

PRNC210

PUERTO RICO NUCLEAR CENTER

?HE RAINFOREST PROsECT

A Renewal, Prop.

Fiscal Year

eee 7 ontario ?OF PUERTO RICO UNDER CONTRACT

NO. AT (4@-1)-1899 FOR UL \$. ATOMIC ENERGY COMMSEION

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PUERTO RICO NUCLEAR CENTER

?UNIVERSITY OF PUERTO RICO

?RIO PIDRAS, PLR,

?THE RAINPOREST PROJECT

?A Renewal Proposal for

fiscal year 1967-1968,

Subattted by

Jerry R. ine

March i, 1967

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Premises, Facilities, Equipment ant Materials to be
furnished by the Contractor

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3) ABSTRACT

Tate to @ renevel proposal for the rainforest project vbich covers
?ovo major areas of work. Part one concerns doctmentation of the recovery
of vegetation in the area which vas previously irradiated with 137os, In
?this part ve will propose to continue mapping the new vegetation as it
?appears, to continue the biological productivity measurements, and to
contimie guch iniices of recovery as leaf area index meagurement and
optical density neasurements. Other studies to be carried out include
?the continuation of photographic reconis in the area, the initiation of
optical spectral measurements, the initiation of nev species diversity
measurements ani the continuation of measresents on nev shoote from old
?trees.

Part. two emphasizes continuation and amplification of the mineral
cycling objectives of the project and inclutes proposals for further vork
4m fallout redionuclide distribution, and biological residence tine neasure-
ments Viiich includes the use of tritiatea water to atudy the flov of water
4m soils and plants, These as well as other stulles are designed to provide
8 relatively complete picture of minerel cycling processes in the? tropical
econysten including rates and quantities of mineral flov in these cycles

and the measurement of enounts ani rates of input and escape from these cycles.

Other phases of the proposal provide for the continuation of soll
conteninstion experinents, for metabolisa measurements and for contima-

Station of EL Verde field station including the recording of certain selected

weather variables

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4) SoDRRPTPrC BACKGROUND

The Rainforest Project has been in effect since 1963. In the first three years of the project a section of the lower mountain rainforest in the Tuguito mountains of Eastern Puerto Rico was irradiated with 10,000 curies of ¹³⁷Cs for a three month period. The irradiation of the forest was preceded by about one year of general ecological survey studies of the plants and animals of the area and was followed up after the irradiation with similar studies where relevant in order to measure radiation effects. Many of these studies were carried out by visiting investigators from other institutions who came to Puerto Rico to contribute to the project within the area of their own specialties.

This phase of the work is at present

being organized into a volume entitled A Tropical Rainforest by H.1. Odum former director of the project.

The important results of this work are two fold. Firstly, the damaging effects of gamma radiation on « tropical ecosystem have been directly observed and will serve as a tropical basis for comparisons with other similar studies in temperate zones which have been carried by ABD and should provide an objective basis for the prediction of effects of other types of radiation exposures which may occur in the tropics. Secondly an extraordinarily extensive ecological survey of the environment of Eastern Puerto Rico involving Ang TO or more scientific specialties has been accomplished, This survey is similar in approach and scope to that demonstrated in the volume edited by Wilimovsky and Wolfe* and demonstrates again the efficacy of this method in obtaining environmental data.

* Wilimovsky N.J. ed., Wolfe, J.N. assoc. ed, Environment of the Cape Thompson Region, Alaska. UGABE Div. Tech. Int. (2ME-i81) 1965, 1050 pp.

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In the present project the ecological surveys are no longer an important objective. It is intended rather to select certain restricted study areas which were shown to be potentially productive in the previous surveys for intensive work, two areas of major importance which have been selected are the study and documentation of the recovery and succession in the irradiated area, and the study of mineral cycling in the tropical forest

These form the major basis for this proposal and are discussed more fully in the Scientific Scope section.

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5) SCIENTIFIC SCOPE, WORK PHASES

Introduction

The ABC rain forest project is a study of irradiation effects, and mineral cycling in a section of lower montane rain forest located at 1500 feet elevation on Mt. Yunque mountain of Eastern Puerto Rico. The originally stated objectives of the project were:

(1) to measure the effects of irradiation, direct and indirect, on the ecological system and its components.

(2) to determine the quantitative nature of the biogeochemical cycles within the forest through tracer and fallout studies so that movements and fates of radionuclides may be predicted in rain forest.

(3) To determine the general structure and processes of the rain forest system as part of the general quest for principles which will permit an understanding of radiation effects and isotopic movements in this and other ecological systems.

These objectives continue to be the central motivation for the Project.

The experimental emphasis however shifts as demanded by circumstance. The present proposal for example is strongly oriented towards observations leading to the complete description of the recovery of the forest system with only minor effort directed to continued damaging effects. The specific objective of these studies is to determine whether the recovery is related to the source of damage. Thus many of the proposed studies include observations on

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other plots in the rainforest which have sustained damage from other sources than radiation.

The recovery of the irradiated center will undoubtedly require many decades. It is anticipated however that the intensive recovery studies may be completed in a relatively short time. In a matter of only two or three years we expect to be able to show the extent to which the recovery

of the radiated center resembles recovery elsewhere in the forest. There after the recovery studies will decline with regard to overall project effort with perhaps only annual observational measurements of selected indices being required. Correspondingly the staff will be increasingly available for

other projects, some of which are presented for preliminary discussion in this proposal.

The mineral cycling aspects of the Project are expected to increase. Extensive new laboratory space in the PREC building has been tentatively allocated to the Project contingent upon construction of a new building wing. Thus at about the time that recovery studies begin to decline the project will be in a position to propose a fully diversified and extensive program in mineral cycling.

The present proposal is written in two major sections covering the recovery and succession studies, and the mineral cycling studies. In addition there are several proposals for relatively minor effort in other

areas. The:

do not necessarily imply that the subject areas are of minor

importance but only that with present staffing we are unable to make well developed proposals.

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As an example we propose only to maintain continuity in the accumulation of weather records while fully realizing that there is strong potential for highly relevant micrometeorological research in the forest, The existence

of an automatic weather station, and of a giant cylinder, and recent successful efforts in the use of tritiated water in the forest combine to make an unparalleled opportunity for systematic research in gaseous diffusion for example.

Other ideas are presented at various points in the proposal to serve as a basis for future discussions of Project activities, The specific funding proposal for the next fiscal year is given in the following pages.

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ECOLOGICAL STUDIES: RECOVERY AND SUCCESSION IN THE
IRRADIATED AREA; GRASS ECOLOGY; WEATHER RECORDS

Recovery and Succession

Radiation center map. The radiation center has been at out £n 900

Individual 1 meter square grids for the purpose of mapping the individual

Plants as they emerge in the radiation center. One survey was completed in 1966 and we will continue to make one such detailed map each year so that a record of the rate of change of populations in the irradiated center can be obtained. The map to be made in September of 1967 will show all plants then existing in each grid by species. Comparisons with that made in the previous year will show changes which have taken place during the interval.

Net productivity calculation. The survey of the radiation center grid

will also include the taking of stem diameters, tree heights, and in the

case of grassy plants areas of coverage. Since we have already shown that these data are reasonably well correlated with the individual biomasses of the plants, we will use them to calculate the total net biological production in the radiation center. Data for this calculation are already available for 1966 and another identical survey and calculation will be made in 1967.

The PRIC computer is not adequate for this task and the services section of the budget will reflect costs for programming and computer time to complete the calculations,

Comparison of radiation recovery with that from other types of. Several

areas on El Yunque mountain have sustained catastrophic damage from various

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sources. These include the irradiated center, the cut center which was established as a control for the irradiation experiment, and several areas which were damaged by herbicides as part of another project. Many of the herbicide areas are in the approximate same stage of recovery as the irradiation center. The Project will make two surveys of an herbicide damaged area and the cut center for the purpose of comparing the recovery and succession in these areas with that of the radiation damaged area. The surveys will consist of several optical density transects and several leaf area index transects of the damaged areas. Both measurement series will take place at six month intervals starting in September of 1967.

Both types of transects are taken on a line running from undamaged forest through the area of maximum damage and continue to the undamaged forest on the opposite side. The data obtained yield curves which are functions of the amount of vegetation in the areas. The change in the curves through time are related to the rate of regeneration of the damaged areas. Transects of the type described will also be run in the irradiated center in an identical manner. The data obtained will enable us to determine whether the rate or character of the recovery in the irradiated area is in any way unique or different due to the fact that the original source of damage was radiation rather than chemicals or mechanical clearing.

At the time that the data are collected in the areas of mechanical and chemical damage series of color photographs will also be taken of each

are to provide a visual record of the recovery. These photos will be used along with the more extensive record taken in the radiation center to give a visual comparison series for recovery from various types of damage.

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Photographic Records. The project has accumulated a series of color slides of the radiation center which were taken monthly from the walk up tower in the plant site. This series provides a useful record of the further changes which take place in the radiation center. We will expose at least 20 frames of 35 mm Ektachrome monthly from the walk up tower to show the changes which continue to occur in the irradiated center.

The project now has a tower erected in the radiation center at the border line of radiation damage. This tower provides an excellent platform for viewing the succession of new plants in the area.

A monthly series

of both color and black and white photos will be taken from the tower to show the rapid changes which are taking place in new growth.

A monthly series of color and black and white photos will be taken of the radiation center from ground level to provide another perspective in the recovery.

Another series of serial photographs of the radiation center will be taken during the summer of 1967.

Leaf Age Experiments, Bridence tron tracer experiments, from the recent injection of Chinese doria, and from leaf scarring experiments indicates that tropical forest leaves are efficient collectors of radionuclides by surface interception from air or rain. Biological half life measurements from the EL Verde forest show long nuclide residence times. Data collected from leaf fall collection stations however imply that leaf ages in this forest might be relatively short. It is not possible to reconcile these two points of view. We therefore need a direct measure of leaf age in this forest in order to gain insight into the mechanism of radionuclide retention,

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Several hundred leaves from tree species which can be reached from project walk up towers will be tagged with light aluminum tags extending the petioles. The tags will be counted individually until

a reliable measure of age has been obtained,

The radiation center may still be dying back due to radiation damage

fewer 40 48 not possible to observe this internally any longer because

the Clebsch if it exists is extremely elev, Since the new vegetation cent

ower has been placed at the current tondor of vegetation damage ve exe able

to make objective measures:

OF canopy recession. These measurements «42

the new way tagging individual leaves rex each of severed species vith

can be reached from the tower and counting at biologically intervals Zor at

Least one year, Comparison of Ste off curves with those Obtained in Ses the

WIE will give an objective measure of further emoyy & check If

1 et

The Leaf age measurements are of importance not only to the Si Vente

Forest but to others as well. 1

4s of pextieular interest to essinste

tts qumtity in the Eifin forest atop HL tungue because of the Leu

SSuunss of fallout xationelide present im the vegetation there, As 2

of the general leat age project we vi2L tag in excess of 200S2ceves cx each,

of 5 dcatnant tree species in this forest and vill cheere thes bixostidy watt]

a mulizdio die off curve has tech obtained,

Stacies Giverstty ?dex. Species Atversity ie presently in a repid period

Of chenge in the raiation center end the out center. Initielly the axa

?were invaded by only one species whtle presently both areas have several

wyecies of plants. It ts of bustc ecologies) interest end of spectfic

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B

Interest to the raltetion recowezy program to inot the pattern of diversity

change through tine. The rate of change data vhen obtained will be of value

in determining the relationship between the achievement of full forest

at maturity and full forest maturity, and will provide « test of the hypothesis

that diversity may be achieved considerably in advance of final maturity.

These curves will also be of value in comparison with the current measures

of net production since current energy budget: theory would predict that

energy spent in diversification would not be available for biomass

production,

These curves will also have a considerable empirical value in comparing

the recovery of the irradiated area with the cut area and should help in

providing a basis for determining whether the character of recovery is in

any way influenced by the original source of damage when such damage occurs

as an essentially single catastrophic event.

In the area between 10 and 15 meters from the old source position

from the radiation center we will obtain « diversity index by counting the

number of species encountered per 1000 individuals, in a circular manner

about the center. This will be done at 6 month intervals subject to modification

according to rate of change observed until a reliable diversity

function has been obtained, the procedure as described will also

be carried out in an identical manner in the cut center.

Sprouts. An important factor in the regeneration of the radiation center is

sprouting from the base of old apparently dead trees. We have already verified

that in a large percentage of cases the points of sprouting occur in positions

?which had line of sight protection from the radiation source, his indicates

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ab

?that even though the main stems of trees were killed by the irradiation,
?local shielding of the predominantly surface roots in this forest may have
been an important survival factor.

Emerging basal sprouts in the radiation center will be tagged and the
center will be surveyed at 6 month intervals for the occurrence of new
sprouts. These sprouts will be counted and tabulated according to whether
?they had line of sight protection from the radiation. Tagging of the new
sprouts as they are surveyed will give method for determining the rate
of emergence of new sprouts as a function of time,

Spectral studies. Using the project spectroradiometer we will take spectral
?transects of the forest across the irradiated center and running at least
100 meter

from the center. The purpose of these transects is to look for

Possible long distance radiation effects which have not been previously

observed. Qualitative evidence from a series of aerial photographs recently obtained indicates that such long range effects might be present although this proposal represents the first attempt to objectively measure them.

Arrangements of transects will be made in a transect series and at least two such series will be done during the year. Each transect will start at the radiation center and will proceed along one of the cardinal compass directions for at least 100 meters. A complete light spectrum in the visible region will be obtained along these transects at 10 to 15 meter intervals, at the forest floor.

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is

General Ecology

Tree Growth. The 260 trees which were previously taped with vernier tapes will continue to be observed at monthly intervals as in the past.

Phenology of higher plants. The higher plant phenology records will to be taken in order to provide a more reliable record of fruit and flowering in the forest. The measurements to be made monthly in a manner identical

to the methods used in previous years will be done as follows:

8) Count of fruit and flower fall on ground quadrats for 5

?tree species,

D) Weights of fruit and flower fall in the leaf fall baskets

©) Counts of fruits and flower stalks on 50 selected pairs

land at 100 basket stations,

Hingest, Dr. Elizabeth McMahon (Univ. of North Carolina) will return to

the project during the summer of 1967 to continue her detailed studies of

termite sites in the El Verde area. The objectives of this visit are to carry

out field studies on the survival of termite nests which were originally

exposed to radiation during the forest reforestation project, and to carry

out controlled radiation exposures of termites using the FRC Cobalt-60

Field and laboratory studies to be carried out are listed as follows:

4) Identification and mapping of termite nests which have

survived and those which have been abandoned during the year

since they were last observed.

2) Measurements of the behaviour and distribution of castes in

surviving nests

3) Measurement of population vigor in the field as indicated by

tendency to repair controlled damage to nests.

4) Measurement of CO₂ metabolism in irradiated versus unirradiated
nest

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5) Attempt to measure LD₅₀ of various species of termites and
antons. We had systematic exposures of known populations

Dr. Mel Mahan will visit the project for a minimum of 60 days during
the summer of 1967. Application has been made to carry out this project,
under an Oak Ridge Summer Research participant grant. If this is not
obtained for any reason the project will provide financial aid in the
form of expense per diem and travel expenses, with no salary or consultant
fee included.

Another insect diversity index should be measured in the radiation
center to provide information on changing populations as the center fills
in with vegetation. This will be carried out under the supervision of Dr.
Mel Mahan who will select a graduate student to come to Puerto Rico for a
short stay. The project will pay for travel and a per diem.

?Too otatent vill sample the insect population in the radiation,
control ant cut centers using aveop nate until at least 1000 iniividuals
lhave been gathered in each place. Collections will be done at least once
uring daylight hows and once during night tine hours for each center.

he insects vill be separated by species, and the munber of spectés per

thousand initvidusls vill be reported ae the insect diversity index.

Wosther Records

?The weather station st HL Verde 1s a temporarily rigged, uncon=

?venttonally dnetgned system which was built for the purpote of giving

?8 short tem description of the major weather variables in the area.

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at

Te fuletiied this purpose during the early yours of the project but

Would nov seem to have exhausted its wiefilinese in its present state.

Prinstple objections to the station in its pret

#t conition are related

to data reconiing on Rustrack reconiers which do not pemeit ready retrityal
of large anounte of information, ax lack of personel? epectficelly astgned
to equipment matatenance, calibration,

?Tae operation of a functional reliable weather station 1s of benefit
to our prograns in recovery ant succession, phenology, tree growin trittim
experiments, ant netabolign, In addition the station wi21 provide a long
?term meteorological record in the vicinity of Eastern Puerto Rico and could
Provide the basis for future proposals for research in aicroclinatology tn
?the tropical forest.

We therefore propose to create a meteorological data acquisition aysten
by weditying the exteting M1 Verde aysten in the following ways

1) Obtain the services of an electronic technician who to
familiar vith meteorologics) equipment and who can see to
?the constant calftretion and Aincloning of all apparatus.

2) Obtain at Least the consulting services of a recognized
scientist microclinatologiat who oan recoment ani initiate
investigations relevant to biclogy snd to diffusion problens

in the tropical forest.

3) Discard Rustrak data recording and convert to digital recording entirely. Overhaul digital data logging system including replacement of present nonfunctional and inadequate digital millivolt meter. Replace with digital voltmeter and external amplifier designed for continuous service.

4) Process all data through modern commercially available computers with high speed paper tape reading capability

5) Replace certain field sensing equipment such as wind speed and direction indicators, and pyranometers and restring data and power cables to meet approved standards of industrial safety.

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After the above modifications have been completed we will record

twenty channels of digital information as shown in the following table,

VARIABLE CHANNEL VARIABLE CHANNELS

Temperature 3 Solar Radiation 1

Rainfall, 2 Optical Density 2

Wind Speed (hot wire) 2 Surface water runoff a

Wind Speed (cup) 2 River Stage record a

Wind direction a ?trunk runoff a

Relative Humidity 1 lysimeter water conductivity 2.

Voltage check a lysimeter water volume 2

Most data will be recorded at hourly intervals on a 24 hour per day

schedule, Computer summaries including diurnal variations and averages,

daily averages, weekly averages and monthly averages will be for all data

Where appropriate, at six month intervals. The data will be available

to all project scientists and consultants and will be summarized in the

annual report to ABC.

Costs directly related to the outlined improvement of the station

are itemized and not included in the overall project budget.

Item Cost

Salaries, including overhead and fringe benefits for a technician,

and fee for programming and consultation, 110,000

Services, estimated 20 hours per year of computer time at 60

dollars per hour. 1,600

Materials 500

Total Operation 22,200

?Bquipment (See appendix 3) 8,200

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cMmaStRY oF Tan FOREST

The objectives of the forest chemistry program are: 1) Measure the amounts of fallout radionuclides, the amounts of corresponding stable chemical elements, and the amount of possible neutron activation products now existing in several components of the forest system. 2) Identify for these elements pathways of movements and measure rates of movements along these pathways. 3) Generate a suitable predictive model for the retention and movement of these elements within a rainforest system,

Work phases in this section represent a continued effort with our last year's proposal. We will continue the work started in trace element characterization of the rain forest with emphasis on thermal neutron activation products in forest materials and further exploratory work with ^{240}Pu shielded neutron activation, and ^{11}D activations. We propose new effort in the trace element characterization of microbial vegetation of the redwood center. The work concerned with distribution and retention of fallout radionuclides will continue with new efforts directed to regional wide geographical distribution as related to forest type and elevation, The

interforest comparison work will be de-emphasized although we will continue
to take samples in the Elfin Forest of #1 Yunque in order to more fully
characterize biological half-lives of nuclides in this area.

We will propose major new effort in our program to evaluate the dynamics
of element movement in this forest

This program will be based as before on
the use of radioactive tracers as well as stable element analysis. We have
already installed more than 30 lysimeters of the type developed by Dr. Jontan

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at the soils of El Verde station. Fermenton has been secured to we
tritium as well as nuclides of Cs, Sr and others in experiments. We are
therefore in a position to propose the measurement of both water and elemen-
tal movement in parts of the area, in addition to further studies on the
behaviour of nuclides in plants,

Trace Element Composition of the Forest

Neutron activation products. We have shown in parts of El Verde and other
points in Puerto Rico as well as for soils from Fajardo that the primary
neutron activation products which can be measured instrumentally after the

decay of interfering ^{50}Ti and ^{56}Mn are 50 and 5Pe, hie 12 consistent with J.B, Khine's previous vorla wide surwye of solla, Tropical soils of Puerto Rico and Pansna appesr to be relatively depleted in La and Co, Further work is desirable in the instrmental neutron activation characterization of plant meteriaie in the tropical forest.

Instrumente neutron activation analysis will be earriet out on at least 5 sanplos ench of ashod tree leaves, exiptyLiese scraped from leaves, Pre resulting guma ray opectra will be used to identity trace elements in these materials and epiphytic plants to include broneliags, fems, and mo

which can be neamured ty this method and to make quantitative detercinations

Where possible.

Cosm Clat Activations. At present 1t is not know vwhether plants end soils have characteristic gama rey opectra vion ixradiated vith neutrons of higher than themaal energies. Exploratory reactor irradiations of st least 5 sot)

semples from Puerto Rico and 5 ashed plant eamples will be carried out with

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The samples enclosed in specially designed Cadmium cups. The resulting gamma ray spectra will be used to identify elements in these materials and

to make quantitative determinations where possible.

Further development in the technique of using ^{115}In to produce ^{115}mIn

neutrons is required. We have designed a Cadmium cup which allows access

of thermal neutrons to a ^{14}D source while at the same time protecting the sample within from these neutrons. Further work is needed to develop convenient handling and packaging techniques for ^{14}D which is a hazardous material when exposed to the open air. Upon solution of this problem we will carry out irradiations of at least 5 soil and plant samples using ^{14}D as a converter of thermal neutrons to fast neutrons. Gamma rays emitted during irradiations which are produced in these irradiations will be identified and

measured quantitatively where possible.

Chemistry of Successional Vegetation. The vegetation now invading the irradiation center is in a vigorous state of growth. This implies that the essential mineral nutrients required to support this growth are both present and chemically available. In order to characterize patterns of mineral

nutrient uptake 12 « mecessional area aasples of leaned gtaaa vill be
contested from plante tn the ars at the time of the annual mapping aod
ome survey for chemical analysia, the mples vill be analyzed for Ky
Ca, Fe, and Ou ty flew apectrophotonstrie or atonic sbecrbtion analya
Tin omits vill be combined with the blouasa calculations to give stenting

state of these elements. Annual repetition of the curvey and analysis will
reveal patterns of mtrient uptake as conpared with biomass production, At
east 50 samples of plant materials will be analysed during the first year
of the project.

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Concurrently with the wagstation aalysisa soils will be obtained fran
?the aren ant subject to analysis for the sine clenents. ?These elements vill
De determined primarily o aqueous extracts from the solls which are thought
to be Andtces of chenical evailubility. Such extracte may constet of neutral
smmonium acetate solutions or dilute mineral ucla sclutions. At least 5

Soll soxpleo will be thus analyzed the fizet year of the survey.

Distribution und Retention of Fallout Ralionclides

?Retention Time. Biological retention time for the melides 952r, S4n, and

Measurements have been estimated in the forest at HL Verde. It was found during «

period of exceptionally low fallout that the forest plants bind these nuclides

very tightly and that the major factor in the decline of radioactivity was

the physical decay of the nuclides themselves. An estimate for the environmental half-life of ^{137}Cs was obtained which indicated that this quantity

was about nine years for this nuclide. The result was not statistically

reliable because of the short time interval of measurement as compared with

the apparent long environmental half-life. These measurements were complicated

by the fact that the area received a fresh input of radionuclides within 20

days after the Chinese nuclear test of May 9, 1966.

We now intend to continue the monthly sampling program at the EL Verde

station in order to characterize the behaviour and immediate attribution

of nuclides after a fresh injection. The nuclide which is most readily

detectable from this injection is ^{90}Sr ,

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The Chinese injection of nuclides did not appear to alter the forest

concentrations of ^{137}Cs or ^{90}Sr . Thus the opportunity still exists to

obtain reliable environmental half life for both nuclides, An apparently
?anomalous result was obtained for hm in our previous measurements in that
?the environmental half life was longer than the physical half life. While
?this is a possible result further measurements are needed to verify its
reality.

We will continue as before to collect monthly samples from 5 canopy
and 5 understory trees along with samples of litter and soil, for analysis
by gamma ray spectrometry. ?The data will be used to provide more reliable
estimates for nuclide residence times in the Hl Verde Forest.

Residence times; Hl Verde Forest, Wattle nuclide levels in the Hl Verde
forest on East Peak in the Lagunitas Mountains are now finally established
in comparison to those at Hl Verde the reason for the difference is not yet
clear, the data from past measurements is not yet sufficient reliable
statistically to determine whether retention or accumulation are factors in
?this increased burden,

We will continue to sample the leaves of two species of trees, nossea,
femms and ground litters on a bimonthly basis for at least another year for
gamma ray spectrum analysis. The data for ^{37}Cs and ^{210}Pb continue to
be used to estimate environmental half lives for these nuclides.

for Moe ana 9%ee-95xb will give sous intention of the immediate tehaviour

The data

of fresh injections of radiomelides in this forest.

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Geographical Distribution of Muslides. Preliminary evidence indicates

that there may be a geographice? gradient of radionsclides on the dalant
rumining from 2 high in the east toa low in the west. ?This gradient if
it extate could be caused by effective precipitation ecavanging of the
provadling easterly trate winds ss they strike the Inguillo Mountains of
Rastern Pierto Rico.

In order to contin or reject the presence of these possible gradients

?the vegetation will be sampled on the ialend in a series of adjacent transects

Which run fron the north to the south coasts. Four such transects will be

done, The first will done on the eastern edge of the {sland in the mountainous

fares. The second will be done parallel to the finst but 30 miles further vest.

The third will be done 30 miles west of the second, and the fourth will be

done near the west coast in the mountains near Maricao Puerto Rico.

Each transect will have 5 sampling locations. These locations will

consist of the northerly

level foothills, the northerly middle montane

region, the peak region, the southerly middle montane region, and the south-

erly sea level foothills. At each station 5 to 10 samples of vegetation

will be taken. These will consist of leaves from prominent trees of the area,

prominent epiphytes such as ferns, mosses, and bromeliads, leaf litter, and

samples of surface soil.

All samples will be analyzed and counted nondestructively by gamma

scintillation spectrometry. The complex spectra will be resolved using

our existing computer solution and the resulting data for ^{95}Zr - ^{95}m , ^{137}Cs ,

^{137}Ba , and ^{137}La will be plotted over a map of Puerto Rico to illustrate any

differences found,

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Strontium-90 Retention. A procedure for the determination of Sr has been successfully adapted to the analysis of tropical foliage. Samples which were counted nondestructively for gamma emitting nuclides have been retained. We are thus in a position to measure the environmental half life of ^{90}Sr in the El Verde and Elfin forest regions. Approximately 100 plant samples from the collection will be ashed in a furnace and analyzed radiochemically for Sr. The samples will be selected from various dates over a period from 1964 to 1966 from both the El Verde and Elfin forests. The results will be plotted on a semi-logarithmic scale as a function of time and will be subject to regression analysis in an effort to establish the environmental half life for this nuclide.

Pathways of Movement Within the Forest

Tracer Experiment. Plant growth phases of the tracer experiment described 4 months ago have been completed and the plants growing in the area have been harvested. The uptake of nuclides was slow and much of the original concentration remaining where it was placed. The presently barren radioactive plots offer the opportunity to study uptake of ^{134}Cs and ^{90}Sr in this successional

vegetation.

The plot area will be cleared of surrounding trees to produce @ small sunlit open area, This area will be allowed to reestablish plant growth naturally. When 611 plots have sufficient plant growth, samples will be taken for radioactive counting. The course of cesium uptake will be followed by periodic sampling for at least one year or until a reliable description of uptake patterns has been obtained.

---Page Break---

The radioactive soil in this plot has been subject to natural weathering for more than one year. The cesium in the soil should now be in an equilibrium state, Small amounts of this soil will be removed from the

Plot for laboratory studies, The

studies will consist of chemical extract=

ions of soils from each of the four plots as follows:

1) Replicated extractions of field moist soils from plots with solutions of neutral normal ammonium acetate. The soils will be counted before and after the extraction to determine extractability of ^{137}Cs and ^{90}Sr .

2) Replicated extractions of soils from 4 plots with solutions of dilute mineral acid. Determination will again be made by the method of before and after counting.

3) Samples of the field moist soils will be subject to three wetting drying cycles and will then be extracted according to the method in (1) above to give an indication of the fixing power of the soil for Ce and incidentally Ma .

Tracer Experiment 2; Behaviour of Epiphyllae. An area of the ZI Verde forest has been set aside exclusively for low level tracer experiments involving leaves and plants. This area has been fenced, warning signs have been erected, and Health Physics Division approval has been obtained. The areas consist of approximately 500 square feet and was selected because of the high abundance of plants supporting epiphytic growth.

Epiphyllae have been previously implicated in the interception and retention of radionuclides and mineral elements from air and rain. They

have been shown to absorb nuclides rapidly from solutions in the laboratory.

It remains unknown whether minerals thus captured by these surface plants

can be transferred to the supporting leaf and thereby form a source of supply

of

nutritional nutrients to the higher plants which is outside of the normal

routes involving root uptake and translocation.

---Page Break---

The following experiment will be done to aid in answering this question:

2) Mature leaves of understory plants showing vigorous epiphytic

growth will be contaminated on the surface, with known neutral

solutions containing known levels of ^{60}Co and ^{137}Cs ,

2) After a brief uptake period the leaves will be rinsed in

distilled water and cut into sections of approximately

10 square centimeters each.

3) Thirty of these sections will be placed on the surface

of thirty intact growing leaves in the field and held

in place with a rubberband. Fifteen of the intact leaves

Will have vigorous epiphytic growth and fifteen will have no visible growth. The overlays will remain in position for 24 hours, and will then be removed and discarded.

4) The growing leaves will be harvested in groups of ten at the end of 3, 6 and 10 days after labeling. Five clean and five epiphytic leaves will be taken in each group. Each leaf will be sectioned into three parts which will consist of regions below the overlay, the overlay region, and the region above the overlay.

5) Each leaf section will be counted on the project single channel analyzer, first in the Sr energy region and then in the ^{134}Cs energy region. The complex spectrum will be resolved using detector standards counted in the same way and the movement of fission products from epiphytic leaves into leaves will be determined.

Epiphytic leaves have been shown previously to be accumulators of fallout fission products. It has also been shown that environmental residence times for these fission products are long. It would seem then that these plants might be involved in the mechanisms which result in long retention times. We will study this point in the following experiment:

2) Both epiphytic covered and clean leaves will be labeled with neutral solutions containing carrier free ^{137}Cs and

using a micropipet to deliver exact volumes to each leaf surface. The solutions will be allowed to evaporate to dryness. Each leaf will be marked for later identification,

2) Leaf samples will be harvested immediately after the ¹⁴C solution has dried to serve as a set of counting standards. Other harvests will be made first 2 weeks after application, and then at longer intervals until at least 6 harvest covering at least one year after application will have been made.

---Page Break---

3) The dead gamphon will be counted independently in the project single channel analyzer, first for ¹⁴C and then for ³H. The resulting data will be plotted as a function of time for epiphytic and clean leaves. The results are expected to show whether surface retention is an important factor in observed long biological residence times for fallout, and whether epiphytes are involved in this retention as is now thought.

Tracer Byeriont 3; Water movement in soils and plants. Using one of the lysimeter installations of Dr. Jordan an attempt will be made to measure some aspects of the water balance in the forest. Several water balance

Plots have been constructed in connection with these installations. Such

A plot consists of an enclosed section of soil surface of one to two square meters which lies directly above one or more of the lysimeters. The plot terminates at the edge of a pit on the downhill side and at this termi

As a trough, At each plot is a specially designed rain gauge for measuring under canopy rainfall. Water falling on the plot through soil is intercepted by the lysimeter end that which runs off is caught in the terminal trough and directed to a container where it can be measured.

One such installation has been fenced and equipped with warning signs for radioactive experiments. Health Physics Division approval has been obtained to use tritiated water in this area. Under Health Physics surveillance we will apply a known amount of tritiated water to a known surface area above the buried lysimeters. Water flowing from the lysimeter and the runoff collector will be captured at periodic intervals and brought to the laboratory for liquid scintillation counting. The resulting data will be used to calculate the proportions of applied water which ran off the plots and the proportions which moved into soil. This experiment is exploratory and will undoubtedly form the basis for other future experiments which cannot be rigorously defined at present.

---Page Break---

Within the same security area another tritiated water experiment

will be carried out to measure the uptake and translocation of water by

canopy tree. Approximately one curie of tritium will be diluted with

2 Liters of water and the solution will be applied to the soil at the

base of the tree. At 2 to 3 hours intervals thereafter leaves will be

harvested from the tree, placed in plastic bags, and frozen. The frozen

leaves will be returned to our PRC laboratory where the unbound waters

will be removed by passing a stream of dry air over the leaves in a heated

chamber and into a standard Liquid nitrogen cold trap. The volume of the

condensed water will be measured and they will be transferred to a vessel

for Liquid scintillation counting. The specific activity of the waters

extracted from leaves as compared to that of the waters originally applied

will give an indication of the dilution with environmental water which has

occurred and will enable a rough calculation of the total water moving into

the tree per unit time. The time of tritium persistence in the tree will,

enable a rough calculation of the total water which has passed through the

tree during the interval of measurement.

The latter experiment is in progress approximately 2h flasks fitted

with an aluminum pipe and containing liquid nitrogen will be exposed to the

atmosphere at varying distances from the site of the experiment. The pipes

contain condensed atmospheric water on their surfaces until the liquid nitrogen has

completely evaporated whereupon the pipes will warm and allow the

condensed water to flow into the flasks, ?These were developed by the Health
Physics Division to monitor safety effects of the experiment. by placing

then a stainless steel grid around the experiment the may yield some information
on the diffusion patterns of water in the atmosphere of the forest.

---Page Break---

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Tracer Experiment of Radionuclide Movement in Soil. Water balance plots

Which include lysimeters at various depths in the soil and water runoff
collectors have been prepared for radionuclide experiments. In one such

Plot milligram levels of both ^{134}Cs and ^{85}Sr will be applied to the soil
surface in a carrier free aqueous solution. At weekly intervals thereafter
the total volume of input water, the volume of lysimeter water, and the
volume of runoff water will be measured. Composite subsamples from lysimeters
at the same depths will be taken for gamma ray counting. Samples for counting
will be taken at first at weekly intervals until patterns of nuclide movement

have been established. After evaluation of these patterns we may find it
feasible to count monthly composites of the water. This plot will be
monitored for at least one year after the application of nuclides, at which

It is expected that this plot will show the relative proportions of nuclides moving through soil, and the proportions of nuclides which have been

immobilized by soil chemical reactions.

Lysimeters were installed in various soils of the EL Verde area. Approximately 36

lysimeters have been installed in various soils of the EL Verde area. These sites include well drained soils, poorly drained soils, soils on ridge tops and soils on hillsides. Most installations have been made at a depth of 5 inches, and each location has been replicated in quadruplicate. At each location a specially designed rain gauge which is two inches wide by 5 feet long was set up to give an integrated measure of rainfall penetrating the canopy.

---Page Break---

These installations will be used to obtain at least one year of water balance records under the indicated variations of soil drainage conditions. These records consist of weekly recording of the under canopy rainfall at each site and weekly recording of volumes of lysimeter collected water. Using performance data from the tritium experiment an effective collection area for the lysimeters will be calculated, and this will enable the calculation of percolating water through the various soils. The difference between volumes per unit area of percolating water and total input will

be ascribed to runoff and evapotranspiration. At some later date when

more experience has been gained in the construction and reliability of runoff plots we expect to be able to propose the measurement of evapotranspiration by difference when all of the mass flow variables are measured accurately.

---Page Break---

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NITROGEN FLUXATION

It is of key importance to the general understanding of mineral cycling in the tropical forest to have specific information on the possibly unique nitrogen cycles. There are two reasons for this:

2) There

no significant geochemical source of biologically available nitrogen

2) Environmental conditions favor the rapid nitrification of biologically

Released nitrogen which may then be rapidly lost from the ecosystem due to

its anionic chemical form and to the high rainfall of the area, Nitrogen

which is lost in large quantities must be replaced in like quantities from

any of several sources if the forest is to maintain its steady state. For stable sources of nitrogen include symbiotic fixation, non symbiotic fixation, epiphytose, and lightning strokes.

Banisten (Univ. of Ga.) has previously examined root nodules of leguminous plants of the area and found them to be apparently active and enriched in nitrogen content. We will initiate a preliminary study in cooperation with Dr. Binston to determine the possible role of epiphytes in the nitrogen cycles and fixation mechanisms in the forest. Dr. Binston will make at least three trips to the EL Verde forest for the purpose of on site study of epiphytes and for specimen collections. The specimens will be returned to Dr. Binston's laboratory where attempts will be made to culture the leaf surface organisms on artificial media, organisms which are successfully cultured will be examined for nitrogen fixing capability. Nitrogen will be measured in epiphytes and leaves to determine any existing patterns of relative nitrogen enrichment,

---Page Break---

The Project will provide costs of transportation and per diem for Dr. Binston, but will not provide a consultant fee, Culturing and analysis of samples will be carried on primarily as graduate student projects under

Dr. Binston's supervision at no cost to the project. Data resulting from the study will be equally available to the University of Georgia, and may be used in annual reports and progress reports, Any resulting open literature

Publications will be under joint authorship from both institutions.

BIOLOGICAL FUNCTIONS

One of the stated primary objectives of the Terrestrial Ecology Project is to study those aspects of biological function in the rain forest which could give theoretical interpretation and perspective to much of the empirical data already collected in the areas of mineral cycling and nutrient recovery. This remains an important one and in an area of research which could provide a unifying framework within which all other project activities are carried out. Because of staff obligations in the areas of mineral cycling and nutrient recovery however we are unable to make major research proposals in the area of energy cycling and biological function. The studies which we intend to carry out are restricted to those which require a minimum of manpower and expense and are listed as follows:

2) Respiration and photosynthesis will be measured on individual

samples of plants using the radiation sensor. This will be

done on a few of the major species

SE Sareea Beat out see: ee

An independent check on the proposed direct method to determine

the reliability of this method, Elsewhere in this proposal

---Page Break---

we indicate that H.7. Ofm will make 4 consultant vette to the project during the year. We expect to have his consultantship and participation in the metabolism work.

2) As indicated in the section of dust experiments we vill measure the netebolion of individual plants 1n the root covering experiment wlong vith controle to determine Vhether covering the roots haz any detectable metabolic effect.

3) The metabolism apparatus vill be carried to the Elfin forest on El Yunque where netabolim vill be measured om several plants including tree leaves, ferns, ani mosses. These wessurenents vill provide the firt indices of the Gifferences in energy utilization between this torent and the one at El Verde.

4) As time ant resources permit we will contime performance testing of the giant cylinder snd attenpt.to obtain usable? neepration and photosynthesis data,
?The performance toste of the cylinder will consist of the attempt to measure recovery of controlled metered releases of pure COz in the middle of the cylinder, while the fan te runing, ?These releases vill. be made from ground level and at 20 foot incresents up the tover until the

final release is made above the forest canopy. The data will indicate levels in which losses of metabolic gasses are occurring out the top of the cylinder and should provide a correction factor which can be applied

to all previous data taken from the cylinder and allow a rigorous calculation of the metabolic activity within.

Concurrently with the performance tests the cylinder will be run for at least one day and night without CO₂ releases in an attempt to measure the natural metabolic processes.

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EFFECT OF SURFACE DUST ON TROPICAL PLANTS

Consistent with the previous years project proposal we have investigated in some small scale experiments the effects of dust contamination in the tropical forest. The purely mechanical experiments show little of interest at least on the small scale experimental level and have been discontinued. In the biological effects experiments however preliminary results suggest that there may be definite detrimental results from relatively small inputs of soil. When the foliage of bromeliads were closed by soil.

applications of goll preliminary data show that the rate of nev leaf
profuction may have been slowed. Pale with ein(ler treatuent have thus
far remained uneffected. Metaboliam and photomyntin

8 of sotl covered

leaves io variable. In come cases ve have seen apparent increases in neta-
olan by as much as ten percent. In others a decrease of the same magnatuie
?vas fount.

Me most interesting experiment involves covering the surface roots
of plants in this forest vith so{l, In thte plot we have clearly produced
accelerated 1saf fall and doath of sone small trees ty covering the roots
with six inches of soll. The effects hovewer are chronic rather than acute
and the plot should be observed for « considerably longer tine, to establish
the effects relisbly,

The exploratory experinents do not Justify an attenpt at this tine to
carry out a major forest prism contamination experiment. While such an
experiment may becone desirable in the future more data from the small scale
experinents is needed to denonstrate the need.

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a)

3)

4)

We will continue the small scale experiments as follows:

Bromeliads: The soil treated bromeliads will be observed monthly along with their matched control plants for the production of new leaves and for the death of old leaves.

Palms: The soil treated palms will continue to be observed monthly for leaf production, stem growth, and leaf death. The same measurements will be made also on the matched control plants,

Metabolism: Respiration and photosynthesis will continue to be measured on soil covered leaves until a reliable effect has been demonstrated or

until it has been shown that such treatment has no effect.

Soil plots: The soil covered plot will be observed monthly along with

matched control plants and the following variables will be measured on
ai plants, 1) stem growth, 2) leaf fall, 3) leaves on ground, 4)
Aeath of planta, ?he soil covering will also be checked periodically
to determine whether there is any tenency for the plants to send their
nev roots back to the gurface, If tine and manpower pemait we will
atteupt to make metabolion measuremente on the plants in the plot as
compared vith the control plants.

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[NORTH CAROLINA PARTICIPATION

In sddition to the consultant services of 1.7, Odum of the

University of North Carolina the Project will continue to partictpate
in the completion of a project being carried out by his in North Carolina,

?This is the publication of the bock A Tropical Rainfores

?The principle project support required for the book publication
involves secretarial services for final manuscript preparation. The
project will provide a secretary for thia purpose to be employod at the
University of North Carolina for 6 montha, atarting July 1, 1967. Tats

4s arranged as in the previous year by purchase order to the University for the amount of actual salary with no overhead charges included. The services section of the budget includes an item for \$2,000 for this purpose.

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Present the station continues to be fully utilized for project activities

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EL VERDE FIELD STATION

The physical facilities of the EL Verde field station have been

described in some detail in previous proposals and annual reports, At

This utilization includes, data recording in the Project instrument room, drying and grinding of field specimens for chemical and radiochemical analyses, final preparation and adjustment of field apparatus, preparation of low radioactivity specimens from tracer experiments for counting, counting of such specimens, housing for project herbarium, housing of project insect collections and office space for project personnel.

Experience from several years of operation of the Field site now shows that such operation corresponds to a hazardous industrial situation.

In order to continue operating the site it will be necessary

to make investments leading to improve safety in the area,

In particular, the site electrical system must be completely re-

evaluated and rebuilt or else abandoned. There now exists 110 volts

power cables lying haphazardly on the ground. These have been in place for more than three years and could deliver a lethal electric shock to any person inadvertently touching them. Cables must be replaced where necessary, they must be encased in approved conduit, and the entire system must be provided with appropriate electrical safety devices to minimize shock hazard.

Rebuilding of this system will take place under the closest supervision of FHMC Health Physics Division. Existing concrete must be rebuilt with concrete

steps and cable hand rails installed at particularly steep portions; the

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Access to the upper parking lot which is frequently used for official
visitor access must be completely gravelled with steps and banister
Installed in hazardous regions, the upper river crossing must be rebuilt.
Fences, gates and signs must be installed to exclude unauthorized project
visitors and tourists from the research area. Guards must be erected
around the giant cylinder fan and engine.

The cost of operating the NL Vorde Station including installation
of required safety provisions is detailed as follows.

Item Cost

Limbo year for maintenance, driving, and
special safety provisions, including over

head and fringe benefits. 6,000

Services. Vehicle 500

Power 4,200

Materials. Gravel, wire, fencing, cable, cement, for
routine and special safety applications. 1,000

Total 11,700

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CESTIM SOURCE; A PRELIMINARY PROPOSAL,

Definite plans have not yet been formulated for future use of the
source, Possibilities for its use as detailed in previous proposals
include. 1) Loan to Canada for Chalk River spruce forest irradiation, 2)
Reef irradiation, 3) Elfin forest irradiation, Alternative (1) is no longer

being considered while (2) and (3) are still possibilities,

A fourth and highly feasible possibility is now presented. It was

suggested by Dr. Howard Andrews (Assistant Director for Health Physics

RIC) the source could be placed in the center

of the giant cylinder for an

anticipated short term irradiation with the objective of measuring the effects

of Arradiation on photoaynthes

» respiration ond transpiration. Under this
plan 1t would not be necessuy to irredtate until lethal effects decane
visible in the plants, Isratiation until darinite patterns of alteration
in these biologice2 mctions had been eatablished would be sufficient.

At least one year lead tine would be require? before this experiment
could be carried out. ?this tine {e requized to establish patterns of variation
of these finctions in the undisturtd forest, and to do further reliability
fant performace testing of the giant cylinder Stuef with the hope of improv=
ng tte performance or establishing correction factors for the knom att
oases vite occur. Final dectafon to do the radiation experiment would
be deferred untii project setentiste vere confident that the giant oylinter
vas functioning properly.

The experiment as outlined seems attractive for several reasons.

1) Tt would be the first attempt to measure the effects of radiation on

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Biological functions at the system level in the tropics. 2) It could be carried out on the existing project site with many of the facilities and staff involved with the first radiation experiment still intact, 3) It could be done at less total cost than any of the other alternatives so far at Atecussea.

The proposed experiment could be carried out under Terrestrial Biology Administration. Extensive ecological surveys carried out prior to the first radiation experiment would not be required and the proposed experiment could be handled internally with the addition of one professional level investigator and one or two field workers to the staff. Outside consultants would be required only for special measurements such as dosimetry.

The experiment could be done without jeopardizing other project programs in mineral cycling or radiation recovery since the source may be exposed only 2 to 3 weeks. While the experiment would result in irradiation of the first radiation center the effects would be slight since no effects were found in the giant cylinder site from the first exposure and since the proposed exposure is for only 1/3 the duration of the first.

This is not a funding proposal for this experiment. This outline
is offered as a basis for future informal discussion only. In the event
these discussions lead to a decision to do the experiment a formal proposal,

AML be submitted,

---Page Break---

6) SCIENTIFIC PERSONNEL

2) Jey R, M.D. Chief Scientist I and Director, Terrestrial

2) Carl F.

3) George

Ecology Project. Experience in plant-soil relationships in
agriculture crops; radiochemical and instrumental investigations
of thermal neutron irradiated soils and plants; investigations
of fallout radionuclides in the environment utilizing gamma-ray
spectrometry and radiochemical separations, Formal training in
Soil Chemistry and Analytical Chemistry. Full time.

Jordan, Ph.D. Associate Scientist I, Terrestrial Ecology
Project. Experience and formal training in Plant Ecology
and Soil Science. Previous work and publication in effects
of fire on old field vegetation in New Jersey, Developer

of simple lysimeter system for the measurement of water and
soil flux through soil profiles. Full Time.

5. Dreyer, MS (Ph.D pending 1967). Associate Scientist I,
Terrestrial Ecology Project. Experience and formal training
in biology and zoology with special interest in animal
behaviour, Previous work and publications on behaviour of
terrestrial and aerial behaviour of Puerto Rican Coqui, Self
taught electronics expert with circuit design capability.
Full Time.

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7) OME PERSONNEL

Henri Watson. Research Associate I. Project Field Botanist. Present
status doubtful due to serious injury on Project. If recovery

permits is employable despite possible physical handicap

due to specialized botanical knowledge.

Hse \$time

Teigon Yercado Buxgoa Ras. Assistant IZ 004

Hipiia Rivera Santiago "

?AieJo atreda Pinto .

eine Rule Reyes *

Charles Rober? Venator (Grea) Fd

?eel Rossy 00h

Giiterto Cinteéa 258

faa Josefina Correa 1004

Hida Rosa Bocobales oof

Noieés Purriia Sosarto 00%

Suan Martine: Yatgonet Field Worker in Terrestrial

Boology I oof

Derotes Martines dares Field Worker in Terrestrial

Boology T 2004

TA) Project Viattora

"mo Project makes lees wie of technical consultants than tn. the

Ist due to the fact that our inéressingly detatlet studies cannot be

exploited effectively by these persons in short tom tripe, ?These are

however certain areas where consultant relationships are advantageous.

Consultant contracts will be entered into with the following persons to

enable them to make site visits.

---Page Break---

Dr. Howard W. Cius. Professor of Biology. University of North Carolina, Chapel Hill, Site visits to permit organization of Rainforest book publication and to serve as consultant in metabolism and energy budget

Dr. Hitzabeth Newnan. Associate Professor. University of North Carolina, Chapel Hill. Served as consultant for detailed study of termite populations and behaviour in radiation center and for experimental determination of radio-sensitivity of termites.

Dr. Joe Binsten. Associate Professor. University of Georgia. Initiation of preliminary studies on possible role of epiphytes in nitrogen fixation.

8) OTHER FUNCTIONAL ASSISTANCE

The project is ordinarily funded jointly from the single ABC grant.

During the past fiscal year an appropriation of \$10,000 was received through AB channels from Battelle Memorial Institute to permit fallout radioclide

studies in Panama and various on site experiments in Puerto Rico, Project obligations resulting from this appropriation were fully attached by the submission to Eattello of two progress reports covering the work performed. No similar arrangement has been negotiated for the forthcoming fiscal year.

Moo project is subsidized to a certain extent by the participation of consulting scientists since it does not usually cover the full cost of research performed. In the usual arrangement the project covers the costs of transportation and a nominal per diem for the participant while the home institution continues to pay the salary and costs of continued effort relating to the research outside of Puerto Rico.

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9) PRRGSES, FACILITIES, EQUIPMENT, AND MATERIALS

TO BE FURNISHED BY CONTRACTOR

The main facility, the forest area and the El Verde field station,

including a house for visiting personnel are furnished through a 5 year

interagency agreement between the U.S. Department of Agriculture and the
Luguillo forest area and the Atonte Buerey Comfacion. Another
residence house, Cionaga Alte house, 5 miles from the El Verde station and
also on Rt. 186 is available by an interagency agreement between FRIC and
U.S. Dept. of Agriculture. The Institute of Tropical Forestry furnishes
2 room in Rio Piedras and Jom of some specialized equipment. Some
utilities of Foreszy Building are paid by FRIC.

A laboratory building, 600 square feet, at El Verde; an office and
two laboratory rooms in the Biomedical Building at Rio Piedras; and
considerable equipment previously bought on this project are furnished

according to the provisions of the general operating contract between, ABC
and the University of Puerto Rico for the Puerto Rico Nuclear Center.

---Page Break---

20) BncEr

Salaries (Itemized in Appendix A)

Travel

Material and Supplies

Services

Overhead (654 of Salaries)

?Total Operating cost

Budget (Itemized in Appendix B)

?Total Project Cost

98,000

5,000

10,000

21,000

0,000

184,00

112,000

196,000

rr

100,600

6,000

312,900

28,000

60,000

193,000

30,000

203,000

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Salary Budget

2) Gatartes

Jerzy R, Wine, Chief Sctenttat T

\$1,250/u0, full. tine

Carl F, Jontan, Associate Sctentist T

\$916.66/a0, full tine

George 2, Drewy, Associate Scientist T

\$791.66/mo, full tine

Henri W. Watson, Res. Associate I

\$566.66/m0, ful tine

Yelson Merealo Burgos, Res. Assist. IT

\$416.66/mo, 012 time

Atomic Absorbtion Analyst, Pull time

Charies R. Venator, Res. Assist. T

?\$275.00/n0, 50% time, graduated stulant

Estrada Pinto, Res. Assist. T

302, 50/mo, full time

Eipidie River Santiago, Res. Assist. T

\$302.50/mo, full time

Hilda Hoon Bocobaies, Res. Assist. I

\$230.00/mo, full time

Sete Role Reyes, Ras. Assist. I.

\$250.00/n0, full time

Gttberte Cinteén Valero, Res, Tecknteten

\$2.75 /te. Aprox. \$1h0.00/z0, Grad.

?eel Roary, Res. Techntotan

\$300.00/n0, uli time

Doa Josefina Correa Lépez, Adm. Secretary IZ

\$302.50/mo, full time

T

35,000

31,000

94500

6,800

5,000

5,300

2,200

3,630

3,630

2,760

3,000

2,680

3,600

3,630

---Page Break---

Moisés Porrilia Rosario, Maint, Foreman

'\$300.00/mo, full time

Juan Martinez Maisonet, Iela Yorker

\$208.33 /n0, full time

Doroteo Martinez Garc{a, Feld Yorker

\$208.33 /mo, ull time

?Total Salaries

Fringe Benefits (9.36)

Lump sum for rats

?Total

) ad oumer assistant

3,600

2,500

2,500

85,230

1,870

4,900

98,000

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Appendix B

euzent

|| tet watts 0

Pu amiciee 00

| (3 Peer suppties 450

| mpiy Rrenontar tum

i

rho

ww

Laboratory Shaker

Combustion Furnace

Hollow Cathode Lamps (5)

Conductivity Cetus (5)

?Twenty five liter Dewers for liquid W (2) 250

vo ter Ban MLLa 300

(citraey cutting ~~ 505~

Barnatend Sti11 for distilled water 206

?Total 12,000

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22) AVIEEW TICATTON

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Signature Title

Sigatare Tele

ae te

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