U. S. Geological Survey.

REPORTS-OPEN FILE SERIES, no. 782: 1964.

Weld - 2905 Int.

GEOLOGIC DIVISION
U. S. GEOLOGICAL SURVEY
Washington, D. C.

For release JANUARY 26, 1965

The U. S. Geological Survey is releasing in open file the following report. Copy is available for consultation in the Geological Survey Library, 1033 GSA Bldg., Washington, D. C.:

Comparison of geochemical environment in areas of high rate of cancer and heart disease in New York and Maryland with that of an area of low disease rate in New Mexico, by Helen L. Cannon and D. Ann Fidler. 11 p., 1 fig., 8 tables.

Comparison of geochemical environment in areas of high rate of cancer and heart disease in New York and Maryland with that of an area of low disease rate in New Mexico

by

Helen L. Cannon and D. Ann Fidler

Given by Helen L. Cannon at the

American Association for the Advancement of Science

Montreal, Canada, December 1964

Editor's note:

This report is in the form presented to the American Association for the Advancement of Science. Statements have been added in brackets for purposes of clarification.

Introduction

Our talk today discusses trace element distribution in plants and soils in 3 areas that differ in the rate of cancer and probably also heart disease. It will raise more questions than it will answer. The data will show overall geologic differences in the areas chosen for study, that affect the trace element content of the soils and plants but will also show the great effects of man-made contamination on the concentrations of trace elements in soils and produce of home gardens maintained over a long period of time in the same location. The importance of proper preparation of the edible produce for analysis if the trace element contents are to be related to human disease will also be emphasized.

The pilot study that we are about to describe was originally begun in Washington Co., Md., in cooperation with the Environmental Section of the National Cancer Institute who had set up a project there to study a variety of environmental factors including radiation, which might correlate with anomalous aggregations of cancer in the county. Comparative studies were later made in cooperation with other Public Health groups in Canandaigua, N. Y., another [relatively] high cancer area [by virtue of its location in the glaciated N.E. United States (see below)], and in San Juan Co., N. Mex., where the occurrence of cancer and probably heart disease is low.

The patterns of disease occurrence, plotted county by county in the U. S., appear to have a curious geographic or geologic distribution. Of these, the patterns of heart disease and cancer are relatively similar.

This map [Fig. 2], prepared by Pope Laurence, of the Cancer Institute, shows cancer mortality rates from 1948-1952 adjusted for age, race, and sex. Cancer mortality is high in glaciated parts of the country, except for the Driftless area of Wisconsin; in poorly drained alluvial valleys; and the Mississippi Delta.

The same general pattern can be seen in this map [Fig. 1] prepared by Enterline and Souer, of the Public Health Service, showing coronary heart disease death rates in non-metropolitan areas for white males aged 45-64 from 1949-1951. Note the low rates in the blue grass country of Kentucky and Tennessee and also in New Mexico; the relatively high rates in the glaciated parts of the country and in areas of poorly drained peat soils, as around Lake Michigan, the Mississippi Delta, Puget Sound, and the alluvial basins of California and Nevada.

It will be interesting then to compare plants and soils in Washington County, Maryland, in Ontario County, New York, and in San Juan Co., N. Mex. In the Townships of SW Washington Co., where

200 samples were collected, cancer deaths had occurred in more than 20 percent of the houses, and on the particular street [studied] in Canandaigua, N. Y., where 21 samples were collected, about 50 percent of the houses had cancer experience. 200 samples were collected in San Juan Co., N. Mex., where the cancer rate is known to be low. The Heart Institute points out that the statistics on heart disease mortality in these areas are not as conclusive although a comparison of these maps would suggest that the same sort of difference probably exists.

The soils are gray-brown podzolic soils in both New York and Maryland. Canandaigua, New York, soils are calcareous glacial soils with a pH of 6.9; the soils in the Maryland area are for the most part Hagerstown loam with a pH of 7.3 overlying Ordovician and Silurian limestones. In San Juan Co., N. Mex., the farms and gardens are all on river alluvium with a pH of 8.2 and the undeveloped land of the county is largely composed of young, poorly developed soils with a pH of 9.1 on Mesozoic sandstones and shales.

The highest cancer mortality rate in Washington County occurs in the town of Sharpsburg, which is a beautiful little village of neatly painted white houses and perfectly kept gardens but with no central water system or town sewage disposal. The town lies in a topographic and structural limestone basin which drains the village outhouses and cesspools into a central flowing spring which was the original town source of water, and is still used by many for household purposes. Each house has a vegetable garden near which or in which is an out-house or cesspool and a shallow dug well for water. Hence there is a cycling of elements through food, people, and refuse imposed in turn upon a larger village cycle. The contamination of metals and of nitrate in the soils and vegetables is very large. In Canandaigua, New York, there has been a central water system and sewage system in existence for some time, but the contamination of soils and vegetables [along the street sampled] is similar to Sharpsburg as the topographic and structural features provide a similar contamination trap.

Soil chemistry

The soils in Washington County have been heavily tilled over a long period of time so that the A and B zones have been largely eroded away and the yellow C zone is much in evidence at the surface. Therefore, plants and soils from the farm wood plots were collected to learn something of the original composition of the surface soils. The inorganic constituents of the soils are here plotted [Table 1] against those of an average soil taken from Swaine (1955). The original soils of southeast Washington County, shown by the white dots are above average in many metals but especially so in K, Cu, and Pb. They were below average in Ca, P, Sr, Cr, and Zn. By plotting the garden soils in Washington County on the same graph with forest soils, it is possible to determine which values owe their origin to the geologic background and which to man-made contamination or other changes of one sort or another. Let us compare then the black and white dots for each element. Fertilizers appear to have raised the Ca, P, and nitrate levels in the garden soils. We believe that the very large increases in Zn, Cu, As, and Pb in the garden soils compared to soils collected from nearby wood plots are caused by contamination from sprays, plumbing, and car exhaust.

The soils of San Juan Co., New Mexico, can be compared similarly as shown in Table 2. The natural soils are appreciably higher than average in Ca, B, Ba, As, Pb, and Zr, and below average in the remainder of elements. The garden soils, composed entirely of river alluvium, are enriched compared to natural soils, in Fe, and K, and also from contaminants, Pb, Zn, and As, but not to the same degree as Washington County soils.

Let us now compare the garden soils of the 3 areas against each other and against average soils. In Table 3 the New York and Maryland samples are compared and we find that they are quite similar. The contaminative elements, Cu, Pb, Zn, NO_3, are considerably above average in these areas of high disease rate. The differences in the composition of soils from Maryland and New Mexico are greatest for the elements Mg, Mn, Cr, B, V, Y, and Ni that reflect the geology and for the elements Ca, P, Zn, Pb, Cu, and NO_3, probably due to contamination. Apparently the influences of man-made contamination on the soil are much less in San Juan County, New Mexico.

Plant chemistry

The inorganic chemistry of both the native vegetation and the edible produce of the two northern areas is quite different from that of the area in New Mexico. First, a comparison can be made in Table 4 between Maryland vegetation of all kinds and the average composition of herbs. Contrary to the soils which were generally above average in most elements, the plants are generally lower than average in most elements and are particularly so in the garden produce.

The effects of fertilizers are probably reflected in the increase in the elements P, K, and NO_3 in the gardens. Contamination is reflected in the Zn value. The concentrations of the remaining elements are higher in the native vegetation than in the garden produce. At least a part of this difference can be shown to be related to preparation of the sample.

The differences between edible produce and native vegetation in San Juan County, New Mexico, are shown in Table 5. The same deficiency of inorganic elements in native vegetation compared with average herbs occurs in New Mexico produce except for Ca, Ti, Ba, Sr, and Cr. The contents in garden produce are lower than the native vegetation except for P and K which have presumably been added in fertilizers. Contamination from sprays, car exhaust, and plumbing are not sufficient to make any noticeable change in these low values. The effect of very thorough preparation of the produce in the Farmington Public Health Laboratories can be evaluated from our data.

Edible produce collected in all 3 areas was thoroughly washed and treated as normally prepared in the kitchen for human consumption. In addition, on the Maryland project, 7 kinds of underground vegetables and fruits were analyzed in both peeled and unpeeled condition. The most significant differences are shown in Table 6. Fe, Mg, Mn, and Ti occur in greater quantities in underground vegetables than in fruits or green vegetables but are 2 to 13 times less in vegetables that are peeled. Copper is much lower in green vegetables than in unpeeled root vegetables or fruits. Possibly the high Cu and boron in the skins of fruits are caused by sprays. Detectible quantities of lead and chromium occur only in unpeeled (but washed) vegetables. All produce collected on the San Juan County project was prepared very carefully in the Public Health Laboratories and frozen for eventual analysis. There is, however, a very significant difference between the washed and peeled produce grown on river alluvium and the native vegetation collected from the same environment. A decrease of the same magnitude and in the same elements as in the Maryland produce can be observed. These data suggest that many elements essential to health and also metals that may have a deleterious effect on health are concentrated in the epidermal tissues of produce and that peeled vegetables and fruits contain considerably less of these elements.

Let us now compare the inorganic constituents in garden produce from the three separate areas. In Table 7, the concentrations in produce from Maryland and New York are generally similar and show below average contents of most inorganic constituents except for very high Ca, Pb, NO_3, and Ti in the Canandaigua produce.

If we compare the northern areas of high disease rate with New Mexico, we find that iron, manganese, magnesium, calcium, and sulfate among the major plant constituents are several times higher in Maryland and New York vegetables than in those of New Mexico, but phosphorus on the other hand is lower. All of the trace elements, except boron and strontium, are considerably higher in Maryland and New York gardens. It is our belief that a part of the zinc, lead, and nitrate are a result of contamination from sewage, sprays, and car exhaust, and that this man-made effect is therefore an important consideration in old gardens that have been in continued use for a considerable length of time.

To test the effect of contamination from highways, the soils were grouped and averaged according to distance from roads. The median in soils collected from 50-500 ft. from a road was 25 ppm Pb; that of soils collected from 1-50 ft. from a road was 150 ppm or 6 times greater.

Conclusions

The ratios between the elements in the soils and plants in areas of high disease rate and that of low rate are given in Table 8. The ratios above the line are of geologic origin; those below are contamination. The quantities of the elements Fe, Ti, Mn, Cr, and Cu, whose values may be attributed to a geologic origin, are higher in both the soils and plants of the high disease area. The contents of elements, Pb, K, and nitrate, whose values may be attributed largely to contamination of various sorts, are also higher in the high disease area. P is higher in the soils but lower in the plants.

The geologic origin of rocks and soils is an important contributor to the geochemical environment. Also the length of time that a garden has been in continuous production, the sanitary practices, drainage and water supply as well as the distance from roads may have an important bearing on the geochemical background.

The data here presented from this small pilot experiment emphasizes the importance of collecting vegetation as well as soils in an area under study; of collecting not only native vegetation but also the vegetables from specific house gardens, and also the importance of preparing the produce as normally used for human consumption when human health studies are underway.

We hope that this study will encourage larger cooperative projects of this kind between health specialists and geochemists, but believe that our data shows the necessity of tying in closely the study of soils and garden produce with house to house epidemiological data on a survey of a particular area or particular disease.

Perhaps the broad general studies of the rocks, soils, and plants, made by the geochemist should be related most closely to those of the veterinarian or range plant management expert, for animal nutrition is closely dependent on native vegetation. This information may later be useful to the medical man in formulating hypotheses on which more costly house-to-house human health surveys may be based.

References

Enterline, P. E., Rikli, A. E., Sauer, H. I., and Hyman, M., 1960, Death rates for coronary heart disease in metropolitan and other areas: U. S. Dept. Health, Education and Welfare, Public Health Reports, v. 75, no. 8, p. 759.

Swaine, D. J., 1955, The trace element content of soils: Commonwealth Bureau of Soil Science Tech. Commission, no. 48, 167 p.

Table 1.-- Chemistry of garden soils compared to forest soils in Washington County, Maryland.

Element	Garden Soils (25)	Forest Soils (12)	Ave. world wide soils (Swaine, 1955)
Fe percent	4.0	4.7	3.8
Mg "	0.9	.8	0.68
Ca "	1.4 (23)	.28 (2)	1.37
K "	3.1 (14)	4.2 (5)	1.4
P "	.11 (23)	.3 (2)	.08
Mn "	.12	.14	.085
Ti "	0.64	.55	.46
As ppm	14 (13)	8 (3)	5
B "	60	50	10
Ba "	740	660	500
Co "	< 15	< 15	8
Cr "	70	70	200
Cu "	120	65	20
Ni "	30	30	40
NO_3 "	140 (21)	110 (3)	--
Pb "	175	25	10
Sr "	120	80	300
V "	110	85	100
Y "	50	40	50
Zn "	130	35	50
Zr "	320	400	300

[Numbers in parentheses refer to the number of samples analysed]

Table 2.-- Chemistry of garden soils compared to natural soils in San Juan County, New Mexico.

Element	Garden Soils (12)	Natural Soils (43)	Ave. world wide soils
Fe percent	3.0	2.0	3.8
Mg "	0.6	0.5	0.68
Ca "	1.14	3.3	1.37
K "	2.2	1.9	1.4
P "	.02	0.016	.08
Mn "	.07	.04	.085
Ti "	0.47	.35	.46
As ppm	13	9.2	5
B "	35	40	10
Ba "	690	650	500
Co "	7	7.5	8
Cr	30	45	200
Cu	25	28	20
Ni	15	10	40
NO_3	100	--	55
Pb	60	18	10
Sr	160	310	300
V	70	60	100
Y	20	28	50
Zn	80	40	50
Zr	425	790	300
pH	8.17	9.1	

Table 3.-- Comparison of garden soils in Maryland, New York, and New Mexico.

Element	World Wide	Maryland (25)	New York (5)	New Mexico (12)
Fe (percent)	3.8	4.0	1.9	3.0
Mg "	0.68	0.9	1.2	0.6
Ca "	1.37	1.4	3.0	1.1
K "	1.4	3.1	1.6	2.2
P "	0.08	0.11	0.11	0.02
Mn "	0.085	0.12	0.062	0.07
Ti "	0.46	0.64	0.4	0.47
As (ppm)	5	14	11	13
B "	10	60	80	35
Ba "	500	740	500	690
Co "	8	< 15	< 11	7
Cr "	200	70	60	30
Cu "	20	120	100	25
Ni "	40	30	30	15
NO_3 "	55	140	300	< 100
Pb "	10	175	420	60
Sr "	300	120	120	160
V "	100	110	110	70
Y "	50	50	40	20
Zn "	50	130	240	80
Zr "	300	320	280	425

Table 4.-- Comparison of inorganic constituents in ash of native and garden plants in Washington County, Maryland.

Element	Garden produce (95)	Native vegetation (38)	World-wide herbs
Fe (percent)	.28	.37	.68
Mg "	2.6	5.5	3.0
Ca "	7.9 (27)	19.4	8.5
K "	32.0	17.0	24.3
P "	2.5	1.9	2.8
Mn "	.037	.344	.21
Ti "	.030	.039	.023
SO_4 "	1.59	3.22	3.0
B (ppm)	200	410	460
Ba "	270	970	550
Cr "	~ 10	~ 15	14
Cu "	90	150	120
Ni "	< 10	< 20	34
NO_3 (d.w.)	6850	400 (3)	4730
Pb (ppm)	~ 30	~ 100	41 (?)
Sr "	375	700	950
V "	< 20	< 20	20
Zn "	500	300	630

Table 5. Comparison of inorganic constituents in ash of native and garden plants in San Juan County, New Mexico.

Element		Garden produce (39)	Native vegetation (101)	World-wide herbs
Fe (percent)		.0765	.6 (100)	.68
Mg	"	1.4	2.6 (100)	3.0
Ca	"	5.0	18.0 (100)	8.5
K	"	26.0	20.0	24.3
P	"	3.6	1.54	2.8
Mn	"	.01	.052	.21
SO_4	"	.65 (4)	2.4 (75)	3.0
Ti	"	.0085	.1365	.0232
B	"	195	355	460
Ba	"	150	600	550
Cr	"	<10	30	14
Cu	"	50	65	120
Ni	"	10	20	34
NO_3	" (d.w.)	490 (32)	---	4730
Pb	"	<10	20	41 (?)
Sr	"	300	3480	950
V	"	<10	20	20
Zn	"	350	460	630
Mo	"	<7	16	49
Zr	"	<50	85	32

(Numbers in parentheses refer to the number of samples analysed)

Table 6.-- Comparison of elements in peeled and unpeeled produce, shown in ppm.

	Fe		Mg		Ti		Cu		Pb		B		Mn		Cr	
<u>Root Vegetables</u>	P	UP	P	UP	P	UP	P	UP	P	UP	P	UP	P	UP	P	UP
Salsify	100	20,000	10,000	20,000	30	1,500	10	150	10	20	100	150	30	1,000	<10	70
Onions	7,000	5,000	15,000	30,000	15	700	200	100	10	20	150	200	200	300	<10	15
Beets	600	4,000	22,000	25,000	40	1,100	40	125	<10	75	80	85	100	500	<10	40
Potatoes	900	2,000	16,000	50,000	50	250	80	120	<10	45	170	60	80	100	<10	~6
Carrots	1,200	2,700	17,000	20,000	100	490	35	100	<10	20	150	160	130	150	<10	14
Average of 26 samples	1,300	4,400	17,500	31,500	54	700	60	120	<10	45	140	108	100	330	<10	15
<u>Fruits</u>																
Peaches	700	1,500	5,000	30,000	100	70	20	150	10	<20	150	300	70	150	<10	5
Apples	600	900	15,000	21,000	60	40	55	170	<10	15	320	530	100	100	<10	10
Average of 8 samples	600	1,050	12,000	15,000	70	45	45	160	<10	12	280	470	90	110	<10	8
<u>Leafy vegetables</u>																
Unpeeled, 22 samples		2,800		25,400		375		70		38		250		300		11
Notes	More Fe and greater difference in underground		More Mg & greater difference in underground		Ti. conc. in root epidermis		Cu greater in epidermis of all plants		Pb conc. in epidermis of underground		B in skins of fruit		Mn in epidermis of underground			

Table 7. Comparison of garden plants in 3 areas of different disease rate.

Element	World-wide herbs	Maryland (95)	New York (14)	New Mexico (39)
Fe (percent)	0.68	.28	.3	.076
Mg "	3.0	2.6	3.0	1.4
Ca "	8.5	7.9 (27)	10	5.0
K "	24.3	32	28	26.
P "	2.8	2.5	2.9	3.6
Mn "	.21	.037	.018	.01
SO_4 "	3.0	1.59	---	.65
Ti "	.0232	.030	.053	.0085
B "	460	200	280	195
Ba "	550	270	200	150
Cr "	14	10	13	<10
Cu "	121	90	90	50
NO_3 " (d.w.)	4730	6850 (52)	11,140	490 (32)
Pb "	41 (?)	20	66	<10
Sr "	950	375	455	300
Zn "	630	500	500	350

(Numbers in parentheses refer to the number of samples analysed)

Table 8. Ratios of greatest significance between inorganic constituents in soils and plants of Maryland and those of New Mexico.

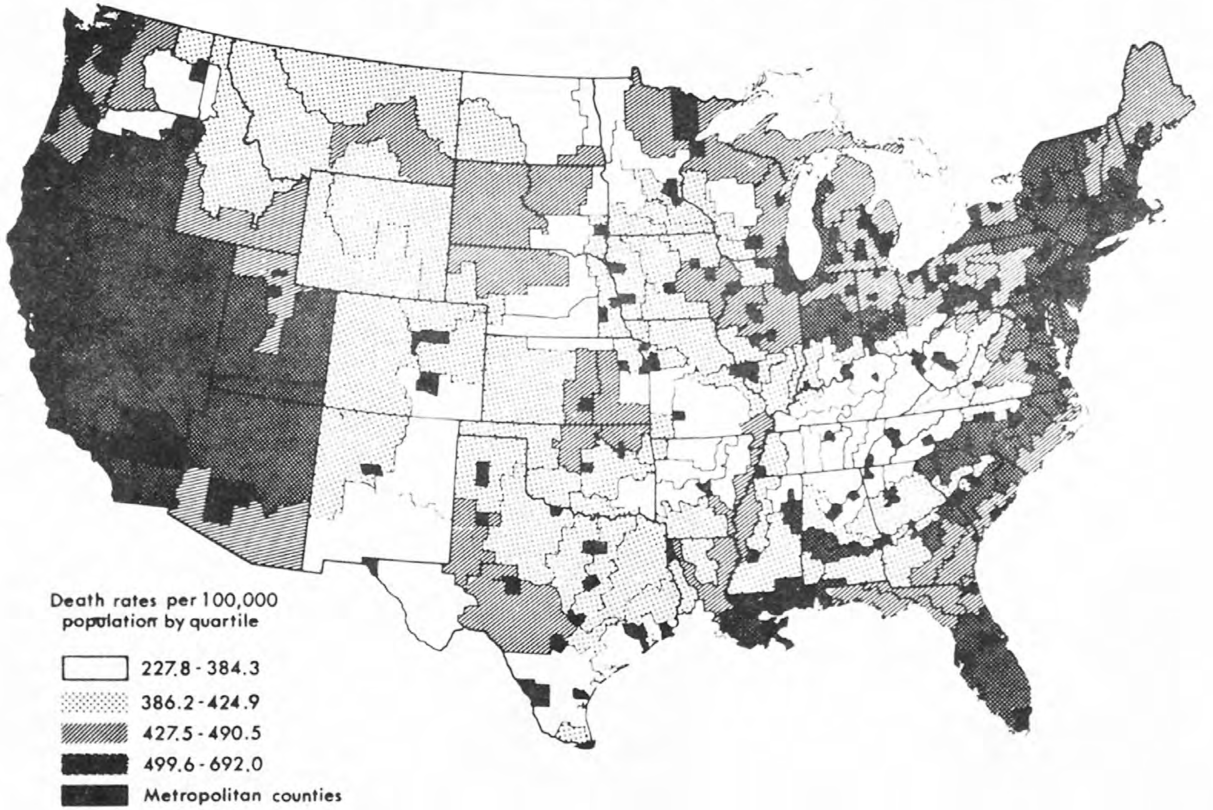
		Maryland/New Mexico			
		Soils ratios	Students't	Plant ratios	Students't
Geologic	Fe	1.3	N	3.7	H
	Ti	1.4	P	3.2	H
	Cu	4.8	H	1.8	H
	Mn	1.9	H	3.1	P
	Cr	2.3	H	>1.0	P
Contamination	NO_3	>1.4	P	13.9	H
	K	1.4	H	1.2	H
	Pb	2.9	H	>2.0	P
	P	5.5	H	0.7	P

Note: N = not significant

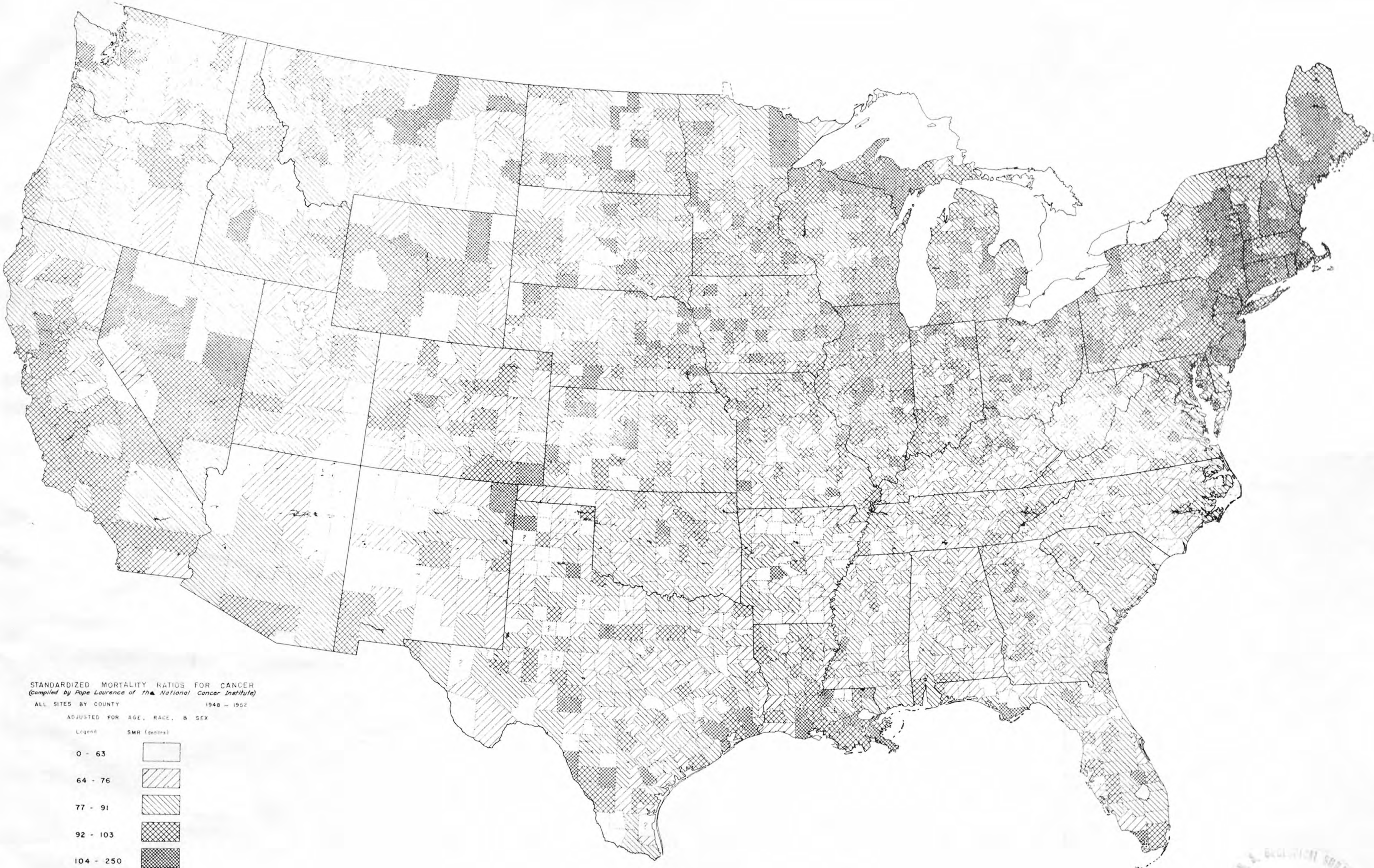
P = probably "

H = highly "

Figure 1. Coronary heart disease death rates for 116 economic subregions, nonmetropolitan areas only, white males aged 45–64, 1949–51



NOTE: Age adjusted in 10-year intervals.



STANDARDIZED MORTALITY RATIOS FOR CANCER
(compiled by Pope Laurence of tha National Cancer Institute)

ALL SITES BY COUNTY 1948 – 1952

ADJUSTED FOR AGE, RACE, & SEX

Legend	SMR (deciles)
0 - 63	
64 - 76	
77 - 91	
92 - 103	
104 - 250	

P.A.L. - 1958 NCI

? indicates SMR of a county in which number of cancer deaths was too small to give stable statistics.