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DETERMINATION OF THE FEASIBILITY OF REDUCING THE SPATIAL DOMAIN OF THE HEDR DOSE CODE

Hanford Environmental Dose
Reconstruction Project
Dose Code Recovery Activities
- Calculation 006

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PREFACE

This report documents one of a series of scoping calculations performed as part of the dose code recovery activities for the Hanford Environmental Dose Reconstruction Project. These scoping calculations form a mutually-dependent set that build upon each other, and each is best read in the context of the others. The complete list of scoping reports is given below.

Title	Calculation Number
Scoping Calculation for Components of the Cow-Milk Dose Pathway for Evaluating the Dose Contribution from Iodine-131	001
Determination of the Contribution of Livestock Water Ingestion to Dose from the Cow-Milk Pathway	002
Determination of Radionuclides and Pathways Contributing to Dose in 1945	003
Determination of Radionuclides and Pathways Contributing to Cumulative Dose	004
Determination of Dose Distributions and Parameter Sensitivity	005
Determination of the Feasibility of Reducing the Spatial Domain of the HEDR Dose Code	006
Determination of the Spatial Resolution Required for the HEDR Dose Code	007
Determination of the Temporal Resolution Required for the HEDR Dose Code	008

Additional scoping calculations are in progress or planned, and each will be documented in similar project reports.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

A series of scoping calculations has been undertaken to evaluate the doses that may have been received by individuals living in the vicinity of the Hanford site. The primary impetus for this scoping calculation was to determine if large areas of the Hanford Environmental Dose Reconstruction (HEDR) Project atmospheric domain could be excluded from detailed calculation because the atmospheric transport of radionuclides from Hanford resulted in no (or negligible) deposition in those areas. The secondary impetus was to investigate whether an intermediate screen could be developed to reduce the data storage requirements by taking advantage of locations with periods of "effectively zero" deposition.

This scoping calculation (Calculation 006) examined the spatial distribution of potential doses resulting from releases in the year 1945. This study builds on the work initiated in the first scoping study, of iodine in cow's milk, and the third scoping study, which added additional pathways. A projection of dose to representative individuals throughout the proposed HEDR atmospheric transport domain (Ramsdell and Burk 1992) was prepared on the basis of the HEDR source term (Heeb 1992). Addressed in this calculation were the contributions to thyroid dose of infants from 1) air submersion and groundshine external dose, 2) inhalation, 3) ingestion of soil by humans, 4) ingestion of leafy vegetables, 5) ingestion of other vegetables and fruits, 6) ingestion of meat, 7) ingestion of eggs, and 8) ingestion of cows' milk from Feeding Regime 1 as described in scoping calculation 001.

Recommendations determined from scoping calculations are provided to the HEDR Technical Steering Panel (TSP)in order to furnish a definitive technical basis to assist in deciding the overall spatial domain that should be included in the HEDR process for estimating dose to individuals. This scoping calculation is designed to provide information pertinent to developing the dose code, especially information relevant to deciding whether particular areas of the current domain should be evaluated in detail, either at any time or for specific time increments; the intent is to simplify the amount of information that must be stored and retrieved.

2.0 TECHNICAL METHODS

Thyroid doses were calculated for highly exposed infants throughout the current HEDR atmospheric transport domain, using results from the detailed HEDR source term (Heeb 1992), the HEDR atmospheric transport model RATCHET (Ramsdell and Burk 1992), and the spreadsheet developed for scoping calculation 003. Individuals were assumed to have a rural lifestyle, with milk supplied by a backyard cow supported on Feeding Regime 1 (HEDR staff 1991, page 2.17). Parameters in the calculations were selected to be approximate average, median, or best-estimate values, rather than conservative upper-bound values. In the analysis for scoping calculation 005, the single-point, deterministic values used for this calculation were shown to adequately represent mean doses.

Surface-deposition data used were not Phase I values; rather they were recalculated (J. V. Ramsdell, Jr., personal communication, December 1992) using the RATCHET atmospheric dispersion code (Ramsdell and Burk 1992), based upon the latest Hanford iodine-131 source term information reported by Heeb (Heeb 1992, page 4.36). Monthly surface depositions from 100 realizations were averaged and used in these scoping calculations (J. V. Ramsdell, Jr., personal communication, December 1992).

2.1 CALCULATION OF DOSE FACTORS

The case simulated was that of an infant drinking milk from a backyard cow that was being fed on Feeding Regime 1. Monthly thyroid dose results from iodine-131 were estimated in scoping calculation 003 for the combined pathways of 1) air submersion and groundshine external dose, 2) inhalation, 3) ingestion of soil by humans, 4) ingestion of leafy vegetables, 5) ingestion of other vegetables and fruits, 6) ingestion of meat, 7) ingestion of eggs, and 8) ingestion of cows' milk from Feeding Regime 1 as described in scoping calculation 001. These monthly doses were divided by the monthly releases used in scoping calculation 003 to generate dose-per-unit-deposition factors for each month. These factors included the seasonally dependent variation in vegetation growth, cow feeding patterns, and fresh food availability.

TABLE 1. Monthly Factors Relating Month-End Deposition to Infant Thyroid Dose (rad to thyroid per Ci/m^2 at the end of the month)

Month	Conversion Factor
January	3.32E+06
February	3.22E+06
March	3.15E+06
April	3.00E+06
May	2.65E+07
June	5.11E+07
July	4.89E+07
August	4.92E+07
September	2.81E+07
October	1.56E+07
November	6.95E+06
December	3.06E+06

The monthly deposition-to-dose conversion factors for iodine-131 derived from scoping calculation 003 are listed in Table 1.

2.2 ESTIMATION OF MONTHLY DEPOSITION

The initial production runs of the RATCHET code are becoming available. The RATCHET results are 100 realizations of daily time-integrated air concentration and daily deposition per unit area for all nodes in the HEDR atmospheric transport domain. In order to use this voluminous information, some simple reductions were performed. For each month, the daily depositions calculated within one realization for each node were summed, and then these 100 sums were averaged for each node. A month-end value accounting for decay was approximated, using an assumption of uniform deposition, with the correction factor

$$Correction = \frac{\sum_{i=1}^{30} e^{-\lambda_r i}}{\sum_{i=1}^{30} i}$$

This factor accounts for daily deposition, buildup, and decay of the material on the ground to the end of the month, and converts the daily sum into a month-end value in units compatible with the more accurately determined value provided by Ramsdell for scoping calculations 001 and 003. For iodine-131, this correction factor has a value of 0.3427. For each month, the dose to an infant with backyard cow was estimated as the product of this deposition and the monthly deposition-to-dose factor.

2.3 MAPPING OF RESULTS

The actual calculation of the average doses to the representative infant at each node for each month was performed with the ARC/INFO® geographic information system (ESRI 1989). The dose results were then plotted as contour maps of potential dose for all nodes within the domain. The Appendix presents maps of estimated 1945 average monthly thyroid dose to infants drinking milk from cows fed Regime 1 diets. A sum for 1945 of the individual monthly node values is given as Figure 1. This is a very crude estimation of the spatial distribution of potential doses to the thyroids of infants drinking milk from a family cow being feed Feeding Regime 1 at each location.

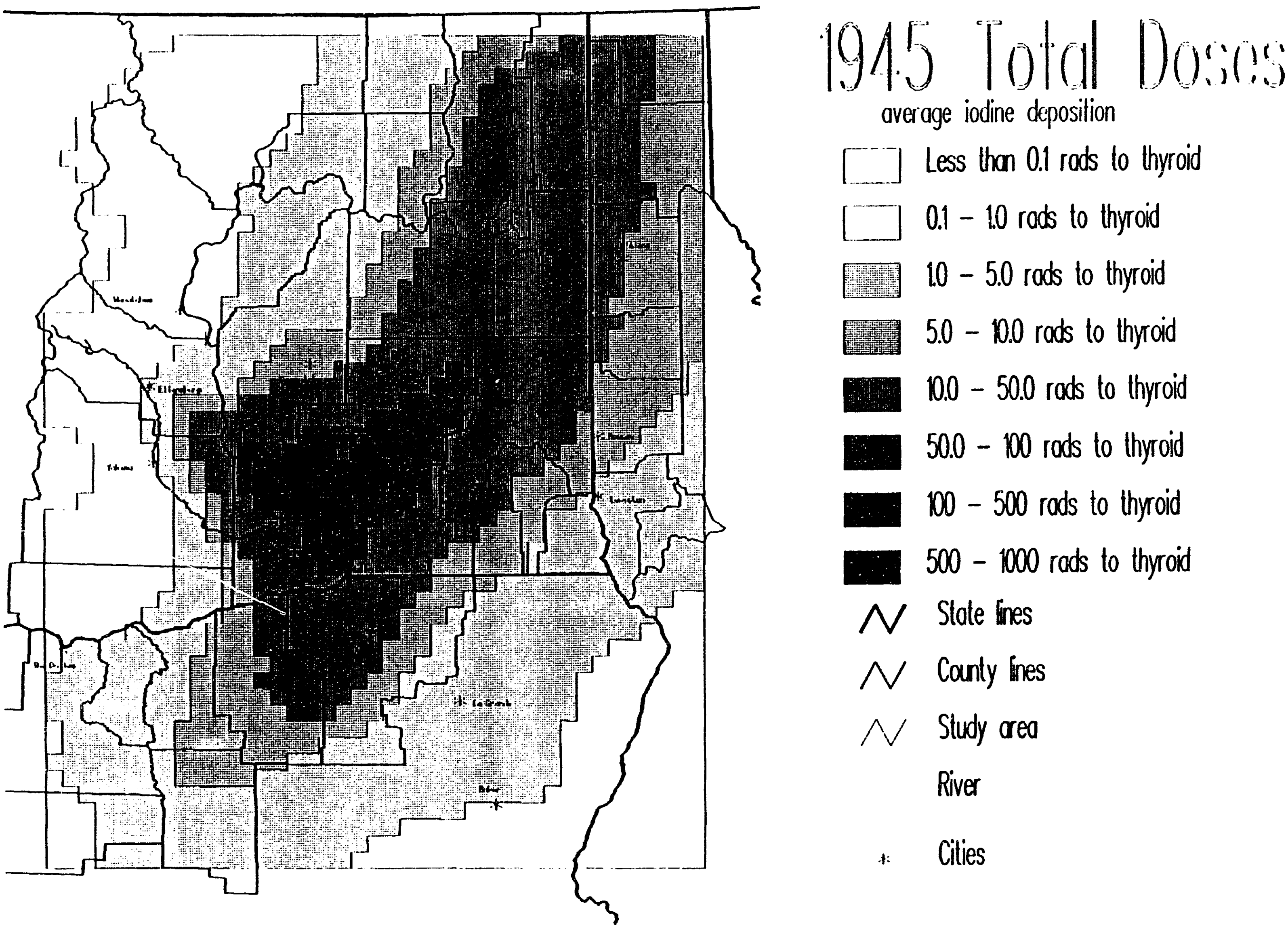

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FIGURE 1. Total 1945 Dose to Reference Infants Drinking Milk from Cows on Feeding Regime 1

3.0 RESULTS/DISCUSSION

The primary impetus for this scoping study was to determine if large areas of the HEDR atmospheric domain could be excluded from detailed calculation because the atmospheric transport of radionuclides from Hanford resulted in no (or negligible) deposition in those areas. The secondary impetus was to investigate whether an intermediate screen could be developed to reduce the data-storage requirements by taking advantage of locations with periods of "effectively zero" deposition. The mechanism for these determinations was to be evaluation of the proportion of the domain meeting a criterion of 1) total dose over the year 1945 of less than the TSP dose decision level of 1 rad to infant thyroid (Shleien 1992), or 2) dose over a given month less than a fraction (about 0.1%) of the dose decision level.

Cursory evaluation of the composite map of Hanford doses shown in Figure 1 indicates that, for a large part of the current HEDR atmospheric transport domain, certain individuals have the potential to exceed the TSP dose decision level for the year 1945. For essentially all of the domain, except the far western edge, individuals have the potential to receive a mean dose of at least one-tenth of the dose decision level. Given that the mean doses were used, and the range about the mean is rather large (see scoping calculation 005), a "safety factor" of about 10 would imply including essentially the entire domain.

Evaluation of the individual monthly plots in the Appendix show that often areas of up to half of the domain could be considered to have no deposition for periods of one month or longer (i.e., incremental monthly thyroid doses of less than 0.001 rad). Results from the atmospheric transport code RATCHET are transferred within the HEDRIC system in one-month blocks. This indicates that a simple pre-screen, based on the algorithm developed for this scoping calculation, could reduce the computer storage and computational effort expended by the HEDR environmental accumulation and dose codes by a large fraction. Additional calculations not shown here indicate that the operational domain could be reduced significantly in later years when the source term is a small fraction of that in 1945.

It must be emphasized that the graphics presented in this scoping calculation do not represent final dose estimates for any person living in the HEDR study area. The computations use depositions averaged over many individual realizations multiplied by average deposition-to-dose factors. The "average" map is a composite of doses calculated at single locations with no accounting for milk transport from node to node. The composite map assumes that infants living at each node had relatively high- exposure lifestyles. For large areas of the domain, the assumptions used in the derivation of the dose functions are not appropriate. Areas within the domain that were desert or heavily forested in the years around 1945 would not support the necessary pasture to feed a cow to supply milk to the postulated infant. A "real" map that considered the presence of irrigated areas, commercial agriculture, and other parameters, should look considerably different than that illustrated. The computation described herein is intended solely as a theoretical screening device to direct the attention and level of detail needed in the development of the final dose code package.

4.0 RECOMMENDATIONS

Scoping calculations were performed to determine, first, the reasonableness of the HEDR atmospheric transport domain, and, second, to determine whether application of a screening device to the computational process could save in data generation and storage. Based on the results of this scoping study, and the companion studies on dose, the following recommendations are made for the HEDR Project:

- The project should continue to consider the complete atmospheric transport domain. The potential exists for selected individuals to receive doses in excess of the TSP dose decision level for most of the current area[1].

- A screening estimate should be made on the atmospheric transport results prior to their input to the environmental accumulation module of the HEDRIC package. The potential exists for large savings in computer run time and storage by eliminating computations at individual nodes for periods during which the dose rate was negligible. Calculations should be resumed for these nodes whenever there were deposition events that would contribute doses greater than 1 mrad (0.1% of the TSP dose decision level) per month. Basing the screen on dose assures that residual contamination from earlier depositions would continue to be considered.

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[1] Scoping calculation 7 evaluates the spatial resolution required for the HEDR dose code.

5.0 QUALITY ASSURANCE

Quality assurance was undertaken in accordance with PNL-MA-70, Volume 1, Procedures for Quality Assurance Program, under PNL administrative procedure PAP-70-301, "Hand Calculations, General." Complete documentation of the calculation was prepared by the authors, who prepared the calculational spreadsheets and performed the spreadsheet calculations. A thorough independent review was conducted by a senior scientist independent of the HEDR project. Spreadsheet documentation is on file and available for review.

6.0 REFERENCES

Environmental Systems Research Institute (ESRI). 1989. PC ARC/INFO Starter Kit; Users Guide. Environmental Systems Research Institute, Redlands, California.

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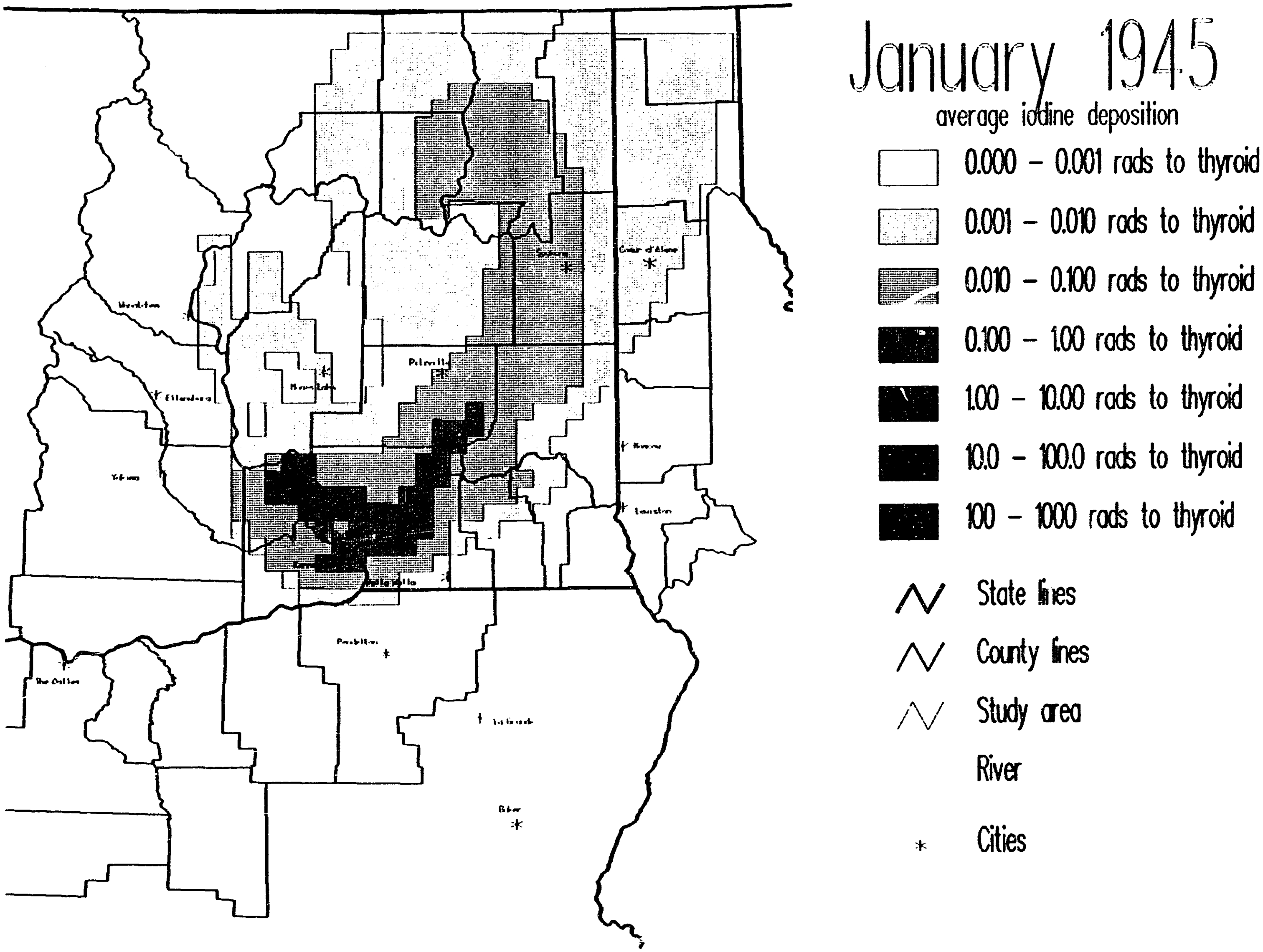
APPENDIX

MAPS OF APPROXIMATE MONTHLY AVERAGE DOSE TO INFANT THYROID VIA THE SCENARIO OF MILK CONSUMPTION FROM BACKYARD COW ON FEEDING REGIME 1



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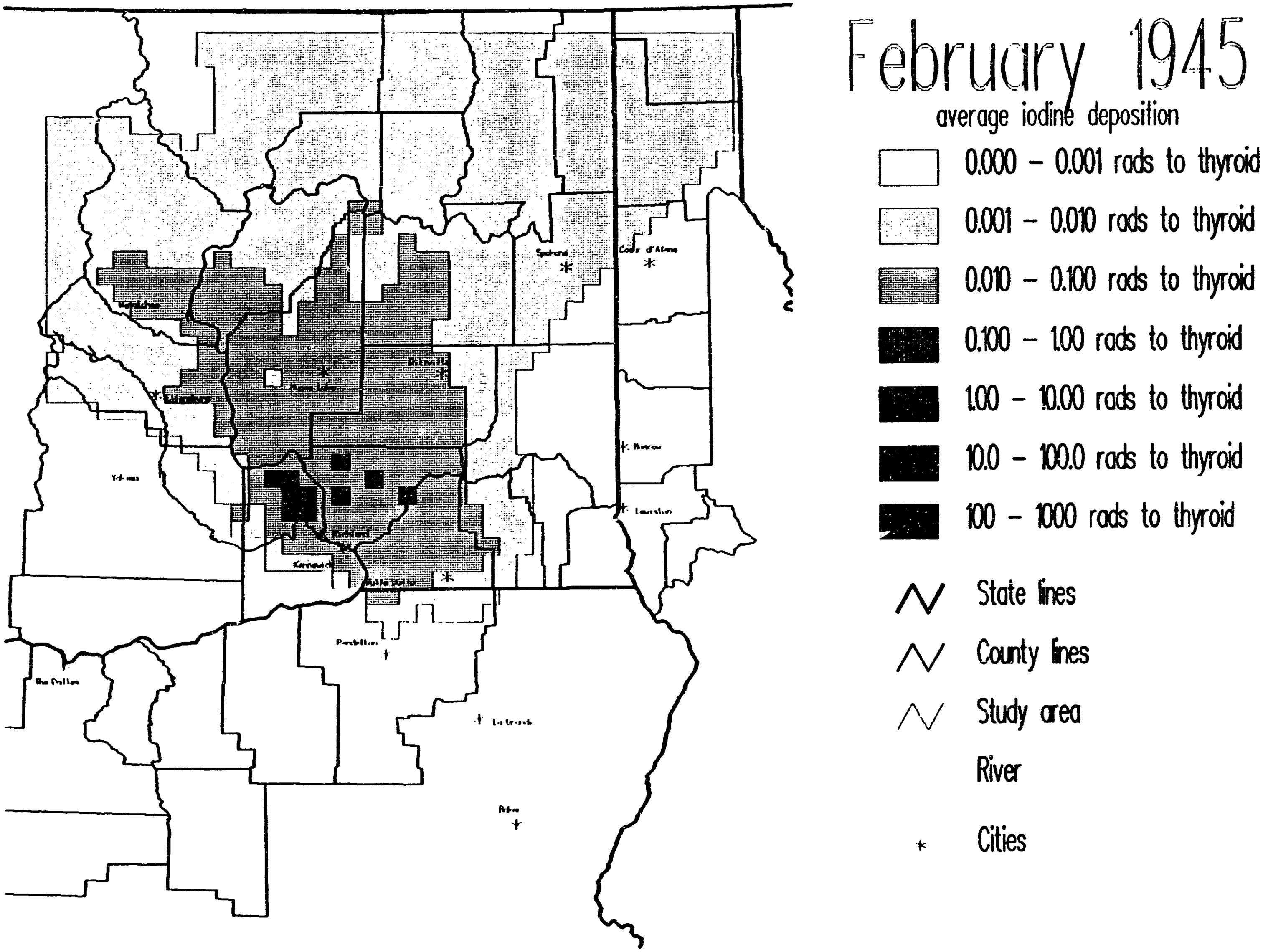

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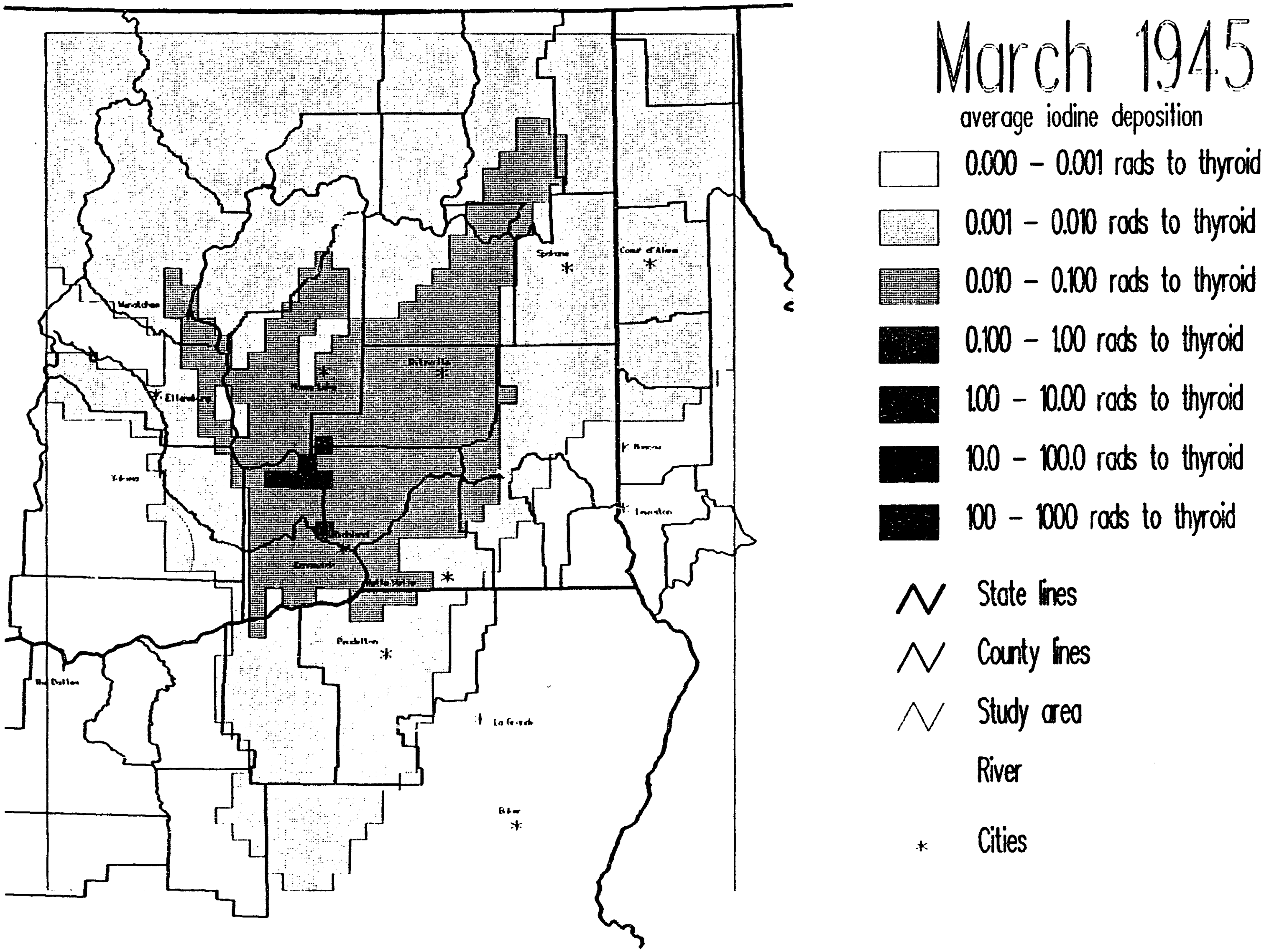

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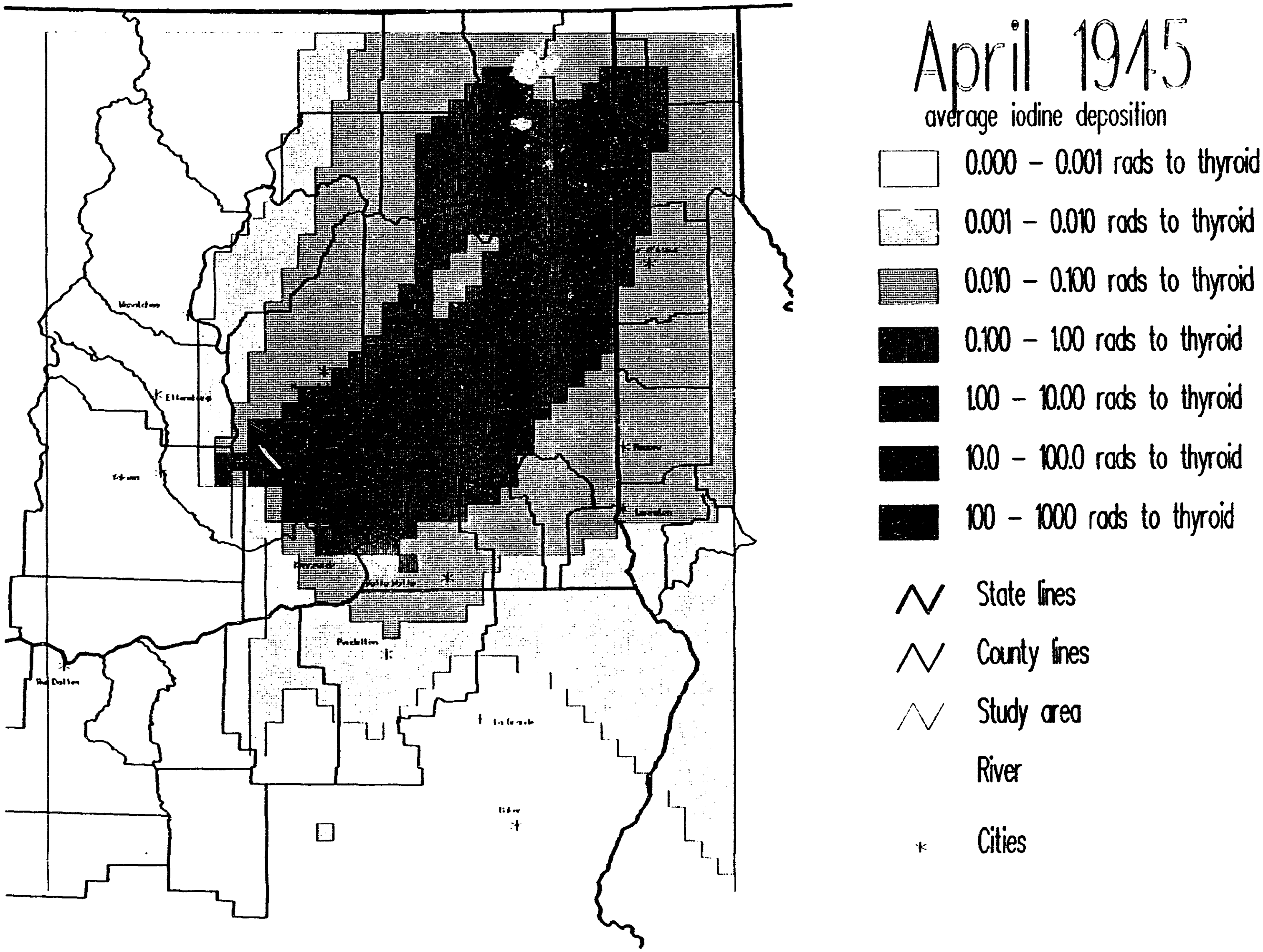

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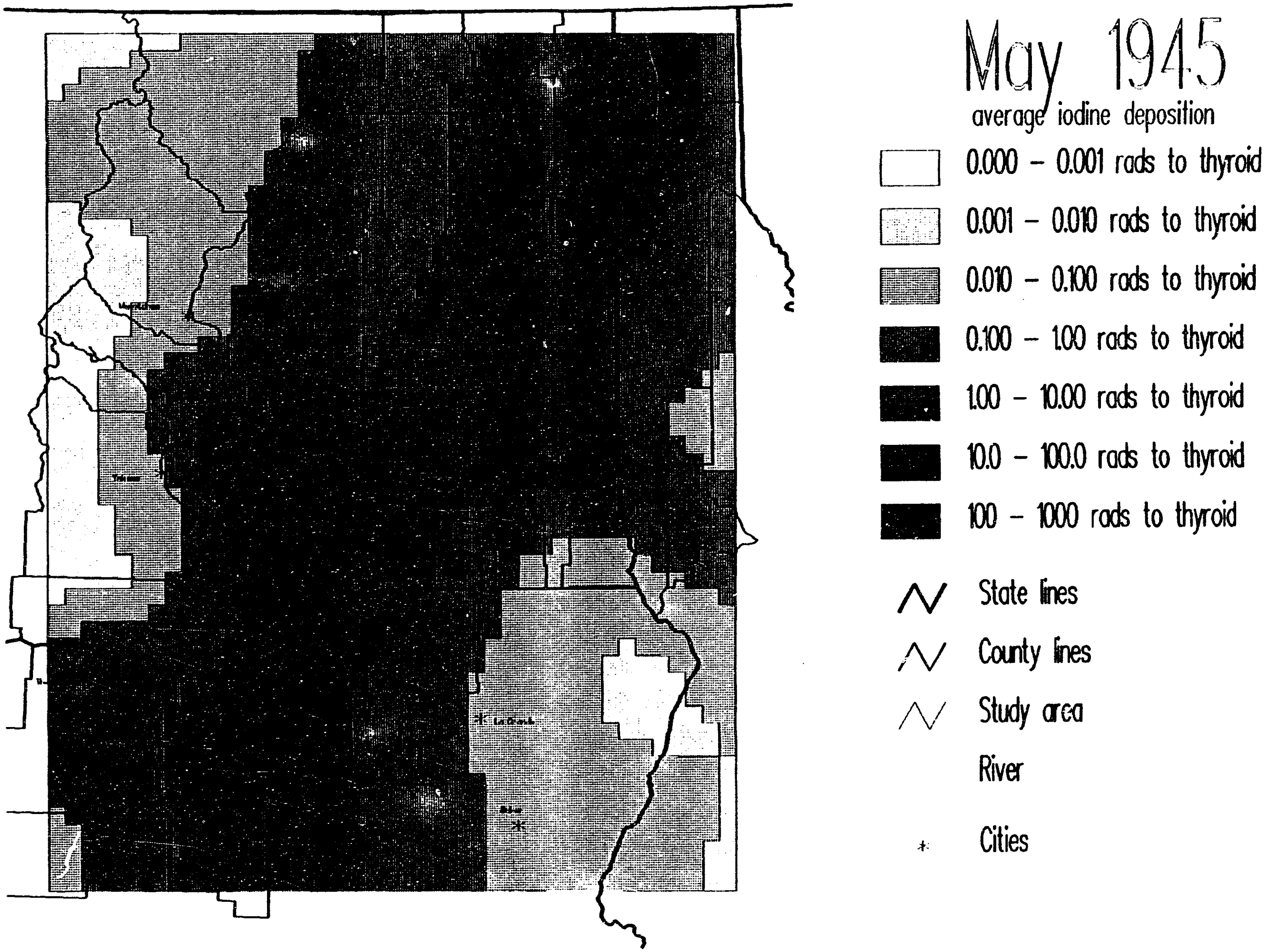

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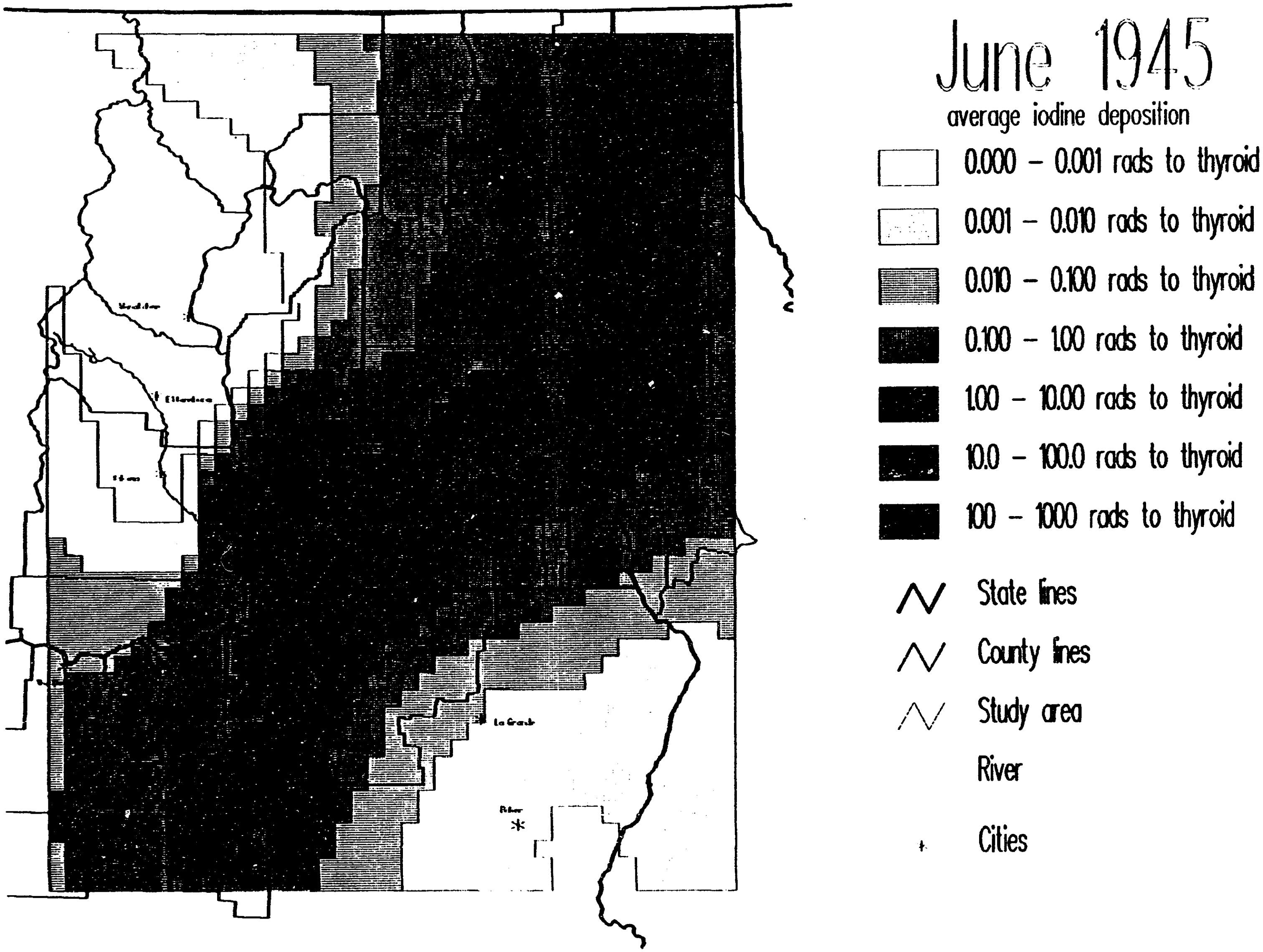

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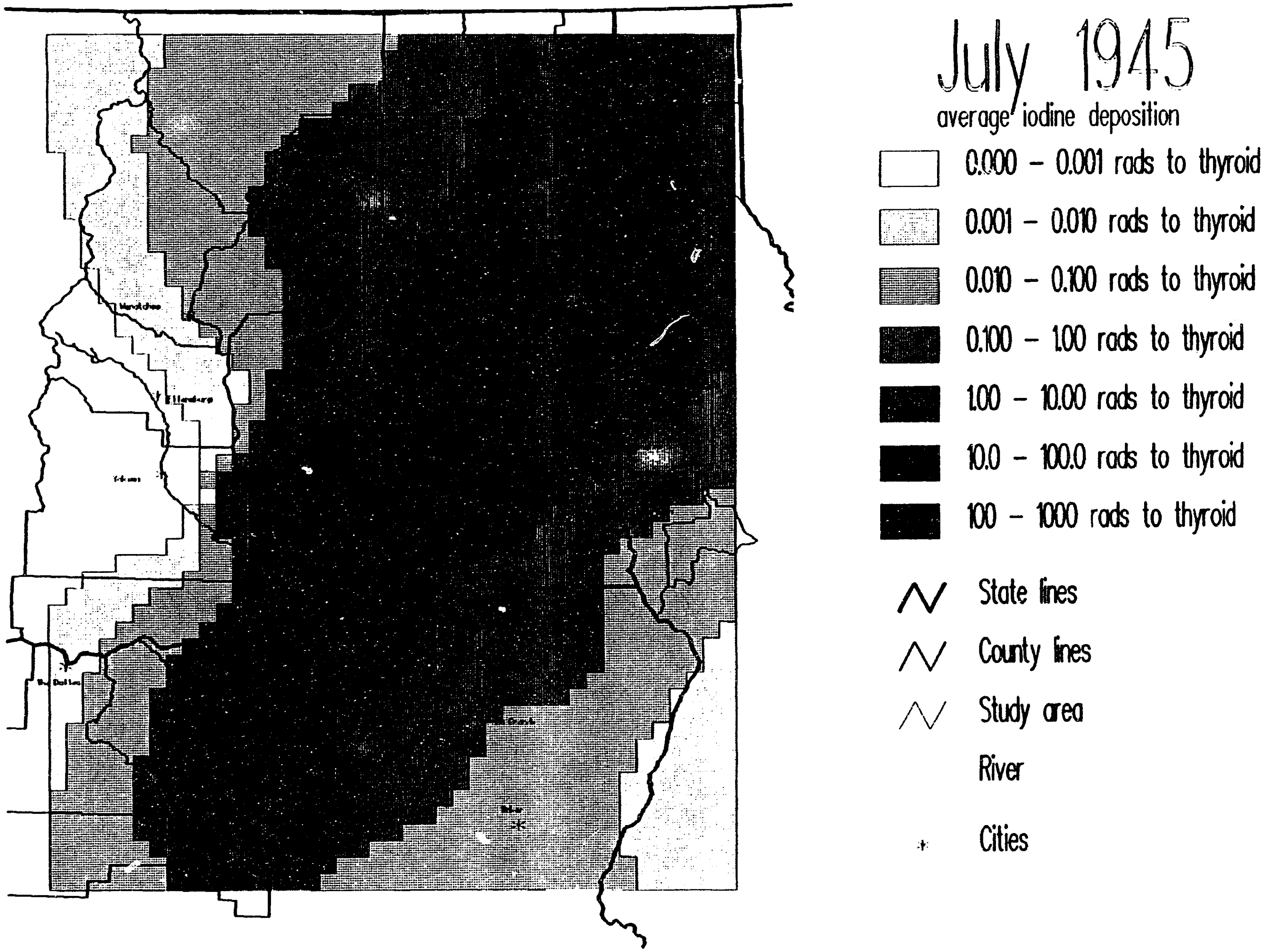

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August 1945

average iodine deposition

- 0.000 – 0.001 rads to thyroid
- 0.001 – 0.010 rads to thyroid
- 0.010 – 0.100 rads to thyroid
- 0.100 – 1.00 rads to thyroid
- 1.00 – 10.00 rads to thyroid
- 10.0 – 100.0 rads to thyroid
- 100 – 1000 rads to thyroid

- State lines
- County lines
- Study area
- River
- Cities

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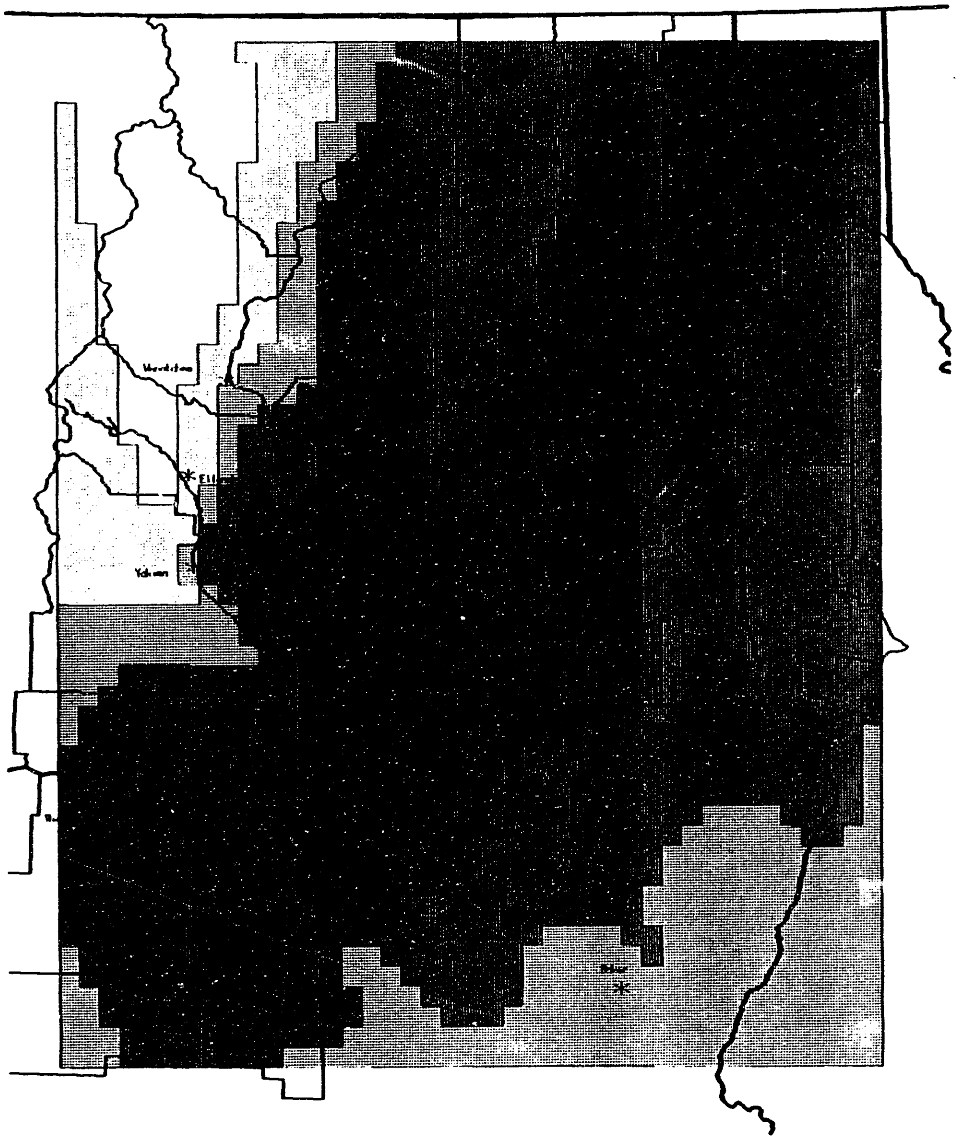

September 1945

average iodine deposition

- 0.000 – 0.001 rads to thyroid
- 0.001 – 0.010 rads to thyroid
- 0.010 – 0.100 rads to thyroid
- 0.100 – 1.00 rads to thyroid
- 1.00 – 10.00 rads to thyroid
- 10.0 – 100.0 rads to thyroid
- 100 – 1000 rads to thyroid

- State lines
- County lines
- Study area
- River
- * Cities

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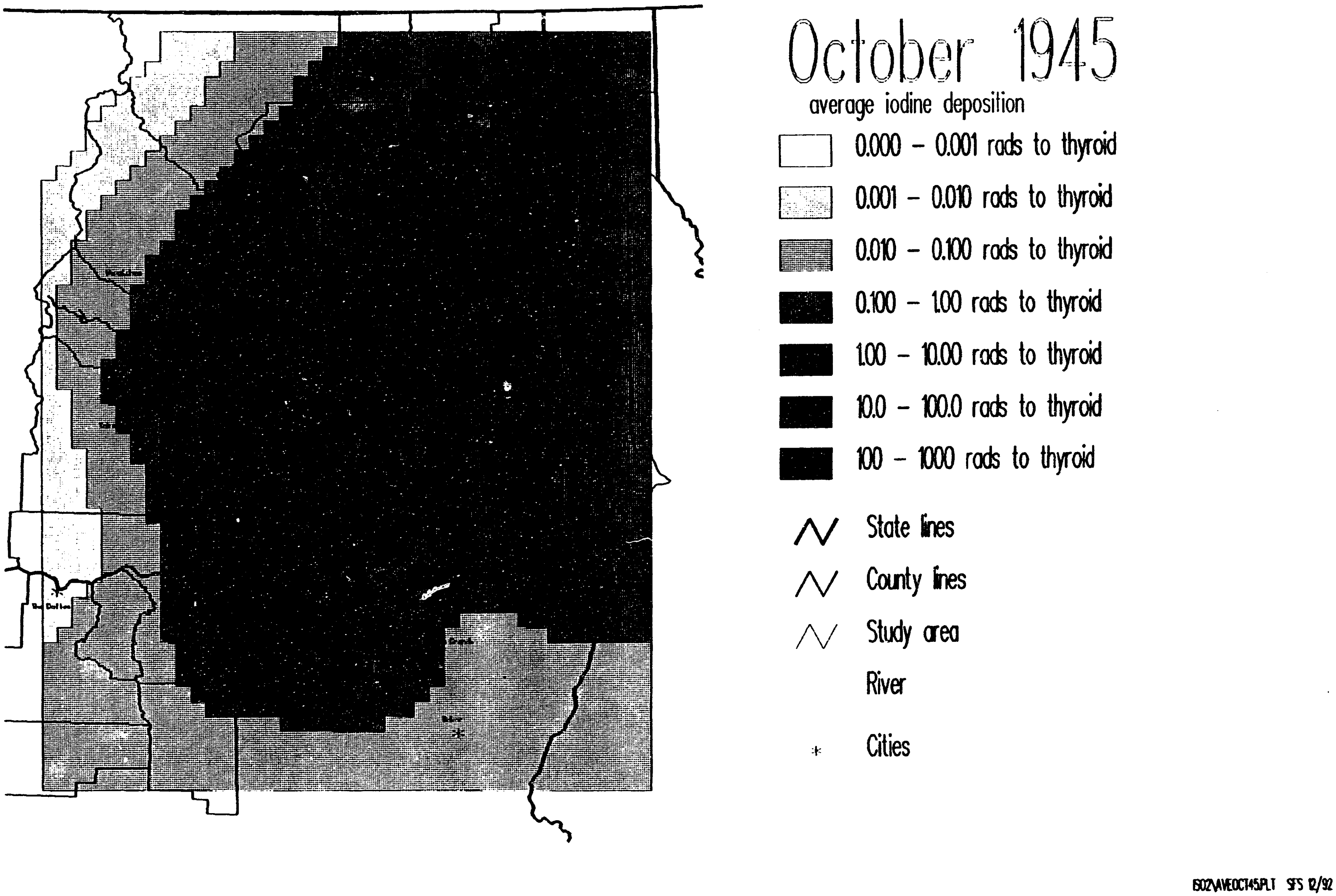
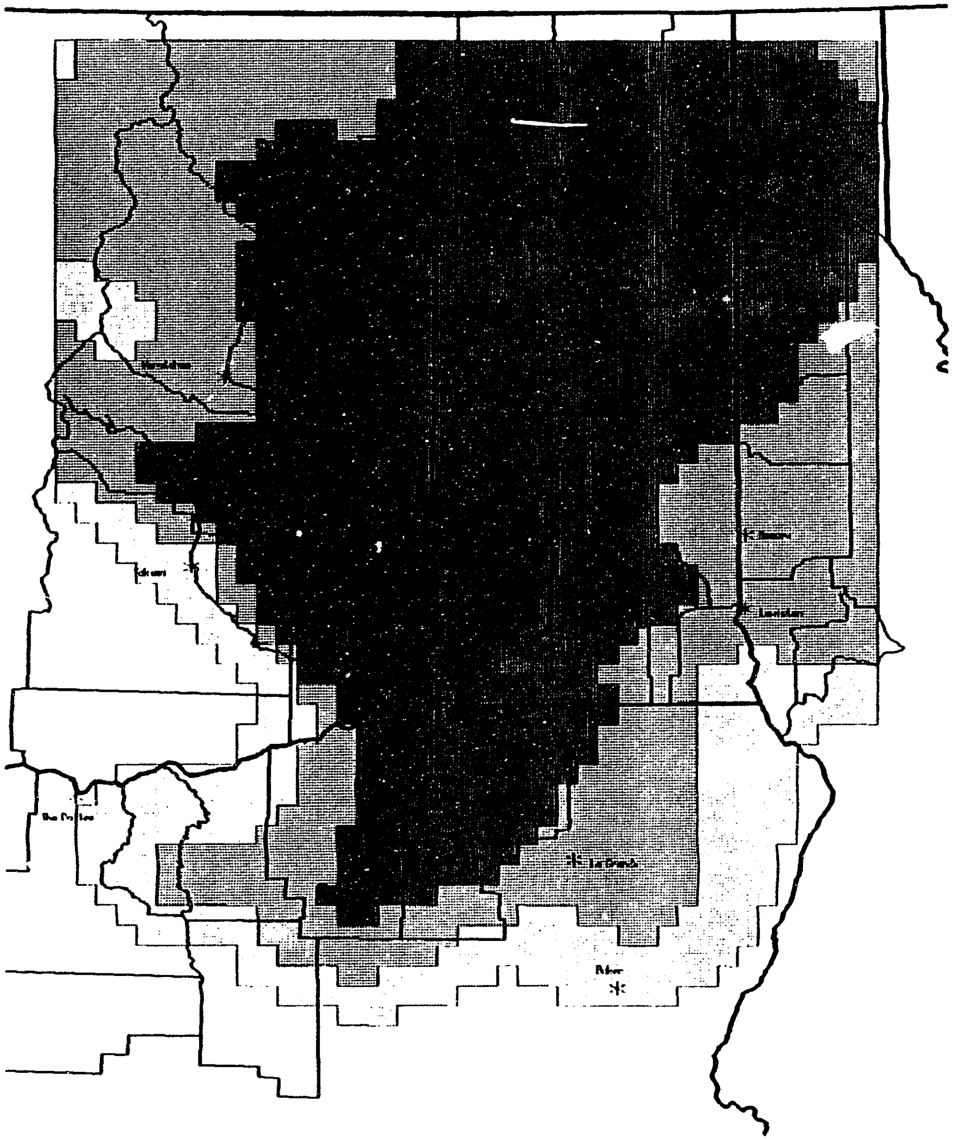

October 1945
average iodine deposition
0.000 – 0.001 rads to thyroid
0.001 – 0.010 rads to thyroid
0.010 – 0.100 rads to thyroid
0.100 – 1.00 rads to thyroid
1.00 – 10.00 rads to thyroid
10.0 – 100.0 rads to thyroid
100 – 1000 rads to thyroid
State lines
County lines
Study area
River
Cities
I502\AVEOCT45.PLT SFS 12/92



November 1945

average iodine deposition

- 0.000 – 0.001 rads to thyroid
- 0.001 – 0.010 rads to thyroid
- 0.010 – 0.100 rads to thyroid
- 0.100 – 1.00 rads to thyroid
- 1.00 – 10.00 rads to thyroid
- 10.0 – 100.0 rads to thyroid
- 100 – 1000 rads to thyroid

- State lines
- County lines
- Study area
- River
- Cities

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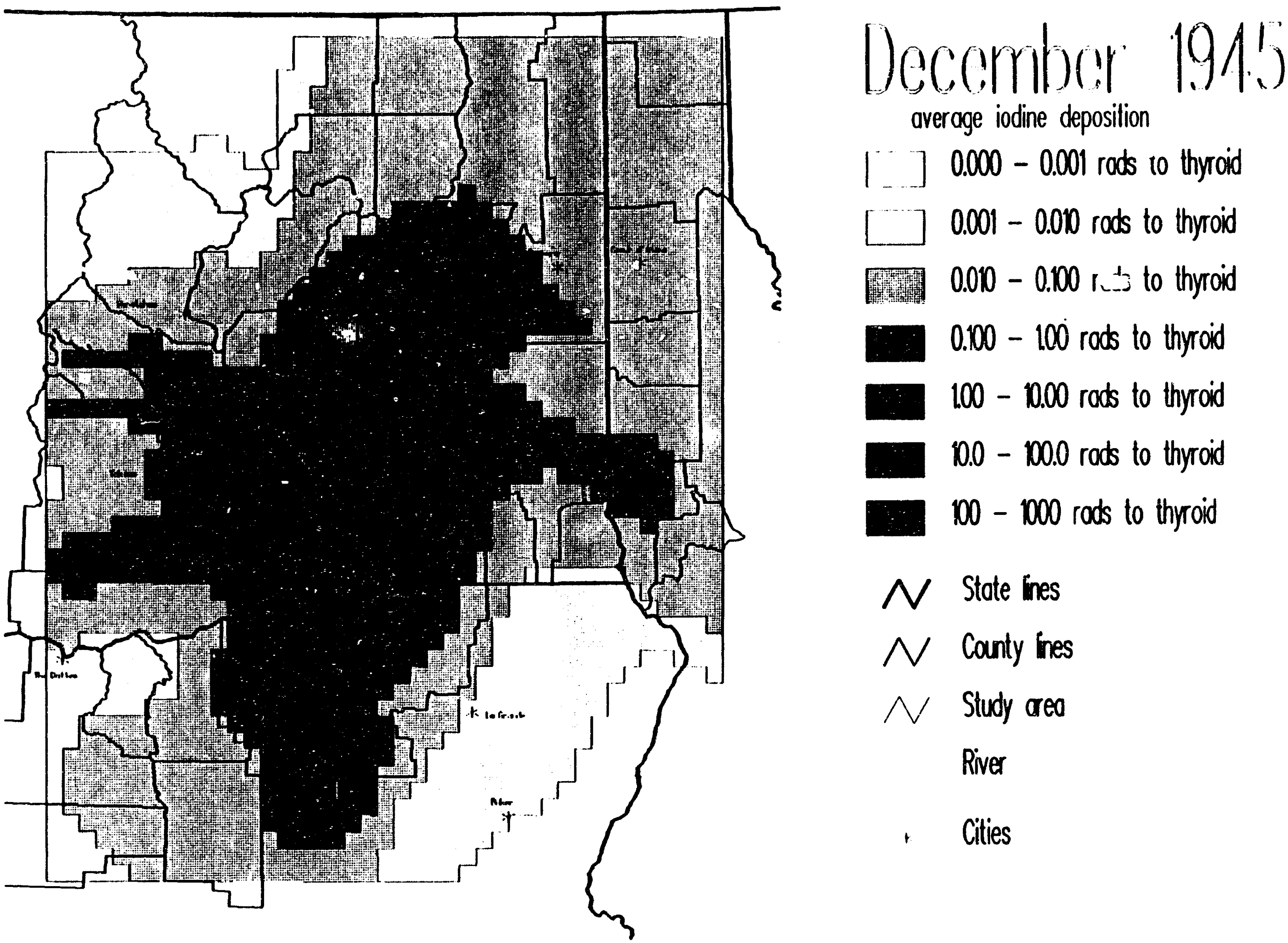

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