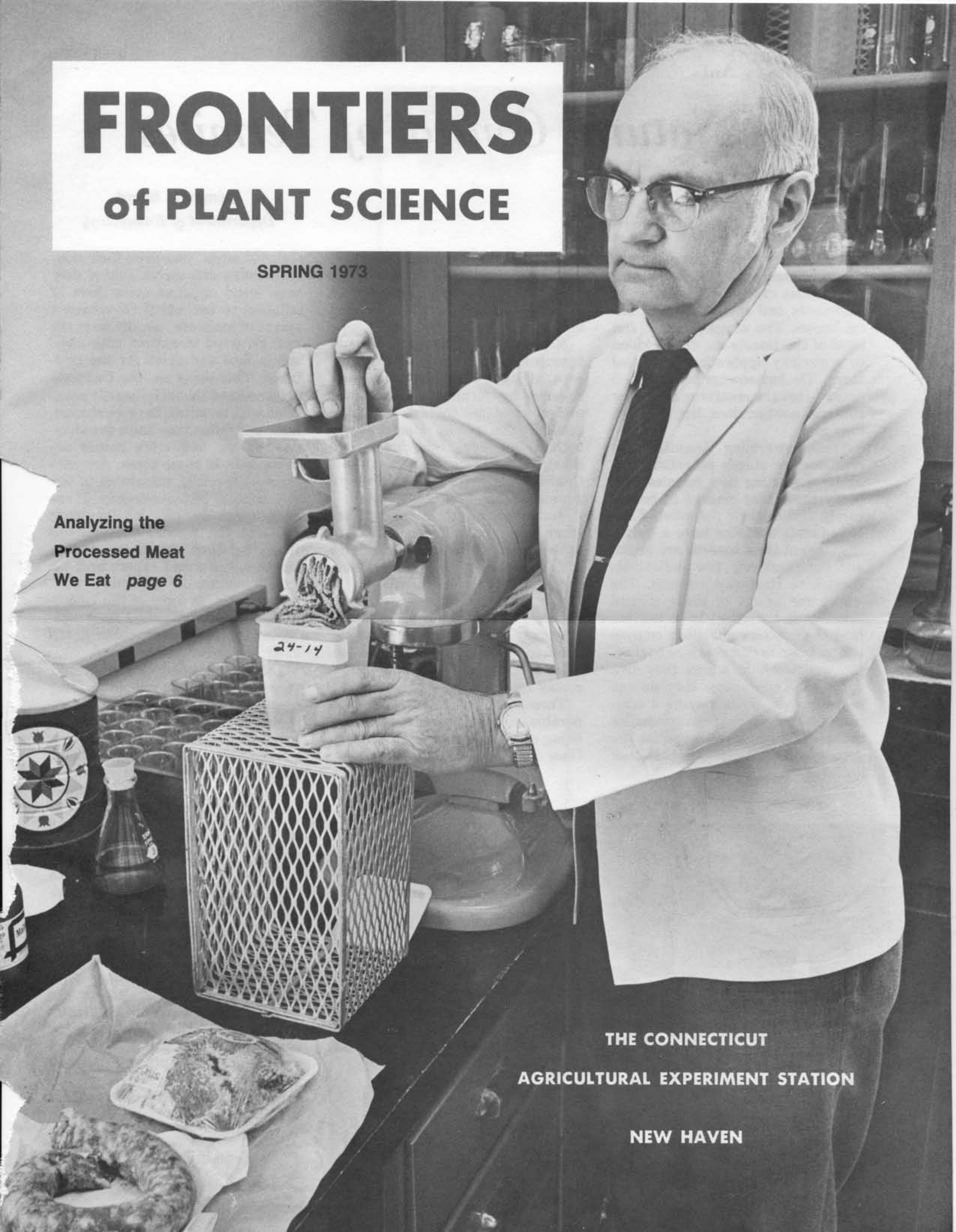
FRONTIERS of PLANT SCIENCE

SPRING 1973



Analyzing the Processed Meat We Eat *page 6*

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

NEW HAVEN

Hungry Ants

A Natural Control of Termites

Raimon L. Beard
Department of Entomology

IN SPRING, swarms of gauzy winged black insects may issue from inconspicuous cracks and crevices in basements and rooms of Connecticut homes. The wings drop off, and most of the insects die or are killed by a panicky application of aerosol spray. The homeowner hopes—even prays—that the creatures are flying ants and not termites. But termites they are.

These swarming termites are reproductive stages potentially capable of starting new colonies. Actually those that emerge in houses rarely realize their potential. Similar swarms outdoors have a better chance, but their hazards are great, and comparatively few individuals survive to start new colonies. The worrisome aspect of these winged termites is that they have left behind their sisters and their cousins and their aunts that continue to chew the woodwork in which they live and feed. The damage they do can be extensive. What may be a common biologic event can prejudice the sale of a house or jeopardize the getting of a mortgage. On the other hand, what may be a budget-breaking, unexpected expense for a homeowner may be employment for an exterminator and a carpenter called in to repair the damage.

Reproductive pairs of swarmer termites may indeed, if they escape all their hazards, start new colonies by forming a small nest under wood in contact with the ground. The colony starts slowly with a few eggs that hatch into slowly developing termite larvae. Gradually numbers increase to form a social group of different castes.

But termites form colonies in another way, too. From an established nest, termites forage for some distance seeking other feeding areas. When a suitable site is found, foragers accumulate there. Either intentionally or accidentally, they may become isolated from the main colony. Reproductive individuals develop and an independent colony results.

These incipient colonies are vulnerable to many hazards, especially being eaten by other small animals. Once they gain strength in hidden, secluded nests, time is on their side.

Larvae and soldier termites.

Termites can thrive only if they have wood or some other form of cellulose to eat and if they have a source of moisture, usually from the soil. So wood in contact with moist soil is food and drink for the creatures. This being so, the Connecticut woodland should be heavily populated with termites, for here stumps, logs, and fallen tree limbs are abundant. More and more homes are being built in these areas. Are such houses especially vulnerable to termite attack? Not necessarily. If one seeks termite colonies in likely spots in the woods, one can find them, but they are far less numerous than one would expect from the great number of favorable sites. Why is this, in view of the longevity of termite colonies, their ability to form autonomous colonies, and their powers of reproduction?

I first suspected that ants may play an important role in limiting termite numbers when I tried an experiment on termite colonization in a woodland situation. I placed three established, reproducing, thriving colonies of termites in favorable sites. Two weeks later I found three thriving colonies of ants instead of termites. Foraging ants had found my experimental colonies, moved in and consumed the lot.

Tropical termites are well-known to be hunted and destroyed by tropical ants, but our own Eastern subterranean termite has been thought to be much less subject to ant predation. To be sure, foraging ants have been known to eat termites upon chance encounter. But also, ant and termite colonies live as indifferent neighbors in the same piece of wood, practically side by side, and so ants have been given little credit for any biological control of termites. But there are ants and there are ants.

It was the common cornfield ant (*Lasius alienus*) that interfered with my experiment. I was curious to see if under closer observation this kind of ant could destroy a termite nest. I confined a colony of termites and one of the cornfield ant separately. After a few months, when both groups were established and thriving, I connected the two containers with a plastic tube. The ants quickly moved into the termite container and began to occupy the termite tunnels. Within ten days an ant brood was present there, and termites became obviously depleted. By three weeks no termites could be seen, and ants had complete possession of both containers.

A similar, but more dramatic raid was observed with another ant species—*Lasius umbratus*. This is a subterranean ant that forms colonies of great numbers in rotten stumps. A populous community of this ant was kept in a large container. When this was placed in contact with a similar container holding an established termite colony, ants quickly swarmed into the termites' nest. They probed into all channels, capturing termites and taking some back to their own nest. Within two hours the ants had destroyed all visible termites and occupied their runways. By the next day ants had brought some of their own brood to the new site and occupied both containers.

Winged termites.

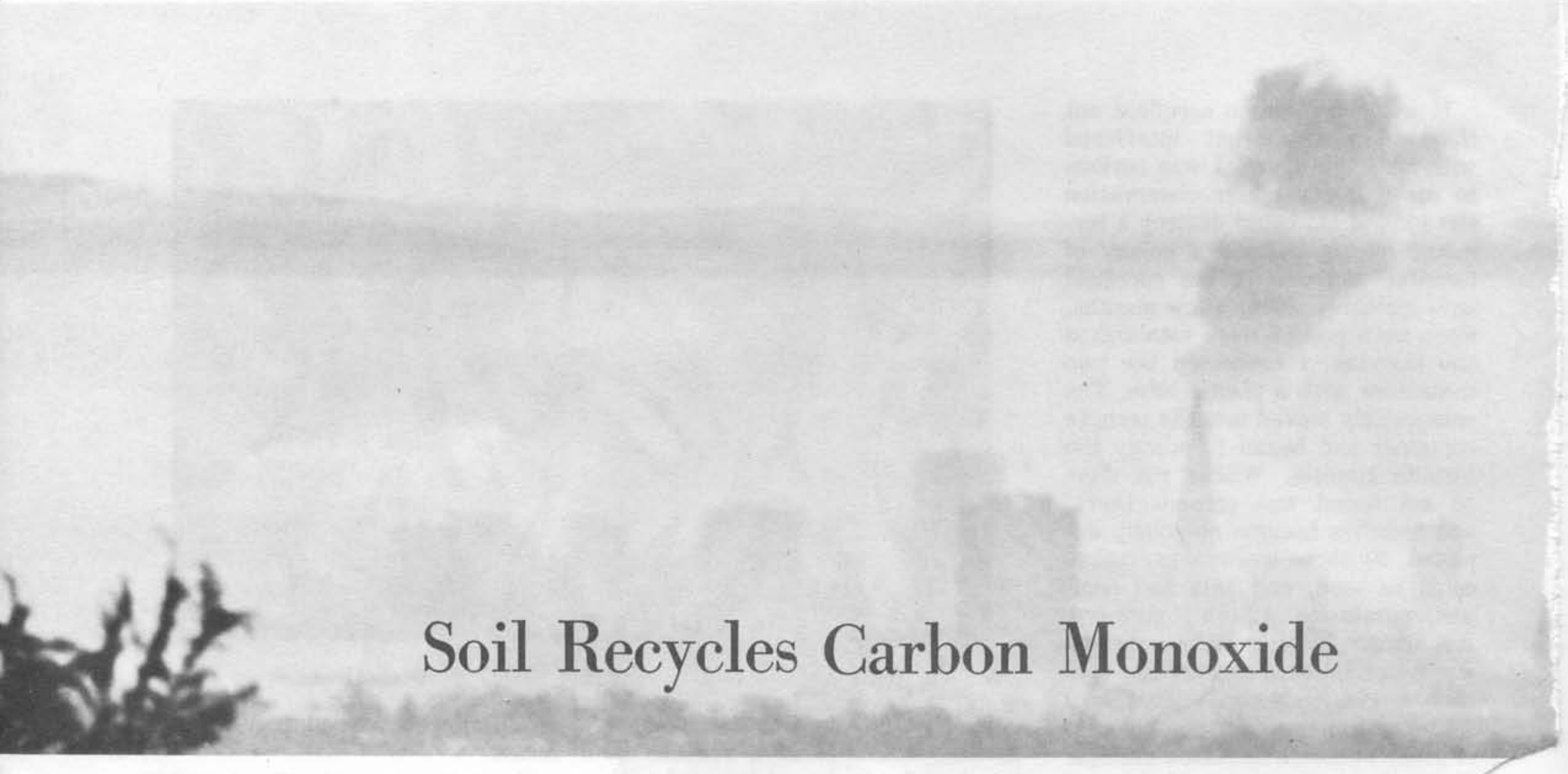
In similar tests and also in more natural situations of a greenhouse bench and a tool shed infested with termites, the termites have been destroyed by the common pavement ant (*Tetramorium caespitum*).

We now know that ants not only feed on the occasional termites they find in foraging, and that incipient colonies of termites are fair game, but that some ants at some times search and destroy active termite colonies. We are trying to learn more about this predation and to see if we can exploit this means of biological control. Actually, in India, ants are introduced into warehouses to check the depredations of termites.

True, some people would rather have termites, that work unseen, than ants that obtrude into a well-kept house. But others panic at the thought of their homes being slowly digested, and would take desperate measures to eliminate the trouble maker. In any case it seems highly probable that in woodland situations, ants may be responsible for limiting the numbers of termite colonies, and perhaps we assist termite attack upon our homes when we kill nuisance ants around our foundations.

Termites succumb to attack by foraging ants.

Termite tunnels in section of log.



Soil Recycles Carbon Monoxide

Inversion over Hartford. Courtesy of George C. Atamian, Talcott Mountain Science Center, Avon.

It's carbon and monoxide, the ole Detroit perfume.
And it hangs on the highways in the morning
*And it lays you down by noon.**

Gary H. Heichel
Department of Ecology and Climatology

THE FOLKSINGER cautions his listeners about carbon monoxide, the most massively generated pollutant in the Northern Hemisphere. Far from being an aromatic gas, carbon monoxide is a colorless, odorless pollutant that signals its presence in air by causing headaches, dizziness, and nausea. On the local scene, carbon monoxide accumulates near the ground in urban areas during inversions, when a stagnant layer of air a few hundred feet above the ground throttles turbulence, and prevents vertical mixing of the air and rapid dissipation of this gas.

More than 330 million metric tons of carbon monoxide are released each year into the atmosphere from sources related to man's activities. About 75% of this total, or 250 million metric tons per year, is produced by the combustion of gasoline in automobiles. Approximately 12% is released by burning of wood, about 8% is released by incineration, and 5% is attributable to the burning of coal for power generation and manufacturing (Fig. 1).

The hourly course of carbon monoxide concentration in the air above the Station's Slate Laboratory, which is located in a residential area 1.7 miles north of the center of New Haven and 0.2 mile from a heavily traveled commuter route, was measured during an inversion on November 19 and 20, 1971 (Fig. 2). During this inversion, the concentration of carbon monoxide averaged over 10 minutes ranged from 2 to 15 parts per million (ppm). The concentration of carbon monoxide nearer the heavily traveled com-

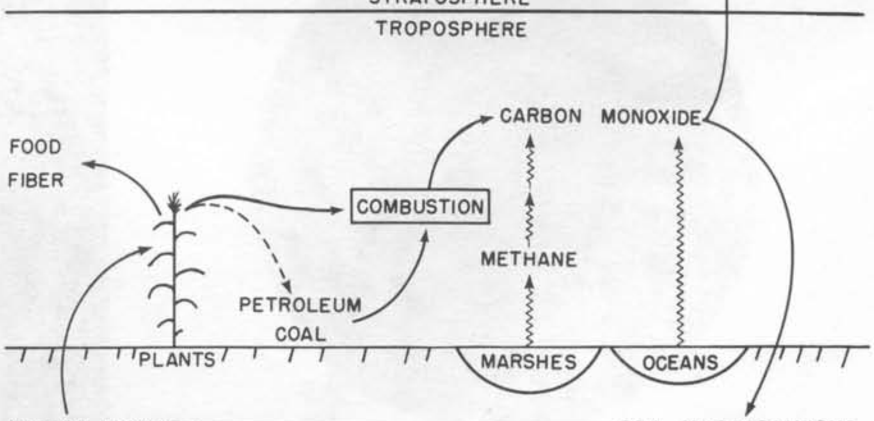


Fig. 1. A cycle illustrating the generation and disappearance of carbon monoxide in the atmosphere.

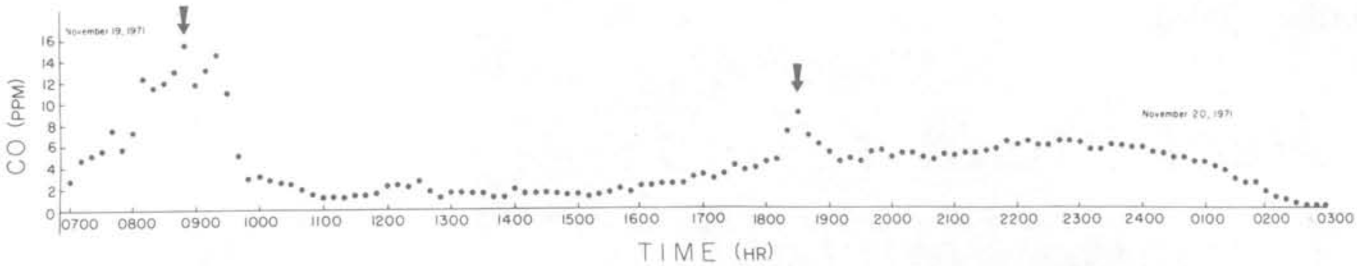


Fig. 2. Record of carbon monoxide concentration in the air above Slate Laboratory between 7 A.M., November 19, 1971, and 3 A.M., November 20, 1971. The marked increases in concentration in the early morning and late afternoon correspond to periods of peak traffic.

muter route was undoubtedly much higher. The arrows indicate the sustained increases in carbon monoxide concentration that are especially characteristic of the air above urban areas during periods of peak morning and evening traffic. In comparison, the average concentration of carbon monoxide in the air on days nearly free from pollution is 0.2 to 0.4 ppm. Paradoxically, the average concentration of carbon monoxide in the troposphere, the lower layer of the atmosphere contacting the earth, has not changed since observations commenced more than 20 years ago, although sources related to man's activities renew 20% of the tropospheric burden each year.

To make the paradox stronger, natural sources apparently renew the small and steady burden of carbon monoxide in the troposphere about once in three months. The natural sources of carbon monoxide are not clearly established, but they are probably about 10-fold greater than the sources related to man's activities. Forest fires, the metabolism of seaweed in the oceans, and the reaction of sunlight with the aromatic vapors emitted by coniferous trees account for about 3% of the natural emission of carbon monoxide. Another 3% is released during autumn when chlorophyll, the green pigment in plants, degrades. The remaining 94%, or about 2,800 million metric tons annually is attributed to the oxidation of methane generated in swamps, marshes, and rice paddies (Fig. 1).

Long mystified by the circumstances that permit the air to purge itself of such prodigious quantities of carbon monoxide, scientists are searching for "sinks" or natural processes that drain it from the air. A natural process that removes about 11% of the accumulation is the vertical transport of carbon monoxide from the troposphere, or lower atmosphere, to the stratosphere, or upper atmosphere (Fig. 1). The oceans were once thought to remove carbon monoxide from the air, but we now know that oceans emit the gas.

Plants remove small quantities of carbon monoxide from the air, but the removal is only temporary since chlorophyll releases carbon monoxide when the plants die. More than 60 years have elapsed since the first observation that a bacterium isolated from the soil could metabolize carbon monoxide. This discovery lay dormant until observations in California and then Connecticut showed that soils populated by prospering microbial communities help cleanse the air of this pollutant.

A forest soil obtained in Glastonbury exhibited particularly vigorous removal of carbon monoxide (Fig. 3). The speed of removal of carbon monoxide increased with increasing concentrations of this pollutant. An especially surprising result was that soils remove carbon monoxide more effectively at high than at low concentrations of the gas. For example, increasing the concentration 3-fold from 10 to 30 ppm speeds carbon monoxide removal about 10-fold.

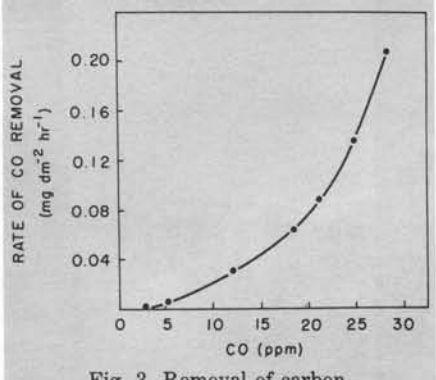


Fig. 3. Removal of carbon monoxide by a forest soil.

Moist soils cleanse carbon monoxide from air more rapidly than dry soils, but overloading the soil with moisture retards the removal (Fig. 4). Carbon monoxide removal by the forest soil increases between 20% and 60% soil moisture content as the activity of the microbes increases. Above 60% moisture content the removal of carbon monoxide slows because some of the pores in the soil become filled with water, and movement of the pollutant to the microbes is impaired.

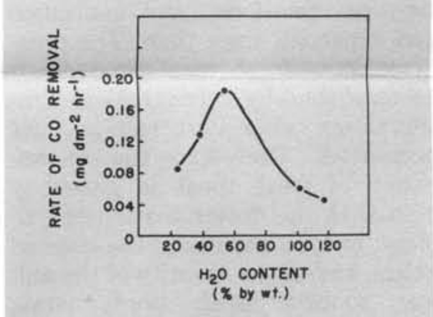


Fig. 4. Response to soil moisture of carbon monoxide removal by a forest soil.

Soils covered with a dry, hard crust also remove carbon monoxide from air very slowly, but tillage to expose the moist undersurface renews the capacity of soil to cleanse the air. Removal of carbon monoxide by soil is more effective on breezy days when the transport of the gas to the soil surface is rapid, than on calm days when the air is stagnant.

From our studies on the removal of carbon monoxide by soils, we estimate that in one year the soil surface of the earth removes about 14% of the annual additions of carbon monoxide to the atmosphere. Ob-

(Continued on page 7)

Station Chemists Report

Meat Product Analyses Increase Fourfold

J. Gordon Hanna
Department of Analytical Chemistry

PREHISTORIC and preagricultural humans depended on fresh meat as their principal food supply. Basic procedures for processing meat evolved and were well established before the beginnings of recorded history. Historical references to meat preservation based on drying, smoking, and salting go back to about 1000 B.C. Today, although meat is not a universal food, its consumption is increasing in direct relationship to the increasing prosperity of peoples.

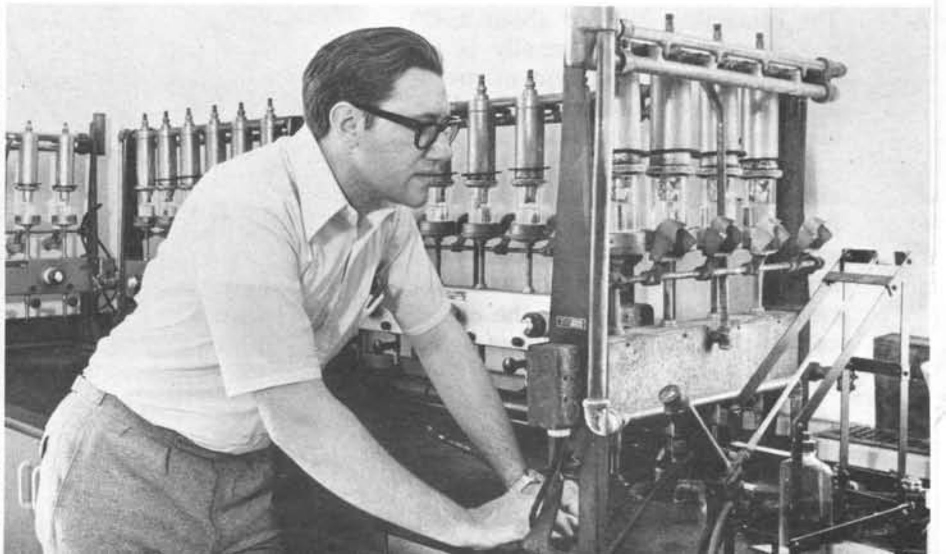
Inspection of meat products began at the Station in 1895 primarily to detect adulteration, and laboratory examinations have continued and expanded since then. The preservation of fresh meat products is accomplished by refrigeration. Preservatives other than salt are not permitted. Therefore the examination of fresh meat is generally limited to the determination of edibility, of conformance to the claimed grade, and of the identity of the animal species: beef, pork, lamb, horse, and so on. Except possibly to confirm the animal species, little laboratory work is required.

The analyses of processed meats, on the other hand, are both complex and difficult, requiring tests for compliance with the numerous federal and state regulations that govern the compositions. A variety of cured and processed meats such as frankfurters, hamburger, sausage, corned beef, and bacon have become consumer favorites. In the United States more than 8 billion pounds of cured meat are produced annually.

To help ensure the wholesomeness of meat products for the Connecticut consumer, the analytical chemistry laboratory of the Station performs approximately 7,500 determinations annually of ingredients in about 1,000 samples from some 166 wholesale establishments and in about 400 samples from retail outlets in towns and cities. Prior to 1969 samples were collected and submitted to this laboratory by Department of Consumer Protection food inspectors under the authority of the Connecticut Pure Food, Drug and Cosmetics Act. The samples were for the most part from retail stores, with only a limited number from processing plants. Passage of the Connecticut Meat and Poultry Products Inspection Act by the General Assembly in 1969 caused permanent stationing of Consumer Protection Department meat inspectors in each of the state-licensed plants. This has brought a four- to fivefold increase in meat product analysis at this Station. The analytical results are used as bases for deciding the acceptability of batches of meat products for the consumer market.

The analysis of frankfurters, as an example, may include separate determinations for any or all of the following components: total protein, meat protein, fat, total water, added water, nonfat dry milk solids, soy flour, soy protein concentrate, isolated soy protein, sodium nitrite, sodium nitrate, phosphate, salt, cereal, and corn syrup solids. Maximum amounts of materials permitted in some common meat products are shown in the table. Meat content minimums also have been established for such products as meat pies (15%), poultry pies (14%), pizza with meat (15%), soups (2%), ravioli (10%), and spaghetti with meat balls (35% meat balls). Raw products intended for use as meat addi-

Mrs. Lucia A. McLean determines the dry skim milk content of processed meat. Below, John J. Hayes extracts fat from a sample.



Cover Photo

A. F. Wickroski, with 27 years of service in the Station Department of Analytical Chemistry, grinds a processed meat sample for analysis.

tives are also checked to assess their suitability as food-grade materials before they are used. The results of all meat analyses are published each year in the Station Bulletin, "Food from Connecticut Markets and Farms." The 1973 report, Bulletin 737, will be ready for distribution early this summer.

The analytical procedures followed by Station analysts are as far as possible those standardized by the United States Department of Agriculture. However, satisfactory methods are not available for the determination of all ingredients in the great variety of combinations in which they are found. For example, there is no laboratory procedure to discriminate between meat protein and hydrolyzed plant proteins after they are mixed in sausages.

Now, the amount of vegetable protein added can be monitored only by inspectors who supervise the product recipes in processing plants. Chemists here are investigating the possibility, with some indications of success, of making a laboratory differentiation based on the amino acid and peptide contents associated with the hydrolyzed protein, with essentially none expected to be contributed by the unhydrolyzed meat protein. Some of the analytical methods for the isolation and determination of constituents present in minor amounts are tedious and time consuming. Novel analytical approaches are being developed and applied to save time and improve the accuracy of the results for such ingredients as the flavor enhancer, monosodium glutamate, and for the preservative, sodium nitrite.

About 60% of the total laboratory food analysis effort is apportioned to meat. Among other food analyses are determinations of the ingredient contents of vegetable oils and salad dressings, the caloric contents of dietary foods and beverages, the egg contents of macaroni and noodle products, pesticide residues in fruits, vegetables and milk, the fruit contents of fruit beverages, and the examination of many food products for possible off-condition and adulteration. Recently enacted state legislation requires flour and bakery products to be enriched with vitamins and minerals. To meet consumer desires an increasing number of labels of packaged foods are being required to state the nutrient values of the contained food. It is the responsibility of the laboratory to supply the analytical data needed for the new enforcement activities.

Maximum amounts of materials permitted in some common meat products

	Percent					Parts per million
	Fat	*Added water*	*Phos-phate*	*Binders and extenders**	*Corn syrup solids*	*Sodium nitrite*
Frankfurters, bologna, and other cooked sausages	30	10	0.5	3.5	2	200
Breakfast sausage	50	3	0.5	3.5	2	200
Hamburger and ground beef	30	0	0	0	0	0
Corned beef	–	10	–	–	–	200
Ham	–	0 10**	0.5	–	–	200

*Individually or collectively; cereal, vegetable starch, starchy vegetable flour, soy flour, soy protein concentrate, isolated soy protein concentrate, nonfat dry milk.
**If declared.

Soil Recycles CO

(Continued from page 5)

viously, other biological or chemical "sinks" for carbon monoxide await discovery, or the concentration in the atmosphere could not remain constant. However, soil is apparently equally as important in cleansing air of carbon monoxide as the only other known natural process, the diffusion of carbon monoxide from the troposphere into the upper atmosphere. The microbes in the soil apparently convert most of the carbon monoxide into carbon dioxide, the raw material used by plants in the photosynthetic production of food and fiber (Fig. 1). Clearly, soils teeming with microbial populations are the catalysts in an important natural cycle that converts a gaseous pollutant into a gaseous resource important to plants and people.

New Publications

The following new Connecticut Station publications have been published since the last issue of Frontiers. Requests for copies should be addressed to Publications, Box 1106, New Haven 06504. As readers understand, results of many other scientific investigations at the Station are published in professional journals. During the past 6 months, 75 such articles have been submitted for publication.

Entomology

B 735 Aerial Application of *Bacillus thuringiensis* Against Larvae of the Elm Spanworm and Gypsy Moth and Effects on Parasitoids of the Gypsy Moth. Dennis Dunbar, Harry Kaya, Charles C. Doane, John F. Anderson, and Ronald M. Weseloh.

Inspections and Analyses

B 734 Pesticide Inspection Report for 1972. J. Gordon Hanna.

B 736 Commercial Feeding Stuffs Inspection Report for 1972. J. Gordon Hanna.

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Paul E. Waggoner
Director

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PLANT SCIENCE DAY

Wednesday, August 8 Lockwood Farm

What About High Food Prices?

Paul E. Waggoner

IN THE SPRING of 1973 the director of any agricultural experiment station would be guilty of dodging the question in all minds if he did not answer "What about high food prices?" I'll not dodge.

The causes are clear. In the long run, nations have been increasing their eating faster than farmers have been increasing the yield of grain and meat. This has come about because we, and most other nationalities, have multiplied our numbers. Also, in the United States and abroad, consumption multiplied as more and more people were able to move from the 400-lb-per-year grain consumption of the plant-eating classes to the 2000-lb-per-year grain intake of the meat-eating classes and their cattle. On the supply end, no new continents have been discovered recently, and, as James Horsfall reported with accurate but unhappy foresight in this column nearly 2 years ago, yields per acre have not increased recently as they used to.

In the short run this grocery system with its eroded margin of safety was brought to its present state by corn blight in the United States, drought in Asia and bad weather in Russia. The ill luck has been passed around as the Russians bought wheat that might have gone into bread here, and we bought meat that might have gone to Britain.

What's to be done? In the short run the economic lash will probably make us eat more grain and beans ourselves and feed less to cattle, saving the energy otherwise lost in the feed lot. A more pleasing remedy will be taking the 10 to 20% of our cropland out of reserve while hoping we were not clever enough to put only erodable and infertile acres in that bank, and hoping those acres in the bank won't require large capital investments such as irrigation. Unfortunately these short-run measures will further decrease the margin of safety in the grocery system.

Long-term remedies also can be conceived. There is population control, but if we avoid an apocalyptic turn, only a gradual leveling—not a decline—can be foreseen. That leaves agricultural research.

The Connecticut Station has had enough success in the past to encourage hope that we can again give significant help. The discovery of the first vitamin and the invention of hybrid corn at the Station in the last generation, and the other worthwhile things in the intervening years, show what a small band of scientists can do. Thus while some of us are improving Connecticut trees and learning how to protect them from bugs and blights, or investigating the nutrients that escape from the soil to green our lakes, or trying to solve some of the other biologic problems that concern an urban state, others are at work on the fundamental problem of growing more abundant food.

In the last issue of Frontiers biochemist Zelitch told of the efficient respiration of a few plants. Research on this, on other promising peculiarities of respiration, and on resistance to the pests that steal our crops are going on full tilt, and a new genetics may show how these advantages can be transferred to our food plants, right in test tubes in our laboratory. This research encourages us.

Only time will tell whether our dream can be realized. But meanwhile the housewife aghast at the cash register, and the poultry and dairy farmers appalled by their feed bill, can be sure that we're striving, too.

Josephy to Speak

Robert Josephy, Bethel, will be the principal speaker on Plant Science Day, August 8, in Hamden.

Frontiers of Plant Science published in May and November, is a report on research of The Connecticut Agricultural Experiment Station. Available to Connecticut citizens upon request.
Vol 25 No. 2 May 1973 ISSN 0016-2167 Bruce B. Miner, *Editor*