INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

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K. Z. Morgan
Building 4500

Subject: Contaminated Old-Field Proposal

Enclosed is a preliminary draft copy of the major part of the technical proposal for the cesium-137 contaminated old-field. It will give you a general idea of the type of investigations we are proposing for the site. The portion that is missing is a more complete description of soil research related to the behavior of the isotope in the field.

The hazards report portion will come later.

S. I. Auerbach

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Human Studies Project

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A CESIUM-137 CONTAMINATED OLD-FIELD SITE FOR EXPERIMENTAL STUDIES IN RADIATION ECOLOGY

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ABSTRACT

Continuation of field investigations in radiation ecology requires the creation of 5-acre enclosed areas with contaminated cesium-137, in which radiation effects and radioisotope movement may be studied in mammals, insects, and plants. This work relates to over-all objectives of discovering and interpreting the consequences to natural ecological systems of radioactive contamination in the environment, and will contribute to programs concerned with radioactive waste disposal fallout, and civil defense. Equal emphasis will be given to the development of radioisotope techniques of value for studies in basic systems ecology.

Research will be a continuation of that performed on the radioactive White Oak Lake bed (to be inundated, in part, from Melton Hill Dam operations) but with three important advantages: (1) control can be exercised over the type, amount, and distribution of radioisotope, (2) adequate uncontaminated control areas can be established adjacent to the contaminated ones, and (3) many of the animal species will be isolated, thus preventing dilution of the populations by emigration and immigration. A radiation field of 100 mR/hr will be established in two 5-acre areas and four 100 m^2 plots through addition of successive increments of cesium-137. Mammal-proof sheet metal fences will surround these contaminated areas and two uncontaminated 5-acre areas and four 100 m^2 control plots, and an antipersonnel fence will surround the entire area. The proposed site is a part of an area which has been under study for four years, and has been selected to provide four 5-acre

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plots of comparable edaphic and drainage factors.

Mammal studies will emphasize: (1) effects of chronic low-level irradiation on population growth rate and structure; (2) radiation damage to blood and somatic chromosomes; (3) accumulation of cesium; and (4) comparative dosimetry. It will be necessary to study population parameters and environmental factors concurrently so that the effects of these variables can be separated from the effects of radiation. Native small mammals (cotton rats, pine mice, and harvest mice) will be introduced into the penned areas separately or in combinations of species for a series of experiments. Population growth rates and structures, blood picture, somatic chromosomes, and radiation doses will be measured with techniques developed and proved on White Oak Lake bed. Cesium-137 accumulation will be estimated through whole-body counting and serial sacrifices, and will include parallel laboratory studies. The duration of each field experiment will be governed by results obtained during the systematic sampling; the projects listed above are expected to require three to four years for completion.

Insect studies will include: (1) radiation effects on population structure and reproductive rates for major insect species; (2) measurement of insect-plant interactions in irradiated and control areas; (3) energy flow through insect food chains in irradiated and control areas; (4) estimates of radioisotope spread to adjacent areas by local movement of insect population; and (5) short-term fluctuations in steady-state Cs^{137} concentrations in response to environmental variables. Techniques similar to those used on White Oak Lake bed will be employed, except where improved techniques for population estimates can be substituted for box-trap and hand-picking methods.

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Laboratory techniques for whole-body counting and maintenance under controlled environmental conditions have been developed previously, as have respiration and calorimetry techniques. Completion of the suggested studies should require three summer?

Botanical studies will include uptake, distribution, and seasonal variation of cesium-137 in the forbs and grass species, primarily as support data for the mammal and insect studies. Radiation effects studies also are projected. These may have to be postponed until mammal and insect studies enter long-term phases or become completed, but final decisions will depend on first results from the animal studies.

Cesium movement in soil will also be measured, to investigate rates of downward and lateral migration, entrance into ground water, and availability to plants. →

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INTRODUCTION

General. -- The task of radiation ecology is to discover and interpret the consequences of the release of radioactive materials into the environment. The magnitude of such releases may range from barely detectable amounts of world-wide fallout to massive contamination resulting from nuclear wars. Radiation ecology must measure the radiation effects upon natural biological systems and the rates of movement and spread of radioactive substances in a variety of biological systems and for a variety of types and levels of contamination.

A corollary of equal importance is the need to understand the ways in which natural ecological systems are organized and function. Broad-scale changes in natural environments are being effected rapidly in response to pressures from expanding human populations. Radiation ecology is making a major contribution to techniques, data, and interpretations for basic ecological studies of natural environmental systems.

Research in contaminated or irradiated field areas has produced most of the information presently available in radiation ecology. Such areas as the bed of the former White Oak Lake and the new Cs^{137}-contaminated forest at Oak Ridge National Laboratory, the Lockheed Reactor Site at Dawsonville, Georgia, the Co^{60} field formerly at Emory University, and the forest irradiation program at Brookhaven National Laboratory have demonstrated repeatedly the productiveness of a combined field and laboratory approach. Phenomena observed in field sites lead to the creation of hypotheses which can be tested in controlled laboratory or field experiments. In turn, the results of tests often provide new interpretations of field data, and permit conclusions to be extended from small areas to broad geographic regions.

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Need for a Contaminated Old-Field Site. -- Further development of lines of investigation originating from studies on White Oak Lake bed will require contaminated field sites at least superficially similar to the lake bed. The operation of Melton Hill dam will inundate most of the lake bed at certain periods, so that only limited types of studies can be continued there. The value of an area such as White Oak Lake bed has been amply demonstrated in publications and reports by Oak Ridge National Laboratory personnel and others. The lake bed has served at a prototype for field studies of radionuclide accumulation by mammals (Kaye and Dunaway, 1962), birds (Willard, 1960), insects (Crossley and Howden, 1961), and native plants (Auerbach and Crossley, 1958). Current emphasis is being placed on radiation effects (Dunaway and Kaye, in press; Plummer, 1960). These studies have figured prominently in shaping current radiation ecology research at ORNL and elsewhere. It is essential that a similar contaminated area be provided.

The contaminated old-field areas will be more than a replacement for White Oak Lake bed, since the facility is designed for specific experiments and to allow modification as further experimentation becomes indicated. Contamination with a single isotope will relieve many of the difficulties attendant in determining the radioactivity accumulated by the biota. The uniform radiation field will ensure that an entire population receives essentially the same dose during a given period of time. The inclusion of identical but uncontaminated control areas will permit evaluations not possible in White Oak Lake bed studies. Perhaps the chief advantage of these areas will be that, for the first time, radiation effects and bioaccumulation of an isotope can be studied in self-sustaining, isolated populations of many species without the dilution of populations and gene pools resulting from emigration and immigration.

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The contaminated old-field areas will complement the Cs^{137}-tagged forest and the remaining portions of White Oak Lake bed, and thus be an essential part of the programmatic development of radiation ecology at ORNL.

The contaminated old-field site also could serve as one of a series of experimental areas to be used in Civil Devense applications of radiation ecology. Ecological information on simulated postnuclear attack environments will become essential as predictions of postattack conditions become more sophisticated. Such information could be obtained from a series of field experiments in which blast, fire, and radiation might be variables. The contaminated old-field site could be one replicate as well as a source of experience and methodology in the design of the additional areas.

CONSTRUCTION AND CONTAMINATION OF AREAS

Site. Four 5-acre areas and eight 100 m^2 pens will be located on an old-field site in Melton Valley (Fig. 1). This site has been chosen because previous studies have shown that it will support adequate populations of animals (Dunaway and Kaye, 1961) and will present few problems related to contamination procedures. The Captina and Wolftever soils will fix cesium extremely well, and a fragipan 16 to 24 in. below ground surface limits the downward movement of water. The drainage of these areas is such that flooding will be no problem as it is on White Oak Lake bed.

Construction Details. Each 5-acre area and 100 m^2 pen will be enclosed with a fence made of sheet metal, extending 13 in. into the ground and 3 ft. above ground. Topping each fence will be a shocker wire to prevent predators from entering. A study of the semifossorial pine mouse (*Microtus pinetorum*) utilizing radioactive wire tags showed that this species does not dig more

than 12 in. deep in this area. Consequently, the 18 in. of metal below ground surface should prevent all small mammals from digging out or in. Pens similarly constructed, but extending only 6 in. into the ground, have been effective in containing cotton rats (Sigmodon hispidus) and white-footed mice (Peromyscus leucopus) for several months. A set of two such pens on an uncontaminated area is shown in Fig. 2. Metal fence posts will be located at the intersection points of a 10-meter grid system to serve as points of reference in the 5-acre areas.

A field laboratory, probably a large trailer, will be located at the field site. It will be necessary for most field examinations of specimens to be done in this field laboratory so that radiation exposure time of workers can be kept within permissible limits. Samples of blood and tissue will be taken in this field laboratory, and an ARMAC whole body counter will be located there for measurement of accumulation and elimination rates for the Cs^{137} in animals. By using this field laboratory, a considerable saving of time will be effected and animals will not be unduly stressed by unnecessary handling and transportation. A road to the field laboratory and around the fenced areas will facilitate movement of equipment and samples. An antipersonnel fence will be erected around the areas.

Contamination Procedures. -- After the mammal-proof fences have been erected (but with a gap left for entry of mobile equipment), the areas will be plowed and seeded with fescue (Festuca). The fence posts will then be placed in the areas. After the fescue attains enough coverage to prevent excessive water runoff and movement of soil particles, the cesium-137 will be applied in increments until the desired radiation field of 100 mR/hr is attained. The fence posts will serve as guide points for uniform distribution of the isotope. It is anticipated that liquid spray machines will deliver a mixture of isotope

and water. The water would provide shielding in the tank as well as serving as a diluent. The isotope is to be applied after installation of the fences so that the contamination will be confined on the study areas and so that workmen erecting the fences will not be exposed unnecessarily to radiation. It is expected that spot applications of isotope will have to be made in such places as corners to bring the radiation field up to the 100-mR/hr level. The control areas will be treated in the same manner as the experimental areas except that the isotope, of course, will note be present in the spray. Exact contamination procedures will depend in part on engineering and health physics requirements.

Cesium-137 is the radioisotope of choice for the six following reasons:

1. The 0.662-MeV gamma radiation is of sufficient energy to supply an adequate radiation field and to permit whole-body counts of live animals.
2. The 30-year physical half-life will permit establishment of relatively long-lasting and constant radiation fields so that series of long-term studies can be completed without the necessity of disturbing the areas by periodic reapplication of radioisotopes.
3. Excellent retention of cesium by the soil will ensure that decrease in radiation levels will be extremely slow and that escape of the cesium from the areas will be correspondingly slow.
4. Cesium is readily accumulated by plants and animals, thus permitting estimates of food chain transfer rates for the radioisotope.
5. Cesium-137 is relatively abundant in many radioactive wastes and after nuclear explosions. Consequently, data on the movement and effects of this radionuclide in the environment will be of special importance.
6. Comparisons of results will be possible with White Oak Lake bed and the contaminated forest area.

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DESCRIPTION OF RESEARCH PROJECTS

The research projects described below are designed to be mutually supporting wherever possible. Most of the studies will proceed concurrently, with laboratory work and other field work being used to complement these studies where necessary. Results from these projects in the next few years will indicate the course of research for the succeeding years.

Mammal Research Projects

1. Radiation effects on population growth rate and structure.--The objective of this project will be to determine the effects of low-level radiation on population characteristics of suitable small-mammal species subject to the stresses existing in a natural environment. Most research concerned with radiation effects has been oriented toward consequences to laboratory or domesticated mammals. Extrapolation of these data to free-ranging populations interacting with the environment cannot be done confidently without testing of hypotheses in field experiments because the effects of radiation on natural populations may be quite different from the responses in confined mammals. Two major hypotheses await testing: it may be that radiation effects are more severe in wild mammals than in caged mammals because the demands imposed by environmental stresses may interfere with repair of the radiation damage; on the other hand, wild mammals may be more radioresistant because physiological readiness induced by the environmental stresses may result in faster repair of radiation damages.

   A nother aspect to be considered is that subtle effects of low-level radiation on individuals may not be detected easily, but the

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summation of all these slight effects may give recognizable totals in terms of effects on the populations.

The procedures to be utilized in this project have been standardized by previous field and laboratory work (Dunaway and Kaye, 1961 and in press). Ten pairs of each species will be released into each radioactive and control area. Biweekly live-trapping periods of three days will allow estimates to be made of population increase and structure. The population increases thus can be compared within areas and with and with the estimated intrinsic rate of increase of each species. Data on breeding periods, litter size, gestation periods, interval between litters, breeding ages, and longevity will be necessary for rate-of-increase estimates. Our previous studies on the small mammals of this area (Dunaway and Kaye, 1961 and 1962; Kaye, 1961; Dunaway, 1962) show that observations on most of these factors made in other years and at other places can be used only for first approximations. Consequently, only data on these factors secured during the actual study periods will be utilized in the estimates of intrinsic rate of increase.

Breeding periods will be obtained simply by recording the breeding condition of the animals during the sampling periods. Litter sizes will be ascertained by removing near-term females to the laboratory, counting the number and sex of the young, marking the young, and returning the mother and litter to the site of capture. Breeding age and longevity will be established by observing the breeding condition and survival of these individuals marked at birth. Gestation periods and intervals between litters apparently do not vary greatly

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for a particular species, and data available from laboratory studies can be used with a modicum of error.

2. Radiation effects on blood and somatic chromosomes in relation to population parameters. -- This project will delineate the effects of low-level radiation manifested in the peripheral blood and somatic chromosomes in the populations of small mammals living on the radioactive areas. Other investigators have shown that a reduction in leucocytes, principally lymphocytes, occurs at a dose rate of a few rads per day in mice (Henshaw, 1944) and rats (Krise, Robinson, and Brown, 1961). Statistically significant reduction of erythrocyte number at 10 r/day was found by Sanders (1962) in the cotton rat but leucocytic values were not significantly different at the chronic doses up to 20 rads/day, in contrast with the findings of others with the albino laboratory rat. Our preliminary studies with rats penned on the White Oak Lake bed and receiving an average dose rate of 2.4 rads/day indicate that RBS and WBC counts are lower than in the rats penned on nonradioactive areas (Dunaway et al., unpublished data).

It is apparent that the results of hematological studies of irradiated laboratory mammals cannot be applied directly to wild mammals in a natural environment. For instance, we found that the RBC count dropped sharply and the WBC count increased sharply in cotton rats released into the outside environment after being held in cages from birth to adult size (Dunaway et al, unpublished data). Our incomplete studies also indicate that cell numbers change in relation to season. In short, and understanding of radiation effects on the blood of wild mammals will require that the effects contributed

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by other environmental factors be ascertained. If hematopoeitic tissues are affected by low levels of radiation, as appears to be the case, it may be that metabolism and ability to resist disease may be impaired in the affected mammals and eventually the whole irradiated population may be affected.

Blood samples will be taken at the field site from the trapped mammals. Blood smears for differential counts will be taken immediately, and the remainder of the samples will be taken to the laboratory for determination of RBC and WBC number, hematocrits, cell-size distributions, hemoglobin, and total serum solids. Starch-gel electrophoresis and paper chromatography will be employed routinely if the results of our studies with these methods this summer warrant continuance.

Aberrant somatic chromosomes are produced at a dose as low as 22.8 r and persist for years (Bender and Gooch, 1961). It is well known also that genetic damage is caused by radiation. The detection of genetic effects by large-scale breeding experiments and intensive cytological studies are beyond our present capabilities, but it should be possible to detect a nonlethal chromosomal aberration of genetic origin if the aberration is distributed in several tissues of an individual. Somatic chromosomal damage will be limited, of course, to the tissues affected. Primary interest in chromosomal aberrations centers around the consequences to natural populations exposed to stringent, and therefore selective, environmental factors. Metabolic disorders resulting from chromosomal damage or minute abnormalities that interfere with functions may not be serious in animals in the equable atmosphere of the laboratory, but these conditions may have serious consequences in a wild population during

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periods of extreme stress.

Epithelial tissues and blood from animals selected from the populations will be cultured in vitro by techniques similar to those used by Chu (1961) and Bender and Gooch (1961). The cells are cultured in media, treated with colchicine to accumulate metaphase stages, spread with a hypotonic salt solution, fixed, stained, and scored for deletions, interchanges, and polyploidy. Although epithelial cells are difficult to culture because of contamination from bacteria and fungi on the skin, we have used this technique successfully to culture tissue from the ears of cotton rats and rice rats (Dunaway and Childs, unpublished data). The control populations would supply information to the incidence of such aberrations in unirradiated animals.

3. Accumulation of cesium-137 in relation to population parameters and environmental factors. -- Uptake and elimination rates for cesium will be determined for the mammals on the radioactive areas. Previous studies (Kaye and Dunaway, 1962) found accumulation of Cs^{137} to be less in free-ranging rats than could be predicted on the basis of laboratory studies by others. It is important that this discrepancy be resolved. We must know the rates of uptake and elimination of cesium and the time necessary to reach equilibrium in order to estimate the contribution of the ingested Cs^{137} to total dose. Estimates of the turnover and transport of cesium by mammal populations also will allow predictions of the spread of cesium from contaminated areas. Food consumption can be estimated by using the Cs^{137} in the food as a tag. Studies of the effects of population parameters such as density and age structure and environmental factors such as weather and available food on radionuclide uptake and elimination rates

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are necessary in order to understand fluctuations in equilibrium values.

Obtaining uptake rates for cesium will be accomplished by placing uncontaminated mammals on radioactive areas and counting them in our ARMAC whole-body counter at 2-day intervals until equilibrium is reached. Determining elimination rates will be accomplished by simply reversing this procedure, i.e., removing the mammals at equilibrium, putting them on a nonradioactive area, and obtaining whole-body counts until the counts reach background. After uptake and elimination rates are established, it will be a relatively simple matter to estimate energy flow by utilizing the data on food consumption and population parameters in conjunction with respiration and calorimetric measurements. The 100 m^2 pens will be used extensively for obtaining data on food consumption and on uptake and elimination rates.

4. Comparative dosimetry of small mammals in radioactive areas.--
The objective of this project will be to ascertain the dose rates for several species which have differing sizes, activities, and food preferences. Variations in absorbed dose received by different species in the same area must be known for the immediate purpose of relating doses to radiation effects observed in the mammals on the study areas and are of interest for the more general purpose of predicting dose rates to mammals living in similarly contaminated environments.

Total doses and dose rates will be estimated by the use of low-Z, silver metaphosphate microdosimeters. These microdosimeters are extremely well suited for determining dose to various biological materials because they are small (1 mm dia. and 6 mm long), they

integrate dose, and they are dose independent. We have used hundreds of these microdosimters in soil, plants, and mammals and have found reproducibility to be excellent. Tiny threaded nylon capsules enclose the dosimeters to protect them from mechanical and chemical injury. Doses accumulated by the dosimeters are read on a Bausch and Lomb No. 33-66-02 reader.

A hypodermic syringe fitted with a plunger is used to implant the encapsulated microdosimeters under the skin of mammals. In each mammal, one dosimeter is placed dorsal to the scapulae and another dosimeter is placed ventral to the sternum so that the shielding afforded by the body can be ascertained. The needle puncture requires no stitches. Dosimeters can be removed without sacrificing the animal by nicking the skin and expelling the capsule through the nick. No modification of our present technique for the proposed study seems to be necessary in view of our extremely satisfactory results so far.

Entomology Research Projects.

Research on insects will consist of new field work on radiation effects as well as continuation of the studies carried out on White Oak Lake bed. This latter research will take advantage of the higher radioisotope concentrations for greater precision in tracer studies, and will extend the work into refinements which were not possible on the lake bed. The radiation effects studies also are a sequential development of both field and laboratory investigations on insect populations. Five research subprojects are anticipated, as follows:

1. Radiation effects on population structure and reproductive rates for major insect species. -- The effects of continuous, low-level irradiation on populations of insects are seldom the subject of

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speculation, probably because most LD_{50}'s which have been demonstrated for acute dosages are on the order of 10,000 r. (Auerbach et al. 1957). Laboratory studies here and elsewhere have shown that immature stages are more susceptible to somatic damage by radiation than are adults (Hassett and Jenkins 1952). Thus present information is not sufficient to predict whether or not the chronic, low-level radiation in these contaminated areas will have measurable effects on insect populations.

Population growth rates will be measured for available grasshopper species and selected hemipteran species, in contaminated and control areas. Laboratory studies may become necessary for standardization of measurements of growth and development rates. Age-specific mortality and growth rates will be calculated from weekly samples in irradiated areas and more frequent samples in control areas. Sweep-net and box-trap collecting techniques will be supplemented by vacuum devices for insect collections.

Community structure, as expressed in numbers of species and relative abundances, may be changed due to differential radiosensitivities of the insect species. The samples used to estimate population growth rates can also provide an index of community structure. In general, a reduced number of species relative to the number of individuals is to be expected in irradiated communities, but in the present instance the effect may not be exaggerated due to the low dose rates. It is important that community structure be measured simultaneously with population growth rates since one change may offset the other. Radiation effects on population growth, for example, can be offset by reduced predation pressure so that no net change results.

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Insects in samples will be sorted to species insofar as ordinary taxonomic means permit, tabulations will be made, and results of abundances will be compared with existing models of community organizations as well as between irradiated and control areas.

The importance of this work lies in the possibility that radiation in the environment might disrupt the balance between producer and consumer organisms. Despite their small size, insects are consumers of major importance; in agricultural situations they are man's chief competitor for food. Ecological work is only beginning to progress towards interpretation of the relationship between the production of living material and the rate at which it is consumed. This subproject will bear directly on this important work.

2. Measurements of insect-plant interactions in irradiated and control areas. -- The association between insect species and plants ranges from a host-specific to a random one. Most plant-feeding insects manifest a degree of host preference, which can be manipulated ecologically. Comparisons between control and irradiated populations of insects as to their plant host responses may reveal changes which are the end results of ecological effects of irradiation. This information would help interpret the ecological consequences of such specialized associations where resources are not acting as population controls. In this subproject the variety of hosts attacked, relative host preferences, and selective feeding sites would be measured for the major insect species. Differences between irradiated and control areas would provide clues as to possible lines of research

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on radiation effects on ecological interactions.

3. Energy flow through insect food chains in irradiated and control areas.-- This subproject will aim at detection of changes in rates of movement of both energy and materials from plants to insect consumers to insect predators. Such a change would ultimately affect all parts of the ecosystem and might prove to be the most serious consequence of radiation in the environment. In addition, this subproject will provide an opportunity to compare radioisotope techniques with conventional methods for measuring energy flow. The radioisotope techniques developed at ORNL have attracted attention and are being used elsewhere. This subproject constitutes a logical extension in the development of these techniques. Equilibrium concentration of Cs^{137} in insects, Cs^{137} content of food plants, insect and plant biomasses, and diurnal variations in termperature will be measured. Calorimetric measurements will be made for insects, plants, and insect feces; respiration rates for mixed samples of insects will be made at several temperatures. Previous laboratory data on Cs^{137} elimination rates will be supplemented by additional laboratory experimentation.

4. Estimates of radioisotope spread to adjacent areas by local immigration of insect populations. -- Spread of contamination through insect movements is not expected to be a significant hazard, except possibly in very localized situations involving high specific activities. The magnitude of the hazard may be estimated from samples of insects taken at increasing distances from the contaminated plots. Of more

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importance is the possibility of using a radioisotope technique to quantify the vagilities of insect species, since rates of migration are not known even for many economically important insects.

5. Short-term fluctuations in steady-state Cs^{137} concentrations in response to environmental variables. -- Steady-state concentrations in animals are used in the estimation of radioisotope intake and turnover by populations. This project will measure the possible fluctuation in steady-state concentrations due to temperature and humidity fluctuations.

Laboratory work has shown that elimination rates increase with increasing temperature. Unless offset by increased feeding, this would result in a lower body concentration of the radioisotope. Combined field and laboratory experimentation will detect whether (a) steady-state concentrations fluctuate in direct relation to environmental effects on elimination rate, (b) changes in intake rate compensate (wholly or in part) for changes in elimination rate, or (c) differential responses of different insect species compensate for the effect of environmental variables.

Soil Research Project

The purpose of this project will be to measure cesium movement in the soil and entrance into ground water. Downward and lateral movement of the cesium will be of interest because of effects on radiation field and changes in cesium availability to plants. These rates of movement also will be of interest from the viewpoint of radioactive waste disposal.

Movement of cesium through the illitic Captina and Wolftever soils of the proposed areas will be extremely slow because of the known high affinity of cesium for illitic minerals (Tamura and Jacobs, 1960).

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The fragipan (16 to 24 in. below ground surface) and the pen walls (18 in. deep) should further limit the downward and lateral movements, respectively, of the cesium.

Soil cores will be taken periodically throughout the areas, divided into depth fractions, and analyzed for radioactivity. Cores will b taken around the periphery of the contaminated areas to test for lateral movement of the cesium. Monitor wells located around the contaminated areas will detect the appearance of cesium in the ground water.

Plant Research Project

The objective of this project will be to measure seasonal variations in the concentrations and distribution of cesium-137 in the above-ground parts of plant species utilized as food by the animals. Radionuclide content of the plants must be known in order to supply information for calculations of radionuclide transfer from soil to plant to animal. Food consumption can also be estimated by using the cesium-137 as a tag (Crossley, in press).

Aboveground vegetation in randomly selected 0.5 m^2 plots will be harvested during each season of the year, divided into species, separated into parts (stems, leaves, flowers, and seeds), and counted for radioactivity in our Packard Auto-Gamma Spectrometer. Plant species actually fed upon by the animal species of interest will be ascertained by direct observations of feeding and discarded parts of plants and by examination of stomach contents in the case of mammals. Biomass or at relative growth of major vegetation species will be measured in irradiated and control areas, primarily in support of other

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projects, since vegetative changes might well interact with changes in animal population. As soon as is possible, a more detailed and exacting study will be initiated on the plant responses to radiation in flux contaminated areas.

Personnel

Four additional persons will be required to fulfill the objectives listed and to continue the research presently underway. These persons would work within the present organizational framework as a cooperative group, since the objectives for the studies on the 5-acre areas are related to the objective of the present studies and are logical extensions of findings to date. Present employees and the additional employees will be rotated in field work as much as practical to prevent any person from exceeding radiation exposure limits.

The additional persons needed would be (1) a vertebrate populations ecologist, (2) an invertebrate populations ecologist, (3) a field and laboratory assistant for the vertebrate studies, and (4) a field and laboratory assistant for the invertebrate studies.

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Illustrations

Fig. 1 Proposed location of contaminated and uncontaminated 5-acre areas and 100 m^2 pens.

Fig. 2 Two 100 m^2 pens on uncontaminated area.

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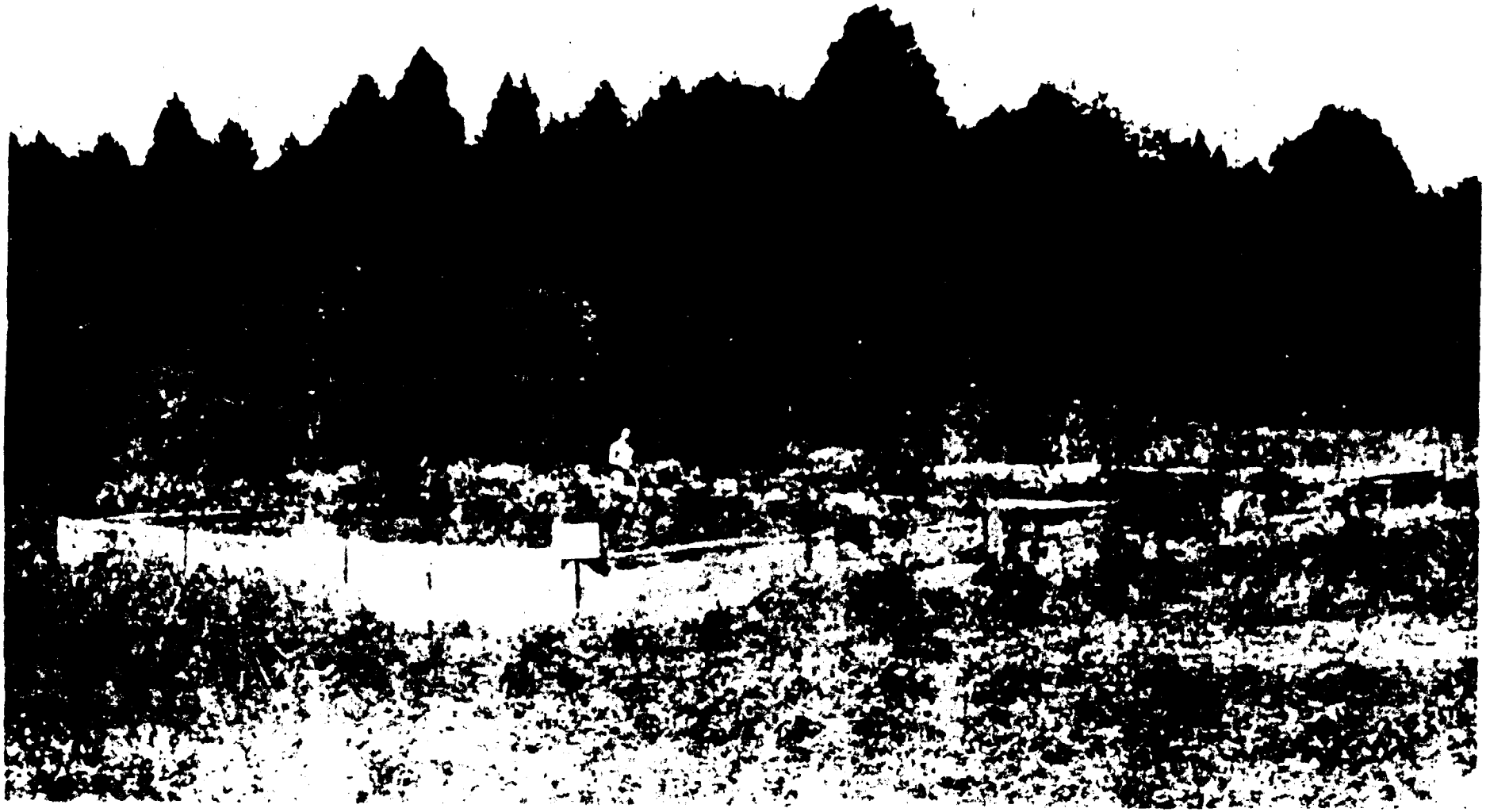

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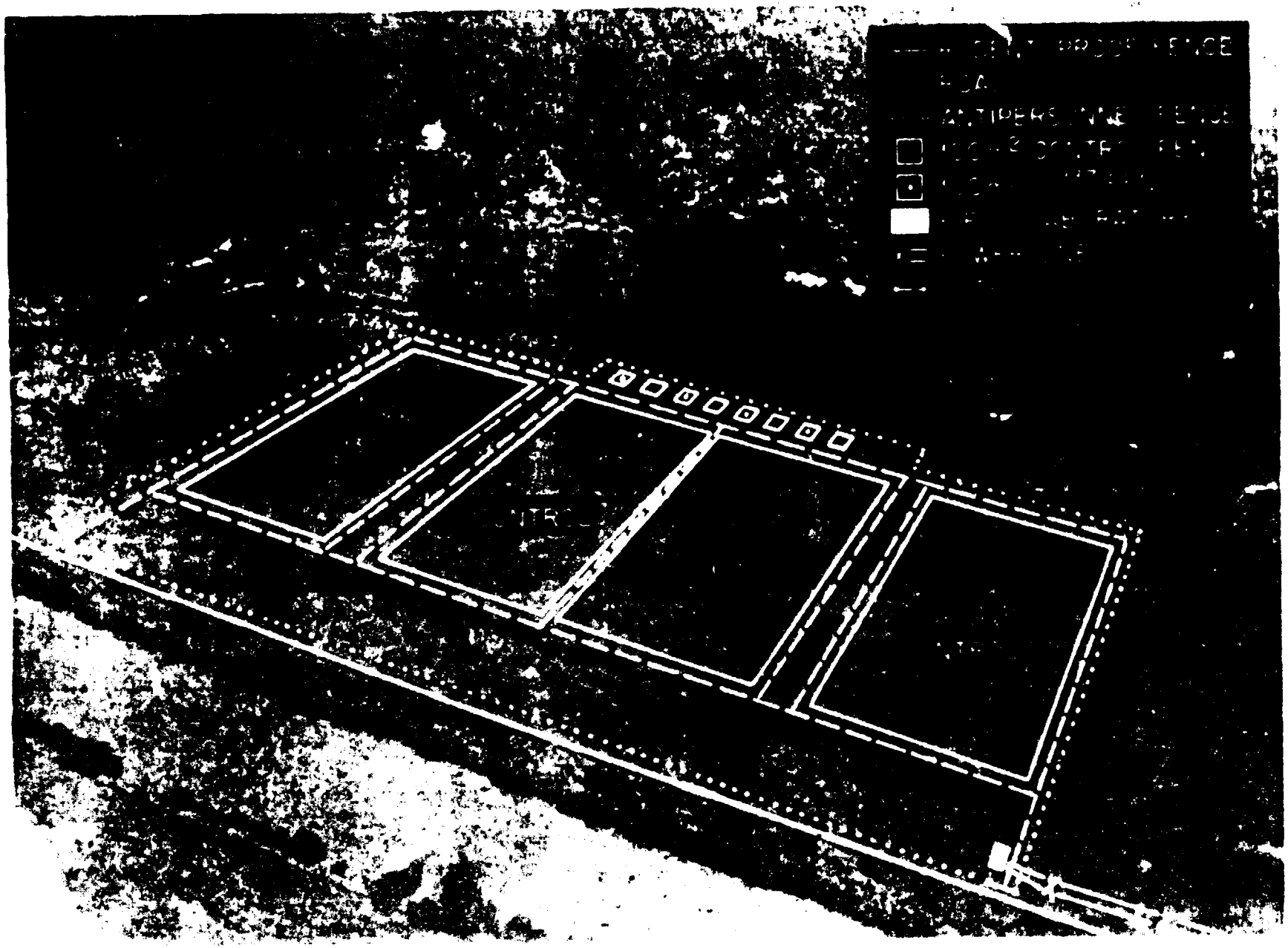
PHOTO 64456



1028411

April 30, 1963

To: S. I. Auerbach

From: K. Z. Morgan

Subject: Contaminated Old-Field Proposal

I was very much interested in this proposal and believe you have presented it on a sound basis. I would like to call your attention to several minor corrections which should be made on the final draft as follows.

On pages 1, 7 and 8, you have referred to a radiation field of 100 mR per hour. This, of course, has no meaning unless the value is stated at a given elevation. In fallout studies in the neighborhood of weapons detonation, when the height is not stated it is normally assumed to be three feet above the ground. In this case, however, I assume you are referring to a reading closer to the ground, perhaps one foot or six inches. One should, of course, avoid stating the dose rate in contact with the ground because, as the distance approaches zero, this leads to an indeterminate, both in theory and in measurement. Therefore, I suggest you give the radiation field as 100 mR per hour at the certain height.

On page 8, item 1, I think it would be well to emphasize that the use of this high energy 0.662 Mev gamma is desirable because the dose rate is not quite so critical with depth of penetration of the radionuclide into the soil. I am sending you a copy of Chapter X which discusses some of the problems of calculating dose from a large area and from a large volume. The great uncertainty in the calculation of dose is, of course, due to lack of knowledge of the pattern of distribution in depth of the radionuclide in the soil but this is less critical for high energy radiation.

On page 15, you state that these glass dosimeters are dose independent. I presume by this you mean to state that they give a true reading of dose over a very wide range of integrated dose and perhaps the lower limit is determined by the inaccuracies of reading low doses. The statement would be more useful if you could state this range of usefulness. Other important perimeters of such meters are related to dose rate independence and energy independence. By this we mean, of course, that the integrated dose from the meter would be, for example, 100 R whether it was exposed at a 100 R per hour for one hour or 1 R

per hour for 100 hours. By energy independence, we mean that the readings in absorbed dose (or rads) represent a response characteristic of ergs per gram in tissue irregardless of the energy of the radiation. Another important characteristic of the response of such meters would be their ability to record the true dose from beta radiation and from mixtures of beta and gamma radiation. I am not an expert on these instruments but suggest you check with John Auxier or someone to get this data. For small animals especially, the surface beta dose could be quite important. Likewise, for large animals the fraction of the dose from beta radiation might give an overestimate of the significant exposure.

Page 10, line 9, remove the words "and with" which are repeated.

On page 11, and perhaps in other parts of the report, you use "WBC" and "RBC" followed by the word "count." Isn't this a redundancy? I thought WBC and RBC referred to white blood count and red blood count.

Sincerely,

Original Signed By
K. Z. MORGAN

Karl Z. Morgan

KZM:jc

Enclosure

cc: E. D. Struxness

1148209

MAY 2 - 1963 E.2

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

May 1, 1963

To: Distribution

Re: Cesium Contaminated Old Field Proposal

Enclosed is a draft copy of the soil description of the proposed cesium contaminated area prepared by H. D. Waller. Please include this with your draft copy of the over-all proposal.

S. I. Auerbach

SIA:cg

Distribution

T. J. Burnett
D.A. Crossley
P. B. Dunaway
W. H. Longaker
K. Z. Morgan
F. L. Parker (3)
E. G. Struxness
H.D. Waller

1148210

UCN-480

PRELIMINARY SOIL DESCRIPTION OF THE CESIUM-137 FIELD STUDY AREA

GENERAL DESCRIPTION OF THE AREA

The study area is underlain by terrace soils. These soils have developed in Clinch River sediments primarily derived from limestone material with a lesser portion coming from a mixture of sedimentary rock (sandstone and shales). This area is dominated by two soil series, the Captina series and the Wolftever series.

The Captina series (Ultisol Fragochrult) (1) consist of moderately well drained red-yellow podzolic soils with fragipans. These soils have developed on stream terraces in landscapes which are derived primarily from limestone materials. Captina soils are closely associated with the well drained Cumberland, Etowah, and Elk soils; the moderately-well drained Wolftever soils and the more poorly drained Taft and Robertsville soils. Their fragipans and mottling in the lower subsoils differentiate them from the Elk and Wolftever soils; and they are browner and lack the mottling in the upper subsoils that characterizes the Taft series. Captina soils occur along many of the larger streams throughout the mid-South and mid-Eastern Atlantic states of Kentucky, Tennessee, Northern Alabama, Maryland, West Virginia, Pennsylvania, Virginia, Missouri, North West Georgia, and Arkansas. (2)

The Wolftever series (Ultisol Umbrictypochrult) (1) consists of well-drained to moderately well drained red-yellow podzolic soils with compact lower subsoils. These soils have developed on low stream terraces which are derived from a variety of rock; however, limestone derived materials are generally dominant. The Wolftever soils occupy low stream terraces

1148211

in close geographic association with the Huntington, Etowah, and Sequatchie soils. They have more distinct horizons, are lighter colored, more acid, much more compact and less well drained than the Huntington and Stasser soils of the first bottom lands, and they are younger, more compact, usually finer textured than Etowah soils of the stream terraces. The Wolftever soils occupy positions similar to Sequatchie soils, but are differentiated from the Sequatchie soils by lighter color, finer texture and compact subsoil layer. Wolftever soils occur in limited acreage along the larger flood areas in Tennessee, Kentucky, Northern Alabama, and Northwest Georgia.

The Captina series occupies the central portion of the study area that is gently sloping to rolling with slopes ranging from 3 to 6%. Captina silt loam is the dominant soil type. Thickness of the alluvial deposit is estimated to be greater than 20 feet. The total thickness of the solum ranges from about 30 to 50 inches and depth to the fragipan from 18 to 28 inches. Permeability to air, water, and roots is limited by the fragipan layer. Surface runoff is slow to medium (3).

The lower landscape on the east and west end of the study area is occupied by the Wolftever series, which is finer textured than the soils on the higher landscape. These soils have a compact, fine textured, mottled layer occurring 20 to 24 inches below the surface. Although a cemented fragipan does not exist in these soils, the effect of this compact layer on movement of air and water is similar. Dominant soil type is Wolftever silt loam which occurs on nearly level to gently sloping low stream terraces. Slope gradient varies from 2 to 4% and thickness of the alluvial deposit is greater than 15 feet.

1148212

There are a few isolated seepage areas at the base of the higher landscape that make up an estimated 3 to 5% of the total area. Soils occurring in these areas are less well drained than either of the above soils. They are similar to the Taft soils. These seeps or wet areas are probably caused by lateral movement of water along the upper surface of the fragipan layer of the Captina soils during periods of heavy rainfall.

Surface erosion and consequent movement of Cs^{137} will be a factor in shifting of the open field radiation dose and also a factor in the hazards evaluation. The estimated surface erosion can be calculated by using the soil loss estimate equation developed for Tennessee conditions by the Agriculture Research Service, Soil Conservation Service, and The University of Tennessee (4).

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad (1)$$

where

A - (amount of surface erosion in tons per acre per year) is a product of the following factors:

R - (rainfall - erosion index factor for Roane County)

K - (soil erodibility factor for soil series in question)

LS - (soil-loss ratio for length and degree of slope in question)

C - (cropping - management factors for cropping system used)

P - (conservation practice values used).

If the most extreme slope occurring in the study area is considered for the equation, one obtains the maximum erosion hazards, which is calculated as follows:

$$A = R \cdot K \cdot LS \cdot C \cdot P = \text{tons per acre per year} \qquad (2)$$

1148213

Where

R = 210 (rainfall erosion index value for Roane County)

K = 0.42 (soil erodibility factor for Captina silt loam)

LS = 0.70 (soil-loss ratio for 6% slope 100 feet long)

C = .009 (meadow renovated every 6 years)

P = 1.0 (no conservation practices such as terracing or contour tillage anticipated)

Then

A = (210)(0.42)(0.70)(.009)(1.0)

A = .79 tons per acre per year.

After this study area has a complete vegetative cover of fescue grass, the soil loss estimate equation suggests that surface erosion will be controlled within satisfactory limits. If the most extreme slope is considered for the equation, one obtains .79 tons per acre per year of top soil removed by erosion. This estimate includes soil loss that occurs during the seed bed preparation, seeding, period required for establishment of vegetative cover, and renovation every six years. Since an estimated 90% or more of the surface erosion occurs during seed bed preparations and during the period required for establishment of vegetative cover, this estimate is considered to be too high for the particular situation being proposed--establishment of a good vegetative cover before the radionuclide is applied. Therefore, a factor should be introduced to reduce the calculated amount by 90% to arrive at a more realistic number. If this factor is used to modify the equation one obtains .08 tons per acre per year of top soil removed on the steeper slopes. These slopes occupy less than 20% of the total land area.

Specific soil profile descriptions in Attachments A and B.

1148214

REFERENCES

(1) Tentative classification of soils into order, suborder, and great groups according to the 7th Approximation of International Scheme of Soil Classification, Soil Conservation Service, U.S.D.A., August, 1960.

(2) Established soil series, Wolftever Series, and Captina Series, distribution and associated soils. Prepared by Southeastern Soil Correlations Office, Soil Conservation Service, U.S.D.A.

(3) Terms used are those suggested by Soil Survey Manual; U.S.D.A. Handbook No. 18, 1951.

(4) Soil Loss Estimating in Tennessee, Proceedings from Soil Loss Predictions Conference held at University of Tennessee, April 10, 1959.

1148215

ATTACHMENT A

DESCRIPTION OF SPECIFIC PROFILES

CAPTINA SERIES

This soil profile was taken on the crest of the higher landscape. Slope gradient was 1 to 5%. Vegetation dominantly sedge grass.

SOIL PROFILE: Captina silt loam

A_p	0-8 inches	Dark grayish brown (10 YR 4/2) silt loam, weak fine granular structure; consistency-friable; medium acid.
B_1	8-14 inches	Light yellowish brown (10 YR 6/4) silt loam with few faint mottles; weak, medium subangular blocky structure; consistency - friable; strongly acid.
B_2	14-19 inches	Brownish yellow (10 YR 6/6) silt loam; moderate to weak medium subangular blocky structure; consistency - friable; strongly acid.
B_{3m1}	19-30 inches	Very pale brown (10 YR 6/6) coarse silt loam mottled with pale yellow (7.5 YR 6/4) and brownish-yellow (10 YR 6/6). Compact, massive or very coarse platy structure; consistency-friable when moist and firm when dry. Abundant soft brown and black concretions which are probably iron and manganese concretions.
B_{3m2}	30-40 inches +	Dominantly lighter colored than above layer, with coarse fragments throughout and more compact.

On April 26, 1962, when profile was taken, perched water table located at 36 inches.

1148216

WOLFTEVER SERIES

This low-terrace soil is located on the lower landscape on the east and west end of the study area. Slope gradients are generally less than 3%. Vegetation is more varied than on the Captina series, however, sedge grass, honeysuckle, and blackberry briars are probably the most dominant types of vegetation. Profile was taken on east side of the study area.

SOIL PROFILE: Wolftever silt loam

A_p	0-7 inches	Brown (10 YR 5/3) silt loam with few faint discolorations; moderate coarse granular structure; consistency - friable.
B_1	7-12 inches	Strong brown to brown (7.5 YR 5/6-5/4) silty clay loam; moderate medium subangular blocky structure; consistency - friable.
B_2	12-24 inches	Yellowish brown (10 YR 5/4) fine silty clay loam or silty clay; moderate, medium subangular blocky structure; firm and compact when moist slightly plastic and sticky when wet. Many dark colored manganese concretions present throughout the layer.
B_{22}	24-34 inches +	Yellowish brown (10 YR 5/4) coarse, silty clay loam mottled with pale yellow (2.5 YR 7/4) and yellow (2.5 YR 8/8); few manganese concretions and dark stains throughout the layer; moderate, medium angular blocky structure; very dense layer that is hard when dry and firm and compact when moist.

On April 26, 1962, when profile was taken perched water table located at 34 inches.

NOTE: (1) Terms used are those suggested by Soil Survey Manual, U.S.D.A. Handbook No. 18, 1951.

(2) Color notations are according to the Munsell Color Book.

1148217

ROUTE SLIP

✓	To	Initial	✓	To	Initial
	S I Auerbach			H D Waller	
	B G Blaylock			J P Witherspoon	
	G N Brown			M Witkamp	
	C L Corley				
	D A Crossley				
	P B Dunaway				
	M L Frank				
	S V Kaye				
	N R Kevern				
X	K Z Morgan				
	D J Nelson				
	J S Olson				
	L L Smith				
	W S Snyder				
	E G Struxness				
	F G Taylor				

DESIRED ACTION

- [ ] Your Approval
- [ ] Your Comments
- [x] Your File
- [ ] Your Information
- [ ] Prepare Report and Forward to this Office
- [ ] Initial and Pass On
- [ ] Prepare Reply for My Signature
- [ ] Please Handle
- [ ] Per Conversation
- [ ] See Me
- [ ] Note and Return
- [ ] _____
- [ ] _____
- [ ] _____

REMARKS: This is a [illegible] version.

FROM S I Auerbach

DATE 5/21/[illegible]

UCN-230
(1235 10-58)

1148218

MAY 22 1963

DRAFT

PRELIMINARY SOIL DESCRIPTION OF THE CESIUM-137 FIELD STUDY AREA

GENERAL DESCRIPTION OF THE AREA

The study area is underlain by terrace soils. These soils have developed in Clinch River sediments primarily derived from limestone material with a lesser portion coming from a mixture of other rocks (sandstone and shales). This area is dominated by two soil series, the Captina series and the Wolftever series.

The Captina series (Ultisol Fragochrult) (1) consist of moderately well drained red-yellow podzolic soils with fragipans. These soils have developed on stream terraces in landscapes which are derived primarily from limestone materials. Captina soils are closely associated with the well drained Cumberland, Etowah, and Elk soils; the moderately-well drained Wolftever soils and the more poorly drained Taft and Robertsville soils. Their fragipans and mottling in the lower subsoils differentiate them from the Elk and Wolftever soils; and they are browner and lack the mottling in the upper subsoils that characterizes the Taft series. Captina soils occur along many of the larger streams throughout the mid-South and mid-Eastern Atlantic states of Kentucky, Tennessee, Northern Alabama, Maryland, West Virginia, Pennsylvania, Virginia, Missouri, North West Georgia, and Arkansas. (2)

The Wolftever series (Ultisol Umbrictypochrult) (1) consists of well-drained to moderately well drained red-yellow podzolic soils with compact lower subsoils. These soils have developed on low stream terraces which are derived from a variety of rock; however, limestone derived materials are generally dominant. The Wolftever soils occupy low stream terraces

1148219

in close geographic association with the Huntington, Etowah, and Sequatchie soils. They have more distinct horizons, are lighter colored, more acid, much more compact and less well drained than the Huntington and Stasser soils of the first bottom lands, and they are younger, more compact, usually finer textured than Etowah soils of the stream terraces. The Wolftever soils occupy positions similar to Sequatchie soils, but are differentiated from the Sequatchie soils by lighter color, finer texture and compact subsoil layer. Wolftever soils occur in limited acreage along the larger flood areas in Tennessee, Kentucky, Northern Alabama, and Northwest Georgia.

The Captina series occupies the central portion of the study area that is gently sloping to rolling with slopes ranging from 3 to 6%. Captina silt loam is the dominant soil type. Thickness of the alluvial deposit is estimated to be greater than 20 feet. The total thickness of the solum ranges from about 30 to 50 inches and depth to the fragipan from 18 to 28 inches. Permeability to air, water, and roots is limited by the fragipan layer. Surface runoff is slow to medium (3).

The lower landscape on the east and west end of the study area is occupied by the Wolftever series, which is finer textured than the soils on the higher landscape. These soils have a compact, fine textured, mottled layer occurring 20 to 24 inches below the surface. Although a cemented fragipan does not exist in these soils, the effect of this compact layer on movement of air and water is similar. Dominant soil type is Wolftever silt loam which occurs on nearly level to gently sloping low stream terraces. Slope gradient varies from 2 to 4% and thickness of the alluvial deposit is greater than 15 feet.

1148220

There are a few isolated seepage areas at the base of the higher landscape that make up an estimated 3 to 5% of the total area. Soils occurring in these areas are less well drained than either of the above soils. They are similar to the Taft soils. These seeps or wet areas are probably caused by lateral movement of water along the upper surface of the fraipan layer of the Captina soils during periods of heavy rainfall.

Surface erosion and consequent movement of Cs^{137} will be a factor in shifting of the open field radiation dose and also a factor in the hazards evaluation. The estimated surface erosion can be calculated by using the soil loss estimate equation developed for Tennessee conditions by the Agriculture Research Service, Soil Conservation Service, and The University of Tennessee (4).

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad (1)$$

where

A - (amount of surface erosion in tons per acre per year) is a product of the following factors:

R - (rainfall - erosion index factor for Roane County) is the local annual value of the rainfall erosion index (EI). EI value/year.

The rainfall-erosion index is a numerical evaluation of the capacity of a specific rainfall pattern to erode soil from unprotected fields. Individual-storm soil losses from tilled fallow plots from 70 to 90 feet are linearly correlated with erosion-index (EI) values of the storms.

1148221

The EI value of a storm is the product of its rainfall energy (in hundreds of foot-tons per acre) and its maximum 30 minute intensity. The rainfall-erosion index for a given year is the sum of the EI values computed for the individual storms.

The rate of soil loss per EI unit varies with soil and slope characteristics.

K - (erodibility factor or K value of a specific soil) is the soil loss in tons per acre per EI unit of a fallow soil on a 9% slope that is 72.6 feet in length.

The basic soil loss in the equation is expressed by the product of the R and K factors. The other factors (LSCP) are relative values to correct for specific conditions and are obtained from specific tables and charts in Ref. 4.

Therefore $A = (R \cdot K) \cdot (\text{modifying factors, -LS,C,P})$

$= \text{EI value/year x tons per acre/EI value } (L \cdot S \cdot CP)$

Since EI value is some numerical value x

$A = (\text{x tons per acre per year}) \cdot (LSCP)$

LS - Soil-loss ratio for length and degree of slope in question.

C - (cropping-management factor) a numerical evaluation of the combined effects of cover, management, prior land use, and distribution of erosion potential relative to planting and harvesting dates.

1148222

P - (conservation practice factor) the effective value of man-made structures or conservation practices on reducing the erosion potential.

If the most extreme slope occurring in the study area is considered for the equation, one obtains the maximum erosion hazards, which is calculated as follows:

$$A = R \cdot K \cdot LS \cdot C \cdot P = \text{tons per acre per year} \qquad (2)$$

where

R = (rainfall erosion index value for Roane County) = 210 EIunits/year,

K = (soil erodibility factor for Captina silt loam) = 0.42 tons/acre/EI unit,

LS = (soil-loss ratio for 6% slope 100 feet long) = 0.70, F.

C = (cropping management factor which is - meadow renovated every 6 years) = .009

P = (no conservation practice such as terracing or contour tillage anticipated) = 1.0

(The above factorial values are obtained from handbook on Soil-Loss Estimating in Tennessee, Reference No. 4):

R value - Table 1 and Figure 1

K value - Table 2

LS value - Figure 2

C value - Table 6

P value - Table 7

then

$$A = (210 \text{ EI units/year})(0.42 \text{ tons/acre/EI unit})(0.70)(.009)(1.0)$$

$$A = .556 \text{ tons per acre per year.}$$

This estimate includes soil loss that occurs during the seed bed preparation,

1148223

seeding, period required for establishment of vegetative cover, and renovation every six years. Since an estimated 90% or more of the surface erosion occurs during seed bed preparation and during the period required for establishment of vegetative cover, this estimate is considered to be too high for the particular situation being proposed--establishment of a good vegetative cover before the radionuclide is applied. Therefore, vegetative cover factor (V) should be introduced into the equation, which may be calculated as follows:

$$A = R \cdot K \cdot LS \cdot C \cdot P \cdot V = \text{tons per acre per year}$$

where

R = 210 EI units/year

K = 0.42 tons per acre per EI unit

LS = 0.70 soil loss ratio

C = .009 crop-management factor

P = 1.0 conservation practice factor

V = 0.10 vegetation factor

then

$$A = (210)(0.42)(0.70)(0.009)(1.0)(0.10)$$

$$A = .056 \text{ tons per acre per year.}$$

After this study area has a complete vegetative cover of grass (Festuca), the soil loss estimate equation suggests that surface erosion will be controlled within satisfactory limits. If the most extreme slope is considered for the equation, one obtains .056 tons per acre per year. This is well below the annual soil loss tolerance of 3[a] tons per acre per year which is a criterion

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[a] Soil Loss Tolerance from Table 2 of Soil Loss Estimating in Tennessee, Reference No. 4.

1148224

used to maintain sustained economic production for agriculture usage.

Specific soil profile descriptions in Attachments A and B.

1148225

REFERENCES

(1) Tentative classification of soils into order, suborder, and great groups according to the 7th Approximation of International Scheme of Soil Classification, Soil Conservation Service, U.S.D.A., August, 1960.

(2) Established soil series, Wolftever Series, and Captina Series, distribution and associated soils. Prepared by Southeastern Soil Correlations Office, Soil Conservation Service, U.S.D.A.

(3) Terms used are those suggested by Soil Survey Manual; U.S.D.A. Handbook No. 18, 1951.

(4) Soil Loss Estimating in Tennessee, Proceedings from Soil Loss Predictions Conference held at University of Tennessee, April 10, 1959, 72 p. (unpublished handbook).

1148226

ATTACHMENT A

DESCRIPTION OF SPECIFIC PROFILES

CAPTINA SERIES

This soil profile was taken on the crest of the higher landscape. Slope gradient was 3 to 5%. Vegetation dominantly sedge grass.

SOIL PROFILE: Captina silt loam

A_p	0-8 inches	Dark grayish brown (10 YR 4/2) silt loam, weak fine granular structure; consistency-friable; medium acid.
B_1	8-14 inches	Light yellowish brown (10 YR 6/4) silt loam with few faint mottles; weak, medium subangular blocky structure; consistency - friable; strongly acid.
B_2	14-19 inches	Brownish yellow (10 YR 6/6) silt loam; moderate to weak medium subangular blocky structure; consistency - friable; strongly acid.
B_{3m1}	19-30 inches	Very pale brown (10 YR 6/8) coarse silt loam mottled with pale yellow (7.5 YR 8/4) and brownish-yellow (10 YR 6/6). Compact, massive or very coarse platy structure; consistency-friable when moist and firm when dry. Abundant soft brown and black concretions which are probably iron and manganese concretions.
B_{3m2}	30-40 inches +	Dominantly lighter colored than above layer, with coarse fragments throughout and more compact.

On April 26, 1962, when profile was taken, perched water table located at 36 inches.

1148227

WOLFTEVER SERIES

This low-terrace soil is located on the lower landscape on the east and west end of the study area. Slope gradients are generally less than 3%. Vegetation is more varied than on the Captina series, however, sedge grass, honeysuckle, and blackberry briars are probably the most dominant types of vegetation. Profile was taken on east side of the study area.

SOIL PROFILE: Wolftever silt loam

A_p	0-7 inches	Brown (10 YR 5/3) silt loam with few faint discolorations; moderate coarse granular structure; consistency - friable.
B_1	7-12 inches	Strong brown to brown (7.5 YR 5/6-5/4) silty clay loam; moderate medium subangular blocky structure; consistency - friable.
B_2	12-24 inches	Yellowish brown (10 YR 5/4) fine silty clay loam or silty clay; moderate, medium subangular blocky structure; firm and compact when moist slightly plastic and sticky when wet. Many dark colored manganese concretions present throughout the layer.
B_{22}	24-34 inches +	Yellowish brown (10 YR 5/4) coarse, silty clay loam mottled with pale yellow (2.5 YR 7/4) and yellow (2.5 YR 8/8); few manganese concretions and dark stains throughout the layer; moderate, medium angular blocky structure; very dense layer that is hard when dry and firm and compact when moist.

On April 26, 1962, when profile was taken perched water table located at 34 inches.

NOTE: (1) Terms used are those suggested by Soil Survey Manual, U.S.D.A. Handbook No. 18, 1951.

(2) Color notations are according to the Munsell Color Book.

1148228