WATERSHED MANAGEMENT
IN THE CARIBBEAN

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WATERSHED MANAGEMENT IN THE CARIBBEAN

Proceedings of the Second Workshop of Caribbean Foresters held in
Kingstowa, Saint Vincent and the Grenadines
Mareh 19-23, 1984

Bdived by Ariel E, Lugo and Sandra Brown

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PREFACE

Tt all started in a hotel room in Saint Lucia when Gabriel Charles suggested the idea of regular meetings of Caribbean Foresters. Only once before, in 1946, had Caribbean Foresters met before Gabriel's suggestion.

This workshop is already the second meeting of Caribbean Foresters. Te was held in Kingston, Saint Vincent and the Grenadines during 19-23 March, 1984. The workshop was sponsored and supported by the following. organizations:

Funding: US Man and the Biosphere Program through its Tropical Forests and Caribbean Islands Directorates,

Administration: University of Puerto Rico's Center for Energy and Environmental Research

Organization: Saint Vincent Ministry of Trade's Forestry Division (local arrangenents led by Mr. Calvin Nicholls) and USDA Forest Service's Institute of Tropical Forestry (Southern Forest Experiment Station).

Attendance to the meeting was 57 people representing nine islands (Puerto Rico, Dominica, Saint' Vincent and the Grenadines, Saint Luci Montserrat, Guadeloupe, 'Martinique, Jamaica, and Grenada), three additional, countries "(Canada, Haiti, and U.S.A.), and six other institutions (Canadian International Development Agency, US' Agency for International Developsent,

Organization for American States, US Forest Service, University of Tirole, and the US Geological Survey).

‘The proceedings for the Saint Lucia meeting were published (Lugo and Brown 1982). Copies are still available through the Institute of Tropical Forestry, P.0. Box AQ, Rio Piedras, P.R. 00928. In that meeting ve nade the commitment of putting forestry in its rightful place among the other sectors of each islands economies and agreed on vhere our priorities stood.

Training and watershed management were high on the List of our priorities from the first meeting. Perhaps coincidentally, UNESO) was Organizing a new progran in the Caribbean: The Caribbean Environmental Action Plan and through the generosity of the US Agency for International Developwent ve secured a grant to put into practice many of the recommendations of the workshop. This grant vas part of the U.S. Government's contribution to the UNESCO prof Exasples of the programs that were impleneated are:

“two S-sonth-long training courses vere held in Puerto Rico and 27 young Caribbean foresters were trained in all aspects of tropical forestry;

-a Saint Vincent forest inventory was conducted

a wildlife inventory was conducted in 9 Caribbean islands;

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=a follow-up assessment study on the hurricane effects on forests was conducted in St. Locia and Dominica:

cthree automatic stream gauging stations with recording rainfalt

collectors and with provisions for sediment and water quality Collections were installed in Dominica, St. Lucia, and St, Vincent and the Grenadines.

‘The second meeting of Caribbean foresters was dedicated to watershed anagenent. Each island presented a paper sunmarizing the state of Watershed prograns and probless and these vere followed by technical presentations of the subject by invited specialists. The papers that follow summarize these formal exchanges.

‘Among the primary objectives of the meeting were the fostering of comunication song islands foresters, reviewing forestry activities taking place’ in. the Caribbean, discussion of probleas of cosnon interest, and the Gevelopaent of an agenda for coordinated future action in the ares of Vatershed management. Meeting participants developed a series of Feconmendations aimed at all institutions concerned vith watersheds in the

Caribbean. ‘The ‘reconsendations took the form of a proposal for integrated faction on island watersheds. This proposal or set of recomendations is Included in these proceedings.

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August, 1984

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[FINDINGS AND RECOMMENDATIONS FOR DEVELOPING WATERSHED MANAGEMENT PROGRAMS IN THE FORESTRY SECTOR OF ISLANDS OF THE EASTERN CARIBBEAN

‘The Caribbean foresters vorkshop on watershed management held in St. Vincent and the Grenadines recognized and concluded the folloviny

“Watershed management is critical for the maintenance of Fesources such as land, forest, soil, water, wildlife, and coastal ecosystens.

~Furtheraore, without the proper natural resource base, economic development” in Caribbean islands cannot be sustained without massive aid from outside the region.

-In_ short, natural resources are a cornerstone of {sland developaent; the forestry sector, through watershed management, can make significant contributions» tovards the goal. of optimizing the contribution of natural resources to” island

Because the forestry sector of Caribbean islands has been neglected for many years, it is necessary that this sector be upgraded to the point where it can perfor ite role in the economy optinally.

“Watershed problens are critical, hence the need for inmediate ‘action in order to conserve options that may be lost if inaction continues to rule,

~The financial resources to address these concerns is frequently beyond the means of these small island states, Therefore, ve ook to the international development community to assist us in carrying out this much needed effort.

‘The workshop recommended a multiple approach to the development of watershed management programs in the forestry sector. Sose recommendations are designed to contribute to institution building, others to improving land management, to develop monitoring systens that can gauge progress, and still others to develop regional approaches to probleas that cannot. be addressed by islands individually. It vas also recomended that state-of-the-art developed technology be applied to {sland problems, hoping that these technologies may mitigate the decades of neglect in this sector fand provide powerful problem solving tools that have proven useful in other Fegions of the world,

These recommendations are not meant to be an all or none proposition. Parts of the total package may be implemented as resources permit. However, a full package is presented as a descriptive contribution of what is needed to elevate forestry and watershed management in its rightful place within island economies.

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(ORGANIZATIONAL OR INSTETUTION BUILDING RECOMMENDATIONS

~The need for training in all aspects of forestry continues to be the top priority of island forestry departments’.

“Public education is also critically needed.

ciligh level policy makers must be involved in and informed of the watershed problens and solutions. Their participation in Fegionsl, local, and international forums where these issues are discussed is encouraged.

“Mechanisms for facilitating intra-government coordination of

watershed managesent actions are urgently needed.

Comparative analyses of the lavs under which forestry programs operate and of the organizations of forestry program are needed.

“A computer Linkage between islands using inexpensive personal ‘computers (about $5,000/island) is needed to facilitate Conmunications and rapid exchange of information.

Lonmunication among all islands and regional research institstions should be encouraged.

Giving legal status to critical watersheds should be considered ‘as an option designed to facilitate their managenent..

LAND MANAGEMENT

<It is critical to learn, as soon as possible, current land uses,

and capabilities, and potential for use. Satellite technology now available could help significantly in the deliniation of ‘and uses.

“Because tropical watersheds are Little known and are subject to @ifferent conditions than the familiar temperate zones ones, it fe inperative to begin land-use-erosion studies designed to provide baseline inforsation on normal and husan~induced rates of erosion.

WATER RESOURCES

“Rivers on the islands have not been gauged adequately. River gouging programs provide information on water quantity, quality, Seasonality in availability, and serve as @ monitor of the Success or failure of managenent actions.

“We strongly recommend that the gauging program started by the U.S. Geological Survey and U.S. Forest Service under funding by USAID be continwed and expanded to other islands.

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IV. DISTURBANCES

“There should be a continuous alertness and interest in Adentifying catastrophic events (hurricanes, landslides, volcanoes, earthquakes, human interventions) to understand their periodicity, intensity, ‘effects, and rate of recovery.

= INTEGRATION AND SYNTHESIS OF THE ABOVE

~We recognize that the value of information is best measured by its use and impact on action programs. We thus recommend that what is learned fron the proposed activities be integrated into ups, models of watershed dynanics (including energy end economic models), managesent recommendations, and watershed management and use' plans.

Wo recommend that action and study plana be inplenented in selected watersheds of participating islands. The three watersheds already under study in Dominica, Saint Lucia, and Saint Vincent and the Grenadines could be the core of Such a program, All activities, training, experiment, Banagenent, etc. could be conducted in the selected watersheds whore monitoring' could be done by gauging stations and satellite inagery. Selected watersheds become centerpieces of development and' for denonstration. Local expertise should be in charge of programs and provide training. Outside assistance would be avail needed, Internatio Feseach would be encouraged.

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[ADDRESS BY THE HONOURABLE V.I, BEACHE, MINISTER OP TRADE AND AGRICULTURE, ST. VINCENT AND THE GRENADINES

I am glad that this meeting is taking place in St. Vincent and the Grenadines St this point in tine, 'There 1s no doubt that we have undergone two recent disasters that have reaped havoc to a certain extent on our environment and to a greater extent to our economy.

Now we are slovly recovering and this is in no small means dve to the forestry Jepartsent. in the Ministry of Agriculture which is really doing a Tot of hard work in' this respect. I'was going through sone papers the other day, and. I vas reading that forests cover about 1/3 of the non-polar Gopions. of "the land surface, and that econosically and financially Contribute to certain countries substantial amounts to their Gross Domestic Product.

Froa the earliest days before civilization developed, our ancestors lived in forests. Before technology developed to what it is today they Tivslved: and. got" all their sustenance, clothing, food, and water from the forests, "This in itself is telling' us that' the 'forest must be very faportase. "In the tropical region, forests becone even more inportant sect "ue have no snow Lines, and whatever water we get must be from rain. fence, "we take forests for granted and sometines we see wanton destruction because of financial reasons and ignorance.

There is quite a lot of cost-benefits in having forests and some of us only Took at ‘the quantifiable benefits; ve can sell lumber, we can use it for’ pulp, we can exploit. the wildlife, etc. But, the non-quantifiable fenefits’ are even more inportant. In St. Vincent and the Grenadines, for Yastance, ‘without the forest ve would have no water supply and it vill mean fascive ‘amount of funds to be expended to provide water either by Tecalinazition or other sources; we have to do this now in the Grenadine {Slonde,, We are very. well aware of what is happening and to this extent have taken the initiative to further extend and anend our legislation to theure that we can have better protection for our forests and other areas.

At present, in St. Vincent and the Grenadines 45% or so of our electricity is ‘generated hydrologically (through C.1.D.A., World Bank and ELEBi)c We have now. put. into place and will soon start constructing Eskihee’ hydroelectric station on the leevard end of the island which, T think, will augment our supply by possibly another. 25% to 35%. Without the yeitkts “this could not be possible because there would be no running vater to do this.

As @ boy I reneaber that when the first hydroelectric station was built we had” so many problews in containing the flov of water that we had to, pay substantial. amounts of compensation to people vhose lands were Washed avay by overflow from what is known as the balancing tank, In those Yepe we had three generators running fully and the dans had to be opened up se chat the water could run out, Unfortunately the decision was taken soon Steer "to allow logging and charcoal-burning operations to be carried out.

Now we do” net hove enough water to run two generators in this same power

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station. Because of these operations large goamier trees that may have been well over 100 years-old which nested one of our most beautiful birds,

the Anazona guildingii parrot were also destroyed. This also resulted in the destruction of “the “natural, habitat of these Bards, andes akateed gradually losing the population of the St. Vincent parrots, so much so that ‘at one time they nearly became extinct. We had'to take some very harsh measures to correct this (in so much that I think the Ministry is not now looked on very kindly). We had to collect birds that vere in captivity. the younger ones that ‘is, so as to prevent the destruction of these very, beautiful species which you may see in their natural environment oF some oF ‘hem that are still in cages in captivity.

‘The Forester is a very ‘hardy’ and hard-working person who has to be dedicated to be able to tramp in the forest day after day in lonely

isolation. This should not only be done because of dedication; the benefits should be comensurate with the responsibilities.

We know that without aid and without dedication, the destruction of our forests would have been sore raapant and to this, I feel that we have to thank those persons, not only in St, Vincent and the Grenadines but within the Caribbean for the assistance received. "I firmly believe that because our close proximity and as it is established that forests play an important role in weather moderation, vhat affects one country, it is bound to have sone kind of reaction on one or more of the other countries.

It is pot only as I said before the quantifiable benefits that are Amportant. The non-quantifiable benefits are even more so, if we take a case in point, Switzerland. ‘This country obtains more out of the scenic beauty from the forests as tourist attractions rather than would be obtained in benefits such as timber.

It is said that the latent energy that comes into the atnosphere because of transpiration cannot be counted but yet scientists feel that it plays @ very important part in this respect. One thing I know it doesn't take a scientist to see is that in any desert there is no forest cover. We must ask ourselves the question, why this is so.

We know that as time goes on, science becomes more involved and T think that ‘more emphasis should be placed on training and education. To this end ve have been trying to arrange courses and seminars. But one of the ‘ironies of this whole situation 1s that the aid donors have their ovn guidelines in this respect. Education, for one thing, is not counted os 2 Productive sector. Most donors are prepared to give assistance only in what they ters the productive sector, e.g., agriculture (yes, grov nore food). They are not prepared to give aid to education, they are not prepared to give aid to re-afforestation because as far as they are concerned these are non-productive sectors; but without the forests, we would have no agriculture. This is well defined, this is well accepted, and this is vel known.

We have all seen what has happened with the forests in Haiti and we have also scen the massive anounts of funds that are needed now to try to get these lands back into some kind of forest cover. I hope that the Message will be clear and for those of you from the Universities, ete, I hope you will bring a little bit of pressure or influence to bear on those

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aid donors, maybe, to alter their concept of whst productive sectors are from what nos-productive sectors are.

I was looking through our digest of statistics just the other day and

noticed ‘that in 1981, which is the latest report ve have, ve spent over EC $6 aillion for. the ‘importation of lunber into St. 'Vincest and the Grenadines. This was about 50% of what ve spend for food. It was more than we spent’ for almost any other single commodity that vas being Imported. If we were able to generate hardwood, for instance, we could save 50 of this; it would have been a substantial saving tovards the econoay of St. Vincent and the Grenadines.

Again Jet me reiterate that I welcome you, I am glad that this meeting is taking place here, | We are very conscious ané concerned about vhat is happening» in our forestry regions, and as such have given Dr. Lugo sometine ago, the assurance that ve would amend our legislation. Unfortunately T am not’ ins position to tell him that this has been done. This is not because of laxity. but bei ‘of pressure of Work on our legal department. However, I can assure you that at the next meeting, if it is held next year of the’ yeor after we would be in a position to give to you copies of our Gmended legislation so that you can have the satisfaction in knoving that ‘Something is being done. Thank you.

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PRINCIPLES OF SOUND WATERSHED MANAGEMENT

Ariel E, Lugo
Project Leader
Institute of Tropical Forestry

The vatershods of Caribbean islands deserve special attention from all sectors of society because of their importance to the economies of the islands (Beller 1979), the extreme human and enviromental stress under which they function, ‘and the little information that is available about, their response to manipulation. Comparisons with continental lands in the Caribbean establish that Caribbean’ islands have a higher population density, higher intensity of land use, and lover forest cover (Lugo et al. 1981). " Thus, it is not surprising that island watersheds yield sediments ‘at high rates (Table 1) and with significant year to year variations (Table 2). The intensity of rainfall, combined with land use (Table 3) appear to bbe the most important variables regulating sediment yield (Fig. 1).

A watershed is a hydrologic unit defined by the catchment area and drained by a river, Watersheds include land, water, and biotic resources and behave as ecological units. A watershed can easily be desarcated and all “its components are Linked, just Like islands. Water is the factor that integrates the function of a'vatershed. However, its quality and quantity fare themselves regulated by other components of the watershed. A watershed hhas many subsystems that function within the context of a larger systen.

A11 subsystems are connected to each other sone hov. When one subsystem changes, all others are affected. In some instances changes are insignificant, but on occasions they cai be radical.

Management of watersheds must be well integi Ly, each subsysten has 9 different manager, Wildlife, trees, agricultural crops, water, and urban subsystems within a watershed are all managed by different Professionals working in isolation from one another bat significantly affecting each other's job. Society, which ons all the subsyatens of 0 watershed, benefits or Suffers from the consequences of watershed mmanagesent .

The total value of a watershed is the sun of all the values of sts pares. However, not all values can be maximized at once because by maximizing a value in one, the value of another could be reduced. Thus, a particularly strong manager who is able to maximize yield from one sector fat ‘the expense of others, could in fact reduce the total value of the region by affecting in a negative sense all other watershed values.

Foresters, through the management of forest lands can usually affect the value of'a large number of watershed subsystens e.g., water, wildlife, soil, agriculture, economic, social, etc. Managing lands with a watershed Perspective uses different criteria than managing the same lands for a wood yield only. It does not follow, for example, that maxinum wood yield will also produce saximun water quality and quantity, or maximum abundance of wildlife, Tn fact, mximizing wood yield way reduce water quantity, could deteriorate water quality, or reduce the diversity of wildlife, Obviously,

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forest managers sust understand the complexities of watershed function if they are to play their role as vatershed managers properly.

Unfortunately there is incomplete understanding of tropical watershed function. It is critical that forestry prograss saintain as strong a commitment to watershed research as they do to managenent, Only through Fesearch and 2 willingness to change manageaent prescriptions | when necessary, will we be able to live up to the responsibility bestoved upon tus by society.

Williams and Hasilton (1982) reviewed the Literature on the behavior ‘of tropical watersheds ond Hamilton (1984) used this review to identify Gyths that confuse watershed management. Anong the myths suggested by Hamilton are the following:

deforestation causes Floods,

“logging of forests lovers the water table, springs, and wells,
-reforestation reverses the trends just listed,

grass is better cover than trees, and

forests increase local rainfall.

Based on what is known about vatersheds, the statements could be rephrased as follows:

floods are not caused by deforestation but by poor zoning of land (which exposes people to floods) and by climatic events,

Jogging incresses water yields because there is less water ‘evaporation by trees,

creforestation has many benefits but it does not increase water yield or decrease floods significantly,

-vhich cover type is best depends on the management objective, ‘and

“forests have Little effect on local rainfall particularly in islands under the influence of trade winds.

Many of these statenents ere debatable and the reader is referred to Hamilton (1984) for @ complete discussion. The point is that what appears to, be connon sense, is not necessarily correct. This by itself justifies Fesearch. On the other hand, there is a wide gap between available Knowledge and practice of" watershed management. The fol loving recoamendations of Hamilton (1984) make sense:

=protect at least 50 mon each side of stream banks because these buffer zones are critical areas in the control of water quality;

“identify and protect areas susceptible to massive erosion, e-8++ ‘steep slopes of a vatershed

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“protect cloud forests because they provide @ major water input to the watershed;

“focus attention on roads, ditches, and logging tracts; these are the uses that promote the most erosion in watershed:

inimize non-absorbing surfaces;

“revegetate critical areas first;
“build management and maintenance into changes of land use; and

walways do research to learn what you are really doing and its ‘consequences.

Hopefully this workshop ill address these issues snd provide recommendations that can help Caribbean islands manage their vatersheds sustainably and for maximum benefit to humans.

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‘Table 1. Representative sediment yields fron watersheds!

Type of wat Sediment yield Source
(e/a.ye)
Temperate
Eastern U.S. 0.31 (&)t Patric et al. 1984
Western US: 37 a3)
Pacific Coast U.S. 8.93 (112)

Tropical Islands

Santo Domingo 9 - 346 ‘Tirado and Lugo-Lopez 1983
Puerto Rico 0.2 = 48 Lage 1980

+ Recomended maximus for temperate region: 0.56 t/ha.yr (Patric et 1984).

‘Table 2, Annual variation in sediment yield of watersheds in Puerto Rico (Lago et al. 1980).

watershed

Tanena river 32.8 18.7 1 13.7 9.0
Pellejas river 48.6 40.7 18 29.7
Vivi river 19.6 323 38 19

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Table 3. Erosion from different land ust
Abruia (1955).

in Puerto Rico (Snith and

Land use Soil loss (t/ha) per inch
rainfall and % slope

Exposed soil 0.30
‘Annual crops except sugar cane 0.20
Coffee without Litter of understory out
Coffee, well managed 0.012
Pastures 0.009
Sugar cane with straw lefe in place 0.006

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(tyno- ye)

Sediment Yield

a
| 70% Urbon
20% Notural
30}
20]
heulture
10) 35% Noturol
7% urban

30-58% Noturo!

45-64% Agricultural 46% Noturel

0 700 00

Woter Discharge (m/sec)

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WATERSHED MANAGEMENT IN DOMINICA

Felix Gregoire
Deputy Director of Forestry and Wildlife

‘and

Arlington Janes
Forest Officer

INTRODUCTION

The Forestry Division of the Ministry of Agriculture Lands and Fisheries 1s mainly responsible for watershed management on the island. Other agencies involved in vatershed managenent are the Agriculture Division, vhich is responsible for soil conservation as it relates to agriculture, the Contral Water Authority which is responsible for legally declared water catchnents and the Physical Planning Section of the Economic Development Unit.

‘The Forestry Division which is responsible for al] government forested ‘and protected lands, has the greatest responsibility for vatershed Managenent’ on the island, The status of forestry in Dominica including a description of the resource, forestry activities and the responsibilities of the Forestry Division are given in Gregoire (1982).

LEGISLATION

There exists a number of lavs which provide for watershed managenent activities on the island. Chapter 80. of the Lavs of Dominica entitled "Forests", makes provision for the control of felling of trees and the extraction of forest products in the state. It also enpovers the forestry fand conservation officers to carry out their duties.

The Stovart Hall Catchnent Rules (S.R,0. No. 11 of 1975) establishes the only legal catchment in Dominica. This law which ie adsinistered by the Forestry Division affords the Stewart Hall Water Catchment protection from felling of free and agricultural practices. The Stewart Hall Catchaent provides the southwestern section of the island, including Roseau, with water.

The National Park and Protected Areas Act of 1975, seeks to protect land in the state for scientific, educational and recreational purposes. ‘The lav stipulates thet there should be absolutely no cutting of trees within a National Park.

‘The Forestry and Wildlife Act of 1976 also provides for the protection of forests as vel as wildlife in Doninica.

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PoLIcr

Embodied in the overall forest policy of Dosinica are provisions for the Forestry Division to sanage forest reserves:

to prevent floods;

to prevent soit or

-to preserve adequat

water supply:

to preserve scenic beauty and ultimately encourage tourism;

to ameliorate climate; and

flora and fauna to retain the balance of nature.

mnt objectives are in addition to those providing for employment, foreign exchange, and

WATER RESOURCES

Dominica is seid to have 365 rivers. Annual rainfall ranges from ‘about 7500 mm (300 inches) in the wet interior to 1000 ma (40 inches) on the drier west coast, It ie obvious then, that there is an abundance of water on the island, as a result of the rugged terrain and mountainous nature of the island.

‘The main watersheds are the Picard River vatershed in the north, the Layou River watershed in the centre, the Roseau River watershed in the South and the Maclauchlin River and” White River watersheds on the east Coast. The Roseau River watershed is being tapped for hydroelectricity While other areas are being investigated for that purpose.

‘Shanks and Putney (1979) estimated that there are 35 water catchsents on the isléndd, providing water for domestic purposes to the populated In 1964, a World Health Organization team proposed a consolidation ‘those 35 water catchments. Under such consolidation, 19 vater Catchments would be phased out, and the island's vater supply would be met by 21. Some of the systens proposed and those to be retained vould have their sources within National Park and Forest Reserve area

though there is a certain level of contamination of water, caused mainly by agricultural practices and hunan settlenent, the quality of vater fn Dominica is rated among the purest in the world.’ Earlier this year, 9 plant to bottle spring water for export was opened, and contract ‘to Bupply water to Aruba vas signed and is being implemented,

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LAND USE

Shanks and Putney (1979) observed that all types of natural vegetation onthe island (Table 1) provide watershed protection and soil stabilization benefits, and there is no evidence that one type is better than another in this regard. Each vegetation type is suited to survival inva particular Climate ‘and’ soil zone, and as such, provides the most reliable watershed protection for that zone. Agricultural crops may or may not provide equivalent vatershed protection, and usually they do not.

‘The ovnership of the lands of Dominica is shown in Table 2.

WATERSHED MANAGEMENT PROJECTS

After the devastation of hurricane David in 1979, and the initiol concern deaonstrated by the government and the general public, a watershed study financed by the U.N.D.P, - F,A.0, vas completed in July 1980. The

study recommended' that while' the critically deforested areas should be Feforested, the other areas should be left untouched, It was felt that Natural regeneration would repair the danage caused to the watersheds by the hurricane.

Although natural regeneration to an extent helps to control land slides, soil erosion, and flash flooding, there was atill need to implenent sone form of reforestation programme £0 improve the quality (merchantable value) of the forest.

A 'reforestation and soil conservation programme financed by the International Labour Organization, (ILO) vas put into effect in 1981. 'At the completion of the first phase in 1983, a total of 506 ha (1250 acres) of land vas reforested in the three major vatersheds of the Roseau River, Layou River and White River. ILO also provided finance for the maintenance of these areas for three years.

Quite recently there has been a great need to gather information on the rivers of Dosinica, Such information is required to assess the Potential of rivers for hydro-pover and to gather information on factors 'such as water-quality, sedisentation, und water-levela,

At the moment, strean gauging activities are being carried out on eight rivers and Streams scattered around the island. The information Gathered vill help watershed managers in assessing the nature of the watersheds and assist them in making decisions.

WATERSHED MANAGEMENT PROBLEMS

The clearing of forest land and the use of this land for other Purposes have created most of the problens on the island. The introduction gf the chain-saw in Dominica has accelerated land clearing operations. Most significant are clearing along steep slopes, rivers, and streams. The cultivation of steeply" sloping land also creates problems associated vith landslides, soil erosion and landslips.

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The absence of adequate and reliable information on the watersheds 'ais creates. problens for the manager, and watershed management is hampered by the unavailability of adequate manpower and equipment.

RECOMMENDATIONS

'The proposals made in this section are by no means exhaustive. They are the minimn required to strengthen the position of the Forestry Division with regards to watershed managenent activities on the island

“The training of local staff in watershed sanagenent is o vital

spect of any watershed management programme. ‘There are many Young officers who have been exposed to the principles of Yatershed managenent who are eager to further their education in this field.

“Only one water catchment is defined and protected by lav. The

difficulties associated with not providing legal status for ater, catchments are’ very evident. The use of pesticides, the Cateing of vegetation and other such malpractices are carried out in catchments not legally protected. All important vater Catchments should be given legal status to safe-guard their water resources.

“Stream gauging activities should be carried out in more rivers. With only eight. rivers being monitored, there is need for sany ore to be studied.

“An assessment of all major vatersheds should be done. Such an jesoment must include factors such as rainfall, vegetation,

Vildiife, land-omership, drainage pattern, soils, land use, and

potential for development to cater for the needs of the country.

‘CONCLUSION

‘tue Forestry Division is very impressed with vhat has been achieved sn the Tolanie “singe. the holding of the First Caribbean Foresters Meeting in Be eats f5fo,"™ avery eftare should be made to ensure that Caribbean Foresters weet on a regular basis.

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Table 1. Land area of major vegetation type (from Shanks and

Putney 1978).

Vegetation type	Land area ha)	% of total
Agricultural, urban, village	23,133	2
Serub forest and savanna	7,507	9
Littoral woodlands	66	1
Freshwater svanp	126	-
Landslide zone	27	-
Montane ovamp forest	1,756	2
ELfin woodland	2,332	3
Montane vhicker	3,758	5
Funerole vegetation a	-	
Riparian rain forest 1	101	1
Secondary rain forest	20,133	23
Mature rain forest	18,222	23

Table 2, Land omership (from Shanks and Putney 1979).

land use ae	1% of total (ha)
Reserved:	15,573	20
Morne Trois Pitons National Park	6,349	6
Contral Forest Reserve	a0	1
Northern Forest Reserve	8,814	n
Vaallocated state land	10,526	3
Privately omed or claimed lands	52,901	°

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WATERSHED MANAGEMENT IN GRENADA

Augustus R, Thoma
Forester,
Forestry Development Corporation

Over the past decades the country's natural vegetation has been subjected to. the destructive activities of man, Indiscriminate felling of trees on steep slopes, both on private and governsent lands, have left the toll, unprotected against the destructive forces of nature. “The Government

Of Grenada is, fully avare of the erosion problens which exists in the Country but there ie still a great need for coordination and funds to effect conservation programs.

Watershed managenent is no longer used as a legalistic ter but refers to an entire concept. Base on the regulation and the utilization of water fn the watershed, the central aim of watershed management is to improve the economy oF at least the value of the watershed to the public in terms of Water" production, prevention of soil erosion and regulation of rivers and Flooding. Moreover, attention is being paid to inprove the private sector of the economy by" promoting growth in production and incone of the Jandovners within watershed areas. The present denand for water in Grenada is 8 million gallons per day, This is expected to increase significantly jn the next. few years to cater for industrial development, growth in population, etc.

LAND EVALUATION SURVEY

During the early part of 1983, aerial photographs of the entire country were taken by the government for use in the preparation of fevelopsent plans. A lend evaluation survey on crop suitability for reined agriculture is now dn progress, The country is divided into three zones in regards to land use: agriculture areas, industrial areas, and residential

Agricultural areas have been further divided into vatersheds, 72 of which "have been identified. A detailed study of soil properties, climate, crop suitability, ete. 18 being conducted in each watershed separately.

'The necessity for sol and vater conservation measures has intensified now that the thrust of the administration is towards crop diversification, Concentrating on the production of non-traditional crops for the expanding 'agro-industry and export market.

'CONSERVATION INSTITUTIONS

Sectors of the governsent concerned with the conservation of natural resources are the Landa Use Division in the Ministry of Agriculture, the Foreat Development Corporation (FDC), Central Water Commission (CiC), and

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'the National Science and Technology Council (NSTC).

WC and NSTC have not played an active role in water and soil conservation and the Land Use Division mainly disseminates information to

on hillside farming. Tae general response of farmers to such however, i# only fair.

‘The Forestry Developaent Corporation is the sole body responsible for lupper watershed management. It was established in 1982 ond charged with the responsibility of prosoting forestry in the interest of the public and the econoay. It controls all government forest reserves which total about 4,050 ha (10,000 acres) plus’ 203 ha (300 acres)

watershed area,

‘The activities of the FOC for the past two years have been limited to exploition. Due to lack of vorking capital and qualified technical staff no afforestation program has been effected. A 10-year afforestation plan, hovever, has been formulated for the Grand Etang Forest Reserve and is now under consideration by the government,

A. three year afforestation plan for the Annadale estate watershed has also been dravn up, This is a pilot project which needs considerable financial assistance to be effected,

The Annadale estate forms the major part of the Annadale watershed which supplies drinking water to the Town of St. George's. The area had water pollution problens ‘resulting from heavy use of herbicides and fertilizers. In 1964, the government took over the area and declared it to be @ protective watershed area. However, the area has served ass center for illegel regular charcoal burning and other forns of larceny. There are virtually no trees left in some sectors, There ia mich evidence of soil and gully erosion, frequent siltering of the tvo dams in the area, and significant drop of ‘vater volume during dry periods.

Tee Les Avocates watershed is a complete contrast to the Annadale watershed. This area once suffered similar problens to that of Annadale ‘but such’ problems no longer exist because the area 4s nov completely forested with Hibiscus elatus. This reforestation programme not only helped in preventing foods, siltation, erosion, etc., but also helped in ‘maintaining a continued supply of good-quality water throughout the year.

CONSERVATION PROGRAMMES

‘The Agricultural Development Project.
(Government of Grenada U.N.D.P./F.A.0.)

‘This project which was formulated in January 1976, became operational March 1977 with three components: soil and water conservation, production ~ including the accelerated propogstion of the non-traditional trees crops, ‘and marketing.

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Project Activities

‘The project was designed to cover the Chenin Valley (watershed No. 9) but such "an undertaking was found to be too anbitious after an evaluation Of the project. All activities, therefore, vere concentrated in Madigras (eite Now 1) which occupies an atea of 30 ha (75 acres). Two dans with an

inated capacity of 3-5 and 0.2 million gallons have been constructed to Cater for irrigation and domestic uses.

Modern soil conservation sethods, e.g., terracing are used in the production of. both annual and perennial crops. Conservation forests are Riso being established on the steep upper slopes and blocks are divided by vind breaks.

Production is being sold to the Grenada Marketing and National Importing Board” or to. Agro-Industries Plant. The possibility of integrating Livestock into the project to provide the exhausted soil with Organic. nutrients is under consideration. Pingerlings of Tilapia ailotica fron Kenya are also been raised in the large ds

Teaching and Training

<The project has four new diploma graduates on its staff vho have been trained in all project activities.

Teaching and training in all aspects of the project work is also provided at the Mirabeau Farm School.

<Inservice training, as required for extension service personnel, is also carried out.

“Farner, 4 H people and other interested individuals are trained ‘upon request.
Research
Observation trials from time to time are established to evaluate planting material, fertilizer response, soil pil, herbicides, and pesticides.
Achievesents

=the project opened avenues for research and training;

uable statistical data on planting material, fertilizer, soil pil, herbicides and pesticide etc. have been accumulated;

“experiments are also being conducted on ‘and gully control measures;

roforestry techniques

“farmers have begun to adopt the methods and practices utilized fon the project, and

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“erosion of top soil has been greatly reduced as demonstrated by the non-appearance of "red sea water” around the coast after heavy showers,

Other Programes
Other conservation programmes which are still in the planning stage

aret Levara Rational Park, U.N.D.P./F.A.0. Upper watershed managenent project, and soil and water conservation with complete gully control.

PROBLEMS OF WATERSHED MANAGEMENT

“Finance - lack of funds is the main probles in vatershed anagenent for without money, conservation programmes cannot be effected.

“Training - our knowledge of watershed management is very Limited; training at professional and sub-professional levels 8

ergently needed.

“Coordination among the various bodies involve in conservation is lacking.

“Protection of watersheds - the old forest act needs revision and laws prohibiting illegal activities in protective forest areas eed inplenentat ion,

“Equipment - machinery and equipeent conducive for conservation

works are needed,

Inappropriate agricultural practices - farming methods on steep slopes is a problem because ot all farmers adopt the use of conservation method in farming.

~The general topography and climatic conditions of the country ‘also Create many problems in watershed management.

‘CONCLUSION

Forestry is a long term enterprise which dées aot yield immediate vonctary benefits. This fact is causing many governments in the Caribbean and elsevhere to' give little or no. priority to forestry. It must be Fealized, however, thatthe intangible benifits of the foresta. in Preventing soil erosion, water conservation, and providing aesthetic values, caunot be measured in monetary terns.

Technical matters in which the country needs cooperation are associated witht comprehensive watershed planning, vegetative cover 'uanagenent, operational issues, forest hydrology research, erosion and sediment studies, and environmental inpact assessment.

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We see research and technical training, particularly at the very basic level: the most critical aspects at this stage of the country's watershed developaent programe.

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WATERSHED MANAGEMENT TN GUADELOUPE.

Francois Wencelius
Directeur Regional
Office National des Forests

The Forest Service action for protecting the forests of Guadeloupe conbined vith a decreasing pressure of agriculture on the lands since World War II have made erosion problems of lesser importance in Guadeloupe, Therefore, and because of rather independent activities of both the Agriculture and Forest Service in the island, the watershed management problens have not been considered as imediately urgent.

In this paper we present sone past actions that have been undertaken concerning agricultural managenent, at different altitude conditions, and a Tecent study that has been carried out by the Agriculture Service because of the need for watershed managenent for the security of Guadeloupe's main city which faces floods,

PAST WATERSHED MANAGEMENT PRACTICES
Matouba

'The management area is located on the fringe of the lower part of the state-owned the southern side of the Basse-Terre sountain range, on the leevard side of Soufriere. Located at 750 m elevation on

steep’ slopes (25 average), this management area occupies rich and thick volcanic soils. Annual rainfall is 5000 ma.

‘The area of concern is state-owned land under long-term lease to seal farmers, on the edge of the forest. Farners grow vegetables and flowers and raise a few head of cattle. Their techniques of traditional cultivation are characterized by intensive use of the soil; tilling and rafting alvays effected along the steepest slope, This causes erosion and ‘accumulation of the fertile soil at the bottom of the slope. The farmer is, ‘hus compelled to collect this soil and spread it again over his field.

In order to cope with the consequences of auch techniques so disastrous to the ground and soil, the "Service Forestier” effected a series of vorks for protecting the soll over a dozen hectares in 1961 and 1962. The “purpose of this project vas to develop a demonstration project to be used “as an example ‘of sound soil conservation practices, This Genonstration project used a network of bench terraces. iaid out ina "Eishbone” design every 4 m dovnward with a slope of 1%, This caused rainwater to flow very slowly from the top to the bottom of the slope. The cost of these experiments, all done by hand, proved to be quite high; it took one whole day to build @ 1m terrace.

In 8 fev years, project design proved efficient in reducing erosion above all, because farsers vere obliged to reduce the length of

sion in their fields. Unfortunately, they never took to using other ew techiques of cultivation,

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The growing dependence of Guadeloupe on food importation and the eruption of Soufriere in 1976, have brought about an important decrease in Sericultural activities in this region. The managesent was given up by farmers due to an increase in cattle breeding and forest activities.

Bouitlante

‘This is an example of another past managenent practice operated by the "service Forestier", It is situated near the coast, at an elevation of about 50 mon the dry slopes of the leeward coast’at a fev kiloneters forth of Bovillante, The Soils belong to the group of volcanic vertisols fand slopes are steep (30% average). Annual rainfall ts 1250 an,

This example of 9 watershed management project vas performed on private land. The "Service Forestier" rented this land to desonstrate how 2o farm the” impoverished land that vas then being used for cattle grazing ‘and over explotated by charcoal producers.

In 1964, the Service Forestier constructed a system of terraces similar in design to that of Matouba. The costs vere cheaper than at Matouba because the terraces were built with machinery which took less Tine. Fruit, trees (Anacardium and mango trees) were planted every 2.5 m long the edge of the benches. For financial reasons, the Service Forestier abandoned the project and it as not maintained by the landowner. Fifteen yeers later the terraces are still in good condition but the planted trees have disappeared.

Basse~Terre

Various torrents flow across the tovn of Basse-Terre situated at the foot of Soufriere (1467 m) because the catchnent basins periodically feceive heavy rainfall bringing about dangerous overflowing to heavy populated areas.

Some sudden and significant flows (10 m3s-lka~2) transport soil, rocks, and broken” trees that are potentially, extrenely disasterous, thus Te a necessary, to. prevent of control such a danger. The local asseably Hinanced an inquiry that was carried out by the Agriculture Service to define the means by which to cope with this worrying situation.

‘The main results were:

nan active” fight

mms to be inefficient because of:

“the abundance of vegetation in the catchment basins no ‘special action 13 necessary for producing continuous cover.

access difficulties, modification of the river bed end slope Would involve considerable effort and money.

<A "passive" defense can only be considered which includes:

construction of small scale works for diverting into

2.

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neighboring valleys the more violent flows which may reduce their intensity in the sensitive zones;

“creation of a series of dans and settling ponds for renoving sediments fron the floodwaters ensuring ‘that the dams are

regularly cleaned;

a network of paths provides an efficient means by which a constant watch can ensure prevention of natural dans from being erected from entangled pieces of rocks and vod. These Fepresent the most dangerous risk vhenever they yield under the rush of waters;

the use of proper agricultural techniques to reverse the consequences of clearing for irrigated vegetable groving.

This recent study has led to a series of observations ‘measurements on torrent flows to prepare the above mentioned map. Agriculture Service has also set up a Series of recommendations:

'-no clearing on the steep slopes
“vind rowing the extracted stones along the contour Lines
building terraces spaced every 2 to 3 =

controlling water-spray.

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WATERSHED MANAGEMENT IN THE CARIBBEAN WITH SPECIFIC REFERENCE TO ST. LUCIA

Gabriel Charles
Forest Supervisor

DNTRODUCTION

Catchment-area-forest, whether natural or crested artificially, are to be seen in many parts of the West Indian islands and are recognized as an Important adjunct of municipal or other ater supply schemes. Their beneficial effects cane into play in hilly and mountainous areas rather than level ground, where there is far less run off. Hence forest hnaintained for the preservation and regulation of vater supply are situated {nthe catchment basins of the hills rather than on level ground in the valleys, It is sometimes customary to. stop all activities in Catchnent-area-forests maintained in connection with tovn vater supplies, the object being to prohibit entry and thus prevent pollution of the vater Supply. These areas, known as forest reservations, were set aside to be maintained permanently under forest.

HISTORY OF FOREST RESERVATION IN THE WEST INDIES

Jamaica: The island vas originally thickly clothed with forest. Since 1655 vhen the British took it from the Spaniards, practically all the

profitable land had been alienated and the great’ bulk of the forests Gestroyed. Tn 1886, E.D.M. Hooper produced @ report recommending the feservation of forests for regulating the water supply and providing protection against north winds. This included the forsation of certain Forest reverves in the mountains and on all Crovn Lands in limestone areas. In. consequence, legislation was enacted in the form of the mountain and river reserves’ lav. of 1889 "and vas amended in 1893, Both laws were Fepeated by lav No, 14 of 1893. The law to regulate afforestation, in 1927, gave pover to declare and’ acquire forest reserves and prohibit cutting or damaging trees and shrubs or cultivating in forest reserves Without permission, The lave were difficult to apply and were Largely Jneffective in. protecting the forest. Up to 1937 only one forest reserve, the Blue Mountain Reserve of 30,760 acres (12449 ha) had been established. This reserve lies for the most part over 5,000 ft (1,520 m) elevation. The slopes on both aides of the aain ridge are very steep and the soil is loose fané shaly. The slopes particularly on the south side have been very denuded by cultivation of coffee and other crops, and large quantities of soll and debris have been washed down the valleys causing silting and flooding. A. Wimbush, reporting on the subject in 1935, recommended the constitution ‘and demarcation of a reserved forest; protecting it against fire, cutting and other forms of damage; appointing a trained forest officer with, the necessary subordinate staff; and revising legislation. & full-tise forest officer vas appointed in 1937. Since then forest reservation has made considerable progress and new legislation have been enacted in the shape of the Forest Lax. Under the new lax, private land Tequired for protective purposes say be declared a protective area, on which clearing, gazing and burning are prohibited or regulated.

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Antigua: With a comparatively dry clisate (rainfall about 44 inches or 1,120 mm) fire is the chief source of danger and the Bush Fire Ordinance, No. 5 of 1901, provides the means of dealing with it, though forest destruction has been extensive. There is no Forest Ordinance:

Montserrat: A Forestry Board vas established under Ordinance No. 10 of 1927. Under the Forest Reserve Resolution in 1932, five forest reserves have been declared on the upper slopes and tops of hilis.

Nevis with St. Kitts had a Forestry Ordinance, No. 10 of 1903, which was amended by Ordinance No. 5 of 1928, giving the Governor pover to’ form a separate Forestry Board for each island. The Forestry Board consisting chiefly of planters, appears to realize the inportance of protecting the

St. Kitts: Forestry Ordinance, No, "10 of 1903,
tablished « Forestry Board and prohibits the clearing of forest land of felling of timber without @ permit from the Board. Its provisions have been well carried out and the mountains of the interior have been strictly

protected by estate omers.

‘Trinidad and Tobago: The Forest Ordinance of 1916 had 20 provisions lying specifically to protection forests, though it prohibits unauthorized’ cutting, grazing, burning and other acts in forest reserves and in Crows Lands’ not included in forest reserves. R.S, Troup wrote in 1940 "that Trinidad with Tobago has a properly constituted Forestry Department. Most of the highland of the island has been reserved, primarily “for protective reasons, and there are other areas set aside for windbelts. In Trinidad and Tobago, soil and water conservation began with forest conservation. The Forest. Reserve on Main Ridge in Tobago 1s. the oldest in the Western Hemisphere. Tn 1766, the Young Commission demarcated narrow 2,430 ha band of virgin forest running along Main Ridge for the "Protection ‘of the rains". In 1904, the original belt vas increased to 3,958 ha and was proclained'a Forest Reserve, which is mainly protective in Function.

Grenada: The Forestry Ordinance No. 13 of 1906, an ordinance introduced to protect and conserve the forests and water sources of the island, gives power to constitute "rain reserves" and "forest reserves". ‘The former term applies to a portion of an estate surrounding sources or feeders of any spring, river ‘or other water supply. Forest Reserves include estates of portions of estates in hilly of mountainous country or on the wooded sides’ of ravines or on areas where reforestation is desirable. The owners of areas to which the law applies are compensated by the remission of land tax or otherwise. The Forestry Ordinance appoints Forestry Board with wide powers but the Board is handicapped by the fact that, except. for the Grand Etang Reserve of 2,727 acres (1,104 ha), almost all "the land is privately owned. At present cocoa and nutmeg plantations afford good protective cover to the soil, but shifting cultivation is practiced too far up the mountain sides and further forest reservation is Gestrable.

Dominica: Prior to 1940, there vere no Forestry Ordinances and the forest had suffered greatly form shifting cultivation and timber exploitation, An Ordinance was introduced in the 1950's and since then ‘mich progres has been mde to protect the forest from further destruction.

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Dominica is the largest of the Windward Islands, The highest peak reaches a height of 4,750 ft (1,408 m), The forests are estimated to cover 65% of the total land area and, for the ost part, cultivation is confined to ands at lover elevations.” The prineipal crops are citrus fruits, benanas, coconuts, and cocoa, These tree craps provide a permanent cover and afford protection to the soil in the sane manner as natural forests. Shifting Cultivation was formally practiced indiscriminately in the more accessible

forests but measures are nov being taken to settle these cultivators on suitable land and to exclude them from areas to be retained as Forest Reserves.

The rugged topography with high mountain peaks and ridges induces heavy rainfall vell distributed throughout the year. quently, the sountains are covered with a luxuriant type of tropical rainforest Containing a variety of valuable and useful timbers, Dominica is usually described' as the land of "rivers", there are 366 rivers. However, in 1979, Hurricane David' visited Dominica'and caused extensive damage to the forest 'and private property and loss of life. The primary function of the forest Of Dominica will alvays be protective and it is essential that they be preserved to regulate strean flow and to prevent erosion and landslides.

St. Vincent In conson with the other islands of the Windward group, it ig volcanic in origin. St. Vincent is a relatively young volcanic "pile" and the Soufriere mountain in the north of the island errupted in 1902 and. as recently as 1978, The topography, ia extremely broken with peaks and ridges rising to 3,500 fect (1,067 m). The mountain mass from the sea induces a heavy and well distributed rainfall, The undulating lend at lower elevations is devoted to the cultivation of arrowroot and sugar Cane, while coconuts and bananas are grovn on the valley slopes and cocoa in the wetter areas up to the 1,200 ft (366m) contour. The rugged mountainous interior ia covered with tropical forest except for the upper slopes of Soufriere which are bare as a result of the eruptions of 1902 and 1978,

'The primary function of the forests in St. Vincent is essentially protective. Oving to the excessively steep slopes and broken nature of the terrain, the land remaining under forest is unsuitable for agriculture. Tt is important that' it should be preserved to regulate water supplies, prevent. landslides ond to maintain the moist conditions necessary for production of cocoa, bananas and other agricultural crops.

In St, Vincent, general protection to trees and forest on Crown lands is given by the Land Trespass Prevention and Crown Lands Protection Ordinance, No. 3 of 188, By proclamation in 1912, the Adainistrator (comparable to Governor) reserved all Crown Lands, 1,000 ft (305 m) in elevation and over, but in. the absence of any clear Line of demarcation fencroachsent has taken place. The situation is very bad at this present time.

St. Lucia: The Crovn Lands Ordinance, No. 45 of 1916, prohibits squatting, encroachment and injury to trees and forest on Crovn Lands. Under Ho. 23 of the Regulation under the Ordinance an attempt had been made to safeguard the water supply by prohibiting timber cutting on Crown Lands 'above' 1,500 ft (457m) without @ Licence from Governor. As the 1,500 ft (457. m)" Line has not been marked the prohibition had only a paper value.

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As a result, considerable areas of forest have been ruined by shifting cultivation, " In 1885, the Castries Watervorks Reserve, Dennery Waterworks Reserve, and Warrick "Forest Reserve were established and proclained and gazetted “in 1916, In 1886, Mr. E.D.M. Hooper produced a report recommending that the central reserve should be in line vith those already reserved. Me. A. Wisbush reported on the subject in 1935. In 1944, Dr. J. S. Beard, then “Assistant Conservator of Forests, Trinidad and Tobago, carried. Gut a preliminary reconnaissance and report on forests in St. Lue in conjuction with similar work in the other Vindvard and Leeward isiands. It ¥as” largely asa result of his report that the Forest Division of the Department of Agriculture vas established in 1946 and the introduction of the Forest, Soil and Water Conservation Ordinance,

The forests of St, Lucia have been steudly exploited from the tine of the first settlement by the Baglish in the year 1638. Gradually, the natural forest has disappeared from the coast inward vhere the cover was cleared for agriculture. Today the forest 1s largerly confined to the more innccessible interior mountainous region. Even in this region ahirting cultivation by the local population has had a marked effect on the forest cover and gardens of bananas, coconuts, citrus and dasheen are not uncommon Unroughout the Forest at the present. time.

The forests are primarily protective and those resaining ove their survival to their inaccessibility. They perform on essential function in regulating stream flow, conserving vater supplies, preventing erosion, and landslides and in maintaining a well distributed rainfall for’ the production of the principal agricultural crops: bananas, coconuts, citrus, ‘and cocoa. With an expanding population, an increasing demand for agricultural land and an’ extension of communications, the broken terrain may not afford adequate protection in future. The existing gazetted forest Feserve 1s 6,220 acres (2,517 ha), a proposed forest reserve recommended in 1885 is 10,100 acres (4,087 ha) and presently CIDA is carrying out surveys With a view to” further extend these areas, A Forest Monagesent Plan was prepared by J. A, Coodiet in 1970, but was never presented to the Cabinet for acceptance’ due to the low priority forestry had at the time. In 1962-83, CIDA vas in the process of preparing for the St. Lucie Government, 3 forest managesent’ plan for Forest Reserve, Crown Forested Jand and Private Forested lands.

ST LuCrA
Introduction
‘The motto adopted by St. Lucia (The Land, The Light, and the People),

reflects national avareness ‘of the island's critical’ resources ~ the foundation upon which to build a young nation.

The island is of volcanic origin and for the most part is very sountainous but there are low-lying hills in the north and a plain at Vie

Fort in the south, Tt is intersected by three wide flat valleys fille vith allivius, tvo’ on the west and one on the east. The total area of these, hovever, is relatively small and the greater part of the country consists of an extremely disordered topography dissected by steep valleys with peaks and ridges rising to 3117 ft (950m). The formation of St.

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Lucia is identical with that of the adjoining islands in the long chain of the the Lesser Antilles. Tt was formed by volcanic eruption through the coral and other stratified rocks below the sea.

‘The island vhen clothed in its natural vegetation used to be well watered with streans running dovn in all direction from the hills. Those Yovards the north and windward side have the longest course while the rivers on the south run ina direct Line from the central hills and have by their torrential flow, cut for thenselves deep courses through the rich soils at the base of the hills.

‘Topography of Forest Reserve

‘The sountainous area comprises the island's main watershed. This is @ south-southwest to north-northeast axial ridge with numerous disorde off-set, steep-sided spurs and valleys extending fron it, Slopes are mainly ‘steep and very. steep and elevations range from 300 ft to 3,117 ft (91-930 -m) above sca level, The general elevation of ridges is 900 fe (274 mm). The highest peaks are Nount Gimie (3,117 ft or 950 m), Mount Houelmon (2100 ft ‘or 640m) in. the geologically younger southwest area, and La Sorciere (2,200 ft or 670 m), Piton Flore (1,875 ft or 572 m), Mount La Combe (1,1442 ft or 439 m) and Piton St. Eepirit’(2,050 ft or 625'm) in the remaining older part.

Climate

The island's tropical climate ie modified by oceanic influences. The main features are uniformly high temperatures the year round, mitigated by the northeast trade winds.

Reliable temperature statistica are few. Moan tenperature (°F) over 31 years at the Botanical Station, Castries, approximately at sea level, are as follows:

JAN FEB OMAR APR MAY. JUNE JULY AUG SEPT OCT NOV aC.
76.2 74.0 74.2 76.2 78.4 7.0 77.0 77.7 77,8 77.3 75.6 74.0

The rainfall of St, Lucia is low and intermittant in the coastal areas and high ‘and continuous in the mountain interior. Generally, the forest ‘area Hes within 60 to 150 in (1,524-3810 mm) zone. The dry season is horelly distinct between January and Nay; Novenber is the wettest month.

‘The prevailing winds are the northeast trades which freshen considerably during the dry season, In addition, hurricanes may occur, Imsinly in the period August to October with accompanying torrential rains. Hurricane damage has been frequent, the most recent ones during 1967, 1979

L961, Hurricane Beulah in 196) and David in 1979 were associated with heavy Tains, causing numerous landslides. In 1981, Hurricane Allen, vhich wes associated with heavy winds, seriously affected 80% of the forest water catchment areas.

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Geology and Soils

St. Lucia is of volanic origin of the Pleistocene age and the main rock types occuring are andesites, dacites and basalt in various forms Most of the rocks occur as pyroclastics, varying from coarse agglomerates and breccias through aggloseratic ashes to fine ashes and tuffs, though coarse frangnental rocks predominate, asalts occur as dykes or flows.

Soils have been derived from the underlying rocks and from more recent shovers of fresh dacitic ash. The number of soils type is large and they vary widely in stability, intensity of weathering and degree of leaching. (he soils of St. Lucia’are described and classified by Start, Lajoie and Green of the Regional Centre, ICTA Univeraity of the West Indies, in "Soll ‘and Land Use Surveys", No.'20 of St. Lucia, July 1966). Generally, they can be described as freely drained acidic clays and clay loama vhich are red, yellov or brovn in colour and of lov fertility. Owing to their usuel great depth and clay texture, landslips are inevitable on the typically steep slopes when the forest cover is removed.

Hydrology

The forest area is drained by nunerous rivers on either side of the main watershed. Those flowing to the vest coast include Cul de Sac, Roseau and Canaries and those reaching the east coast include Marquis, Louvet, Fond D'Or, Dennery, Praslin, Troumassee and Canelles, The Vieux Fort River Hows southwest to Vieux Fort Bay.

Land Use

St. Lucia has alvays had a varied agriculture, with cocoa, coffee, nutmeg “snd a variety of other tree crops being much more inportant in the past. Coconuts were planted in most non-augar areas, particularly in the west, central-west and’ southwest. Over 15% of arable area of the island now “carries some coconuts, but often at lov density and in association with ether crops. Coconuts rémain the second crop of St. Lucia, and production improved substantially after 1950, benefitting fron fertilizer applied to under-planted bananas.

In the 1950's, bananas became important as an export crop while commercial sugar production was discontinued, The result of this was the virtual removal of cocoa and the conversion of suger land to bananas. Bananas, with an assured market has becone the dominant crop and is grou everywhere on all classes of land regardless of land capabilities. Wherever s cultivator can find land, bananas are cultivated,

Problems with Land Us

‘There have been many probleas with banana cultivation, in particular, the indiscriminate use of this crop on land of very varied capability. Severe problens over quality have continued, leading to a high rejection rate of bananas fron small farmers and consequently low returns. The steep

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increase in the cost of fertilizer and chomicals has, however, continued to limit their use by small farmers even though fertilizers are sold at a subsidized price. Much of the excellent vork done by the Windward Island Banana Association (WINBAN) Research Centre at Roseau has benefited mainly the larger producers, despite strong efforts to reach the small farmers in Fecent years.

Beyond these problems, there have been environmental difficulties. ‘The banana boom began in’ the 1950's and early 1960's during a period of relatively high rainfall, The subsequent decline in rainfall has created Uncreasing difficulties because bananas are particularly vulnerable to soil drying. Bananas are also vulnerable to danage by strong winds, which can affect’ fruiting and bruise the fruit even while leaving the tree apparently fn tact. Moreover, the high rainfall in 1981 together with the replanting by almost all. grovers after Hurricane Allen in 1980, created glut conditions by the middle months of the years, The wisdom of banana monoculture was questioned as far back as 1960 by Start, Lajoie and Green. They said "The trend tovards a monoculture of bananas, a crop very susceptible to. hurricane damage is alarming inspite of inmediate benefits derived from this vel organized industry.

Diversification of crops should be actively encouraged as soon as possible, as a safeguard against the chance of disease, hurricane or other ty affecting the banana industr)

Soil Brosion

Soll erosion is widely regarded as a very major problem in St. Lucia and the clearance of “steep slopes for bananas and other crops by small farmers is generally blamed for a great deal of danage. It 1s also maintained, however, that uncertainties over land tenure, by restricting the area that is cultivated and fraguenting that area into parcels, has the effect protecting the land fron the sort of erosion that might follow a Consolidation of cultivation due to land reform.

In the Seland and mountainous area of St. Lucia most damage is caused by mass movenent of soil. This takes several forms. On very steep slopes Where there is little soil and often only a Light forest cover, rock and Soil slides occur frequently during and after heavy rain but they'do Little Gamage to cultivated land, On the lover slopes the most conson form of mass, movement takes the fora of munerous seall landslips many of which fenerate. mudflows, These latter say attain considerable size and flow for Several eters. Exceptional flows, such as those of 1939 (Hardy and Rodriguer 1949, Box. 1939) and nore recently from heavy rains in 1961, may flow for sore than a kilonetre, blocking streans, disrupting donestic vater supplies and causing floods, as well as overwhelming whatever lies in their path. There are also large rotational landslips vhich bring dovn a whole Bection of hillslope. Once triggered these are very difficult to control.

In the drier part of St. Lucia mags sovenent is not a problem of the seme order, but there is abundant evidence both of gullying (locally) and Sheet “erosion. These remove topsoil from the surface of vide areas under only Light vegetation during heavy rain. The most seriously denuded areas

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are probably in the drier tracts of the north, south, and east coast, vhere shallow soil and large areas of outcropping rock provide evidence of top soil removal.

The area of St. Lucia excluding water, is 238 mi2 (609 kn2), with a population of approximately 120,000.

Land use on the island is given in Table 1.

Water Supply and Demand

Most water comes from surface sources and there are no significant impounding facilities for rav water prior to treatment. In most cases the effective capacity of the individual systes is severely curtailed by the Fluctuation of flow at the source, resulting in acute shortages during periods of drought.

Total effective systen capacity for the island vas 4,45 million gallons/day (WGD) in 1975. Treatment facilities are not standardized and Vary widely. Sone saall rural systems receive little treatment if any. It is “estinated that the total island wide domestic denand for vater was 1.70 MGD “in 1975. Denand for comerical/industrial and other uses was estinated at 1.70 MGD, giving a total denand for water of 3.4 MGD. Given the absence of significant raw vater storage capacity, the sharp seasonal fluctuations of flow in sources of rivers and the total service storage capacity of only 3.3 MGD, the island, particularly the Castries/Gross Islet area, renains prone to water shortages during the dry season. Water demand in recent years has risen most significantly in areas of rapid population growth, especially the northwest coastal zone and Vieux Fort. These areas have Witnessed not oaly 8 growth in per capita consumption, as an increasing Proportion of the popilation become served by private connections, but also 2 matching growth in desand from non-domestic consumers, particularly, the tourist sector. Agricultural irrigation is carried out on a very Limited basis only,

The Central Mater Authority 1s a statutory board with authority given under the Central ater Authority Ordinance. They are responsible for ‘Supplying comminities with water for domestic purposes and for industrial se. They have the power under the Ordinance to declare any vater catchment area a Forest Reserve once it can define the area on a map and on the ground. The maintenance and protection of such an area then becomes

the responsibility of the Forest Division. Health authorities in the island also look after some of the water systeas.

Water Abuses

Deforestation or removal of the protective cover from steep hillsides

invites erosion, leaving the soll 80 degraded that it is too poor to support either ‘crops or nev forest. Example of the latter can be Seen at Deleer, Choiseul and Dennery.

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Other abuses includ

“contamination of rivers with inorganic materials, i.e., rubbish (trash);

contamination of rivers with organic material, i.
faeces and timber vaste;

human

“contamination of rivers with harmful chemical agents, 4
detergents, pesticides, etc.

One of the biggest problems faced in the management of our water supplies is wastage. These vastages are often due to the following: dripping tap, faulty tap, running tap while brushing teeth and showering, car washing, and running hose during car wash, etc.

‘A Comparison of Water Problens With Other Island:

A comparison of four Caribbean islands relative to water supplies and vater management problens is shovn in Table 2.

‘A comparison between the water costs of tvo Caribbean islands, namely St. Lucie and Bonaire denonstrates the value of forest cover. The former depends on Forest’ Reserves for water managenent for the conservation of water. The latter is nov a true desert island which once depended on Tmanagenent of forest water catchnents for its supply; it nov obtains its drinking water from a desalination plant installed in 1961, Water cost for St. Lucia in 1973 was BC$1.00 per 1,000 gallons and by 1979 it had risen to E.C.$2.25 per 1,000 gallons, Water’ cost for Bonaire in 1979 vas approximately E,C.$13.50, This high cost is due to the use of the desalination plant.

Forestry Division of St. Lucia

The Forestry Division ia a branch of the Department of Agriculture and is managed by a Forest Supervisor and his staff. The Division is charged with the responsibility of managing and protecting all forest reserves and assisting with the protection of forested Crovn Islands.

‘A working plan vas prepared in 1970-1980 to manage Forest Reserve Lands, the objectives of which are to:

maintain the protective function of the forest;

provide the maximum production of timber from exploitable areas
‘on the basis of sustained yield;

effect improvements in the groving stock in order to increase
ite productivity:

preserve the island's natural flora and fauna in selected sites;
and

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provide amenity, recretion and access for the public.

Field work is divided into five forest ranges, each with a staff of 3 officers and 12 labourers, The officers must patrol all known forent boundaries, check on forest squatters, manage plantation, etc.

‘Timber exploitation has been controlled by a schedule of siniaun girth Limits and the appointment system of sales.

‘The Forestry Division is guided by the Forest, Soil and Water Conservation Ordinance of 194, revised in 1957 ond 1983, Forest officers have the pover to arrest and charge forest offenders, conduct its ovn court cases, and have the pover of search and seizure.

Forest fines were ridiculously low despite efforts by the Forest Divigion to increase it 90 as to be effective. Presently, forest fines have* increased from $240 to $2,000 for the first offense, $3,000 for the second offense, and a jail sentence of one year for the third offense. In addition, there is an amendent vhich makes it mandatory that all existing chainsaws be licensed and that a permit must be issued before an order is mide to purchase nev chainsaws.

‘The biggest problem in managing the resource stems from uncontrolled deforestation due to shifting cultivation by squatters and landless farmers. With the 1983. amendment, the increased fines should have the desired effect.

A "Forest Charge" levy has been recommended by the Forestry Division for consideration by the Cabinet. This levy would appear on the vaterbills and funds raised would be paid into a sundry account. Such a procedure Will have the following advantages: educate the public as to the inportance of forestry and its inter-relationship with water, raise revenue to purchase private lands in critical watersheds; provide funds for the maintenance and inprovenent of existing watershed areas

By charging a meagre 10c BC per 1,000 gallons ve vould raise a total ‘of $300,000 "80 per year without’ adding a large financial burder on the individual consuner.

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Table 1, Land use on the island.

Land use	‘Land	of total Omership
Urban	15,000	6,070 10 Crome Private
Banana cultivation	13,500	5,463, 9 Private
Crops and pasture	23,000	9,308, 15 Government and Private
Mixed agriculture	53,000	21,440 35 MBC and Private
Forest	48,000	19,426 31 Crow lands/Forest
Forest reserve	16,385	6,631 10.8 Forest Reserve

‘Table 2. Rainfall and water use and management problens in several Caribbean sland:

Mater Teland (am/yz)	Water Rainfall (gat/capita)	management production problens
St, Lucta	nedivn, 40	High pumping costs, severe
"2108		restrictions in dry period,
‘high		rate of deforestation,
difficult terrain to service.		
Dominica	high, 48	Difficult terrain to service.
ais		
antigua	tow, 29	igh evaporation rate, Little
119		forest cover.

Barbados tow, 95 Protection of groundwater due
1626 to population pressure on
Limived land.

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‘A REVIEW OF WATERSHED PROBLEMS AND PROGRAMMES IN JAMAICA

Barrington Coneron
Acting Chief Soil Conservation Officer

and

Lennox Taylor
Soil Conservation Officer

INTRODUCTION

Jamaica became aware of the need to protect its watersheds in the 1930's as demonstrated by an article written by Croucher and Svaby in the Department of Science and Agriculture Bulletin No, 19. entitied "Sot] Erosion and Soil Conservation in Jamaica 1937". They listed the chiet Causes of erosion as: unsuitable agricultural practices, unwise selection of land for geiculture; and lack of appreciation for the seriousness of the problem. Today, five decades later, the problem of lack of appreciation is removed, but there still remains the other two factors although toa lesser extont.

LEGISLATION

Having accepted soil erosion and vatershed degradation as serious problems, legislation for the effective utilization of our” natural Fesources vere enacted to support the actual field operations. Four are worthy of note:

“Forestry Act 1939: This act provides for Forest Reserves Prohibited Areas, Protective Arent and Monitoring of all fore: activities,

vLand Authorities Act 1951: This act eapowers Land Authorities to encourage proper land use, participate in improving operations of private “land users, implement compulsory improvesent schenes, inplesent afforestation, rehabilitation, and develop of improvenent areas.

“Watershed Protection Act 1963: Under this act the Watershed

Protection Commission was established which had the power to declare watersheds with an aim of increaving vater yield and/or quality and prohibit, regulate or restrict planting of Particular crops and/or cultivation practices. In addition, 1t allovs for assistance in watershed improvenent work, compulsory improvement schenes, acquisition and granting compensation.

Land Development ahd Utilization Act 1966: This seeks to see that all agricultural lands are utilized.

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‘THE PROBLEM

Jamaica's watershed problems are many. The following is a brief Lésting of some of then:

Ungustable agricultural practices and unwise
for agricultur

ection of land

Following the abolition of slavery in 1838 many freed ® took to the steep but productive hillsides instead of continuing to vork on the plantetions. In these hillsides shifting agriculture vas practiced. Vegetation was cut and burned, trenches made down the hilisides, and clean cultivated food crops produced. All these practices led to severe soil erosion, loss of fertility, and, eventually, a reduction in yields. All types of land’ vere used intensively, irrespective Bf capability. As such, today many slopes are denuded and Severely eroded. In ‘most. countries with a history of ‘agriculture, land capability classification scheme is in place. In Jamaica, a very practical schene exists based primarily on two physical factors, soil depth and slope. Under this Capability systems all’ lands over 25° (irrespective of soil type, depth and fertility status) should be planted in Commercial or protective tree crops. However, due to the Intense pressure on the land, these lands are constantly being cleared for root crops and vegetables, while many thousands of acres of fertile flat lands lay idle or underutilized.

Improper logging and pasturing.

In many instances the practice of skidding logs out of the steeply forested lands leads to serious disturbance of the soil Surface. Channela often develop into deep gullies and

Contribste much silt to reservoirs, beaches, harbours, and other low lying areas.

In many of the islands ps (éeproved and unimproved) overgrazing is comon, leading to Little or no vegetation on Some areas at certain times of the yoar. Intense rainfall at Such tines results in loss of a significant amount of soil.

Roads, Gullys and Honesteads Inadequate of Maintenance.

Jenaica has the greater percentage of its roadways in the ‘steep watershed areas. ‘These roads are necessary to serve the Often high population’ in some rural tovnships. However, the Combination of poor road maintenance and poor homestead water isposel result "in large gullies and loss of ‘many tons of productive soil, and a number of fruit trees annually.

Lack of Coordination among Watershed Organizations.

‘There is adequate legislation and enough trained persons to deal effectively with watershed probleas. However, these

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agencies operate independently of each other, thus the desired effects are rarely achieved as prograннes of 4 complementary nature are done at different periods.

“Land Tenure.

Much of the land is ovned by absentee omers who rent to farsers without long-term legally binding contracts, or the land is Jointly owned and operated by fazilies. With this situation farmers are reluctant to grow permanent crops on such lands. Iit ‘many instances such crops are the most appropriate use for these lands if soil erosion is to be mininized,

Treatment Maintenance.

Thirty years ago, Janaica started an ambitious programe of healing wounded ‘slopes through its soil conservation Programmes. These programses wore implemented with mich vigor, Dut at the point vhere it counts most, all these programes have failed. The Government, to encourage protection of watershed areas, subsidized farmers to do the work, but the non-appearance of 2’ subsidy for maintenance of these treatments resulted in eglect of most treatments in over 70% of all cases.

Deforestation and Fire Protection.

‘The denudation of slopes under natural forest for cash crops, charcoal burning, firewood, etc., is increasingly becoming a major problem, The effects are obviously short term satisfaction and long ter grief in the form of soil loss, habitat destruction and turbid domestic vater supply among other problems. A sister problem to this ia that of fire protection, Although” Jamaica has never suffered from thousands of acre: being destroyed by fie ina single block, nevertheless, fire, frequently occurs in some of our watersheds, destroying vegetation and leaving the area bare for severe erosion in the succeeding rainy season.

“Destruction of Wildlife Habitat.

Any of the aforesentioned problems or combination thereof seriously contribute to the destruction of natural breeding or spavaing areas for birds and fish through pollution and/or over exposure to the natural forces.

‘THE PROGRAMMES.

Once the Government became convinced of Jamaica's vatershed problem erosion control proramnes were developed to reduce the danger to the ‘country.

Sone of the programes were: Farm Inprovement Schese, Farm Recovery Scheme, Farm Development Schene, Land Authorities, Agricultural Developaent

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Programme, and Farsers Production Prograame.

Farm Improvement, Scheme

Was set up in 1945 and offered a subsidy to the farmer for the establisment of soil conservation treatnents. The treatnents practiced then included gras barriers, rock barriers and contour drains.

Farm Recovery Schene

Started in 1952 after the 1951 hurricane and it offered a 75% subsidy for aproprietely established conservation practices on farms. This schene ran concurrently with the Farm Inprovenent Scheme.

Fare Development, Scheme

tinder thin schene 26,000 acres (10,522 ha) of farm lands were treated

with ‘appropriate ‘soil’ conserving techniques. The treatments included, Gruss barriers, contour trenches, runoff drains, strip cropping, bench terraces, stone barriers, etc.

Land Authorities

‘The enactment of the Land Authorities Law in 1951 paved the vay for the establishment of the Yallahs Valley Land Authority and the Christiana Land “Authority, in 1954, They vere given the responsibility of restoring eroded areas, Today there still remains much of their work.

Agricultural, Development Programme

‘This programe ran for two of its planned five years, 1960-1962, and kt offered” incentives for proper land use practices and soil conservation in watershed areas.

Farmers Production Programe

Started in 1963, it offered incentives for conservation works and tree ‘crop development.

‘The Transition Period

‘An important feature of the soll conservation progranses which spanned the period 1944 to" the early 1970's vas their temporary nature in most Cases, resulting in their gradual disappearance. This project successfully sBrtida “our the following activities: vatershed surveys and planning, Wolissent of. demonstration centres, assisted with extension activities, Gfaining of national staff, experincnts and instrumentation in soil losis

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Studies, agro-neterology, and proposed a national soil conservation Programme. The project “designed, developed and tested six major soil conservation treatments and seven different kinds of watervays suitable for conserving Jamaica's hilly lands at the Saithfield Demonstration Centres

These Snvestigations have formed the basis for all the soil conservation activities carried out since 1973 by the Soil Conservation Division of the Ministry of Agriculture,

Projects and Programmes since 1973

Soil Conservation Works Programe

Under this programe soil conservation demonstration centres were developed and maintained, and assistance given to farmers for" soil conservation works in all parishes.

The major objective of this 1s to assist private farmers to conserve their land to increase and sustain farm production.

'There sre two types of projects under this programe namely; as follovst

"Farmers Assisted Project vhere a farmer can benefit up to 75% of 'the cost of undertaking soil conservation works on his holding.

"Authorized Projects which are funded 100% by the Ministry and involve works which benefit @ group of persons or a community.

Allsides Pilot Developaent Project
The main objectives are to:
~develop a new system of production based on aultiple cropping on

'@ group of small hill faras which have been previously treated with soll conservation seasures;

"increase the productivity and production of certain food crops;
"increase food production, income, nutrition and improve the

standard of living of approximately 300 farm fonilies occupying 622 acres (252 ha) of hilly lands in the project area;

~develop an institutional framework capable of implementing similar changes in other areas of Jamaica

"gather accurate production figures for crops grown by the small iM farmer; and

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provide training for local professionals and technicians.

Rural, Development Project

The objective of this project is to complement government rural developnent. policies by increasing agricultural production and income. The project, is located in the County of Cornwall and has three main components: 2gricultural settlement, regional settlement, and regional infrastructure.

Soil conservation and forestation works were carried out under the

ricultural settlenent component.

Development. Project

As part of its current integrated rural development
revitalize the agricultural sector and reduce unemployment, the Ministry of Agriculture ‘had identified watershed areas deserving priority treatment with respect to soil conservation. One such area is the Pindars River/Tvo Meetings project area, Specific objectives of this project are tor

“increase

srécultural production on small hillside farms;

“control oil erosion in the watershed, thereby protecting the ‘agricultural base (soil); and

strengthen the capability of human resources in the Ministry of ‘Agriculture.

(GOJ/PAO/UNDP/NORWAY = National Soil Conservation Programme
‘The two main components of the project are:

“Institutional Strengthening: This vas done through concentrated inservice training locally and supplemented by overseas training to increase the operational capacity of the Soil Conservation Division of the Ministry of Agriculture. Training vas provided in’ seven ‘Key areas considered necessary for any integrated watershed developaent. These were: appropriate soil Conservation measures; watershed forest managenent; agronoay {neluding non-forest tree crops; extension methods, including the. invelvenent of the rural farsers in the development. proce: ‘utilizing the botton-vp approach; applied watershed economics} and. planning and managing integrated watershed development projects.

“Preparation of detailed costed work plan. These plans vere prepared for nine watersheds, and will be submitted to the fovernment for decision regarding implenentation.

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Projects to be Isplenented

Mittatde

Jamaica Saal nore Project

‘This project will be located in five watersheds. ‘The project seeks to increase agricultural production in 7,000 to 10,000 ac (2,833 ~ 4,047 he) of small farmers land through improved sanagenent and’ low cost soil conservation measures.

Smal Farmers Credit, Project

‘This small farmer credit project will provide funds for the agricultural developaent of 4,000 ac'(1,619 ha) of land. ‘The primary goals of ‘the project are to increase fara fanily incone and the development of a ‘snall -farner credit progranne.

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WATERSHED PROBLEMS AND PROGRAMMES OF MONTSERRAT

Wi11tam Johnson
Peace Corps Forestry Technician

INTRODUCTION

Montserrat is a volcanic sland 39 mi2 (100 kn2) in size. It is 11 ai (17.6 km) long and 7 mi (11.2 km) wide, with a discontinuous ridge of rountains runsing north and south. They are, from north to south, Silver Hill, Centre Hills, Soufriere lsils, and South Soufriere Hill. ‘Chances Peak’ in the Soufriere Hills, at 3,002 ft (915m), is the highest point on the island. Generally spealing, the sountain slopes are very steep above tthe 1,200 "ft (366m) contour, but generally gradually flatten to the sea below that elevation (Fig. 1).

Rainfall varies from about 40 in/yr (1010 mm/yr) in the lover, semi-arid areas, to 100 in/yr (2,500 mn/yr) at the tops of Soufriere and Centre liills. There is a direct relation between the anount of rainfall ‘and topography (Fig. 2).

‘THE WATERSHEDS.

‘The main watershed areas of Montserrat are considered to be the Centre Hells and Soufriere Hills, The Centre Hills soils are predominantly of clay, loan, and have moderately rapid infiltration, | This rate of Infiltration may be. seen as an advantage when considering the topography land. slope of the land, which 4s very broken and very steep (35% ~ 602). However, with a view touards dam construction for water storage, this rate fof infiltration. is seen as a disadvantage. Even with a good vegetative cover of rain forest, elfin woodland, and somewhat erosion-resistant soil,

there 4s an erosion hazard where vegetation is tenoved.

‘The Soufriere Hille soils are humic silt, of which about SOT is organic. matter. Land in this area above the 2,500'ft (762 m) level, is one of the few parts of the island that has not been under cultivation at one time or another. Rate of infiltration is rapid to very rapid, which is beneficial when. given the broken topography and 352 to 200% slope, As in the Centre "Hille, the vegetative cover of the Soufriere Hills is rain forest and elfin woodland (Lang 1967).

SSOcTO-BCONOMIC

‘The largest threat to Montserrat's watersheds 1s tradition. For many generations people have practiced slash and burn techniques to clear Tand For food production. From the faraers point of view, this is very logical because the climate is moist and the soil is well suited for agriculture. Another problen caused by tradition 4s indiscriminate cutting of trees for poles and. fuelwood. Although clearing and cutting has not caused major Banage ‘throughout the watersheds us yet, there do exist severe localized erosion problens.

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Lack of understanding by people of what a watershed is and how it works helps to perpetuate the bad practices. These practices are not seen as tad by the perpetrators, but simply as the vay things have always been done.

WATERSHED WORK PLAN

A watershed work plan has not been set forth. Part of the reason is because accurate information on rainfall, runoff, vegetation, spring flow, etc., is not available. Time and money are’ needed to’ produce this information, and the latter is not available locally, Also not available locally is’ a trained vatershed manager. Nor is there any one authority specifially responsible for managing the watersheds, Since there ia no one body to regulate or monitor the use of the watersheds, a sort of apathy tovards them has developed. This apathy extends to enforcement of lave concerning watersheds areas.

‘There does exist in the lavs of Montserrat, under Chapter 171 entitled Watercourses and Waterworks, lavs vhich generally could be applied to watersheds. However, in properly managing a legally established uatershed, these Laws would be insufficient.

While watersheds exist on Montserrat simply by their natural, physical characteristics, there are no legally designated watersheds. The proper legal extablishment of these watersheds is complicated by the number of

private individuals who own land in the watershed areas: eight in the Centre Hills and seven in the Soufriere Hills.

WATER SUPPLY AND DEMAND

Montserrat is fortunate to have a water system which is able to supply water to most of the islands approximate 11,733 people (1983 mid-year population estimate), with very few interruptions, The population of the island has remained' very static since 1976 (1976 mid-year population estimate of 11,647), yet there has been a 2.5% yr increase in vater consuaption (151,154,000 gal metered consumption in 1983). This is due in part to the comparatively high consuaption of the approximately 250 high cost hoses recently constructed on the northwest coast. Most of the owners of these hones are from North Anerica and their consumption tends to be three to four times that of the local population. It is likely that this pattern of increasing consumption will 'continue if the remaining 80% of these lots are developed and the standard of living and industrial use continue to ris

In 1983, about 35 gal/day was consused, It is projected that consumption will reach 45 gal/day by 1993. With only 17 of the islands 28 springs being utilized, and 2 of the islands 28 wells tapped (Pekurel and Hadven 1983), the Montserrat Mater Authority believes it will be able to eet the increase in donand,

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CONSERVATION PROGRAMS

Montserrat has a National Soil Conservation Programe that was established, in 1982, It' vas primarily organized by the island's Kericultural Engineer, and has included a public avareness campaign aereiating of field days with school children, lectures, and film shows.

fev 'pert "of this prograsse there is a denonstration project now beginning, fanded, under @ regional programme, by CARDI, EDF, and Montserrat's Ministry Of Agriculture. The work is being done in the Upper Lees, Molyneaux and St. "George's lis11 sub-vatershed areas, where erosion problems or potential problems 'exist due to farming practices. This project include contour Birks, contoured vegetative barriers, terracing, field drainage systens, Toad "improvement, and reafforestation, Meetings will be held with farsers from these ares' at" later dates to determine their acceptance of the soil conservation measures.

There is a Soil and Water Conservation committee which meets quarterly to review programmes on soil and vater consevation and to advise the Government of Montserrat on related aatters. The committee is made up oft

Director of Agriculture, Manager of Montserrat Water Authority, | an Agricultural Engineer, the Forestry Officer, an Agricultural Extension Officer, and two farners.

‘CONCLUSION

While the programmes now undervay are a step tovards watershed improvenent, there is still a lot to do for proper watershed managenent and Protection.” Education needs to continue, basic watershed data need to be fathered, "a vatershed work plan needs to be developed, an authority with Struonmel trained for management of vatersheda needs ‘to be established, Teeslly, defined watershed areas need to be established, and lavs need to be written to deal specifically vith watersheds:

Montserrat hi

no water problen right nov, but if good alternative
ogricultural {ces are, not” inplenented and” traditional farming and
eerting, practices are alloved to continue, the island will be faced with
Gnereasing. watershed damage, that when combined with future vater desands, could lead to water shorts

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Figure 1. Topographic map of Montserrat.

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PORESIRY IN ST. VINCENT AND THE GRENADINES

Calvin F. Nicholls
Agricultural Officer, Porestry

INTRODUCTION

In recent years the Forestry Division of Saint Vincent and the Grenadines has become an integral part of the Ministry of Trade and

Agriculture. | The process of total integration within the Ministry continues. The acceptance has been somewhat slow, but has come about sainly from the efforts of the Division itself through hard and persistent struggles to change its own inage; and to inpress on the Ministry and the Administration that Forestry is as mich a scientific discipline as any other, area of study. The Forestry Division is aot merely the semi-police organization for vhich it vas previously known.

To bring about this change the Forestry Division also had to sensitize 4 community, hither to almost totally unaware of the beaefits of forestry fond environment quality. Like sany educational programes the process hes been lov. There has been some positive signs, however, that the programme has been ‘filtering through to the community, Forestry and environsental matters are now more readily understood and appreciated,

ORGANIZATION

The Forestry Division is headed by an Agricultural Officer (Forestry) ho is assisted by two Forest Rangera, one of vhom ia currently on a study leave, pursuing forestry studies at’ North Carolina University. Twenty junior forestry officers (Forest Guards) complete the ataff, ‘the Chief Agricultural Officer by virtue of his office (technical head of the Department of Agriculture) continues to carry the title of Chief Forest officer.

In 1982, for the first time, the Division received a Peace Corps volunteer who has been assisting mainly in the area of surveying and toa lesser extent with on-the-job-training of junior staff.

POREST RESOURCES

There has been no recent survey to ascertain accurately the area of the forest estate. Beard (1945) estimated that sainland Saint Vincent hed sone 41,500 acres (16,795 ha) of state lands, of which 99% were under forests.” Figures for "the Grenadines are not available. It 1s estinated, however, that there are approximately 300 acres (121.5 ha) of state lands on Union Island, approximately 250 acres (101 ha) in. Bequia, and approximately 70 acres (28 ha) on Cannouan. State lands in ail the Grenadines once had fairly rich stands of white cedar (Tabebuia pallida), Similarly good stands of mangrove forests once existed there. Unfortunately, oving to mismanagenent and indiscriminate felling in the past, fev of these stands remain.

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FOREST TYPES

In his book "Forestry in the Windvard Islands", Beard mentioned that there were 254 species of trees and shrubs of which seven were endemic to Seint Vincent and" the Grenadines. The rain forest of mainland Saint Vincent belong to the Dacryodes sloanea association of the Lesser Antilles. Trees in this association reach heights of 100 ft (30 m) with a two, sonetines three strata, close ond crowed. The Goanier (Dacryodes fexcelsa), Junbie bead (OnSonia sonosperna), and Laurier (Lauraceae sp.) are good examples.

Of the five forest types identified by Beard, two have bean seriously affected, one through, human intervention and indiscriminate fellings and the other by natural disasters. The mangrove forests and coastal Littoral Woodlands have almost disappeared. 'The primary elfin woodlands have been feriously affected by the eruption of La Soufriere in 1979, Some recolonization of the latter type has begun.

FOREST LEGISLATION

Technical assistance has been requested to update the forest ordinance, and to prepare a nev wildlife act, The present forest Jegislation is grossly inadequate to cope with' the type of offenses currently encountered in the forest.

'The present bird and fish ordinance 18 also outmoded and does not meet the type 'of prerequisite legislation necessary to qualify for project funding proposed by World Wildlife Funds (WF) for the preservation on the Seint Vincent parrot (Amazons guildingii).

MANAGEMENT.

To date, the Forestry Division is without a vorking plan. There is need for a documented plan, rather than the haphazard approach currently adopted. The need has been recognized, and to this effect a strong Tecommendation has been made to seek technical assistance to address that heed.

Within the Limits of ite constraints, the Division continues to carry out "both watershed managenent and soil conservation work in areas threatened by erosion. Since the Saint Lucia Workshop the Forestry Division has stopped up its vigilance in the watersheds and catchment areas. There are sone twenty water supply sources supplying water for domestic purposes and for agriculture, Two of the sources supply vater for hydro-electricity; a third 1s to be harnessed in 1984 for commissioning in 1986/87.

ALL the water used on mainland Saint Vincent is produced from above-ground streane and springs. It is inperative, therefore, that @ proper managesent reginen be carried out in all the watersheds.' In the

Water is collected in private tanks and in public concrete catchments and ponds. The islands depend heavily on rainfall (epproxinately 40 in/yr or 1000 ma/yr) for their water supply.

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Wildlife managenent is now receiving much greater attention. The porrot (Amazon guildingit) being the national bird and currently on the endangered species list, is being given top priority.

Reafforestation to extend existing plantations and to establish new areas continues. Sone 60 acre (24,5 ha) aainly of Blue mahoe (ligbiscus elatus) and Gliricidia sepium have been established during 1983. Tending operations have kept apace. Unfortunately, thinning operations have been somewhat neglected due sainiy to lack of funds to cerry out the operations fond lack of proper utilization of thinnings.

Some Limited managesont prescriptions continue in naturel stands, specifically at "Kings Hill" Reserve 1791, a 55 acre 22.3 ha) parcel of dry woodland mixed species located in the southeast of mainland Saint. Vincent; at Fair Hall, approximately 25 acre (10 ha) of white cedar (Tabebuia pallida); at “Walibou, another mixed species composition of white cedar, angelin “(Andira inermis) and Greenheart (Lonchocarpus spp.); and at Canden

rk where @ 16 acre (6.5 ha) stand of West Indian mahogany (Swietenia mahagoni) and white cedar predominate.

In the area of Soil Conservation, the establishsent of screw pine (Candanua utilis), denboo (Ranbusa spp.), ‘roseau (Bractrix major) and sisal (gave spp.) continued in sreas threatened by land slips and soil erosion. ALL ‘three ‘plant species used to control erosion are useful for and are in great demand in the local handicraft industry.

AGRO-FORESTRY

In addition to natural stands of guava (Peidium graiava) and tamarind (Tamarind indica) currently under managesent, the Division, in collaboration with the Extension Division of the Ministry of Trade and Agriculture, established three 0.5 ha plots of mixed fruit tree species in 1983. Included in these plots were West Indian cherry, sour-sop (Annona guricata), tamarind, red and yello plum, sapodilla (Hanilkara zapota),

‘suger apple (Annona squanosa), citrus species, mango (Mangifera spp), coconut (Cocos mucifers), mauby, cinnanon (Ciananonun zevianicun) and

cashew (Anacardiur occidental).

PRIVATE FORESTRY

Private forestry activities are very lisited in Saint Vincent and the Grenadines. The Division continues to give technical assistance and to offer encouragerent to land owners to improve any potentially good woodlots, or here necessary. to plant new areas, Forestry seedlings are nade available at nominal cost, (sonetines free) to persons who wish to establish windbreaks, boundary lines, livestock shade or ornamentals,

FIRE PROTECTION

Until very recently fire protection vas practically unnecessary. In the last 5 yr, however, the incidence of bush and forest fires has

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increased considerably and is now a major concern of the Forestry Division fan the State. Four of our prized natural stands including the Casden Park Stietenia sahogani/Tabebuia ‘pollida dry forest and the Kings Hill Reserve

fe annually threatened by fires, Some of our hillsides have now developed fire ‘climax vegetation. These areas now present a somewhat depressing Sight to conservationists and to visitors to our State. Training in fire protection and fire Fighting equipment are now essenti

RESEARCH

‘This is probably the most neglected area due to lack of trained personnel to plan research programmes and lack of funds for implesentation. liith technical assistance from our Peace Corps volunteer a limited amount fof work has begun in the folloving areas:

“Surveying, coapartmenting and plotting of plantations.
“Establishing and measuring sample plots.
-Inventoring.

~Seed-tree identification and selection.

<A saall arboretua approximately 0.75 ha was established in 1983. Plans are. under” wy to extend this plot and also to expand our nursery facilities.

In 1979, La Soufriere erupted violently, destroying the vegetation for approxinately’ one mile around the crater’ (except in the Windsor Forest farea)- Recolonization has begun in sone areas and very soon normal plant Succession will start, It 4s unfortunate that the Forestry Division does bot have. the skilled’ manpower to atudy and document this. The result of this constraint is that a unique opportunity to do research is this area is

Likely to be lost.

TRAINING

To date the Forest Division has not been able to attract junior forestry staff with the necessary academic background to undergo formal training, the reason being the very low salaries offered. The opportunity is taken here to record my personal appreciation and that of the Governnent Of Saint Vincent and the" Grenadines to the Trinidad and Tobago Forestry Division for acconodating two members of our staff and to CIDA for funding their attachment. Also. to. the Luquillo Experimental Forest, Puerto Rico for similar accomodation for another tvo and to USAID for funding their attachaent.

Of special mention is the US Forest Service in two 12-veek courses held at the Institute of Tropical Forestry, Southern Forest Experiment Station in' Puerto Rico under the Caribbean' Environmental Action Plan, Sponsored by USAID, Incidentally, the funding for the current first ihventory study and the watershed and wildlife studies vere also provided by USAID. "Six sembers of our staff have benefited from training in Puerto Hico.

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Tt nay be useful to mention that all the above cane as a result of the Saint Lucia Workshop in 1982, Te may not be premature here to serve notice that the Saint Vincent and the Grenadines delegation to this vorkshop will fagain be making strong recommendation for further trainingy the need for Which is probably greater now than it vas two years ago.

FORESTRY EDUCKTION/ TNFORMATION

'There has been increased activities in this area since the Saint Lucia meeting. Lectures to groups, newspaper articles, radio releases to the general public, and film Shows to schools are nov done quite frequently,

Much grester efforts are necessary in this area, however, to continue the dissesination of forestry information in wildlife watershed, fire protection and environsent quality. Technical assistance is welcomed.

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PROGRESS REPORT POR THE PUERTO RICO FOREST SERVICE

Ralph C. Schmidt
Chief Forester for the Commonwealth of Puerto Rico

INTRODUCTION

‘The past two and one half years have seen substantial grovth in Puerto Rico's forest minagenent programs in terms of financial, human, and organizational resources. ‘Due to the efforts of the Secretary of Natural Resources of Puerto Rico, the Honorable Hilda Diaz-Soltero, and a very capable and dedicated staff of young professionals, I an pleased to report that many of the aspirations and projections related to the Pirst Caribbean Foresters Workshop two years ago have today becone realities.

ORGANIZATION

Programs require adequate financial suport to function properly, but just ‘es. important as money is proper organizational structure’ and institutionalized program planning. The Forest Service of Puerto Rico hi been formally reorganized "in the last year, an accomplishment vhich required extensive justification and approval at’ many bureaucratic levels.

‘The land managenent activities of the Departsent of Natural Resources have been unified under the Area of Forests, Sanctuaries, ond Natural Reserves. Five different types of land management units are adninistered by two bureaus each having two divisions, Forests are extensive area often containing plantations and timber management prograns, recreational activities and special land use permits of various kinds, These lands are rnanaged under the Division of Forest Management and protected by the Forest Lay of Puerto Rico of 1975, The Area 0190 manages Natural Reserve WildLife Refuges, and Estuarine Sanctuaries (Fig. 1).

‘These different types of land management units require different kinds of expertise, and the organization allova managers to specialize in that which they know best. The land area managed by the Department has expsnded by thousands of hectares in the past two years and mich expansion is planned in the future. This structure provides the basis for smoothly Incorporating nev areas into management programs.

BUDGET

Due to careful justifications and ceaseless efforts on the part of the Secretary, the Forest Service budget has steadily expanded over the past three fiscal. years. Essentially it has increased from $450,000" in September 1981 to $3,000,000 in 1984. About 10Z of this is from revenues which have increased ‘tenfold in the past three years and continue to show Great potential for future expansion. Most of the rest of the budget Hnances permanent professional positions which have been created within the organization. Only the Assistant Secretary is appointed; the Chief of

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the Forest Service and the Chief of the Sanctuaries and Natural Reserves, Bureau and ali other eaployees are peraanent civil servants.

‘TRAINING

As we have resolved issues of organization, budget and staffing, we have found that training and staff development vas olr major need, with few professional foresters or natural. resource managers and no university-level forestry courses in Puerto Rico, our approach has utilized 8 variety of other techniques.

Experts in hydrology, logging, silviculture, forest inventory, nursery management and treo inprovenent and resource interpretation hove cone from the US Forest Service or universities and conducted group sessions as well as vorked with our staff one on one. Also, we have sent managers on field training asssignnents to participate in and observe mnagenent programs in the United States and other countries.

‘The Department has entered into a new program of tropical resources managenent with The School of Forestry and Environmental Studies of Yale University. Supported by a three-year program development grant from the Andrew Mellon foundation, students earn a Master's Degree completing course work in New Haven and special field projects and courses in Puerto Rico. Mready ve have hosted stulents from Asia, Africa and Latin America as vell a the United States who are pursuing some interesting and useful study projects. Dean John Gordon ‘of Yale 1s interested in encouraging international participation in the program, complete scholarships are available, and I hope all of you will consider sending promising young foresters’ and ecologists to obtain Masters Degrees in this innovative and ‘much needed nev program.

PROGRAMS

‘Timber management programs continue to progress and expand very rapidly and to give good results, All treated posts and lumber that can be produced are immediately sold. With advise from US Forest Service logging land savmilling specialists, many knids of new equipment have been acquired such as post peelers, portable savmills, farm tractor winches, tilt trailers, fork lifts ‘and others. These’ operations are all designed to denonstrate methods to promote forestry activities in the private sector, and are especially adopted to fairly labor intensive ‘operations in Plantations and secondary forests of small area.

A forest cover and type inventory similar to that conducted in St. Vincent and in secondary forests of Puerto Rico has been completed in the

Toro Negro Forest. We are starting @ stand inventory hardwood plantation in the Rio Abajo Forest where 20 to 30 million board feet of teak, eahogany ‘and mahoe stand on 1,000 to 2,000 acres of plantations, It would appear that the sustained yield of these plantations will have a value at least equal to the current annual budget of the Puerto Rico Forest Service.

Reforestation programs are proceeding well on private fares and public lends owned by agencies other than the Department. The denand for timber

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tree seedlings for plantings on private lands is greater than our current Capacity, to supply them. Several agencies have developed interest in Feforesting their lands, and we are currently reforesting reservoir Watersheds, retired agricultural lands including vetlands, and the surface Grea of an extensive limestone cave system. Furthermore, agreement has Been reached between the Coamonvealth of Puerto Rico and’ the US Navy to Gesignate. several. natural reserves and to comence a reforestation project fon the island of Vieques.

Several industries and municipal governments have forned a consortium to land treat secondary sevage sludge by applying it on areas to be planted to forest trees. By adding water and substantial nutrients and organic hatter, productivity in this subtropical moist site may be substantially Increased, Ground vater and soil conditions will be carefully monitored by hydrologists. Sevage wastes are inevitably produced by hunan development on our islands, Once” treated, alternatives to land treateent such as Sncineration, land filling er ocean dumping are expensive and ‘environmentally harmful,

‘The natural reserve and forest system of Puerto Rico should continue expanding. The office of the Secretary has initiated the Propatrimonio Natural Program to identify key biotic. elenents for site selection of Future reserves. This program is conducted in cooperation with the Conservation Trust of Puerto Rico and the Nature Conservancy. The latter aintains an international office with prograns in the Caribbean and Latin America,

Land is obviously at a premium on our relatively snall densely populated islands. We all need land for agriculture, roads and buildings Berwell. as for forests to produce timber and conserve water, wildlife and genetic. resources, However, as we focus on the scarity and value of 1and the prise inportance of water may be overlooked. Recent recommendations for hodern agricultural practices in Puerto Rico concluded that water and not Tend wos’ the primary Limiting factor for agriculture. Slightly less Than 10 of the island's land was all that could be used for econoaically profitable agricultural enterprises, Pasture for all types of livestock

Prograns would occupy no. ore than an additional 252. Even allowing 15% For. trensportation and urban infrastructure, this leaves half of the island (400,000 ha) for" forest conservation. Some of this would produce timber land ‘some ‘would not, Our estimates indicate that about 60,000 ha of vell Ranaged softwood and hardwood plantations vould produce much if not all of the island's currently imported lumber consumption.

‘The lesson seems clear that for Caribbean islands careful selection of critical vetersheds for appropriate land use and management prograns is a top. priority. Furthersore, with quality water for hunan use, agriculture, land industry” becoming an ever eritical factor, lurge proportions of our fugged islands must’ be slated for conservation in programs directed by forest land sanagers.

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HYDROLOGIC CHARACTERISTICS OF ISLAND WATERSHEDS AND SUGGESTIONS FOR THEIR
MANAGEMENT

Russell E, Curtis, Jr.
Chief, Hydrologic Records’ Section, USCS

To Allustrate the hydrologic characteristics of Caribbean islands, T ‘am going to use data collected and analyzed for Puerto Rico (Fig. 1). Although Puerto Rico is larger thon the Lesser Antilles islands, their climate and watershed response are very similar.

The hydrologic cycle shown in Fig. 1 is basically the same on all of the islands. The biggest difference between islands is the heights of the fountain. peaks hich in turn affect the average precipitation and slopes of the watersheds. ‘These factors of course influence the vegetation and land

PRECIPETATION

‘The average annual precipitation for Puerto Rico is about 76 in (1930

mn) but it varies widely from one part of the island to the other. ‘This

type of pattern will occur’ on most of the islands. The almost constant

northeast tradewinds are lifted as they approach the mountains producing

the heaviest rainfall near the north or east coasts. The air leaving the

islands is much dryer, consequently the south or west coastal areas usually feive less rain.

May and October are usually the months of highest rainfall in Puerto Rico but the extrene events do not necessarily occur in these months. The Fainfall pattern that occurred during « four-day period in Decenber 1981 hen a cold front stalled north of the island resulted in storm totals that Fanged" up to. 25 in (635 mm) along the north coast but almost no rain fell fon the south coast.

In. September 1982, a tropical storm passed to the south of Puerto Rico and caused" rains totaling up to alsost 13 in (330 ma) on the normally dry Southwest coast while the north coast received relatively light rain.

STREAMFLOW

As expected, average streamflow follove the general pattern of average rainfall (Pig. 2). These graphs show the comparison between normal and Current streanflow at two of our "index" stations. One is on the north coast and the other on the south. Both streans are at their highest during the fall months and at their iovest during the winter, We compute these records each sonth so that we know the current status of the streamflow.

Most of the streams on the islands will be very "flashy". During a typical flood peak on one of the many sall streams in Puerto Rico, a Strean may rise from less than 2 ft stage to almost 8 ft and back down to 4 ft in 1 hovr.

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Flooding will occur mostly near the islands coastlines. This has eccurred in Puerto Rico over about the last 25 Very few serious floods have affected the interior sountainous areas.

Low flows usually occur during late winter. The result of @ low-flow

survey we made in Puerto Rico during March 1963 (Fig. 3) shows the total

voluse of water flowing to the sea at that tine, This is an indication of

the ‘minimum amount of surface water available during the year- Because of ‘few streams go completely dry.

‘STREAM CHEAISTRY

Flowing water on the islands is quite pure except when polluted by man. Unfortunately, there are very fev streans left that are not polluted, ‘The’ chemical makeup of streanflow is very complex but there are some items hich are practical to measure and give sone indication of ita purity.

One such element is phosphorus. Phosphorus occurs naturally in some areas but asa general rule in this part of the world, it is an indication of pollution by man. High phosphorus content of” streanflow has been measured near the populated areas of Puerto Rico (particularly San Juan) as compared to the low concentrations in the interior mountain streams. ‘Another common indicator of hunan sevage pollution is coliform bacteria. ‘This is a definite indication of human pollution, Heaviest concentrations tend to be around the populated areas, the same as with phosphorus. Drinking untreated water from any polluted streams could cause severe illness and possibly death. Fortunately, coliform bacteria can be killed by clorination, othervise there vould be very little vater left for us to drink,

‘STREAM SEDIMENT

‘The sedient carried by streams varies widely depending on the geology ‘and lend use of the watershed. A very rocky forested area will yield lov sediment concentrations compared to an alluvial farming area. Because of the geology, topography and land use of Caribbean islands, sediment concentrations are relatively lov. However, they do vary from one area to ‘another.

‘There are several reservoirs in Puerto Rico, The loss of storage due to sedimentation varies from 0 to 2Z/yr. After 50 yr, Guayo will be completely full of silt. This type of probles is becoming # serious problem all over the world.

GROUND WATER

‘The occurrence of ground vater on the islands is not nearly as common fas in many other parts of the vorld. ‘The steep, rocky mountains cause most of ‘the water to run off into the sea before it can be absorbed into the ground. The exception to this is Barbados vhich is relatively flat and mostly alluvial soil.

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In Puerto Rico, ground water is used only for about 20% of the public water supply. Puerto Rico probably has a higher percentage of ground water

Wrallable than most of the other Caribbean islands except Barbados.

Fron a hydrologic point of view, the actions required to properly manage a watershed are fairly simple to describe but may be difficult to Schieve. The steps should includ

“Establish a network of streanflow-nonitoring sites, The highest priority should be given to the largest watersheds.

“Continue to operate this network for at least 5 yr and expand it ‘to the snaller basins.

“After 5 yr of data have boon collected, analyze the changes that are taking place. *

“Use these date as a basis for making management decisions for Amprovenent of the watershed

Some progress in this direction has been made on St. Vincent, St. Lucia and Dosinica by initiating step one.

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<< Frecipitation (76) —" ativities
1M surtoce-nowe Evoptransiraion
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Outflow to
Sea (272)

WITHDRAWALS, IN INCHES CONVERSION UNITS

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‘OROUND KATER 2.0, INCHES X 165 McD

Figure 1. The hydrologic cycle of Puerto Rico.

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Figure 2. Discharge curves for two stations in Puerto Rico.

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FOREST WATERSHED MANAGEMENT IN THE CARIBBEAN

George B. Dissmeyer
Hydrologist
UsDA Forest Service

The Proceedings of the First Workshop of Caribbean For
Castries, Seint Lucia, May 1982 revealed several forest watershed
hmanagenent opportunities and probleas including:

“watershed protection and rehabilitation,

-wavershed

march needs,
“Landslide prevention and rehabilitation,

“forest road construction and logging, procedures for preventing
‘erosion and sedinentation,

“forest management for soil and water construction, and
soil compaction and its mitigation.

‘These opportunities and problems were associated with major issues
concerning damaged fisheries, failing vater supplies and impaired soil
productivity, all seriously affecting the vellbeing of the societies. The
participants’ at the first workshop recognized the potential of forestry and
the forest industry a @ means to correct problems and create opportunities
to. benefit society. However, improper forest management can aggravate some
problens. Several practical’ and basic principles can be enployed by forest
Ranagers to prevent or mitigate problems.

Watershed protection managenent is the management of 2 drainage area
for the production of tinber, recreation, wildlife, fishery and agriculture
products, while maintaining or improving water yield, vater quality, timing
Of streamflow, and soil prodvetivity. Watershed’ managers must solve
Tandslide, soil erosion, sedimentation, flooding, soil compaction, rosd
construction and logging problens, "and implement soil and water
rehabilitation projects.

PROBLEMS AND SOLUTIONS FOR WATERSHED MANAGERS

Landslides

Landslides are very difficult and expensive to rehabilitate.

Therefore, the best approach is to try to prevent thea from occurring. To prevent. landslides requires the ability to recognize land subject to Slippage if disturbed (Schuster and Krizek 1978. Good soil maps will Sdentify slide prone soils, but such maps are not generally available.

Foresters need to look for landslide evidence in the field.

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Landslides and unstable soil mantles can be recognized by slopes having protruding toes with scarps and. tension. cracks above (Fig. 1); leaning trees having the base of the stem leaning with the top portion of the trunk growing vertically (Fig. 2); sunken and patched road sections (Fig. 3); and Center Line markings of roads displaced down slope (Fig. 3).

Landslides should be left virtually undisturbed. Roads trigger landslides, thus roads should not be built across them if an alternate route can' be located (Schuster and Krizek 1978). If a road mst cross a landslide, only tvo locations are reasonably safe, if special construction practices' are employed (Gedney and Weber 1978), The two locations are the Nery top and the toe of the landslide (Pig. 4).

When building across the top of a slide, the road is built by removing soil (thus weight) from the top (Gedney and Weber 1978). The weight in the toe balances the weight upslope. By removing weight from the toy stability is increased. The road is built on a full bench section, that is, the road is cut into the slope with all excavated soil transported off the slide to be deposites ina stable area. Runoff fron the road must be carried by an inside ditch and éischarged onto stable soil or preferably carried by pipe to a stream, Never discharge runoff onto a landslide, because gullies form and as gullies grow they trigger larger and larger landelides. Eventually, the whole slope and road will slide downhill.

When crossing the landslide toe, add as much weight as possible, The road is built on fill, adding weight 'and increasing stability to the slide (Fig. 4), Never cut & road through a toe of a slide, because this removes weight fron the toe, reduces mechanical strength' within the slide and creates an unstable condition.

If you plan to cross the center of a slide, you better have a lot of 'money and equipment to keep the road open. There are sone things, however, that can be done to increase slide stability at such a lecation:

~The road should be built as narrovly as possible to minimize the depth of cut into the slide.

“Water concentrates in the soil at the base of 2 road cut and ‘saturated soils led to slides, This water concentration can be reduced by inserting rows of pipe drains into the soil in the eat, with the pipe sloped uphill. Water is collected by the Grains, snd flows into a collection pipe or the inside ditch of the road, which carries and deposits the runoff on a stable site or into 'a stream (Gedney and Weber 1978). Removing soil sointure increased stabllity.

When crossing the top or center of the slide, never build a road by pushing soil over the side to create a fill. The slide is at the angle of Fepose, that is, the angle at which the soil is at rest or stable. Side casted’ material form sliver fills which exceed the angle of repose, are Unstable and will slide dowhill (Fig. 4). When a sliver fill slides, gullies can form leading to a major landslide.

Completely forested landslides are known to slide when saturated. However, forest cover help stabilize landslides by ewo means; trees renove

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soil moisture and discharge it into the atmosphere, and soil is physically bound “together by extensive and strong tree roots. Retaining forests on landslides is & primary management strategy for minizizing their

Forest on landslides should not be clearcut or converted to other land uses, Forest renoval increase soil soisture and the roots will decay, creating an unstable landalide, Commercial forest can occur on landslides ‘and their harvest sust reflect landslide hazards. Selective harvest fysteas which resove a small percentage of the basal area are recommended. Narrow strip or very small patch harvests can work, too. Harvest systems should be. designed to retain. the water resoving function of the forest, while adequate rooting strength is retained to bind the soil together.

Road Location

Roads are known to be major contributors to erosion ané to sedinentation of streaas. Proper location of roads can eliminate the majority of road related problens (Hartung and Kress 1977). Roads should be located 0 thet they ‘can drain properly, avoid springs and seeps, on grades less than 12%, and where they will not trigger landslides. A good Tocation is often just one side of the ridge Line, which facilitates road drainage. The road should cross streams at right angles.

Bridges or culverts should be used to cross streass (Hartung and Kress 1977). These structures should be large enough to pass flood flow through then,” thus preventing the structure from washing out and closing the road.

If the road is to be used only to harvest @ stand, temporary log-bridges can be used and renoved after logging is completed (Pig. 5). Shallow rock Lined streams can be crossed with a ford with minimus impact to the stream. ‘The nunber of stream crosses should be minimized.

Road drainage is accomplished by using outsloped roads, inside ditches and culverts, and the roiling dips (Hartung and Kress 1977), Outsdé roads can be’ used if the road surface is gravel and not slippery when vet. Outsloping allows surface runoff to flow uniformly off the side of the road. For safety reasons, inside ditch and culvert drainage is often used. Rolling dip roads have minor reverse grades spaced to discharge water onto stable ground (Fig. 6). Rolling dip roads are inexpensive to build and to nintain, The spacing of culvert drains, lead out drains, and dips can be computed by the following formula:

Spacing = 400 ft
T grade

Another method for spacing drainage is this rule of thunb: vhen the road has an elevation change of 4 feet above or below the last drain, install ‘another drain,

To control erosion and sediment from roads under construction, build roads during dry periods. Wet weather construction is costly in tine, money, and environmental danage. Sediment movement fron road construction can be minimized by building brush piles just-below the road out of Limbs fand branches, brush, and non-commercial logs cut out of the right-of-way (Fig. 6).

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Road surfacing reduces erosion and sediment over a dirt road. Surfacing with large 2 to 4 inch gravel to a depth of 3 inches or nore will reduce erosion by approximately” 75%. Paving with asphalt will eliminate surface erosion, The cut and fill slopes should be revegetated to prevent

Proper road maintenance reduces erosion and sedimentation. Culvert heads should de inspected for debris plugging entrances. Plugged culverts will cause runoff to over-top the culvert and run either across or dovn the road, carving gullies and possibly washing out the road,

Grader operators are bad about gouging material out from the base of the cut slope. The structural strength of the cut slope is weakened by this practice and often leads to small landslides (slumps) in the cutbank. Grader operators often rebuild the inside road ditch when it is not needed. Vegetation in the ditch is destroyed, accelerating ditch erosion.

Logging

Logging requires skidding logs to deck vhere they are loaded onto trucks to be transported to the mill, The deck should be placed on ridj and not in stream bottoms, Ridge top decks requires skidding uphill, which means that surface runoff is being dispersed (Fig. 7). Stream bottom decks require skidding dowihill, thus surface runoff from skid trails, is concentrated at the deck, thus increasing erosion and sedimentation potential (Fig. 8).

Crossing streams vith skid trails should be minimized (Hartung and Kress 1977). Skid trails should be located before logging begins, Stream crossings should be at stable sections of the stream, for exanple vhere rock is present, Skid tails should have structures to cross streans, for example, tenporary log bridges, culverts and log bundles, The latter should "de used in only very small streans that carry a little runoff during the shortly after heavy rains, All stream crossing structures should be Yenoved after logging is completed.

Skid trails, -decks and tenporary roads cospact soil, increase surface runoff and erosion, and decrease soil productivity in the compacted urea. ‘The area of compacted soil should be limited by careful location of skid trails, decks and roads. Generally, roads and decks should be leas than 5k of harvest ares. Skid trails should’ be limited to 15% of the area.

After Logging is completed, temporary roads, skid trails and log decks need watershed rehabilitation treatsents, Roads are closed by using chains between trees, locked gates, or ditches dup deep enough to prevent a vehicle from ‘crossing (Harting and Kress 19/7). Roads, skid trails and decks are vater barred (Fig. 9), diverting surfece runoff onto vegetated and stable soil. Waterbars are spaced by using Table 1.

Waterbars can be constructed with hand tools or bulldozers. (Fig. 9). It is best to start at the end of the skid trail or road and construct

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waterbars as the tractor backs out because waterbars are danage if crossed by equipment. Waterbars are angled across the trail or road at 30° dova slope. The vaterbar is created by digging 6 to 9 inches into the soil with the excavated soil piled adjacent to the downhill edge of the ditch forming 2 mound running the Length of the ditch, The outflow end of the water must be open to permit proper drainage.

Conpacted soils can be rehabslitated by plowing or ripping to # depth of 6 to 12 inches, respectively. Ripping is done by a bulldozer equipped

With road rippers.” Rip when the soil. is dry enough to shatter as the Jmplenent is pulled through it. If the ripper slices through the soil, it is’ too wet. "Aninals or’ a tractor can be used to plow compacted soil. After plowing or ripping, the soil should be disked to create a seed bed, Seeded “and possibly mulched with straw or herbaceous vegetation depending fon, soil erosion hazard, amount of precipitation and other factors. Sometines fertilization "is needed because soil nutrients are low or have been removed during the construction of the trail, road or deck.

Filter Strips

A technique used to reduce the amount of eroded soil from roads and Logged areas reaching a stream i to leave a filter strip, an essentially undisturbed strip of vegetation, and forest floor to intercept surface runoff and sediment (Pig. 10).’ Filter strips are not taken out of production, Timber can still be harvested and regenerated, but heavy Cquipnent and major soil disturbing activities are excluded. For example Toads and skid trails are excluded, except at stream crossings.

Filter strips should be left between any forest disturbance and intermittent or perennial strean, Table 2 has are recomended filter strip ‘dutha on various. slopes in the temperate USA. These eay need adjustment for tropical regions because of higher rainfall.

With proper road and skid trail location, construction, maintenance, and closures, these filter strip guidelines vill keep the majority of the Sediment out of the stream.

Site Preparation for Tree Planting

Sone general watershed principles must be applied when preparing sites for tree planting. To prevent erosion and surface runoff, the soil surface must be. protected by leaving Litter and debris in place. How auch litter land. debris to leave increases as the slope increases. On 0 to 10% slope, 50. to 702 of the soil might be exposed without excessive erosion. However, fon slopes >50T, 20% soil exposure might be unacceptable. Specific guidelines will vary by climatic and soil conditions.

‘Also, implenenting practices thet retain organic litter and topsoil on site will aaintain soit productivity (Dissmeyer 1984), Organic materials Contain. @ large quantity of nutrients, If these materials are renoved to prepare a site for tree planting, valuable nutrients for tree grovth are Penoved. "In the United States, ‘early tree growth is a function of the ‘mount of nutrients on site at the time of planting. Therefore, those

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practices that retain organic material, thus nutrients, are those practices
That reduce erosion and runoff, while best maintaining soil productivity.

[EROSION EVALUATION AND RESEARCH

To formulate sound soil and water conservation policy and direction, agencies require date on the nature, extent and magnitude of the problen. For erosion and sedimentation, watershed analysis and planning can be done with tools prasently available. Watersheds can be divided up into area of the sane soil, slope class, timber type, and potential forest management , Af source maps and information are available of they can be generated. An erosion rate for forest conditions can be developed from field observations and with the Universal Soil Loss Equation (USLE; Dissaeyer and Foster 1980). The condition class area tines its erosion rate will yield an estimated erosion volune fron that specific condition. Erosion volunes from all conditions are sumed to produce a total for the watershed. Agriculture and other land uses can be evaluated by the USLE (Wischneler ‘and Snith 1978) too, and incorporated into the vstershed analysis and yion total. These data and analysis can be used to develop # soil and water plan and policy for addressing erosion problens on a priority basis.

‘The USLE has been adapted to forest conditions in the United States and validated (Dissmeyer and Foster 1980), The use of the USLE is expanding into many countries. Before adopting the USLE for use, it should be ‘checked to seo if any ‘of the equation’s factor relationships need modification (Lissmeyer and Foster 1983). Technical expertise in the USLE can be sought and the equation can be checked using an inexpensive technique ~ fabric dans.

Fabric Dans

Fabric dams are basically fences constructed on a slope, faced with an erosion control fabric (Fig. 11; Dissaeyer 1982). The fabric allows water to seep through while filtering out sediment. The dan has wing walls straight upslope at each end to prevent runoff from escaping around the ends. The volume of trapped soil can be measured (Fig. 12) and compared to. the éstinate made by the USLE,

Fabric dans have some advantages over other research techniques because they are cheap and can be used to demonstrate how mich erosion is occurring in various landuses (Fig. 13). People not expert in erosion evaluations and terminology have a. very’ difficult. tine relating to or visualizing what is meant by tons per acre, tonnes per hectare, milligrams per liter, and parts per million, However, soil trapped behind @ fabric don 1s visible.

Fabric dans have been installed in @ thinned pine plantation, pasture,

anda banana plantation in Puerto Rico. Last summer, no sedinent was observed behind' the dan in the pine plantation, a very small anoune in the pasture dan, and a lot of soil behind the banana plantation dam. Such visual observations by laymen and policy-makers creates in their minds "hard" evidence as to which land uses yields the most erosion and where to concentrate efforts to minimize erosion and sediment. problens.

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(CONCLUSIONS

'This paper has tried to summarize many of the practical and common ynse practices that can be used to minimize watershed impacts from forest anagenent activities, Behind these practices are many fundanental principles of watershed management, When evaluating @ proposed managenent br land. use practice, careful evalustion and judgement must be employed to

termine which practice to implement, The guidelines and tools suggested fare. starting points and with experience in using thea, sone modifications Milt become evident to improve vatershed management in a particular country.

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Table 1. Waterbars spacing

Approximate distance

Road and skid needed between
trail grade waterbare
@ (fe)

1 400
2 245
5 125
10 80
15 6
20 50
25 '0
30 3
40 30
50 25

Table 2, Recomended filter strip widths.

Slope of land between Width of filter
oad and atrean strip
@ (te)
° 25
10 45
20 6
30 35
40 105
50 125
60 5
70 165
80 185,
90 205

5.

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LANDSLIDES

Pigure 1, Landslides have humicky and protruding toes,

and tension crack commonly found at its head:

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Figure 2. Unstable Landslides often have deformed trees.

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CROSSING LANDSLIDES
WITH A ROAD

‘Take Weight Out
of Top of Slide

Figure 4. Basic principles for crossing landslides.

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ASIMPLE LOGGING ROAD BRIDGE DESIGN

Figure 5. Temporary log bridges

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Figure 6. Rolling dip road.

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Figure 7.

Skid trails
Log decks | __—~
Stream

Road location governs the nuaber of stream crossings, log
deck location, and direction of skidding.

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Ne ee nnn ee an

Figure 8. Valley bottom location of roads increases the nunber of stream crossings, fosters downhill skidding and increases the poten-
tial for erosion and sedimentation.

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WATER BARS

SF Grade % — Spacing (ft)
a 5 25

on

20 50
30 35
40 30

Figure 9. Treating abandoned roads and skid trails with waterbars' controls surface runoff, reduces erosion and sedinentation.

Bie

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Figure 10. Filter strips left between roads or other foreat disturbances 'and streams will intercept eroded so{l and redice stream sedimentation,

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Figure 11, Fabric dame are # good technique to deaonstrate erosion associated vith various land uses and to validate erosion prediction equations.

Figure 12. Broded soil trapped behind fabric dams can be measured periodically to docusent erosion trends.

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Figure 13, Fabric dams can be used in aide by aide comparisons of

various landuses, including roads and skid trails

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DEVELOPING DATA BASES FOR SUCCESSFUL WATERSHED MANAGEMENT IN THE CARIBBEAN

Russell B, Curtis, Jr.
Chief, Hydrologic Records' Section, USCS

To properly manage any watershed for any purpose it is necessary to collect background" data and then continuously monitor changes. The most Smportant items that foresters need to monitor include streanflow and Uissolved or suspended material in the vater. Once these paraneters are documented under "normal" conditions, it should be relatively easy to honitor the changes taking place in the watershed.

Last year, Dr. Lugo asked us (US Geological Survey) to assist him in his watershed-nonagenent project by installing a streanflow-sedinent gaging Station on each island, and helping train local foresters iit the methods of neasuring and sampling st-eanflow. We agreed to do this and last November, Dr. Luge and I cane down to talk to the local foresters and decide on the dest locations for gaging stations. We chose watersheds that drained from Rostly natural, undisturbed forests, and yet were large enough to Fepresentative "of a large part of the island. We also required a bridge that was, suitable for the snstallation of an inexpensive gaging station. lie chose sites on St. Vincent, St. Lucia and Dominica.

We have (with the complete cooperation of the local foresters)

ablished. one. continuously recording, gaging station on each of the three

Sslands. We also established a recording raingage in each watershed and 'a channel survey at each streanflow gage site.

After gage construction vas completed on each island, our hyérographers' gave their local counterparts a short training session on streamgaging and sampling.

MEASUREMENT OF STAGE (OR GAGE HEIGHT)

Although river stage 48 not something ve need to know, it 1s the most practical way to calculate streamflow. The continuous' measurement of Streamflow "is possible but it is usually too expensive to be practical. The most, connon way of seasuring river stage is by constructing a stilling Well. The basic. requirenents are a "well" vhich resains in contact with the 'river at all tines ond an instrument shelter that is veather proof and

hot subject. to flooding, The stilling well creates a vater level the sane is the river but without the velocity and surges. A float can then be put tn the stilling well and attached to a stage recorder at the top. The Tver “gages we installed for this project ere of this type but of @ much Timpler design, The stilling vells are made of 6 inch (15.2 em) PYC pipe land attached to bridge piers or abutments,

The next most commoi type of stage-measuring device is the mercury nanometer or "bubble gage". ‘This is the type of installation we use sost Of the tine in Puerto Rico. The river stage is measured indirectly by Dubbling nitrogen gas through a tube fixed permanently in the streambed and

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measuring the back pressure. ‘The higher the river tage, the more pressure that's required to cause the gas to escape. The mercury manometer attached to the other end of the bubble tube measures the preawure in the bubble tube and converts it to feet of stage.

‘The instruments are somewhat complicated. The advantage of this type of installation is that the shelter can be easily located almost anywhere and a bridge is not required. The disadvantages are that the equipment. is expensive and hytrographers” must be highly trained to operate them properly. The recorders used in these river gages are the same regardless of whether it is a stilling well or bubble gage. The standard since 1935 hhas been the graphic recorders

About 25 years ago the USGS developed the Automatic Digital Recorder (AbR). This recorder converts the river stage to nunbers and punches these funbers on a paper tape. The paper tape can be translated directly into our computers which eliminates "the need for the gage-height data to be. computed manually. The only disadvantage of this recorder is that it is not easy to read in the field and gaging problens are sometines overlooked, This is the type of recorder we are using here on this project «

MEASUREMENT OP DISCHARGE.

‘The discharge of a stream is the volume of vater passing the gage site at the time of the measurement. We measure it in cuble feet per second,

‘The equipment required is a tagline (to measure width), a wading rod (to measure depth), and a current meter (to measure velocity). The seter is suspended on the wading rod. The width and depth are measured directly.

‘The velocity is measured by counting "clicks" on the current seter,

The Price AA current meter has been the standard mensuring device for the USGS for at least’ 50 years. Each time the bucket wheel makes one

Fevolution, the hydrographer “hears a "click" in his headphone. He counts clicks and after- at least 40 seconds, he records the number of clicks and the number of seconds as shown on’his stopwatch. He then looks at his conversion table, This converts the readings into feet per second, By multiplying the “depth (in feet) by the width (in feet) by the velocity (in feet per second) he computes the volune of water floving at that section,

‘Twenty-five to thirty sections are usually required to properly define 2. stream channel. The volunes of the subsections are then added up to give the total flow passing the gage site. The gage height of the stream is, also noted before and after the measurement. Tf any change occurs, @ ‘mean-gage height 18 computed,

For the project gages in the three islands only wading-type measurenents will be attempted. The equipment and training required to fnuke high-stage current-meter measurenenta mike it impractical

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‘STAGE-DISCHARGE RELATION

Now that ve have @ continuous record of gage height and discharge measurements at various stages, ve can develop a relationship between the two to give us discharge continuously.

Figure 1 is a typical stage-discharge anslysis. A curve is dravn between the meaturesents to give a discharge for every gage height. This project will have measuresent data only for low flows (up to maximum vading Stage). "The channel analysis I mentioned earlier vill provide a theoretical relationship for medium and high stages.

By selecting points along this 12 into our computer, we can obtain a "rating table". This table can be used to Gonvert any gage height at this station to discharge in cubic feet per Second. “These rating curve points can now be stored in the computer and Glong ‘with the gage-height data fron the digital tapes, be used to utonatically compute discharge for every day of the year.

SEDIMENT SAMPLING

To define the sediment concentrations and copute the total sediment Load of @ stream, samples mst be collect

Figure 2 shows a diagram of a sediment sampler in a stream. The sompler mist be moved up and down fron the water surface to near the Streanbed to get an accurate sample, The vater is collected in a glass milk bottle.

‘The sample must be capped securely and identified (Pig. 3). The

information required is station name, date, time, gage height and initials Of person taking sample. Since we vill only take one sample at a tine on this project, we.don't need to show the section station or bottle number. ‘The important ‘thing is to take samples at different river stages.

‘The sediment concentrations change rapidly vith stage and on @ major rise, many samples may be required. On this project ve are suggesting 3 or 4 samples at different stages during a major runoff event. During low-flow periods, 1 sample every 1-2 weeks is sufficient.

‘These sample results are used along with the gage-height record to draw continuous concentration curves (Fig. 4). This 18 an example of the {dea1 situation with mony samples to define the curve. Unfortunately, we don't very often have this many samples to work with.

Now that we have continuous stream discharge and sedinent concentrations, ve can compute total-sediment load. Simple mathenatics Mill give the total-sediment loeds (in tons) for each day, month or year. Over 50,000 tons of sediment can pass 2 station during one year.

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CHEMICAL SAMPLING

In_ addition to sediment samples, ve will be taking chemical sample. ‘These samples will be taken at the same tine as those for sediment and wiil be mailed to the Center for Energy and Environment Research of the University of Puerto Rico for analysis.

‘These samples will be analyzed for nutrients including nitrate, ammonia, and phosphorus among others. Like sediment data, these analysee can be’ combined with strean-discharge data to calculate the total amounts of the various itens leaving the watershed.

‘RBOORDING RAINFALL,

In each of the three watersheds in this project we installed a recording rain gage. The same type recorder (ADR) is used with a float and standpipe. The rain catchnent on top of a shelter funnels the rain water into the plastic pipe and every 15 min the ADR punches the elevations on the paper tape. The gage is calibrated to record in hundredths of Inches and will record up to about 5 inches before it must be drained manually. We have plana to add @ siphon arrangement which will drain the gage automatically.

‘The paper tapes from the rain gages will be fed into our computer and

it will, calculate the rainfall for each 15 minutes, hour, Jay, month and year. These data can then be correlated with the streanflow, sediment, and chemical data. By monitoring the rainfall-runoff ratios over long periods, we could determine what changes are taking place in the watersheds.

USES OF THE DATA

ALL of the data collected and analyzed vill be published in @ report similar to our annual data report. It will be furnished to the local foresters as soon as it is considered final. It is also anticipated that the individual investigators will use these data for various interpretive reports of their own.

The results of this project should produce @ data base that can be used to monitor the changes taking place on the various islands and provide sone basis for suggestions for' inprovenent in vatershed management. Tn addition, these data can be used for decisions regarding water supply, dam 'and reservoir construction, flood control, bridge and road construction, 'and pollution control.

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Figure 2. Measured and unmeasured sampling zones in a stream sampling vertical with respect to velocity of flow and sediment concentration (J.K. Culbertson; written communication, May, 1968)

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Desired ronge for water level

Mark with o soft

Pigure 3. Diagram of sample bottle shoving desired water levels and essential recorded information. Sonetines other inforna~ tion concerning type of sampler used, the section location, and stream conditions should also be noted.

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Time of Doy in Hours

Figure 4. Gage height and sediment-concentration graph typical of many epheneral streams shoving desirable sample distribution.

Gage Height in Feet

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‘TIMBER PLANTATIONS AND WATER RESOURCES ON ST, VINCENT, WEST INDIES

Peter L. Weaver
Institute of Tropical Forestry,
Research Forester

and

John Valenta
Peace Corps Officer

[INTRODUCTION

St. Vincent (Pig. 1) is one, of the windward islands of the Lesser Antilles. Tt ig located ,ot 61910" W longitude and 13°15" W latitude and occupies 345 kat (133 mi2). A north-south mountain range divides the Ssland into to nearly equal parts. The high point is 1220 m (4000 ft) bove sea level just north of the crater of Soufriere, This active volcano dominates the northern third of the island, The southern 2/3 of the island fare highly dissected by deep, narrov valleys to the leeward and sonevhat gentler sloping lands to the vindvard.

Rainfall gauging stations show that both the windward and leeward coastal areas ‘receive over 2000 mm/yr (about 80 in/yr). Mean annua) temperature for the same areas is about 260C (about 80°F). The interior mountains are cooler and vetter, with rainfall estimates ranging from 3800 to over 6000 sn/yr (150-235 in/yr) at the highest elevations (Macpherson 1977} Caribbean Conservation Association et al. 1960).

‘The natural vegetation was described by Beard (1942, 1949) and consists of lovland. rainforest between 300 to about 500 = (1000-1650 ft), palm brake above 500 to 600m (about 1650 to 2000 ft), and dwarf forest on

the sumaits ‘of the highest mountains. Secondary vegetation surrounds the ‘area ‘doninated by Soufriere vhich was disturbed by volcanic activity in 1902-03, 1971, and 1979. Secondary vegetation is also found in areas worked for subaistence crops in the southern two-thirds of the island,

Population grovth has placed increasing demands on the island's forest, water and soi] resources, Expanding from 48,000 persons in 1930 and. 89,000 in “1960 (Byrne 1969) to 111,000 in 1979. (Wichotis 1982), the current” population density is 320/km? (about 835/12). Although terrain ‘above 300 = (1000 ft) is ovned by the government, shifting cultivators are groving dasheen, tannia, and sweet potatoes in’many areas. Belov 300 permanent cultivation with bananas, coconuts, arrovroot and sugar cane is Commonplace, along with scattered ‘sango, breadfruit, cacao, and citrus trees. Future development of vater supplies for domestic and commercial uses, and hydropower, will require the careful management of the government's forest resources (Weaver 1982).

The main objective in visiting the island was to initiate an inventory of the forest resources of St, Vincent similar to that conducted in Puerto Rico (Birdsey and Weaver 1982). Because information on structure and

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growth of plantations was not avoilable, a quick survey of representative Species was conducted in order to: characterize standing timber (height, diameter, dasal area and volume), and growth rates, by species and site. In addition critical water supply sources were located and silvicultural practices were suggested to enhance stand grovth.

erHons

Hibiscus clatus, Pinus caribaea, and Swictenis macrophylla, the most connonly used plantation species (Nicholls 1982), vere selected for study. In addition, Calophylium antillanun and Cordis’ alliadora were examined on three sites.

Plantations of the above species vere inspected visually and representative areas, usually midslopes, were selected for sampling. A Stake vas placed in the ground for the plot center and all trees intercepted "by a basal area 10 prism (that is, 10 ft2/acre or 2.3 mé/ha) were tallied. Diameter was measured on all intercepted trees to the nearest, 0,1 em and “height was determined to the nearest 0.1m using an optical rangefinder. The dates of plantation establishment were obtained from the offices of the Ministry of Trade and Agriculture and confirmed with field Personnel, Thinning dates were estimated from stump dianeters and likewise Confirmed (Table 1). ALL initiol spacings vere 1,8 x 1.8 m (6 x 6 ft).

A previously measured secondary stand dominated by Swietenia mahagoni and Tabebsia pallida at Canden Park vas also included in the analysis. In this “instance, three 0.10 ha (0.25 acre) plots were established and height was determined with a Clinoseter.

Mean diameters, mean heights, total volumes, and growth rates vere then derived. Volunos were estimated using the following equations:

“for llibiscus lata, Cardia alliadora, Caloshyllua antiUanun,
‘Thbebuia pallida, Swletenia sacropivila, and Swietenia mahagont

V = 0,0368 + 0,545 GH where
V 4s the volume in m3, G is the basal area in a? at 1,3 m above the ground, and Wis the total height in ®, The equation (r2 = 0.98) was derived from

50_trees of eight species, one of which w ‘macrophvlla, in three ‘different Caribbean countries (Dawkins 1961).

“for Pinus caribaea
V = 3,639 + 0,036972 (02H) where
V is the volume in de}, D is the diameter in cm at 1.3 m height, and His

the sheight in, It vai derived from 664 tree measuresents in Surinam but no r2 was given (Voorhouye and Bover, no date),

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RESULTS AND DISCUSSION

Of the 50,6 ha (125 acres) of plantations for vhich ve could find records, “libiacis elatus accounted for a litele over 70% of the total area (Fig. 2), Pinus caribaea and Swietenia macrophylla accounted for another 16% ‘of the plantations. About @ third of the plantations were established iu 1968-69 and about 402 in 1982 with a steady rate of 2 to 4 ha (5 to 10 acres) planted in most intervening years (Pig. 2). ‘The increase in activity. starting in 1981 vas possible due mainly to financial assistance fron USAID under its basic Wunan Needs Programme, adsinistered by the Caribbean Development Bank. At the First Workshop of Caribbean Foresters lichotla 1982), Hibiecua "vas reported to occupy 75 ha (185 acres) on St. Vincent, Einus "30 ha (75 acres), and Swietenia 18 ha (45 acres). The dinenaions and use of these and other species surveyed in this study are ‘sumarized in the Appendix.

Stand structure varied considerably by species, site, age, and previous silviculture, and ranged from 5,6 m3/ha (about 80 £¢3/acro) for Gordia at Government House to 575 n3/ha (about 8220 fr3/acre) for Pinus at Hermitage (Table 2). In Young man's Valley, vhere all the species were planted in 1969 and thinned in 1976, Pinus attained the greatest mean

Giaseters, sean heights and total volume. At Hermitage, where plantings were done in 1962-63 and thinnings in 1976, again Pinus showed the largest mmesn dimensions and volume. The latter plantation was located on a terrace ‘and appeared to have been vell tended. Both of these factors contributed to the fine grovth. The thinned Sxietenia plantations at Hermitage had higher mean diameters, mean heights and total volumes than the unthianed stand.

‘At Versont, Calophyllun, Hibiscus, and Pinus vere established between 1971 ‘to 1973 and had never been thinned. Pinus again had the largest dimensions and volune. Hib: ind Calophyliu had nearly equal diameters land volume while the height of Hibiscus averaged about 2m taller,

At Montreal, the plantations of Hibiscus and Pinus were established in 1966 and 1967. ' The Hibiscus were thinned in 1974. One of the Pinus plantations was thinned in 1979 and another in 1982 while the last Plantation renained unthinned. The Ilibiscus growing on the slope had Larger dimensions and volume’ than that on the bottosland, The Pinu thinned in 1979 hed greater mean diameter and mean height but less volune than the unthinned stand, both of which were on gentle midslopes, The renaining Pinus stand, thinned in 1982, vas situated in an area exposed to wind and had Less height ond voluse than'the other stands.

In the secondary forest at Canden Park, Svietenia aahogani composed 75% of the steas (Table 1). Its mean diameter and height vas considerably less than that for Tabebuia gollida (Table 2). Basal area for both species combined "yas 17,8 a2/ha (07.4 U2/acte) and the total volume 134,8"13/ha (1926.3 tr3/acre).

Diameter growth rates ranged between 0.62 and 2.05 em/yr (0,24 to 0.81 in/yr), height” growth between 0.66 and 1,00 m/yr (2.15 to 5.91 ft/yr) and volume’ growth between 0.42 and 28.76 m3/ha.yr (6.00 to 410.98 ft3/acre.yr) for all species and sites conbined (Table 3). In general, the best grovth was attained by Pinus and the poorest by Cordia. Hibiscus shoved the least

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variation in diameter, height and volune growth regardless of age, site or silvicultural treatment. On the other hand, Svietenia macrophylla’ appeared to have better dianeter and volume grovth when thinned,

The variety of conditions affecting growth and development of the afferent stands and the Linited data herein make valid comparisons. seong species and sites impossible. Sone premilinary observations, however, are possible even in a quick survey like this one, Among’ thea are the Following:

“Swietenia sactophylla shoved poor form on most sites, with low ranching and excessive crovn development. Moat of this poor form is probably attributable to shoot borer

arandella) infestation. Lack of a 16 foot (5 m) cleer stem vill Seriously reduce the stand value and utility at maturity.

“About 70% of the stands had high basal areas in excess of 25 ‘m2/na (108 ft2/acre). Although Pinus and Hibiscus are narrow-crovned species, and able to tolerate high stem densities Tor several years, continued development vithout thinning will result. in slover ‘growth on the rotation trees and high stand mortality. — Without studies using different spacings and thinning regimes on several” sites, it vill be difficult to prescribe the beat managenent pract: Unthinned Swietenia at Hermitage has already begun to slow in diameter growth because of stand density.

<Incosplete records make assessment of grovth and development, ‘and the extrapolation of volumes on an areal basis, extrenely difficult, Accurate data on plantation establishment dates, original “spacings, dates and types of thinnings, and recurrent measurenent of select plots for growth analyses are needed,

MANAGEMENT RECOMMENDATIONS.

“Except for Guvernaent House, the forest plantations are concentrated high in watersheds where clearing and cultivation of subsistence’ crops is underway, Most of the land is government property that has been "reclaimed" through the establishment’ of plantations, Efforts to increase plantations in these areas should continue both for the provision of lusber and to deter further advance of cultivation into the interior of the island.

‘Twenty water supply sources and hydropower sites are located in several watersheds circumscribing the central mountains (Fig. 1 and Table 4). With population grovth, donestic water demands will increase. Likevise, future expaneion of tourien or the introduction of small industry on the island will create greater demands for water. ‘The continuous supply of good quality vater throughout the year is dependent on maintaining forest cover on government owned lands in the interior. These lands should be protected against further intrusion and plantations should be established on steep slopes to conserve vater, and to reduce

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soil erosion and reservoir sedimentation,

“Many of the plantations are very dense. The close spacing that is traditionally used throughout the island offers a chance for selection of better stems after 4 or 5 years. Thinning at this time would enhance the development of better trees and maintain good growth over a longer period of time. Other spacings and Uhinning regimes should be studied. Perhaps the 1981-82 plantations established with USAID assistance could provide a starting point for silvicultural research in cooperation with outside institutions.

vAn alternative method for the establishaent of Swetenia macrophylla should” be investigated. The tree's high value and utility assure a ready market. Shoot borer infestation nay be ininished by Line planting widely spaced Swietenia interspersed with “other fast growing timber species. Ta su

Uhinnings, the better formed Swietenia should ve favored.

ACKNOWLEDGEMENTS

We are grateful to Mr. Calvin F. Nicholls, Agricultural Officer in the Ministry of “Trade and Agriculture, St. Vincent, for assistance vith plantation records and in the conduct of this study. He also reviewed the manuscript. Dr. I. A. Farle Kirby kindly assisted with local uses for the island's timber and in locating pertinent literature.

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Figure 1.

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Location of existing water supply intakes and hydropower sites (ounbered) and plantations sampled in this study (lettered). ‘The letters are coded to takes 1, 2, and 3 and the numbers to table 4:

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Figure 2. Planting records for St. Vincent. (a) Percent of total area planted by species with actual areas in hectaren (acres).
(b) Chronology of planting since 1965 without regard to species, Records may not be completed.

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Table 4, Kanes of exigying water supply soure

ind hydropower sites on

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6 Raney 1 River 30 30
7 Georgetown 3 Springs 9s 9
8 ores 2 Springs % 100
9 Higher Lowans 1 Spring 100 100
1 River
10 John win 1 River 170 250
Ml Layou 1 Spring 100 150
12 Lively 1 Spring 20 30
13 Majorca 1 River 500 850
14 Maroon 1 River 40 200
15 Montreal 1 spring
4 Rivers 400 1,000
16 Owis 1 River 30 30
17 Richmone!!
18 Sandy Bay 1 River 90 90

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Table 4. (conta)

Number Name Intake Capacity
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1 orestry Division, Ministry of Trade and Agriculture, Kingstown,
St. Vincent.

2 yabers are coded to Figure 1.

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CONSERVATION OP NATURAL, RESOURCES IN ST. LUCIA

Paul Butler
Conservation Advisor
Forestry Division

Wise management and conservation of our Limited natural resources are not just esoteric concepts but ones essential for the sustained development of our islands, Be it soil, watersheds, mineral deposita, or wildlife, all have, in one vay or another, a vital role to play in our socio-economic Well being. However, all tod often conservation 1s seen as an opposing force acting against development, and when this idea is set in the minds of decision makers, irrepricable danage can be done. It has been estinated that worldwide,’ an area of forest, the size of St. Vincent is destroyed every two days, week after week, ‘year after year. Such indiscriminate removal of natural cover has led to an increase in soil erosion, 2 Feduction in land fertility and to a rapid disappearance of a large number of plant and animal species. IF we continue to destroy our environsent, fan's own survival will be threatened, Without top soil, we will have no food, without water there can be no life,

Conservation, like development, is for people. While developent ains to achieve human goals largely through the use of natural resource conservation aims to achieve them by ensuring that such use can continue.

In St. Lucia, conservation of the environment in general, and of

wildlife in particular, is based upon four cornerstones. As the term implies, each’ is as important as the other, and all are integrated. They fare: ‘legislation, environmental education, research/captive breeding, establionent of reserves.

LEGISLATION

Legislation is the "big stick” with which those policies that Government has deemed essential to the well being of the country as a whole fare implemented, For legislation to be effective it must bea real deterrent; penalties and fines should be in Line with the cost of living ‘and should be amended at regular intervals to prevent inflation eroding {nto ‘the deterrent values lave should be rigidly enforced and in an unbiased fashion.

Legislation must also be fair inasmuch as its "clauses" should be well publicized so that the general public is avare not just of penalties Imposed for the various legal infringesents, but also the reasons behind the legislation itself,

The protection of St, Lucia's terrestrial wildlife falls under the broad umbrella of the Forestry Division's Wildlife Protection Ordinance of 1983, This Act is divided into "Absolutely Protected Species" (37) "Partially Protected Species” and unprotected species (rats, mice, songoose and fer-de-lance). However, Section 9 (2) Reads, The’ powers of the

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Minister.....,shall include the power to declare, for any period not exceeding thee years, a closed season in respect of any or all species of Wildlife in the "second/partially protected schedule". With the habitat devastation resulting from the recent passage of Hurricane "Allen" and the resultant adverse effects on wildlife populations, this clause vas applied, fand today all but the four unprotected apecies are "absolutely protected”.

‘The penalties for infringement of this Ordinance are stiff with a maximum fine of §5,000.EC ($1,886.US) or one year in Jail. Knovledge of this” ordinance is widespead anong the population. To date we have had very fev legal infringenents and most have involved the collection and posseusion of reptile species.

This véldlife ordinance is conplisented by:

="Porest, Soil and Water Conservation Act and its 1983 ‘Avendsent, which protects our forests, habitet for so many of the native wildlife species;

"Turtle and Loteter Protection Ordinance", of the Pisheries Departnent thet provides legislative coverage for a range of marine speci

Our Wildlife Protection Ordinance is further complimented by our Government' having ratified CITE (Convention on International Trade in Endangered Species). CITES entered into force in 1975 and has since been ratified by more than 8 countries. Its prime objective is to attempt to regulate international trade in rare or threatened species of wild anisals or plants and to prevent their over exploitation and their ultimate extinction. CITES operates on a system of permits and those species which fre subject to trade controls are listed in three appendices.

"Appendix Includes species presently threatened with 'extinction. A11 shipments of such species including their parts

srivatives require two permits. One from the country of

'one from the country of import. These permits vill 4 only when such shipment will not be detrimental to the of that species. This appendix includes St. Lucia Parrot, St. Vincent Parrot, and both Deninican Parrots, as vell 'a8 most Caribbean Sea Turtles.

"Appendix II: Includes species not presently threatened with 'xtinctton but may become so unless their trade is regulated. Inport permits are not required for Appendix II species but an export "or re-export permit must accompany each shipment. Included in Appendix II is black coral and the boa constrictor.

"Appendix. IIT; Includes species which do not fall into Appendix T oF Ii but are regulated for conservation purposes by a party ration. International shipsent of these species requires either 'an export or re-export from any other country. No import permit is required.

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ENVIRONMENTAL, EDUCATION

It is quite obvious that the plight, of the Caribbean's wildlife is intimately linked to habitat destruction. This is in turn is due to short term economic goals and a general lack of understanding as to both the value "and fragility of the "resource. Environsental education has 3 Valuable role to play in avakening an interest and understanding of our hatural, cultural and historical resources. The potential of environnental

education is trenendous, especially in small island states such as ours, for several reasonst

“A Limited population size enables programmes, backed with only Limited financial support, to reach the majority of the people:

“The distribution of age groups is such that a large proportion fof the population is attending sone form of academic institution (29% in St. Lucia) and can therefore be relatively easily reached;

“The lack of teaching aids and curriculum development materials makes the donation of educational handouts/booklets especially welcomed by teachers and parenta al ike;

“Large family size results in quite a small nunber of households within the population, making distribution of materials less Gifficute; and

<The mass media is often limited to a small nunber of newspapers, radio. and television programmes many of which are quasi-government and this assists in gaining complete coverage.

An environmental education package should: be interesting as voll a informative; reach the entire community rather than only a particular Segment of it; build upon initial successes and be guided by pre-determined goals as to what a specific education project is attempting to achieve.

The Forestry Division in St. Lucia has placed considerable emphasis on environmental edvcation and the Division regularly holds film shows, SLidetalks and publishes articles in our nevspaper. Visual aids such a: billboards, posters, t-shirts, and bumper stickers have also featured in our work,” A sali interpretive centre has been constructed in the forest for tourists and locals alike, and a self guide trail is currently under

The Forestry Division has printed a booklet entitled "A-Z of St. lucia's Wildlife” and this has been distributed to schools and is available for sale to the public. A second series on the A-2 of trees has also been Featured in the Voice newspaper.

A monthly environmental broadsheet entitled "Bush Talk" now plays @ sajor role in our progranse, "Bush Talk” vas originally conceived as a teaching aid for children aged between 8-19 years, and it set itself the im of covering a different topic sonthly from a broad range of environmental concerns. To further involve the community it was decided to ‘s1s0 reproduce this broadsheet in the weekend issue of our national

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newspaper, and to seck production costs from public sponsorship.

Now in its 28th issue "Bush Talk" appears on a monthly basis and has covered a diverse range of topics including: water, indigenous wildlife, soil erosion, plantations, family life, mangroves, coral reefs, town birds, turtles, litter, bonanas, illegal forest squatting, hurricanes, coconuts, and forest folklore.

‘The response from both echools and the public has been excellent; today it is" read not just by the children but by a broad cross section of the comunity and the desired changes in attitude are becoming evident. In @ survey carried out under the "Man and Biosphere Prograame” a questionnaire asked the public to comment on the perceive seriousness of Certain environsental problems ~ sone 73% of St. Luciana questioned defined Geforestation as a "very serious hazard” (second only hurricanes at 792), compared to 26.42 on St. Vincent).

Questionnaires circulated to teachers were enthusiastically returned, complete with constructive criticisns, suggestions and comments thet "Bush Talk" is being widely used and appreciated by children with an age range of 5-15 years. An essay competition vas held, and the winners published in an anniversary” issve, A second competition ia currently being held. If funds can be located it is hoped to publish "Bush Telk" in book form for Permanent use by our nation's achool children and for sole to the public.

RESEARCH

Wise management goes hand in hand with research, and cach is intimately inked, for without an accurate data base, management cannot exist on a scientific basis, Wildlife research consists of:

“A Bird Banding Programme: Bird banding 19 @ sampling technique ‘used t0 census wild birds to obtain a rough index of species composition, species diversity, bird densities and population fluctuations. "Sixteen mist nets are placed in a straight Tine, each net being 2.5 m high and 12m long, Individual birds are captured as they fly into the nets and get entangled in the fine 30. mm nylon mesh. Each bird is "ringed" with @ numbered metal bend, Birds are weighed and measure before being released Uunharmed, Standard” weasurements taken include body weight and bill, leg and tail lengths. These measurenents together with observations on plumage aid scientists in determining variations In geographical "populations of the sane species. Trapped birds fare 0180 examined for signs of discase and parasits

A Gagtive Breeding Programe for Endangered Indigenous Species:

Because of @ lack of finances and lack of adequately trained manpover, our captive breeding programes are currently run in collaboration with internationally recognized zoological institutions. Captive breeding programees can act as a valuable safety net for endangered species, for when animal populations reach a critically lov level, the conservationist must become concerned with the fate of ‘individuals, Captive breeding Programmes should alvays be: established in a manner not

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detrimental to the survival of the species in the wild aintained without augumentation from the vild, except for thé Sccasional addition of animals from wild populations to prevent Meterioration in breedingy and managed in a manner designed to saintain the breeding stock indefinitely.

‘The goal of any captive breeding prograsme should be to re-introduce or supplement existing wild stocka and to improve the species survival chances in the wild.

Lucia is currently participating in two captive breeding

“St. Lucian Parrot, Amazone versicolor, programe at Jersey Zoo here a single chick was successfully hatched in 1982.

Maria Island Lizard, Cnemidophorus vanzoi, programme recently established at the San Diego Zoo in the USA.

ESTABLISHMENT OF RESERVES AND PROTECTED AREAS

To counter continued habitat destruction, the steady decline in species diversity or abundance, and danage to Soil and water supplies, it hhas become the tradition of Governments, St. Lacia included, to deciare areas of critical habitats as national parks, forest reserves or wildlife Senctuaries, In. gnall territories, these often serve many purposes, {ncluding protection of critical watersheds, protected wildlife-sabitats fand as recreation areas. Discussion on watershed areas can be found Clsewhere in this volume, and thus this section vill concentrate on areas for wildlife conservation and amenity.

Nature Reserves must have @ people component and should not be area: set aside solely for wildlife protection, as this may alienate then in th eyes of the. local population. The citizens of many third world cosmunstie fare” often "environmentally unaware" having lacked the priviledges of an fSdvanced education and easy access to the media, Further, they have little

time of from their labours, and even less "free money to’ spend on visiting their country's protected’ areas. Yore often than not, they see then as areas set aside for foreign visitors. Conservation, to them, is therefore fan abstract concept, with little or no bearing on’ their day to day life, fand may even be seen as a barrier to their material progress.

Education/Interpretive Centres, self guiding trials, school and conmunity visits all. have a role to play in making the people understand the value of protected areas.

Within the St, Luca Forestry Division's Central Forest Reserve, an area of approximately 1,600 acres (648 ha) haa been set aside as a Nature Reserve to" protect the "St. Lucia Parrot and other forest wildlife. Artificial nest. boxes have been erected and the planting of preferred tree species has occured on a limited basis.

Two small islets (Maria Islonds), lying off the southeast coast of St. Lucie have been’ declared a Nature Reserve to protect the indeginous Maria

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islend Lizard and
comprise.

ike, unique to the 30 acres (12 ha) that the island's

Savannes Bay, lying on the southeast coast near Micoud is an area of mangrove that has been declared a Nature Reserve, although at present its development as a reserve has been stalled due to a lack of funds,

Other areas recommended for protection include Marigot Bay, (mangrove), The Pitons (scenic ares), Bois D'Orange Swamp (fresh water svanp) and Dennery Knob. Official recognition of these and development funds have yet to be obtained.

‘The Forestry Division actively encourages children and youth groups to wrticipate in field studies as these both stimulate the child's curiousity as_well as re-inforce their classroom activities. To date, approximately 12% of the island's school population have participated in the guided forest tours. Other tours are operated for the benefit of our foreign tourists and a per person levy of $17.50 BC (US$6.6) 1a charged, To date, since its conception in 1979, an excess of $71,250 BC (US $26,886) has been raised for conservation and a total of 5,547 tourists have visited the forest.

Today, the concern of the Forestry Division for conservation and sustained ‘management extends froa the restricted confines of the forest

itself, to encompass the broader environment. Part of the reason for this, broader interest stens from the fact that the forest is intimately Linked to other ecosystems (consider that deforestation results in the silting of rivers, and the fouling of reefs, that trees can form valuable windbreaks or that mangroves are only forests of a single tree type),and that of the Personal interest of senior meabers of the Division.

Such an interest for the vider environment has manifested itself in the fact that the Forestry Division has played a key role in the formation of the following:

Environmental Commission: A multi-disciplinary group of Government and non-Goverament representatives ho meet to discuss wide ranging probleas impinging onthe wider ‘environment, and ho offer advise and impact assessments to the planning and developsent authorities.

“Parks and Beaches Comission: A commission set up to protect,

‘enhance and develop St-Lucia’s beaches and parklands for the benefit of tourists and locals alike, and. to advise Covernnent on policies related to the sase.

“St. Lucia Katuraliats’ 4 non-Governmental body open to interested menbers of the public whose objectives are education fané research, as well as’ to act as a "conservation pressure group” if the’ need arises.

‘The Forestry Division is also represented on the following:

“St. Lucia National Trust
Central Water Authority

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“Timber Industry Developaent Board
“Urban Beautification Committee
“Caribbean Conservation Association

People everywhere ust learn to appreciate the meaning of CONSERVAFION, “within the context of their ovn lives, and the lives of their children and their” chiléren's children. Our approach towards stimulating this appreciation must be balanced and appropriate. We mist not emphasize Conservation to. the exclusion of development; but rather seek to foster an Understanding that there can be NO long term developsent without teaching the community why it. is needed. Nor mist we undertake grand managesent programmes founded without an accurate data base. It is alvays better to

Start small and to achieve one's aims than to have grand progremaes that fail,

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‘THE FOREST BCOSYSTEM IN FRENCH CUYANA
BOOLOGICAL STUDY ON TTS EVOLUTION UNDER MAN-MADE CHANGES

Francots Vencelius
Directeur Regional
Office National des Forests

INTRODUCTION

One of the main projects for developing French Guyana is industrial pulp-milling. This vill be supplied, at first, by a large scale Clear-felling of natural forest. Saal’ areas of the cleared forests vill be established with plantations of fast growing species, the reaainder will be used for agriculture and for natural regeneration of the forest.

Such transformations of the original forest ecosystem will bring about heavy risks with predictable and worrying consequences: erosion, modification of water economy, various biological danages and presusingly & fast reduction of yields in these nevly created ecosystens, “Accordingly, the Freach Government’ has decided to’ finance studies and experiments, called Program BCEREX, whose objectives are: to have a precise and comprehensive knowledge of the initial ecosystem, to define vays of its xploitation ané transformation a6 well as new simplified ecosyetens, to

ess the effects of the changes of the various yield factors of ‘the natural balance, to give an estimate of the nev aystens yields and draw and managenent schemes’ to be extended on a large scale.

METHODOLOGY

The research nd studies vill be multidiseéplinary so as to collect most of the basic data and information and to interpret them for practical use. Thus the whole operation, belonging to the UNESCO Program MAB (Ecological Effects of Hunan Activities on Tropical and Sub-tropical Ecosystess) involves various research institutes, (ORSTOB, INRA, MUSEM, ATIONAL, D'HISTOIRE NATURELLE AND CTFT) the leadership being given to the CIFT. The project activities are led in close connection with the Developsent Services: DDA and ONF.

The initial ecosystem has to be precisely known in order to accurately compare the initial situation with the modified ones. Thus, a first set of studies deals vith the various natural factors (soil, water, cLimat.

botany, zoology, etc.) and a second one with the hydrological behaviour the catchment basins. ‘The studies will be performed during the two years preceding the modifications.

‘The experimental design for testing these modifications has to cover the variable conditions of the project area and allow for extension of the results to a large scale. Observations and measurements mist be carried ‘out within @ long-term program.

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‘EXPERIMENTAL LAY-OUT

‘The experiment is located beneath the tovn of Sinnsmary, on the so-called ““Bonidoro Schists", in a landscape of low altitude hilis. The drainage conditions of the different soil types vary from a free vertical drainage (FVD), with no land use problens, to a locked vertical drainage (IND) situation whose value for agriculture is unclear.

‘The different land uses considered for the experiment are: natural. regrowth, Pinus and Bucalyptus plantations, orchard, pastures end foodcrop by shifting cultivation. They are tested within’ 10 different catchsent basins, each one having a 1 to 1.5 ba area, after clearing by "pi Standards: logging, wind-rowing of the reaaining vegetation and burning of the vind-rows, Considering the different drainage conditions, the "ereatmente" vere assessed, fron 1979 to 1982, (Table 1).

PRELIMINARY RESULTS

‘The data collected to date mainly deal vith the initial ecosystem, ‘Those on clearing effects are not yet available. Very briefly summarized, nt results are as follows

‘An analytic map of catchment basins has made it pos jetermine the soils of the initial covertype. pedological characteristics of @ catchment basin may now be precisely known by only indicating its evolution grade. Organic hatter, carbon and nitrogen components linked with biological Betivities strongly decrease after clearing; the C/N ratio increases significantly after cultivation. The biological Gvolution of ‘the soil 1s deeply stressed by burning; its Fecovery after burning depends on the Litter from neighbouring regrowth.

“Mater balance and erosion: In the natural forest, with an ‘annual rainfall of 3,320 ma, 7% of the water is intercepted by the canopy, 1% returns as stemflow, and 1,470 mm in

evapotranspired. The amount of run-off and erosion depends on the oil typer

Run-off Internal flow Mechanical erosion

@ @ (e/a)
Pv 4 10 0,26
a) 16 15 0,24
LVD + Thalveg 24 a 0.5

After clearing, the flow (average and peak) increases by a factor varying fron 1.5 to. 2 even. vhen the pastures or the orchard (with its grasses) are established. Mechanical erosion ‘amounts to 3,2 t/ha on a "FVD" soil and to 11.2 t/ha ona "LID" soil,

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Water run-off varies from 60% on poorly established pastures to 30% only on the good ones (Digitaria svazilandensis, Brachiaria,). Erosion on these land use types after a very high peak during establishment is reduced to 0.5 t/ha.

“lora: Within the trees over 20 cm diameter, 45 fanilies have been identified. The lecythidaceae represent 26% of the total ‘and the caesal’ piniaceae 22%. Drainage conditions of the soil have significant effects on the composition of the flora, on the basal area and the size of the largest trees but not on stand density.

‘The biomes amounts to 323 t/ha + 302. During the natural regeneration after clearing, the dominating species (size and density) are fev; they are fast growing and require strong Light. Within six years after clearing, the basal area amounts to 23 m2/ha compared to 38 a2/ha in the natural forest before clearing.

Species having on economical value, Goupia glabra, 18 the ‘most promising.

“Crop yields: Pastures with Digitaria gvazilandensis and ‘Brachiaria behave well and, three years after ‘establishment, still give an annual yield’of 12 t/ha dry matter ‘on "LVD" soils.

-Binua growth does not yet depend on the soil type; the hydronorphic parts of "LVD" soils only have a depleting effect.

Accumulation and wind-roving zones are favourable to

Eucalyptus and Pinus growth.

‘CONCLUSION

‘The PCEREX program has reculted in a greater understanding of the forest ecosysten in French Guyana and of its behaviour in relation to soil. moisture. This program is now able to give various data for establishing a developsent policy for the country. Tt deals with the industrial outlook for using the land after forest clearing (pastures, orchards, fast groving trees plantation) and also with traditional shifting cultivation and natural regeneration. The program should prove a great value even outside Preach Guyana,

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Table 1. Experimental treatments by drainage condition under various land uses.

	FVD	Intermediate	LVD	Total
Natural forest (control)	-	1	1	2
Natural regrowth	-	2	-	2
Binus plantation	-	-	1	1
Bucalyptus plantation	-	1		1
orchard	1	-	-	1
Pastures	-	1	1	2
¥od crop	-	1	-	a
‘Total	1	5	4	10

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PRELIMINARY RESULTS ON VOLUME TABLES OF BLUE MAHOE (Jitbiscus elatus) AND HONDURAS MAHOGANY (Swietenia macrophylla) IN ST. LUCTA

WiLliem Butler
Peace Corps Volunteer

Permanent plantation sample plota were begun in St. Lucia in 1980 by Peace Corps Volunteer Ton Ward. Ward was not able to complete his programme, so subsequent plots were established by Verna Slane (three), and Willian Butler (five). Fourteen 500 m2 sample plots for Honduras mahogany have been established. Of these, three plotw vere established at Edsund Forest (approximate elevation 1,500'ft or 457 m), two at Quilesse (1,000 ft

‘or 305 m), one at Union (250 ft’or 76m), and two at Barre de L'Isle (1,000 ft or 305 m). For blue mahoe, fifteen 500 m2 sanple plots have been established: nine at Edmund Forest, two at La Sorciere, two at Mare (1,000 ft), one at Barre de L'Isle, and one’at Union (Whitman 1980),

veTHODS

‘The plots vere established by running a 50 m (horizontal distance) string line through a portion of the stand, zach end of the centerline vas Persanently marked with a piece of orange painted steel rebar driven into the ground, Trees within 5 m on either side of the ceaterline vere neasured. Each plot’ is therefore 10 m wide and 50 m long or 500 m2 (0,05 ha or 0,124), A 4m buffer strip vas also established on all sides of the plot (Ward 1982).

After the plot was established and all qualifying trees tagged and neasured, the stand vas marked for thinning if it vas found necessary. The thinning” regime used vas based on opening up the cron, which varied from stand to stand.

‘Tree volumes were determined by felling those trees marked to be thinned and measuring both the over~bark and under-bark diameters of the midpoint of each 3 moter log, Volumen vere measured to a top diameter of (7.62 cm) (3 inch), Voluses of the renainder of the standing crop after thinning was elo determined. The standing crop vas separated into large, medium and snall dianeter classes. Two representatives trees for each size class outside the plot were found, felled, and the volume of 3 meter logs determined. The volumes of these representative trees were then extrapolated to give a final voluse of those treees left on the plot.

Ward's measuresent techniques vere altered after he left. Where Ward chose trees >5 cm DBll, plots measured by Slane and Butler used a 10 cm DBH Minimum for trees to qualify for measurement. Ward also counted all trees with DBH > 6 cm as having merchantable volume. Caleulations from Slane and Butler and all future calculations will assume that only trees over 21 cm (8 inches) DEK will have merchantable voluse. These neasurenent. changes will help to reduce field work time and this allo the research forester to establish more plots across the island,

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RESULTS.

‘The local volume tables presented here for blue mahoe and Hondur mahogany are” strictly of a preliminary nature. They vere constructed from Bll the tree volune results currently available from the permanent sample

plots established since 1980, The volume results shown here (Tables 1-4, Pig. 1-4) should only be used as @ rough comparison with results from other countries of the tropics. Future harvests in St. Lucia will have a Tesearch forester on hand to measure the volumes of more trees. Only then can volunes be separated according to site class.

‘The data dase was 90 snall that volunes of all three site classes had no definitive variations, It waa oaly vhen all three site classes were Combined” that an adequate volune curve could be constructed. Because many Of the measured stands vere of aimilar age groups, there were several tree Yolunes for one diameter class, vhile another dianeter class vould not be Fepresented at all. For instance, blue mahoe had eleven trees of 14 cm DBH that were measured for volune, while no trees were measured for 26 cm DAH (Table 1). Similar gaps can be seen in the Honduras mahogany data, where ho tree voluse data vere gathered for 33, 35 adn 37 cm DBM classes’ (Table 2). The combined data did allow for constructing an initial curve for estimating individval volumes for blue mahoe (Fig. 3) and Honduras mahogany (Fig. 4.

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Table 1

Volumest of blue mahoe (Hib:

sus) arranged by dianeter

a Volume under bark!

(em) (=)
8.00-8.99 023.007.022.013 015 0.016
8 O13 021 017.018.026.028 .011
S008 ‘019 0.018
10 029.030 042 0.034
n 1024 029.019.049.040 013-011 0.026
2 024.029.081.082 .084 .064 .000
'0s6 [057 ‘059 0.058
rt 078 0.078
“ +099 «121.054.079.097 150.074
Toso 1135. ‘043 L035 0.092
1s <115 069 103.085.044.075 142
‘095 0.091
16 +162 200 142.084.109.073 .089
fuss 1195 L125 0.132
v 202.170 135 0.169,
18 +169 195.260.200.146 047.119
fis 1185 0.157
w 1.259.078 ASL 196-198. .294 27 0.204
20 225.351.208.233. 222.137 «153
tau 0.232
a 278.231.293.279 170,140 0.231
2 2285 361 0.308
2 M8 362.210 179.395.375.399
1398 0.346,
2 1439 648.383 323 0.398
2 426 441.464 459.397 0.437

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Table 1. (conta)
au Volume under bark! Average volume
(c=) (ex) (x3)
6 - -
2 «S78 382.452 618.563.323.229
1538 0.460
28 509.556 0.533,
23 834.734 0.796
30 1367756 655 0.659
a - -
2 “617 0.677
3 897 1,025 0.961

* Volume to a 7.6 ca top diameter.
5) Bach value represents. a tree.

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Table 2, Volumest of Hondurs
dianeter classes.

iaahogany (Swietenia macrophylla) arranged by

pa Volume under bark’ Average volume
(=) (23) (=)
9,00-9.99 015. .017 0.016
10 1020 .029 025 0.025
n 064.029 030 0.031
2 058.041 0.050
3 064.058.048.045 0.054
“ +057 .054 059.082.039.048 0.087
as 028.083.063.083 0.064
16 +084 090.065 0,080
v 124.085 0.105,
18 s121 104.142.088.136 4127 «160
Tuo logo 143 L175 0.126
9 <143 157.096 155.166.134.079 0.133,
20 s14 170.212 130-169 147.159)
her 0.156
2 206 153.166.190.269 0.196,
2 s1I7 314.218.268.303 .185 0.231
23 206.206 172.274.228.368 «399
1398 0.260
2 254.167.253.277 335 387.232 0.22
2s +337 366.208. «183 0.273,
26 <3 .262 0.317
2 +302 206.463 «186 0.289
28 +393 531.525 422 0.473,
29 665 0.665

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Table 2. (cont'd)

aH Volume under bark! Average volume
(c=) (en) (23)
30 273.581 0.427
3 +562 .690 0.626
2 -T35 621 0.678
3 - -
4 2582473 481.549.666.637 0.564

35 - -
36 720.978 946 o.881
37 - -
38 1.074.975 908 9.986
39 1.383 1.170 1.126 1.226
4 1.374 1.374
4s 1.146 1.422 1.284
46 1.866 1.866
48 2.484 2.486
6 3.701 3.701
65 3.932 3.932

* Volume to a 7.6 ca top diameter.
Each value represent a tree.

=u

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Table 3. Volume of blue mahoe traes based on curve projections of data for 134 trees measured island-vide.

De Volume under bark
Tea) Ginehesy io Hey
10 3.94 0.033 0.472
n 4.38 o.044 0.629
2 an 0.055 0.786
13 5.12 0,068 0.972
“ 5.51 0.084 1.201
4s 5.91 0.100 1.430
16 6.30 0.120 ne
v 6.69 onan 2,016
18 7.08 0,163 2.331
9 7.48 0.188 2.680
0 7.87 0.215 3.07%
a 8.27 0.246 3.518
2 8.66 0.279 3.989
2 9.06 0.315 4.504
2 9.45 0.385 5.076
2 9.84 0.393, 5.620
26 10.24 0.436 6.234
a 10.63 0.475 6.792
2 a.02 0.513 7.335,
29 tard 0.553, 7.907
30 aaL 0.593, 8.479

iz

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Table 4. Volume of Honduras mahogany trees based on curve projections of data for 122 trees.

au	Volume under bark		
Tea)	Ginehesy	ey	CEE
10	3.94	0.020	0.206
u	4.33	0.030	0.429
2	an	040	0.572
3	5.12	0.050	ons,
1“	5.91	0.065,	0.929
15	5.91	0.800	ary
6	6.30	0.095	1.358
uv	6.69	0.110	1.573
18	7.09	0.125	1.787
9	7.48	0.145	2.073
20	7.87	0.165	2.359
a	8.27	0.185,	2.665
2	8.66	0.210	3.003
23	9.06	0.235	3.360
2	9.45	0.265	3.789
2s	9.84	0.295	4.218
26	10.24	0.325	4.647
a	10.63	0.360	5.168
28	11.02	0.400,	5.720
2	tery	0.440	6.292
30	eer	0.485,	6.935
3a	12.21	0.535	7.650

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Table 4. (cont'é)

be	Volume under bark		
Ta	neha	wy	Ey
3212.60		0.585	8.365
33299		0.635	9.080
sh	3.39	0.690	9.865
35	13.78,	0.750	10.724
36	kaa		11.582
”	1.37		12,440
38	14.96	0.940	13.441
3915.38		1.010	14,442
so	18.75	1.090	15.586
a	16.16	1.180	16.873
42	16.54	1.270	18,160
a	16.93	1.360	19.407

4 17.32 1.455 20,805
“on 1.560 22.306

130.

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Volume of

Higure 1.

Oph et Tee (om)

Comparison of blue mahoe voluses (under bark) from the thr
site classes fround on St. Lucia. (Volumes measured to a
7.6 em top diameter).

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fbn of Tree fem)

Figure 2. Comparison of Honduras mahogany volumes (under bark) from
the three site classes found on St. Lucia. (Volumes
measured to a 7.6 cm top diameter).

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cm)

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Figure 3. Comparison of the volunes of blue mahoe based on field
measurenents (all sites combined) with those based on
curve projections.

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Figure 4. Comparison of the volumes of Honduras mahogany based on
field measurements (a1 sites conbined) with those based
‘on curve projections.

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‘TIMBER STAND MANAGEMENT INITIATION ON ST, VINCENT WITH SPECIAL REFERENCE TO
‘SWIETENTA mahagoni/TABEBUIA pallida MANAGEMENT AND UTILIZATION

J.T. Valenta
Peace Corps Officer

INTRODUCTION

Plantation initiation on St. Vincent dates back to 1949 with the establishment’ of approximately 15 acres. (6 ha) at Eyry Hill of Honduras mahogany (Suietenia mactoplulla) and tesk (Iectona grandis), Tree planting Teveled off during the 1950's. During the 1960's and 1970's an upsurge of plantation establishment took’ place, in response to a groving need for Watershed protection, Operations wore based around three watershed areas, Montreal, Buccanent” Valley and Cumberland Valley. The early 1980's reafforestation activities were focused tovarda the Colonaire River, in which a hydroelectric plant has been established at South Rivers. Approxinately 75% of plantations established on St. Vincent are within water-catchnent areas. Recorded description of these plantations are not available, Is addition, thinning schedules have not been incorporated. Watershed’ reafforestation serves a two-fold purpose: water conservation and timber production.

In response to the initiation of @ timber management scheme, a two phase project has been incorporated.

PHASE I - plantation and natural stand area seasurenent and mapping. Natural stands will be measured if recognized by the forestry division.

PUASE II - plantation and natural stand inventory. Upon initiation, this, phase will select specific forest management operations’ that correspond with specific stands. Eventually every stand will be inventoried to determine stand structure for Incorporating specific silvicultural prescriptions.

menHoDs

Stand area measurement incorporates traversing procedures to deternine total area, Traversing implements a lead person seasuring slope for correction purposes and back azimuth, and a rear person measuring azimuth. A chain is'' stretched between persons at distances of 33, 66, 99 or 123 it (10,20, 30 or 37 m) and both points are marked. ‘The lead person's point is “utilized to. sight in the next lead point, This procedure is continued until the stand boundary is measured. Traverse data are plotted at

110,000 scale, the stand areas are divided into triangles for area meastirenent. Stand outlines are transferred into 1:10,000 scale maps, Utilizing specific land locations on the map to accurately locate the stand, Traverse error of St and less is acceptable.

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‘Traversing Considerations

To date a total of 42.42 acre (17.2 ha) have been traversed and calculated. The efficiency of traversing is questionable because of the considerable asount of field hours for data collection. Aerial photographic rea determination has been considered, but not accepted because of the large number of shadoved photos. However, I feel traversing implements basic concepts and field procedures necessary for a developing forestry prograsne.

Canden Park Secondary Swietenin sahagoni/Tabebuia pallida Stand

Camden Park, Tocated on the southwestern coast of St. Vincent, vas formerly cultivated in arrovroot and sugar cane under estate ownership. Galctvation yam abandoned aroun 1925 and ovede of Sxigkenin maaaoad tod ida vere planted. This deciduous seasonal forest (Beard 1949) BiStenia “='7ivobuin foreation receives. mean Fainfeil.79 in (1.950 we) The rainfall rate is high for this formation. Soils within the’ stand are shallow, steeply sloping clays with rock-out, crops, hence influencing dryness’ of the site’ (Watson etal. 1958). The forestry division first recognized this 16.3 acre (6.6 ha) stand” in 1955 and various forss of thinnings have been incorporated with no managenent objectives. Illegal cutting along with haphazard thinnings has caused a hygradation of vell formed’ trees” in the stand, Species composition is 75 $. mahagons and 25% ZT. pallida*. Trees are poorly forsed, averaging 13 well-formed seed trees per “acre (32/ha). Another consideration related to poor-formed 8. mahagons BS" shoot ‘borer."(Uisipyia spp.) attack at early ager, Evidence of HysipyTa does not exist within the regenerating stand at present. Studies done in’ Puerto "Rico and St. Croix indicate S. sahagoal resistance to. Hysigyla randolla. attack (Geary et al. 1973, Geary nd Nobles 1980). liysipyla spe ‘onsiderations for” the “Ganagenent'of $. mahagoni could be eliminated ¢om this stand if future indicators stay the osm

1 have typical sweeping characteristics, ideal for boat building “(Adams 1973). "Natural seed germination is abundant as exhibited by the large nunber of Saplings and seedling

Silvicultural Considerations

Silviculture of Canden Park S. mahagoni/T, pallida stand consists of

fan irregular sheltered wood, seed tree system, incorporating @ series of Secondary fellings and a final felling being administered with full establishment of the reproductive seed tree crop. With the present establishment of seedlings and saplings in the stand, regeneration fellings fare not required, Secondary fellings consist of two cuttings, st @ seven year

Data vere taken from the first three plots established within this stand, data could change upon completion of the inventory.

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interval, adjustments vill be administered according to results of the firat release, scheduled to tart with the completion of plot sampling.

If results indicate the presence of lysipyla spp., secondary fel1ings Will be increased and years between fellings extended,

Plot Sampling

Sixteen 0,25 acre (0-10 ha) permanent plots will be established vithin exch plot. Trees are. seasured for total height vith a clinoneter and Gianetar at breast high. Troe damage will be also be recorded, Each tree Will be numbered, coded with paint, and tagged for easy identification in future samplings. Seed tree selection recognizes vell crowned and good seed producing trees as residuals. Specifications for inimun bole neagurements will be determined for commercial volume estimations. Establisment of perminent plots will detersine voluse of growth rate values ‘and also evaluate resvits of silvicultural operations.

Diagnostic samples of 0.25 acre (0.10 ha) are located in the north east section of each plot where stand regeneration will be determined. Both seddlings (4 ft or 1.3 tall) and saplings (4 to 15 ft or 1.3-4.6 tall) are recorded. Four’ corners of the diagnostic samples wili be permanently marked for future sampling.

RESULTS

Three plots are completed and Limited information acquired (Tables 1 and 2): 128 trees have been neasured and seven S, sahagoni and three T. pallida seed trees selected indicating an abundance of poorly formed individuals in the stand. Commercial tree volune methods will be adapted from the US Forest Service Southern Forest Experiment Station inventory work plan (1983) with modifications, and paraneters include: bole length (nininun 8 feet), bole top dianeter outside bark-minimun 4 inches, cubic foot cull, and tree class. Volume measuresents vere postponed 30 that

methods Correspond with stand conditions, determined from {eld Feconnaisance and initial plot samples.

As would be expected seedlings outnumber saplings, although sapling occurence is high, Plot 2 partially occurs inside a burned area and T. pallida seedlings ‘outnumber S. aahagoni seedlings by over 220%. The February 1983 fire covered 0.25 acre in Canden Park. Sapling destruction wes very high. T. pallida vere also’ affected by fire scars and Adventitious rooting was observed within the fire scarred sections of the trees.

Dry Woodland Timber Utilization

Camden Park's S. sahagoni/T. pallida stand is a typical deciduous seasonal forest located on the coastal Teevard side of St. Vincent. Only 2 ery small percent is available to the forestry division irregardless of the” considerable value placed, on these apecies, especially 5. auhapont~ Recognized aso presier cabinet’ wood, i -aghagani 1e used locally for

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furniture, carving and charcoal burning. The wood's high resistance to marine borers and decay, makes it an ideal boat building wood. T, pallida is still considered excellent ood for the boat building industry on St. Vincent and the Grenadines. The majority of boat building occurs on Bequia in the Grenadines where T. pallida supply is dvindling. On Union sland in the southern Grenadines, the boat building industry is almost non-existent due to the over-exploitation of T, pallida, Camden Park's salagont/T. | pallide stand, if properly managed, could supply the Grenadines with adequate seeds for’ both S. joni ‘and T. pallida plantation

ptiahents Boat bullders. of” Bequie declare wiitetcader (2 pallida) grovn on St. Vincent possess inferior strength quality resuiting from Higher ‘rainfail (Matthes 1983), This contention ‘could be valid, for rainfall in Canden Park, a dry site on St. Vincent, has an annual’mean rainfall of 15.0 in (381 mm) more than Bequia. Figure 1 shows rainfall distribution on’ three possible 'S. mahagoni/T, pallida plantation sité The graph indicates Camden Park's wet season, when growth rate acceleratei well “above Bequia's. Matthes (1983) contends that wooden boat building within St. Vincent and the Grenadines vill continue into future generations but a gradual shift tovards fiberglass boats can be expected.

CCONCLLISTON

Proper forest managenent incorporates organized record keeping in order that tinber resources are utilized efficiently. This orgenizations starts with basic knovledge of vhere, how much and vhat kind of plantations

fand natural stand exist’ within a’ forestry division's managenent plan. Project phage I, stand area measurement will provide basic information for St. Vincent's Forestry Division. Project phase II, plot sampling, will evaluate stand areas in detail and managenent proposals will be submitted according to sampling results. Management considerations must also be given to timber resource, objectives to coincide vith national demand. With the establishment of this project, timber resource planning vill affect silvicultural practices for proper site utilization and thus timber resource availability.

ACKNOWLEDGEMENTS.

‘The author is grateful to Mr. Calvin Nicholls, Agricultural Officer (Forestry) for his Support in initiating this project and acquiring instruments. Special thanks are given to Brian Johnson, Administrative Cadet and Forest Guards Lennox Quansic and Cideon Cordice, whose team work nade data collection possible.

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Table 2. Diagnostic sampling sumary for plots 1, 2, and 3.

Plot Seedling species
‘

Wumber Sampling species Munber

1 Seieten:

ahagoni

1 Tabebuia paltiga

24 Swistenia mahagoni

28 Tabebuia pallida

3 Suietenta mahagont
Albizia lebbek

96 Swietenia mahagoni 62
2 Tabebuia paltide 1

wn ybebuia pallida 1
388 Swietenia mshagoni 20
21.8 Swietenia mahagoni 34
17 Abizia Lebbek “

* Plot partially affected by fire,

Additional tree species occuring in the diagnostic
‘Barsera sinarub
spinosum and Lanchocarpos.

include

smpLing
Tabebuia glonerata, Citharexylun

ifoliue.

ue

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Figure 1. Rainfall comparisc

ween three Svietenta mahagont,
Tabebuia pallida «

10 year mean.

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‘CHARCOAL, PRODUCTION AND LEUCAENA IN ST, LUCIA

Michael Andrey
Research Forester

Charcoal has traditionally been the major fuel source for cooking in St. lucia. Tt is produced by the earth pit method which is inefficient in terms of yield but acceptable in terns of quality and texture produced.

Between 1934 and 1942, St. Lucia was an important exporter of charcoal, exporting a total of 25,600 tonnes mainly to Barbados. Hovever, since then the export trade declined to very low levels, due, among other things, to a decline of nearly 602 of the area under natural forest. The present industry is carried out by some 3,000 households of which perhaps 25 - 30% rely on charcoal production as a major source of cash income.

Due to the constant changes in the prices of kerosene and liquid petroleum gas (LPG), there is greater demand for charcoal and to a lesser extent fuel-vood by’ rural anda few urban communities. This has created greater pressure on the forest reserve, resulting in devastation of forest ands, an increase in rill and gully erosion, destruction of vatersheds and

the reduction in water quality and quantity.’ In view of this, the Forestry Division of St. Lucia have sade sone positive steps tovards solving these existing problens and rehabilitating the charcoal industry.

The following is an outline of projects undertaken and vorkshops attended by forestry staff to derive valuable information concerning chareoal production and identification of fast groving species. Most projects are in their preliminary stages.

In late 1979 a research project vas undertaken to identify fast growing species, These would be used to revegetate denuded forest lands fand establish plantations on marginal forest lands and shrubland areas Specificially for chareoal production and fuel vood. The result of this project vas the discovery of a versatile leguminous species, Leucaena Teucocephala. It ie one of the fastest groving species knovn in the sub-tropical and tropical world (e.g., grovth rate in St, Lucia at one provenance trial given in Table 1).

In 1980, two departanental staff of the Ministry of Agriculture were trained in Dominica in the operation of portable metal kilns, That same year the Forestry Division received tvo charcoal metal kilns donated by British Development Division Tropical Products Institute (T.P.I.). The trained personnel have been involved in demonstrations on kiln operation at exhibitions, on forest lands and private estates. Very soon, the T.P.I. Kilns will’ be loaned to private farms at a fee to be decided upon and under the guidance of the Charcoal Pronotion Officer (C.P.0.).

‘The introduction of the transportable setal kilns for the production of charcoal vill approxinately double the yield of charcoal froa a given quantity of wood. "These kilns are also less time consuming and allow the largely wasted fallen trees to be brought into productive use. There is also. potential to manufacture charcoal from coconut shells as a by-product of copra processing.

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In 1981, a feasibility study for a charcoal enterprise using nontraditional’ methods of production was carried out by Tropical Products Institute and Industrial Developsent Unit. This was requested by the National Development Corporation of St. Lucia, The result of this study was compiled into an informative booklet titled "St. Lucia, the Manufacture of Charcoal”.

Between 1981-1982, kiln produced charcoal vas undertaken in different parts of the island ‘by the Forestry Division. The raw material used was mainly branches and defected wood from vhite cedar (Tabsbuia pallida). The ‘ain vas to check the quality and quantity of charcoal obtained because aost

of the shrublands identified for charcoal enterprise consisted of these species.

‘There were 21 burnings, yielding 238 bags (i.e. SOlb

In. 1983, 9 Leucaena Pilot Project vas initiated. A 25 ac (10 ha) plot was selected’ in the drier southern area of St. Lucia, consisting of dense shrub following cultivation many years ago. The area chosen is accessible and fencing is provided for the plot. Management of the plot will be based on a rotation period of 5 yr which i suitable for charcoal production. Actual volune growth expected is unknown for now, however , from experinents it varies between 30 =) - 80 n3/ha.yr. An average value of 52.5" mi/ha.yr (or 750 fe3/ac.yr) has been used for an estimate for this project.

‘The project is the first of many expected to be carried out to replenish ‘and promote the charcoal industry or enterprise, To date 1,223 ‘ac (495 ha) have been planted and maintained.

‘This on-going project is funded jointly by the Governsent of St. Lucia and O.A.S., with St. Lucia Government investing $10,000 E.C, and the O-A.S. $16,000 "E.C., respectively, for the first six ‘months. The O.A.S. is expected to invest §18,360 annually for the next five years:

‘An additional pilot project using Leucaena was also entablished late 1983 “with 5 scres "(2 ha) planted to date, This was done in the ‘southeastern part of the island at Non Repo

Another Leveaena project has been started in the northern section of the island. Already 3 acres (1.2 ha) have been planted with other planting to be done during the rainy season, The aim of this Leucaena plantation is slightly different fron the previous pilot projects. In the charcoal project, the spacing is 6' x 6" (or 1.8 = x 1.8 m) with rotation age 5 yr But in’ this “plantation project the spacing is 9" x 9" (or 2.7 mx 2.7 m) with unknown rotation age. The aim is C0 develop good timber trees.

The first regional fuelwood/charcoal/cookstove workshop was held in Montserrat in September 1983, One senber of the St. Lucia Forestry Division attended the workshop and reports shows that it was successful.

‘The highlight of che workshop vas the Montserrat Project which dealt with four main components:

are

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“Fuelwood Species Trials - to determine the most suitable species

‘to grow on a plantation scale or small fare wood lots}

“Resource Aasessment - to determine locations, species and
‘quantities of fuelwood available in given areas:

Cookstove - to determine the most desirable wood fuel and
charcoal cookstoves from the standpoint of efficiency,
‘acceptability and low cost investment; and

“Charcoal Production ~- to determine the ost suitable method for
‘charcoal production so as to derive the highest efficiency,
‘acceptability and lov economic investment.

Sone 21 species vere tried at two different sites and results for the firat six months shoved good performance from: Le eucocephala, Seabenia grandiflora, Gliricidla, sepoin (seedlings) and’ Enterolebiun ‘gjelocarpun. Tn relation to the other areas of the project, sore work and Eme is needed for better evaluation. Nevertheless, the earth pit method tused for charcoal production is still considered to be the number one method.

The recently completed Forest Managesent Workplan for 1984-1994 caters for the establishment of 325 acres (131.5 ha) of tinber for promoting the charcoal industry.

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Table 1. Sumary of results from Leucaena plots in St. Lucia

Location Plot Age of plot Average height Average Dail
Ge =) (a)

Union Nursery,

northvent Plot, Ay 4 6
Plot Ay 3 92 15
Vieux Fort,
‘southern Plot B os ray
Mon Repos,
southwest Plot ¢ 0.25 12
Lowvet,
northeast Plot D O85 Ls

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ISSUES OF PLANTATION FORESTRY IN WATERSHED MANAGEMENT ON SMALL CARTBBEAN ISLANDS IN THE 1980's

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ery

INTRODUCTION

‘Two years ago I Listed sone advantages and disadvantages of plantation forestry compared to alternatives for natural forest management. The conclusion was that either plantations or natural forests cen meet a country's specific wood needs depending on local circumstances such as Inherent’ site fertility, ‘native flora and fauna complexity and specific feconomic-narketing-social’ welfare considerations (Ldegel 1982). A Successful reforestation project attempts to balance all factors as judiciously as time, money, and personnel permit.

Issues of plantation forestry versus natural forest management practices on watershed objectives are particularly complicated. On any one island, conflicting vatershed objectives frequently exist for major or populated drainage basins. Thus, issues cannot be summarized adequately by Simply Listing advantages and ‘disadvantages of either forest managesent aysten, The purpose of this paper is fourfold:

to quickly review the standard or traditional role of forests in protecting watershed values,

“to explain several phenomena that complicate applying traditional viewpoints to many situations in hunid temperate and tropical areas,

to list sone advantages and disadvantages of plantation -ablishmont in meeting basic watershed goals, and

to review three key restraints that I believe must be considered ‘when deciding forestry watershed project alternatives on small Caribbean islands in the 1980"

‘TRADITIONAL VALUES OF FORESTED WATERSHEDS

Forested vatersheds are traditionally viewed as producing less sediment than tilled cropland, pasture and grasslands, and exposed sites Such a8 unreclaised mine spoils’ and nevly” developed residential and industrial sites. The protective nature of a forest rests in its extensive

canopy and continuous Litter layer (Patric el al. 1984, Wischseier 1975),
‘This relationship can be expressed in equation form

Closed forest canopy continuous litter layer high infiltration
fand reduced force of + and resultant large = and Little overland
raindrops on ground porous surface Flow to cause erosion

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Other benefits of forest trees and forest cover in vatersheds are:

deep root systems that aid infiltration and increase percolation
‘eo greater depths, and

shaded overstory that reduces evaporation of water from the
‘soil surface and keeps stream (surface) temperatures lover.

Tf forest trees facilitate infiltration, increase percolation, and
reduce evaporation, then there is little difference, at least
traditionally, between natural forests and planted forests’ in producing
similar results: producing far less sediment than do nonforested
vatersheds, This is true within a vide range of forest types where local
Beology, climate, and physiography are also diverse (Patric et al. 1984).

‘SPECIAL, PROBLEMS IN ASSESSING FORESTED WATERSHEDS
Overland Flow Phenomena

Primary erosional processes on (exposed) agricultural lands are sheet,
rill, ‘and gully erosion, All three are products of increased overland flow
caused by ‘high-intensity storms and restricted infiltration, the latter
‘quite common for” compacted fare soils (Eechner and Patric 1982). Other
factors modifying actual soil loss per unit area for given storm
intensities are soil type, land slope, and post/present tillage practices.
Soil loss by overland flow in forested lands is usually considered small to
onexistent because raindrops falling fron a forest canopy normally hav.
Jess erosive power and forest Litter increases infiltration and reduces
runoff velocity if and vhen overland flow occurs. Because the Universal
Soil Loss Equation (USLE) vas developed primarily for relatively open
Farmland conditions, difficulties arise when using it to predict soil
losses from forested (covered) watersheds (Wischmeier 1975). Thus, special
cover-managesent subfactors mist be considered when estimating sediment
yields from forest environnents (Dissmeyer and Foster 1980).

A recent study in the eastern United States postulated that overland
flow and subsequent debris landslide phenomena in upland forested
watersheds are such more conson and less phenomenal than previously thought
possible (Eschner and Patric 1982). Individual storms produced slides with

Soil losses amounting to hundreds of tona per ha and ankle-deep overland flow on 70Z slopes. According to the theory, heavy rains from intense convection or long-duration cyclonic storms saturate soil over bedrock and other imperseable soil strata. As the rains continue, saturated layers expand, with water sometimes coaing to the surface and causing overland flow On the forest floor. As soil and water float over impermeable layers, shear ‘stresses are exceeded and debris avalanches oceur, The visible effects of frequent large landslides in mountainous areas of humid tropical countries are all to common for foresters vorking on the small or large islands (Ford and Liegel 1981) and elsewhere in the Caribbean (Ulate and Morales 1966). If overland flow/debris landslide phenomena are widespread in humid tropical forests, then such forested areas must be viewed as Significant non-point sources of sediment and related lover vater quality standards.

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Qualitative versus Quantitative Data

Data on effects of plantation and natural forests on vater and sediment yields in tropical regions are scarce. when available, such data fare usually qualitative (e.g.y estimated percentage of A and B horizons or vegetative ‘cover lost in accelerated erosion along poorly constructed Jogging roads). When quantitative data are available, many units of expression are used: tons/ha.yr (tons/acre.yr), tons/kx2, tons/km stream length, and acre-ft/mi2, Without standard” units of measuresent,, comparisons of water and sediment yields between countries must be left to hydrologists who have similar technical vocabularies

Greater availability of quantitative watershed data from tenperate than tropical regions must not be interpreted as watershed methodologies being different in tomperate and tropical areas (Hamilton 1983). Basic Physical and chemical lavs of equilibria are the sane in any environment. Intensity and magnitude, hovever, of particular processes will vary vith local circumstances, Such reasoning justifies the successful technology transfer of several important agronomic managenent systens (e.g. soybeans land” tobacco) from tenperate lov base, low pl, high alusinua Ultisols to areas of similar soils in tropical areas. The similarity of overland fHow/debris, landslide phenomena in humid temperate and tropical areas al ‘suggests that other watershed phenomena in the two regions may be more Sinilar than dissimilar. Scientists and practitioners from tropical and tenperate areas can readily learn from one another. Obtaining quantitative data {ros forested watersheds in tropical areas can be done cheaply and effectively, if planning and ingenuity are used (Dissmeyer 1982).

‘Timber Harvesting Influences on Water/Sediment Yield

Sone generalizations about harvesting influences on vater and sediment yields my or say not be similar for tropical and tenperate forests. Cutting uaually ine water yields because evapotranspiration is reduced. “Water yields are higher in areas with higher annual rainfall and increases in yield are usvally greatest innediately after cutting and diminish as che replacesent forest grovs back. However, where forest regrovth is slow, as in drier tropical areas, or soils are deep, increased Water yields after cutting will persist longer (Anderson et al. 1976).

Cutting can, but does aot always, increase flood runoff and sediment yields, even after clearcutting, the” aost severe harvesting technique. Even in clearcuts, overland flow does not generally occur unless the forest floor is severely disturbed by skid trails, access rosds, or yarding areas. Good planning can minimize these problem areas. Clearcutting can be Scheduled so that only a small percentage of a major drainage area is affected at any one point in time. In humid tropical areas, where rainfall is high and uniformly distributed throughout the year, vegetative regrowth is fast and ‘complete; invading grasses and shrubs effectively intercept Teinfall and protect the ground against raindrop impact (Anderson et 1976). In drier tropical “areas and those with shallow and fragile cover, these generalizations mst be modified.

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Tree Planting and Type Conversion Influences on Water/Sedinent Yields

Planting and natural regeneration of cutover areas usually reverse hydrological processes observed after harvesting: reduction of water yaelds, flood flows, erosion, and sedimentation of dovnstrean reservoirs, Topography, soil, slope, rainfall and other climatic factors influence vegetative’ regrovth and therefore determine rates of reduction in water and sediment’ yields. “Unfortunately, certain site preparation techniques increase erosion on some forested sites. On other sites, brush and secondary forest. regrovth are as effective and cheaper than’ planting to improve water quality in fornerly farned watershed:

In humid tropical areas vhere rainfall is high and uniformly distributed, hardvood and conifer vegetation transpire all year long. Short- or’ long-term differences in water yields for both kinds of vegetation occurring on the same site have not yet been docunented. Also, in areas where soils are almost always at full field moisture capacity, problems of maintaining vater quality are usually greater than problems 1 haintaining or increasing water yield:

[ADANTAGES/DISADVANTAGES OF PLANTATION FORESTS IN WATERSHED MANAGEMENT

Ae "din the Introduction, I presented detailed explanation in 1982 on advantages and disadvantages ‘of plantation managenent systems compared with natural forest systems. The folloving discussion therefore focuses only on those factors vhere plantation establishment vill have a ‘substantial impact on local vatershed objectives as well as social and cultural expectations.

Economie:

Large reforestation projects with conifers or hardwoods are usually undertaken because they anticipate future economic returns, either in local for export markets, Truly integrated forest development projects vill provide year-around enployent in depressed rural areas. If planned properly, such integrated projects can turn former highly eroded wastelands Ante productive forests that reduce sediment and stabilize water yields for downstream urban centers.

After cutting, certain forest species especially eucalyptus regenerate by coppicing. Additional vood crops are obtained without costly replanting. This plantation system minimizes site disturbance in iccessive rotations and reduces exposure of the ground to erosive ‘lenents.

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‘Tree Inprovenent Potent’

Fast-growing plantations of exotic trees are desirable because tree Anprovenent techniques are easily employed to improve wood volune growth ‘and insect and disease resistance. It 1s also possible to breed trees with Foot systens that are tolerant of high aluninus or other chemicals found on errosive mine spoils (e.g., bauxite areas). Aluninun-tolerant grasses have been developed for revegetating acid soil roadbanks. The implications for converting useless and highly erosive, acid mine spoil or borrow pit site in the tropics to productive forest lands are positive and enormous.

Disturbed Sites

Planting trees and grasses stabilizes landslides and areas devastated by hurricanes and volcanoes more quickly than natural revegetation processes. Experience in Puerto Rico shovs that seeded grasses (and presumably trees) modify the harshness of disturbed sites so that native grasses and shrubs are established more quickly (Ford and Liegel 1981). Where stream vater quality in disturbed areas must be improved and saintained quickly to provide potable water to domstream cities, planting trees for protective purposes and simultaneous building of various mechanical controls (e.g.

Check dans) seen nore practical than relying on natural revegetation processes alone. However, on really large slides vith actively eroding headwalls and aidevalli

time and money. In such cases, erosion control vork should not be started luseil either nature- or man-induced processes have created a more stable ‘angle or repose over the entire slide area.

Disadvantages
Beonosien

Replacing natural forest with plantations is costly and vastes large volumes’ of wood and fiber, Site disturbance in such operations will be great unless time-consuming precautions are taken that reduce erosion/potential on the site. If large clearing or harvesting operations fare done prior to the start of rainy seasons, danage risks fron floods and erosion after long-duration, high-intensity storas, of frequent incidence in rainy seasons, are minimized.

Biological Considerations

Woon plantations replace existing virgin natural forests, local ecological ‘diversity in flora and fauna can be reduced. However, Feforestation of open savannas and highly-eroded wastelands may actually improve wildlife and vegetative habitat diversity. There sre increased hazards of insects and diseases in plantation aonocultures but supposed problens nay be highly overrated; even natural coniferous temperate forests Gnd native tropical pine forests are subjected to periodic insect or disease outbreaks.

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Site Productivity Decline

It is often asserted that successive rotations of fast-growing tree species increase nutrient removals fron a site, Unfortunately, there are great difficulties in quantifying nutrient renovals by different species. Only certain species perform vell on infertile and dry sites, Observed long-term poor growth on such sites is probably the result core of improper ‘species selection and inproper planting/tending technique than a result of site and productivity decline.

KEY RESTRAINTS IN USING PLANTATION MANAGEMENT IN WATERSHEDS ON SMALL ‘TSLANDS

Conf icting Objectives

‘The most obvious restraint for deciding to use or not use plantations in watershed management on small Caribbean islands is the ssount of conflicting, usually competing, watershed objectives that exist. Watersheds "that must provide drinking water to cities frequently have cron lands or other public lands that are also managed for wood production. The sane watershed say be dotted with small landowners who indiscriminantiy use

‘and herbicides on their cash crops; excess chemicals are easily washed into nearby streans polluting the for husan and animal use. And, the same watershed may be the most important source of Large amounts of irrigation water used for mechanized coastal agricultural /horticultural projects. In such instances vhere there are so many uses for water in relatively snail, finite watersheds, effective planning seems an impossibility,

Soils/Topography

Most small and large Caribbean islands have steep and rugged topography. This factor plus the high clay, slov-infiltration capacity of many soils combine to create very high natural erosional losses, even under forested conditions. When farm, road, and urban development go unchecked fon such upland sites, erosional processes are accelerated on the exposed ‘areas. When experiments are contemplated to monitor disturbed and lndisturbed areas, steep topography can limit accessibility to areas that are truly representative of a country's overall vatersbed problem:

Because all people need to eat, need homes to live in, and need to travel between farms and cities, effective control measures that regulate land clearing are hard to legislate, implesent, and enforce. One noteworthy exception to this generalization is a iaw passed in the U.S. Virgin Islands in 1971. Tt requires that an “earth change pernit™ be issued before starting construction activities for private, industrial, or government buildings and projects. Violators are subject to fines or Imprisonment and there have been successful prosecutions.

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Disturbances

AI Caribbean islands yearly face the dangers of hurricanes and other cyclonic storms, These storms create havoc by washing avay topsoil and bridges as well as by blowing dovn homes and entire plantations. Just as catastrophic is loss of experiments designed to monitor short- and long-term sediment and water’ yields from watersheds receiving different management treatments. If continuity of watershed research in. the Caribbean islands is to be maintained, then all studies must be replicated

fon several sites in individual countries, Experimental replication in space is needed to protect the integrity and investaent of projects that are costly and time-consuming to instell and maintain,

‘CONCLUSIONS

Under comparable conditions, watershed research from teaperate areas is transferable to tropical regions. The closed canopy, continuous litter cover, and deep rooting habit of plantation or natural forests reduce raindrop erosive forces and promote high infiltration rates. Hovever steep and hunid watersheds in tropical areas face considerable soil 1. ‘and long-tera reduction of other water-quality factors because of overland flov/debris ladslide phenomena, even in forested watersheds. Depending on Jocal_ watershed objectives, environmental and climatic factors, and existing social, cultural, and economical realities; plantation forests may for may not offer suitable alternatives for combining wood production with Feducing “sediment yields or stabilizing long-term water’ yields. Each vatershed presents a unique case of human and natural elenents. Failure to Fecognize these and possible results from periodic catastrophic disturbances will mean eventual failure of any short- or long-term watershed project.

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