for sugarcane energy crop production (Table 10). The steepness of sone of the 736,000 acres would prevent its use for biomass produc

tion, If we allow 29% of the land as inaccesible for harvest, we would obtai

589,000 acres of woodland yielding 4,712,000 dey tons of biomass fuel. Of

course, los:

ties and economics of handling the woody aateriel will have to be developed, but this energy crop can not be ignored in 2 balanced food: eneray

crop program.

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- a5

5. The use of certain species of genera Euohorbia, Calotzopis,

Ceystotegia, and Parthenivm te produce plant hydrocarbons ca margioal Lands

Guystotegia, and Sartheniun

fn the

inrid area with about 230,000 acres in ateep and shallow soils.

More research is needed on the yields, convertability, and economic# of this

type of crop for energy. At present these soils are not productive for any

econonic crop.

6. The use for boiler fuet of grass clippings and weeds collected from

com rather

the grass median barriers and borders of the Island's autopista ey

than being left on the roadside or trucked to the nearest munie{pal dump,

There are about 1200 acres

jailable that could give yearly 4800 tons of dry-

bionass fuel (35).

7. The ace of cho rice straw in the proposed rice enterprise for boiler

fuel i

fn the rice drying and processing plants (34). One thousand acres in rice

?can produce 4,000 tons of dry rice straw equal to 60 million BTU's,

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Hexander, a.

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! wy percewt oF store 2/

Percent of stove Area in Acres Percent of total

0-5 393,196 w

615 373,312 18.4

16-35 333,838, oy

nes, 372,372 38.

46-59 172, 266 8.4

coe 608,372

Teal 2,051,258

AY This excludes approximately $2,550 acres in urban oF man

ductive use as well as che land area of the islands of Culebra,

Vieques, and Yona.

2/ Afvor Fiele (a).

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TABLE 2, A BRIE! DESCK:PTECS &f TMS STE ORDERS oF BRO RICA SOTLS

fcGuxDING 0 THT MEW TAMOKLE SYETEN 2

Fatlsots not devenoped

yay (orgtlise)

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iDiuviol with sttseate

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Oxisots reddish teow

sno {luvial hoctson

vieisols cloves subborizon nore

?acid then murface

AU exived fron (22)

2 Very rare in Puerto Rico

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aftocted by {oct and high

Water tables

on stoping tence

soise having heh base scat

tah oa:

cracking and clayey

accumulation of AL no organic

Satter in second aut z0n

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acid with low base exehance

Capacity; alvances eeage =f

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oxides of Al or Fey oF seth,

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acid wish low Lage exchange

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OF Aigh rainfall; where Lescting

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USLE 3. ACREAGE £00 PERCENTAGE DISTRIBUTION OF SOILS BY ORDER IN THE SIX SOIL

Sune AtzAs' OF PoeRTD #160 27

Acreages and percent déetribution for Arse

oxter lajasMayaguertomscno Arecibo Pesce

ratio! 169 yy Baas, aoe 3,970

ain wn ain Gio ay

Teceptieol ? 28,525 125,813 ym 1.636

Gry Gay ak6 ony

satieot saa 30,382 °

Go oe

wotieer 8,209 66,796 90

wo ey Gi,

Weretwot 25,346 ° ° 16,186

ay 63

Sree ° ° ° ° °

oxinad ° 21,199 ° aso

ay oo

heteor 4310 wera 28,369 asa

ay Gils Gay Gy

corners Agst 97.240 83,097 74,843 57,8998

aay iy Git) Ge SG)

Totele 102,609 460,853 470,202 son.aes 447,279 303,402

(260) ab)" ?soy? ?bo ?3? "hao

A/- derived from toonet (12, Table 7).

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THBLE 4. S00L APsOUECES oF oATO RICD cnovED BW ACcoRDAKCE WITH THEER

seacoast Berea

Ay Sole of the fut constad region

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AL beep, ativvial ets

Gupiscane, tice, scary vepseables)

Nevterone 123,408 103,326

Beep, ved sotte

(Gintappies, Pageosoean,

starchy vegetables, daffyie3) 18,112 94,490

AL. Sof of the

Gian

?cleus, dairying) 34,392 107,674

TOL, Soite of sho turt sountaie region

DL Reap soide vith SOR stoves

(cateer, plactsiery sananasy

tte, dhlsyias, beet cattle) 696,640 495,222

4B. Medioe deep aoiis with SO% slopes

(Comereiat ferent) 350,578 280,462

F. Shallow gotta or aoste S07 stopes

Gaearen'woodtandsy wlidlite, Fecveation) 283,106 227,585,

(satorat wecdiands, Sildit-e, veezeatfon) 101,740,408

TY, Soils of thw sunt-arte ceptor

N. been, tovets Nesey, Lerigable sits

(Gotiecene, bass Beane, few crope) ss.st0 ase

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toldvip Ieesaredon)

(eangot, avocados un! other fruits) saas2 39,322

K. $teep shattow sotte

(aattral vocdtanday wilelife and recreastion) 220,016 230,016

V. Side of she coustat toviande

Le suting cena, mary ov sandy

(Gquacultate, ecological Feserves) 26.850 26,050

2,109,026. 1,817,415

A/F discounted for wren, induatrioly Tow

groupe fund Le

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TABLE 5. ACREAGES AIO) PERCENT DISTRISUTION, BY ORDER, OF HECHAKIZED AND ON-MECHASIZED SOILS OF PUERTO RICO 1/.

order Mochanizet __Non-mechanized Totad

Entisol 61,286 (2.8) 37,208 a.) 98,492 (4.5)

Tnceptisol 118,190 (5.4) 726,652 (32.2) 8AL82 (38.6)

Alfisot 45,963 @AY 45,969 A) 92,926 (4.29.

setlisen 96,303 (4.4) 120,379 (3.5) 226,682 (9.9)

vereisot 52,529 (2.4) ° 52529 2.4)

Spedasot 2,189 (0.1) ° 2189 (0.1)

Histosol 4,377 (@.2) ° 4,377 (0.2)

oxtaot 41s86 G9) 4327 (0.2) 5913 (2D

uieiso! 11,626 (5.3) 396,187 (28.2) 507,781 (29.2)

Totals 534,065 (24.4) 1,930,735 (69-8) 1,864,781 (85.2)

Af darsved fr08 Bonnet (12, Tabte 13)

B/ Sunbers in parontheses refer to percentage distribution by Order.

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{WOUE 6. AVASLAMLE WATER aAGAHCe TOR THK SIMARD RUCION OF PUENZD AICO (EXMLLDIG

{WE LAIAS VALLEY) IM HGLLIONS 9F GULENG oF WATER DATLE 1)

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TABLE 9. NUMBER OF FARMS AND ACREAGE BY FARM SIZE, 1974 2/

sice Nunber of Sams Acreage of farms _

heres Actual ¥ of total Acres of total

Less than 32,782 Ms 4.061 0,3

?9 14597 38.9 59,8 4.9

10-18 5,083 20.5 Bur 6.6

19-48 5.283 ane 153,367 aa.

49-96 1,785 6.0 1812 9,7

97-169 285 ae mano

170-252 ae Ls 85,607 7.0

2534 sr 29 610,618 49.9

?TOTAL 29,650 100, 1,223,632 100

so

A/ Derived from (5, Table 454).

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oe a

scree StI Netty an?

Sacarcone ?orep, tora aiswvisi 129,000 a7 2a, r02,000

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