"RCEER-x-115, RADIOLOGICAL SURVEY REPORT FOR EL VERDE RESEARCH STATION CENTER FOR ENERGY AND ENVIRONMENT RESEARCH HEALTH AND SAFETY DIVISION November, 1961 Revised May, 1983, CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

RADIOLOGICAL SURVEY REPORT FOR EL VERDE RESEARCH STATION CENTER FOR ENERGY AND ENVIRONMENT RESEARCH HEALTH AND SAFETY DIVISION November, 1981 Revised May, 1983

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TABLE OF CONTENTS CERTIFICATION, BRIEFLY INTRODUCTION, HISTORICAL BACKGROUND, SUMMARY OF THE RADIOLOGICAL SURVEY, RESULTS OF THE RADIOLOGICAL SURVEY BEFORE DECONTAMINATION, INSTRUMENTS USED, DECONTAMINATION, PRESENT STATUS AND CONCLUSIONS, REFERENCES, APPENDIX

10, 13. Map of Puerto Rico Showing the Location Verde research area, Luquillo Forest, and approximate location of the Laboratory Area, El Verde Research Station. Details of Old Laboratory Building, Areas 4 and 5. Numbers Indicate Survey Points. See Appendix 1A for Results.

Details of Old Laboratory Building, Area 6 and Shops. Numbers indicate survey points. See Appendix 1D for Results.

Approximate Location of the Six Areas where Radiotracers were used.

Radiation Levels, Expressed in uR/hr, in the Laboratory Area.

Radiation Levels and Sampling Locations in Area 2. See Appendix 1 for Results of Samples Analyzed.

Radiation Levels and Sampling Locations in Area 3. See appendix 1 for Results of Samples Analyzed.

Radiation Levels and Sampling Locations in Area 4. See Appendix 1 for Results of Samples Analyzed.

Radiation Levels and Sampling Locations in Area 5. See Appendix 1 for Results of Samples Analyzed."

Radiation Levels and Sampling: See Appendix 1 for Results of Samples Analyzed. Radiation Levels and Sampling Locations: See Appendix 1 for Results of Samples Analyzed. Radiation Levels After Decontamination of Area 8. Radiation Levels, at the Present Time, in Area 4.

CERTIFICATION: It is hereby certified that the areas described in this report do not represent a radiation hazard to the public nor to any person working in El Verde Research Station. (See Appendix 1)

Head, Health and Safety division.

ABSTRACT: The Remediation and Decontamination, as indicated, has been completed. Areas were found contaminated. All contamination was removed from areas 2 and 5. Figures 12, 14, and 15. The contamination in area 6 (Figure 16) was identified as Cs-137 and was removed down to a radiation level of 200 uR/hr. Even though this level does not constitute a hazard for the public or to an area, access to it has been controlled by appropriate means.

On December 1961, an application was requested for the use of Cesium-137 and Tritium in the forest. The Nuclear Regulatory Commission granted to CEER-UPR license No. 52-1934-02 in March 1982. The contaminated soil that was removed from areas 3, 5, and 4 was packed in DOT approved containers and was shipped to a low-level waste disposal site in Oak Ridge, Tennessee in September 1982.

The Clear Center was developed during the early stage of the Atomic Energy Commission with the main goal of developing a comprehensive program for research and training for nuclear applications of nuclear energy in medicine, agriculture, and industry. As part of the projects developed in order to achieve this goal, the Terrestrial Ecology Division was started in 1963. In 1964, a Memorandum of Agreement was signed between the Atomic Energy Commission and the Forest Service, Department of Agriculture, allocating 156 acres in the Luquillo Experimental Forest, El Verde Rain Forest, for conducting detailed ecological studies, Figures 1 and 2. The main study area is located on the northwestern side.

"Slope of the Mountain" and the research station is built on the site of a former coffee plantation. Several study areas were developed just up the mountain and to the east across the Sonadora River (9). Access to the area is controlled by means of a hog wire fence, 8 ft high. The presence of patrol dogs also aids in the security of the area. From 1964 on, large amounts of research projects were made in El Verde. Vegetation was quantified and identified, pollen was analyzed, a detailed study of the climate was made, soil was studied and many other aspects of the Rain Forest were thoroughly studied (11). Radiotracers were used, beside other techniques, during the study of mineral cycling and forest metabolism. In 1976 the goals and objectives of PRNC changed. PRNC became the Center for Energy and Environment Research and the AEC-ORO (then ERDA and now the Department of Energy) concurred on transferring CEER.

Facilities to the University of Puerto Rico and terminating the agreement with the Forest Service, CEER/UPR will continue to use this research area under a use permit from the Forest Service. In the process, a radiological survey was planned and has been done during the last three years. The area under CEER's responsibility was thoroughly surveyed using portable survey meters. Instrumentation used for this survey is listed on page 12. During this walk-through survey, some soil plots were found fenced and marked with radiation safety signs. These areas or plots were

surveyed in more detail and samples were taken and analyzed for gross beta and alpha contamination. Spectrometric analysis was done to representative samples of each of these areas. Except for three of these plots, no other area was found with contamination or radiation levels higher than background. This report summarizes the activities carried out during the radiological survey and documents the results.

The Terrestrial Ecology Program was initiated in April 1963. A month later, the work at El Verde Rain Forest started.

The text with corrections:

With three major objectives:

1. To determine the effects of gamma irradiation from a 10,000 Ct+ sealed source, on a plot of lower montane rain forest.
2. To measure the cycles of fallout elements in the rainforest.
3. To determine the circuits of energy flow and metabolic processes of the ecosystem in order to understand the observed phenomena.

In the first year of work at El Verde, all efforts were directed towards the study of the general conditions before gamma irradiation. There is no record of major tracer studies during 1963 except in August when three trees were tagged by injecting 1 mCt of 32-P-phosphoric acid into each of the tree stems.

On September 16, 1966, an agreement was reached and a memorandum of understanding between the Atomic Energy Commission and the Forest Service, United States Department of Agriculture was signed in order to separate 156 acres of the El Verde Rain Forest for conducting detailed ecological studies of the effects of gamma radiation (Cs-137) upon tropical forests. Figures 1 and 1-A show the location and details of the area included in the agreement.

A preliminary irradiation with a 60 Co sealed source was carried out in August 1964 to help predict the attenuation of gamma radiation in the forest and to verify the hazards report for the 3 mCq sealed source. The sealed source was installed on top of a small ridge in the Rain Forest on December 7, 1964. The area was exposed to gamma radiation for the period between January 19, 1965 to April 27, 1965. It was removed and shipped to the USA during July 1966. This source had no record of leakage and therefore did not constitute a potential source of contamination to any area in the forest.

It must be mentioned, though, that during the arrangements made for this irradiation project, the El Verde site was fenced at radii of 80 m, 160 m and 500 m from the radiation center. These fences have been used as reference points during the radiological survey being reported at present. See Figure 2.

When the irradiation was completed and the immediate post-irradiation effects were under study, plans were developed for studying mineral cycling, cycles of fallout elements, and metabolic processes. Among other methods, radioactive tracers were used in numerous experiments during

this period of time. In January 1966, tracer experiments involving the use of Strontium-85, Cesium-134, and Manganese-54 were initiated. These experiments were carried out throughout the whole year and ended in December 1966. The objective of the experiment was to determine whether these nuclides could be transferred from litter to soil to roots of understory plants, and if so, at what rates.

Four plots were established within a fenced enclosure on a gently sloping ridge top within El Verde contract area. These plots, which ranged from 1 to 1.5, were encircled with corrugated aluminum garden edging to a depth of 3 inches and roots to this depth to prevent export of nuclides to trees outside of the plots. The plots were stripped of all litter and two were left intact prior to the application of nuclides. On January 6, 1966, approximately 5 microcuries of each Cesium, Strontium, and Manganese were applied to the plots, in the form of a spray from a hand-pumped garden sprayer. All plants within the plots, at this time, were covered with plastic bags and aluminum foil to prevent contamination when sprayed.

Purchase order records indicate that on May 1966, the Terrestrial Geology Project bought 1 Curie of Tritium to be used in future experiments within the Rain Forest. During February 1967, twenty microcuries of Tritium were diluted to 1 Liter of water and the mixture was applied to the surface of a 0.94 square meter soil plot.

Later on August 3, 1967, three tree trunks were tagged by spraying each with 1 microcurie of carrier-free Zinc solution. This study was designed to evaluate the utilization by the snail Caracolus caracola, of lower plants growing on the tree trunks. On August 10, 1967, 1 microcurie of Strontium and 0.8 microcurie of Cesium were diluted in 2,500 milliliters of water.

The text was corrected as follows:

The solution was evenly applied to a small plot of soil. (5) Teitiua repeatedly used during 1968 and 1969, five soil experiments using this radiotracer were planned and carried out.

One of the experiments consisted of injecting three trees with different amounts of an isotope. A large Dacryodes excelsa received 20 mCi, Sloanea berteriana 6 mCi, and a small Recurvades excelsa received 1 mCi. Another experiment, done in May 1968, consisted of evenly spraying four liters of water containing 50 mCi of Tritium to a 3.7 square feet plot. Two more experiments involving the use of Tritium were reported in June 1969, but there is no record of the amounts of the isotope used.

(1) Experiments using Cesium-137, Strontium-90, and Manganese-55 continued. In September 18, 1968, a tree of the species Shadowinguensis was injected with 0.46 mCi of Cs-137, and a Dacryodes excelsa was injected with 0.19 mCi of Sr-90, 0.34 mCi of Mn-55, and 17.69 mCi of May. Also during 1968, another experiment using tritiated water was reported but the amounts of the radioisotope are not mentioned.

The next reference to the use of radioisotopes was reported on June 29, 1970. In this report, Mn-55 and Sr-90 are mentioned as the radioisotopes used to study nutrient pathways and depth of nutrient uptake. This experiment apparently was carried out in plastic trays in the laboratory. (11).

Another reference to the tagging of trees using P-22 does not specify the date of the experiment but it is mentioned that a certain amount of the isotope was used for injecting two trees of species Sloanea berteriana and Dacryodes excelsa. Reference to this study is made in "A Tropical

Rain Forest." (10) Since this book was published in 1970, it is assumed that this experiment was performed in 1969 or before. After 1970, the Terrestrial Ecology Division reported only one experiment involving the use of radioisotopes, i.e., the tagging of a Giant Tree Fern, Cyathe arborea. The tree was tagged in June 1971 with unknown amounts of isotopes. Based on these data, Table 1 has been prepared. It is a summary of...

The radioisotopes used, amounts used, and date and location of the experiment.

ISOTOPE(S) DATE AND LOCATION ACTIVITY
Jan, 6 1967, Area 2 (Fig.#) - 20mCi
May 1968, Area 3 (Fig-10) - 50Ci
12s 3p y903, 1 act, 357.07 3p we 46 mci 280.57 $e 137¢q
Sept.18,1968, Area 4 (Fig.1) - 0.46 nCi, 0.5 86,0 Ci, 17.69 Ci, 293-41 Ci
0119 mCi, 84162 54 nCi, 0134 nCi, 1743 Ci
Aug-10, 1967, Area 5 (Fig.12) - 1 act, v0.26 Ci, 0.8 mCi, 7.77 Ci
Aug. 95 1967, Area 7 (Fig.13) - 3 Ci, 16.99 Ci
1946, Area 8 - 1 Ci, 5.25 Ci

Table 1 - Summary of radioisotope usage in El Verde Rain Forest

It must be mentioned that associated with the activity, there is a laboratory building that was constructed in 1965. Another laboratory, adjacent to the first one, was constructed later. There is no record of radioisotope usage in the new laboratory. On the other hand, it is assumed that some sample preparation involving the use of radiotracers was performed in the old laboratory.

Fig. 3 shows the SUMMARY OF THE RADIOLOGICAL SURVEY. A Radiological Survey was planned and performed in order to determine the status of El Verde facilities and research areas from a radioactive contamination standpoint. The survey included a survey of the radiation levels and removable contamination in the old laboratory building and a walk-through survey of the forest. Also, soil and vegetation samples were collected and analyzed.

Survey in the Laboratory Building:
The radiation levels within the laboratory were measured using portable Geiger Muller and Scintillation survey meters. The benches, tables, drawers, instruments, floors, walls, materials and other surfaces were scanned on contact and at 1 meter high. Since the laboratory building is included in NRC License No. 52-1994-02, and at the time of the survey there were plans for the use of radioisotopes such as Tritium, no efforts were made to survey the drains, hoods exhaust system, sink traps, etc. The survey for removable contamination was done using the standard smear.

The text should be corrected as follows:

The technique, Figures 4, 5, and 6 show the areas where the smears were taken.

A walk-through survey was done in the forest, starting from the laboratory area through the trails up to the road. The fun center where the Se was installed on IS64. The survey was extended to three, and twelve meters from the trails. The area with a 10-meter radius was surveyed in a grid of approximately one meter. This part of the survey was performed at ground level, and one meter high, using headphones in order to more precisely detect variation in radiation levels in spite of the inequality of the ground. During the walk-through survey, six areas were found fenced with chicken wire screens and marked with radiation safety signs. These areas were marked as follows: areas 2, 12, based on already existing within the fenced plots. For the purpose of this report, these areas will be called hereinafter, area as numbered. Figure 7 shows the approximate location of these areas. Each was thoroughly surveyed, and a detailed map of the radiation levels was done. Also, soil and vegetation samples were collected in the areas. In order to have a complete idea of the status of the surrounding grounds, soil samples were also collected outside of the fenced areas, beyond the radiation safety signs. All soil samples were collected from surface 6 inches and from next 6 inches deep in the ground. Soil and vegetation samples, representative of each area were analyzed for radionuclide content in a Germanium Lithium drifted detector. Also, other portions were oven-dried, grinded, and an aliquot of 200 mg was counted in a Gas Flow Proportional Counter, for gross

Alpha and beta-gamma contamination. Microcuries per gram were calculated using the following formula + eps where Am amount of sample analyzed (g) is ———___, (7) 2.22 x i Fe efficiency factor = 507 VEY REVORE DECONTAMINATION. The initial radiological survey for EL Verde Research Areas was carried out during different intervals of time in FY 1978 through FY year. The background radiation

The level varies from 2 uR/hr to 6 uR/hr in the laboratory area and in the forest. Figure 8 shows the detailed radiation levels in the laboratory area. Each one of the areas was surveyed in detail. Figures 9, 10, 11, 12, 13, and 14 show the radiation levels and location of the samples taken inside and beyond the fence of each area. Samples taken beyond the fence are identified as control samples. Based on the description and clues found in each area, spectrometric analysis of some samples and the descriptions found in the literature searched, the isotopes used in each sampling zone were identified as follows: Area 2 - Th, Area 3 - Pu, 3p, Area 4 - Me, Se, At, Sp, Area 5 - Sr, Me, Area 7 - Sc, 1g, g, gp, 54, Area 8 - Me, He.

Appendix 1 is a summary of results of the samples analyzed for gross beta-gamma and gross alpha contamination. Appendix 2 is a summary of the samples analyzed in the field. Three of the areas were found with radiation levels higher than background: Areas 4, 5, and 6. See Figures 1, 12, and 16. No contamination was found in the laboratory building. Appendix 14 shows the results of all the samples taken in this building. No samples were taken in the new laboratory constructed in 1976. Samples from areas where no radioisotopes have been used were taken and analyzed in order to establish a background level for comparison purpose. The results of these control samples are included in Appendix 3.

INSTRUMENTS LIST:

1. Ludlum Measurements, Inc. Model 3, with 1.8 uR/hr window, Sweetwater, Texas
2. Resuscitation Gamma Ratemeter Type 13974, Sector Control Division, Elliot Process Automation Limited, Lewisham, London, SE13
3. Nuclear Measurements Corporation Gas Flow Proportional Counter, Model PCO-LIT-DS-IT, 50% efficiency for gamma energies from 0.500 Mev to 1.3 Mev, Indianapolis, Indiana
4. Nuclear Data 4410 Spectrometer with a GeLi Detector, Nuclear Data Inc.
5. Liquid Scintillation Counter Beckman Model LS 31337, Beckman Inc., California, 30% Efficiency for

Corrected Text:

The text has been dissipated in the atmosphere as water vapor. Jordan estimated the half residence time* for tritium in the vegetation and in the air of tropical ecosystems such as El Verde. (2) According to Jordan, tritium moves into the air through evaporation of the water in the litter, in such a way that, the half-residence time of the 3H in the soil and litter, necessarily controls concentration in the water vapor above the spiked soil. The results in his experiments indicated that: "29 days probably is a good estimate for the half-life of tritium in the soil as a whole." (2) He found that for trees growing in soil spiked with tritium, the half-life is between 41 and 55 days. For those trees (Dacryodes excelsa) where the isotope was injected, the half-life of tritium was 6.6 days. (2) If one Curie (1 Ci) of tritium bought in 1965 was used during 1969 and experienced a half-residence time of 55 days, the amount remaining in 1983 would be 1.95 x 10^7 Ci.

*Half residence time is the length of time that it takes for half the activity in a compartment to be removed.
**Biological half-life is the time required for the body to eliminate by regular process of elimination one-half of a dose received of any substance.

Based on the above observations, we can conclude that biological cycling and the residence of tritium in a tropical ecosystem like El Verde is such that tritium used in the research area has been dispersed to the atmosphere in very low levels not dangerous to either the public or people working in the area.

References:
1. Carl F. and Drees, George E. "The Rain Forest Project Annual Report." Puerto Rico Nuclear Center, PRSCA-13, (June 1967)
2. Koranda, J.J., Eline, Z.R and Marx, J. "Tritium Movement in a Tropical Ecosystem." History, p. 807.
3. Kline, Jerry R. "Terrestrial Ecology Program: The Rain Forest Project." Puerto Rico Nuclear Center Annual Report 1966. PR 102, (Sept. 1967)
4. Jerry R. and Staff. "The Rain Forest Project Annual Report FY1967." Puerto Rico Nuclear Center.

Ney, Carl T., Jordan, George E. The Rainforest Project and Its Reports. Puerto Rico Nuclear Centers PRIC-IIY, (June 1962), 200, 220. Trees KCRP (1979) National Council on Radiation Protection and Measurements, Radiation in the Environment, NCAP Report No. 62 (National

Council on Radiation Protection and Measurements, Washington). Puerto Rico Nuclear Center, Annual Report 1967, PRNC-121, 170, 173. Oguz, Howard T. The Rainforest Project Annual Report FY-1965. Puerto Rico Nuclear Center, PRIC-61 (March 1, 1963) 3. 4. Odun, Howard T. A Tropical Rainforest, A Study of Irradiation and Ecology at El Verde, Puerto Rico, Washington DC. Howard T. The Rainforest Project. Puerto Rico Nuclear Center, PRNC-H34 (April 1, 1964) 34. Odun, Howard T. A Tropical Rainforest, A Study of Irradiation and Ecology at El Verde, Puerto Rico. Washington DC: Division of Technical Information, 1970. Stark, Nellie, The Rainforest Project Annual Report. Puerto Rico Nuclear Center, PRNC-147 (June 1970) 130-140.

APPENDIX 1.

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH. HEALTH AND SAFETY OFFICE ENVIRONMENTAL SAMPLES Summary Report. Instrument used: Kec 217. Background: 8. Sampling zone: Wn 22.

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH. HEALTH AND SAFETY OFFICE. ENVIRONMENTAL SAMPLES SUMMARY REPORT. Date: April '72. Instrument used: Ds<1T. Background 8. Technician: Omg. Sample. Vol: We. Sampling zone: Ayes #3. Type of sample: Soil.

Note:
* Net Results = uCi/g sample ~ u Ci/g background
* Error range + 2.3 x 10^5y Ci/g
* Vs vegetation c= control S= 201

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"Tritium is used. "If the average concentration of tritium in urine for any single individual during a calendar quarter is less than 10 microcuries per liter, urinalysis may be performed on that individual at monthly intervals for the following calendar quarter and may continue at monthly intervals as long as the average concentration in the calendar quarter remains below 10 microcuries per liter. The urine specimen shall be collected on the same day of the week as far as possible. Any average concentration in excess of the limit specified in B(L) above for any individual shall be filed, in writing, within thirty (30) days of the end of the calendar quarter with the Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, with a copy to the Regional Office of Inspection and Enforcement. The report shall contain the results of all urinalyses for the individual during the calendar quarter, the cause of the excessive concentrations, and the corrective steps taken or planned to assure against a recurrence. (4) Any single urinalysis which discloses a concentration of greater than 50 microcuries per liter shall be reported, in writing, within seven (7) days of the licensee's receipt of the results, to the Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, with a copy to the U.S. Nuclear Regulatory Commission, Region II, Office of Inspection and Enforcement, 101 Marietta Street, Suite 3100, Atlanta, Georgia 20303.

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