RESPONSE OF A FOREST ECOTONE TO IONIZING RADIATION

Progress Report

For Period October 15, 1976 - October 14, 1977

Peter G. Murphy, Principal Investigator

Michigan State University
East Lansing, Michigan

and

Rebecca R. Sharitz, Co-Investigator

Savannah River Ecology Laboratory
Aiken, South Carolina

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

July 1977

PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT

ADMINISTRATION UNDER CONTRACT EY-76-S-02-2283

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed or represents that its use would not infringe privately owned rights.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Abstract

Compositional and structural characteristics of three forest types, including aspen dominated, maple-birch dominated, and an intervening ecotone, were studied before and after irradiation in northern Wisconsin. Preirradiation findings are reported in papers by Murphy and Sharitz (1974) and Murphy, Sharitz, and Murphy (1974). A detailed analysis of the overall results obtained through 1975 is presented in the appended published paper (Murphy, Sharitz and Murphy, 1977).

Irradiation occurred during the summer of 1972. By the summer of 1973 the density of viable tree seedlings at 10 m from the radiation source was substantially reduced in all three areas relative to the preirradiation densities of 1971. As of the summer of 1976, establishment of tree seedlings continued to be inhibited by the vigorous development of ground vegetation. At 20 m, the density of seedlings in the three areas increased during the period from 1971 to 1973 in response to the partially opened canopy. The overall density of seedlings of Populus tremuloides and Acer rubrum increased markedly in the three areas and P. tremuloides invaded some areas in which it had not been found prior to irradiation. By 1974 many of the seedlings at 20 m had reached the sapling size-class. Viable trees greater than 2.5 cm in dbh were eliminated at 10 m in all three areas by June of 1974 and were reduced in density at 20 m. At the present time it appears that recolonization of the 10 m irradiated zone by the original tree flora will be a very slow process.

Leaf litter production was reduced by up to 92% at 10 m and 62% at 20 m during the period from 1971 to 1973 in the irradiated areas. The reduction was greatest in the aspen area. Leaf litter reduction in the ecotone and maple-birch areas was less severe, averaging 50% at 10 m and 24% at 20 m. By 1974 the heavily irradiated zones in all three areas showed a pronounced reduction in the ratio of tree leaf litter produced to shrub leaf litter produced but by 1975 and 1976 the ratio had already begun to increase (suggesting recovery) in the aspen and ecotone areas, respectively. As of 1976 shrubs continued to increase in importance at 10 and 20 m in the maple-birch area.

In most respects the ecotone has shown properties and responses to radiation intermediate to those observed in the aspen and maple-birch areas. The rate and compositional characteristics of succession in the ecotone relative to aspen and maple-birch forest types is presently under study.

Preface

The investigations discussed herein were originally undertaken as a cooperative research effort with the Radiobiology of Northern Forest Communities Project of the Institute of Forest Genetics at Rhinelander, Wisconsin. While that project has been terminated, this study has continued as originally planned. Our study is the only on-going effort directed toward an analysis of long-term patterns of succession and recovery in the irradiated forest.

Approximately 15% of my time (Principal Investigator) has been devoted to the project since the beginning of the current term of the agreement. At least 15% of my time will be devoted to the project during the remainder of the current term. Dr. Rebecca Sharitz (Co-Investigator) has devoted approximately 15% of her time to the project and expects to devote a similar proportion of her time to the project during the remainder of the current term.

Activities for 1976 - 1977

One sampling trip to the Enterprise Radiation Forest has already been made during the current contract period and two additional trips are planned, one in August and one in October. All sampling proposed in the 1976-77 renewal proposal has, therefore, been completed or is on schedule.

A detailed discussion and analysis of the data collected from the beginning of the project through 1975 can be found in the appended reprint (Murphy, Sharitz and Murphy, 1977). Information contained in the reprint will not be repeated here. Two reprints of publications concerning our preirradiation studies have previously been submitted to ERDA (C00-2283-2 and C00-2283-3).

An oral presentation of the findings of this study was made at the Fourth National Symposium on Radioecology at Corvallis, Oregon and several seminars concerning the study have been presented as well.

Addendum to the Appended Published Paper

At the time the appended paper was prepared, the data concerning changes in the tree flora in 1976, and leaf litter production for 1975 and 1976, had not been collected and/or analyzed. The comments that follow will, therefore, serve to update our most recently published paper.

Changes in the Tree Flora

Figures 1 - 3 (adapted from Figs. 1 - 3 in the reprint) show densities of seedlings, saplings and trees in the three irradiated

Figure 1. Density of tree seedlings in the aspen, middecotone, maple-birch, and control forest areas. Distance from the radiation source is indicated in meters (m). C, control area. Irradiation (R) occurred in 1972.

Figure 2. Density of tree saplings in the aspen, midecotone, maple-birch, and control forest areas. Distance from the radiation source is indicated in meters (m). C, control area. Irradiation (R) occurred in 1972.

Figure 3. Density of trees (dbh 2.5 cm) in the aspen, midcotone, maple-birch, and control forest areas. Distances from the radiation source is indicated in meters (m). C, control area. Irradiation (R) occurred in 1972.

areas from 1971 through 1976.

It is apparent from the figures that the trends described in the paper, through 1975, have continued through 1976 as well. In all three areas, competition from successional ground vegetation has as of 1976 prevented reestablishment of tree seedlings under the opened canopy at 10m. The trends described for saplings and trees have also continued to 1976 with no significant change. Reestablishment of the original forest vegetation in the heavily irradiated area has been inhibited to an extent greater than originally expected and this phenomenon will, therefore, be monitored closely.

Leaf Litter Production

At the time the appended paper was prepared, the leaf litter production data for 1975 and 1976 had not been analyzed. Figure 4 (adapted from Fig. 4 in the reprint) shows leaf litter production for the three irradiated areas and includes values for 1975 and 1976. In each of the three areas at 10 m, rates of production in 1975 and 1976 were still well below 1971 preirradiation levels. More specifically, in 1976 total leaf production was 25, 31, and 65% below 1971 preirradiation levels at 10 m in the aspen, mid-ecotone and maple-birch areas, respectively. In the mid-ecotone and maple-birch areas recovery, in terms of leaf litter production, is proceeding very slowly while in the aspen area leaf litter production is much more quickly approaching preirradiation levels (Fig. 4).

One of the patterns of leaf litter production noted in the appended paper is a shift to increased importance of shrub litter production in the heavily irradiated areas, reflecting increased

Figure 4. Total leaf litter production (g/m^2 , air-dry) in the aspen, midcotine, maple-birch, and control forest areas. Distance from the radiation source is indicated in meters (m); C represents the control area. Irradiation (R) occurred in 1972.

dominance by successional species. Figure 5 (adapted from Fig. 5 in the reprint) includes information for 1975 and 1976 and shows that the ratio of tree to shrub litter at 10, 20, and 30 m in the aspen area increased gradually from 1974 to 1976, suggesting partial recovery. The increased ratios were due to an increase in tree foliage and a simultaneous decrease in shrub foliage although on a weight basis tree leaf litter production in 1976 was still 44% below the preirradiation level while shrub leaf litter production was 119% above the preirradiation level, at 10 m.

In the middecotone too, the ratio of tree litter to shrub litter now shows signs of increasing at 10, 20, and 30 m although this shift toward an apparent recovery phase did not occur until 1976, one year later than in the aspen area. Interestingly, no sign of recovery in the ratio of tree to shrub litter can be detected in the maple-birch area at 10 or 20 m. In fact, the proportion of shrub litter continued to increase through 1976 at which time shrubs contributed 70% of total leaf litter at 10 m as opposed to only 2% prior to irradiation (Fig. 5).

In interpreting the leaf litter data it is important to consider that some leaves are transported laterally by wind. For example, as the data concerning changes in the tree flora indicate that little reinvasion of the 10 m zone by tree species has occurred, the increased tree leaf litter within 10 m must be attributed to increased levels of production somewhat beyond 10 m.

Our original prediction (Murphy and Sharitz, 1974) was that the aspen area would initially be most extensively modified by radiation but that it would also be the first area to recover to

Figure 5. The tree (▨) and shrub (▤) components of leaf litter at 10, 20, and 30 meters (m) from the radiation source in 1971 (preirradiation) and 1974-76.

a near preirradiation state. The accumulating data on leaf litter production suggest that this prediction may have some validity. We feel that ratios of tree to shrub (i.e. climax species to successional species) leaf litter production may serve as good overall indicators of successional change, when interpreted relative to information on preirradiation conditions and undisturbed control areas.

Future Sampling

We are interested in continuing observations on the influence of the opened forest canopy on the rate and compositional characteristics of succession, especially the interaction between ground vegetation and tree seedlings. We also wish to determine the rate at which leaf litter production and ratios of tree to shrub litter return to original preirradiation values. We hope to continue these observations over a period of several years, particularly since reinvasion by the original forest vegetation is taking longer than initially expected. The overall impact of the radiation stress will obviously depend upon the rate at which forest succession proceeds in the damaged areas. Information on succession in disturbed northern forest types is virtually nonexistent.

Reprints removed

References

- Murphy, P.G. and R.R. Sharitz. 1974. Properties of the tree flora in the forest transition from aspen to maple-birch type, p. 97-104. In: The Enterprise, Wisconsin, Radiation Forest: Preirradiation Ecological Studies, T.D. Rudolph (ed.). U.S.A.E.C. TID-26113.
- Murphy, P.G., R.R. Sharitz, and A.J. Murphy. 1974. Leaf-litter production in the aspen and maple-birch forest types and the contribution by individual tree species, p. 115-118. In: The Enterprise, Wisconsin, Radiation Forest: Pre-irradiation Ecological Studies, T.D. Rudolph (ed.). U.S.A.E.C. TID-26113.
- Murphy, P.G., R.R. Sharitz, and A.J. Murphy. 1977. The response of a forest ecotone to ionizing radiation, p. 43-48. In: The Enterprise, Wisconsin, Radiation Forest: Radioecological Studies, J. Zavitkovski (ed.). Technical Information Center, ERDA, TID-26113-P2.