

1969

## Fall 1969

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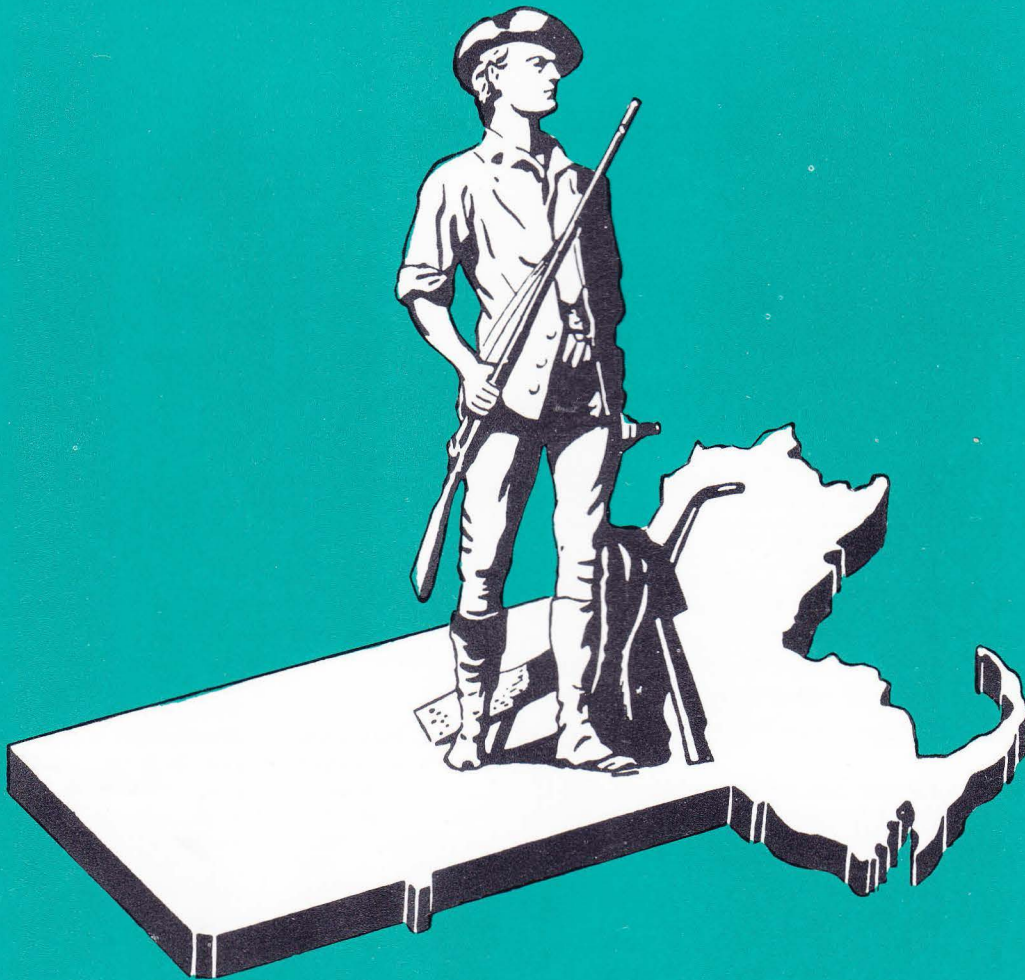
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# TURF BULLETIN

MASSACHUSETTS TURF  
AND LAWN GRASS COUNCIL  
I N C O R P O R A T E D



FALL 1969

BETTER TURF THROUGH RESEARCH AND EDUCATION

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Vol. 5, No. 4

Fall 1969

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# ARTIFICIAL TURF FACES CREDIBILITY GAP

By Dr. Gene C. Nutter, Editor

—Reprinted from  
Turf Grass Times, Vol. 4, No. 4  
April 1969

There is beginning to be a lot of talk from stadium managers, coaches, P. R. men and other so-called experts about how — despite big maintenance budgets — it is impossible to produce safe and satisfactory turf in sports complexes, so artificial substitutes have been brought in. Some very ardent salesmen of artificial substitutes and a lot of promotion money by manufacturers of synthetic turf products have apparently convinced supposedly objective architects that real turf just won't work on new athletic fields — so synthetic substitutes should be specified. Promotion minded owners of sports complexes have seen the synthetic route as a great source of publicity since the advent of the Astro-dome. Even some coaches have taken to this new fad.

Three things disturb me in this issue — none of which involve the basic concept of whether or not the present "varieties" of artificial turf are really adequate to replace true grass. What is actually involved, is a credibility gap. The full story is not being told. In many cases all the facts are not even in; time only can provide the answers.

## CREDIBILITY GAP #1 THE TURF MAINTENANCE MYTH

First, in regard to the comments about the size of turf maintenance budgets, just think in your own area how many sports complexes you know that have enjoyed top turf management and adequate budgets. It is a well accepted fact that athletic fields as a group have been among the most neglected of turf facilities. This is particularly true of scholastic and municipal fields as well as many collegiate and professional fields. In many cases, the man charged with the responsibility of establishing and maintaining healthy turf probably was never exposed to this work before. If he were not professionally trained in turf management, he could not be expected to understand the complex biological relationships involved or the technology



The astrodome in Houston revolutionized sports complexes. An allweather protective dome and air conditioned comfort greet the spectators. A giant carpet of artificial turf greets the players, who must dress out in special shoes in order to maneuver on the artificial surface. Some like it, some accept it, some voice disapproval — but it is unique. The cost for artificial turf installation was reported to be between \$250,000 and \$500,000. (Turf-Grass Times photo.)

associated with growing turf conditioned to withstand athletic functions. Chances are he probably never had training in any kind of agriculture. Quite likely he was a building custodian, and an expert on floor waxes, sweeping compounds and cleaning materials.

Just as incredible is the talk about the adequacy of money for maintaining sports complexes. Some have provided both qualified turf specialists and reasonable budgets. Unfortunately, however, these are the exception. Too often the ownership or management of sports facilities has provided money for every facet of their operation before

dealing out a pittance to turf management.

At the same time it could not be reasonably expected that the custodian or untrained caretaker would be in a position to either spell out turf budget requirements, or carry them out fully if they were provided.

Such being the case, it seems to me rather incredulous to air statements about the failure of turf despite the adequacy of management and money. Had there been adequate money and adequate turf know-how, there might be no need for talk about artificial turf. In

(Continued on Page 5)

**I**N RECENT months there have been serious criticisms of what agriculture and industry may be doing to "upset our environment." One individual in particular has made a concentrated attack on the nitrogen cycle, and what modern-day technology is doing to upset it. He says that "The nitrogen cycle is very vulnerable to human intervention. In the U.S., the over-all annual biological turnover of nitrogen amounts to about seven or eight million tons." Actually, the amount is vastly greater than that as I will point out later.

This critic charges that current technology and agriculture introduce "about seven million tons of nitrogen compounds from chemical fertilizers, and two to three million tons of nitrogen compounds generated by automobile exhausts and power plants," into this cycle.

While these quantities of nitrogen may have significance in the nitrogen cycle, I would like to suggest that these amounts are quite small in comparison with the total amount of nitrogen, long present in our soils.

Consider that through various biological means, 100 million tons of

*Excerpts from talk presented at the Annual Tennessee Fertilizer Short Course, Nashville, February 18, 1969.*

—Reprint from  
Plant Food Review  
Number 1, 1969



*W. H. Garman*

Dr. W. H. Garman  
Vice President,  
Member Services,  
National Plant Food  
Institute

nitrogen are fixed annually over the world's surface, chiefly by algae in water and bacteria on land. Only about one-fourth of this amount of nitrogen is fixed annually by commercial means. But this commercial nitrogen is very important because it represents the difference between survival and starvation for most of mankind.

#### Livestock's Contribution Great

The nitrogen mentioned thus far does not include the amount excreted by livestock. I do not have figures for other countries, but for the U.S. it is estimated that around 10 million tons of nitrogen are contained in the 1.7 billion tons of animal excreta which must be disposed of annually in this country. How fortunate we would be if there were an economical means of getting this excreta distributed over

the land where its nutrients could be utilized, and filtered through the soil for sanitary purposes. Unfortunately, the cost of doing this exceeds the value of the nutrients and the organic matter, thus most of the vast 1.7 billion tons go to waste through one means or another with much of the soluble constituents entering wells, streams and lakes. Indeed, disposal of manure is one of the biggest problems facing mankind, yet it goes unmentioned by the critic mentioned earlier.

Runoff from farmyards and feedlots is causing growing concern, and the State of Kansas already has passed a law pertaining to operators of feedlots where more than 500 head of livestock are fed, which requires certain physical facilities be installed and certain precautions be taken to handle the manure.

Another false accusation made regarding nitrogen is based on the fact that nitrogen occurs in living things, usually in combination with hydrogen rather than with oxygen. Critics have made quite a point of the fact that nitrogen in combination with oxygen is a form that does not exist very long in nature, except when it occurs in inorganic mineral deposits. One individual states that "It is precisely this slender span of the nitrogen cycle

# NITROGEN FACTS AND FALLACIES

*Consider that through various biological means, 100 million tons of nitrogen are fixed annually over the world's surface, chiefly by algae in water and bacteria on land.*

*Only about one-fourth of this amount of nitrogen is fixed annually by commercial means. But this commercial nitrogen is very important because it represents the difference between survival and starvation for most of mankind.*

which is most affected by human intrusion, for nitrogen introduced into the environment by technology is almost entirely in oxidized forms."

Now, I must take issue with this statement because the nitrogen introduced into agriculture in the form of commercial fertilizers is largely in the reduced form. Only about one-tenth of the nitrogen added in fertilizers last year in this country was in the nitrate form. Thus, almost 90 per cent of it was in the reduced forms of ammonia and urea.

Of course, the ammonium and the amino forms are readily oxidized in fertile soils to the nitrate form. Fortunately, this is so because all nitrogen must pass into the  $\text{NO}_3$  form before most higher plants can use it. The nitrate form, then, is very important to the nitrogen cycle because it is essential to almost all plant life on earth.

#### Facts About Algae

*Observations have been made to the effect that hazards to human life are generated when nitrogen concentrations are "artificially increased," and that pollution of surface water is one such hazard. One individual has said that "resulting 'algal blooms', which soon die, overburden the water with organic matter, which, on being oxidized by microorganisms, depletes the oxygen content of the water, causing the natural cycles of self-purification to collapse."*

Here's what Dr. D. R. Keeney of the University of Wisconsin says about such observations:

*"It's a grave over-simplification to equate algae growth in surface waters with the concentration of nitrate in the water. In fact, algae are plants and must have all nutrients in sufficient supply before they proliferate. Most studies indicate that either or both N and P are limiting nutrients. Environmental contamination certainly has added to the phosphorus load of lakes and streams—particularly from municipal and industrial sources. Because some species of algae are N-fixers, there is a strong possibility that phosphorus has stimulated these growths, causing N to be fixed biologically. Biological breakdown of these algae would then add to the nitrate load of surface waters."*

It's a fact that 40-some species of algae fix nitrogen and that these algae have been very significant factors in providing the nitrogen required to

**Make no  
mistake!  
Nature alone  
could not  
sustain the  
world's  
population  
for one day —  
not in food  
— not in  
clothing.**

change so many of our ancient inland seas and lakes into peat bogs, coal beds, and muck soils throughout the world, and that these same species will continue to fix nitrogen in years ahead.

One self-styled nitrogen expert has taken note of the work required by plants to take nitrate into their root system. He reasons that when nitrate content in soil water is low, plants somehow find the necessary "energy" to pull in the nitrate.

It seems just as logical to reason that unless plants have a mechanism to exclude the  $\text{NO}_3$  molecule, it will go wherever water goes. Whatever the processes involved, oxygen is required because every living cell respire. Don't forget that respiration can take place and does, even under anaerobic conditions. Energy likewise is expended here, but to supply the necessary oxygen in such instances, the nitrate molecule itself is often the oxygen donor. So here again,  $\text{NO}_3$  is necessary.

#### Role of Organic Matter

Seemingly, supernatural powers are attributed by many critics of chemical fertilization to organic matter and humus. Of course, nobody can deny that in a fertile, sandy loam soil, for example, organic matter and humus

will impart desirable qualities, but not necessarily on account of making the soil more permeable for oxygen to facilitate nutrient absorption by plants. Instead, the more desirable qualities from a plant-growth standard are imparted through improved moisture-holding capacity and to some extent, by greater nutrient-holding capacity.

Barring toxic substances, any soil that is fertilized and watered properly will grow huge quantities of top and root material, sufficient to keep the soil in optimum tilth. In fact, the best practical and economical way to get organic matter down into the soil is to grow it there through proper fertilization.

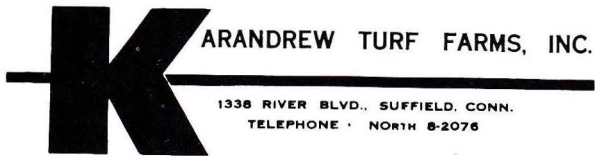
When plant nutrients are applied in proper amounts, and there is ample moisture for crop growth, very little nitrate or any other nutrient will escape the root zone by leaching. Frankly, I doubt if the amount of nitrate lost from any farming region where crops are harvested and where soil erosion is controlled, exceeds the amount being lost under virgin forest or grassland conditions. But, whatever amount is lost under native conditions, we should find out what it is as a benchmark for comparison with farming areas. Certainly, there has always been an appreciable quantity of nutrients in all waters prior to the days of man-made technology. Otherwise there would have been no marine life anywhere on earth and there would have been no pre-civilization eutrophication.

#### Vast Organic Soil Deposits

Back to the subject of algal blooms, certain individuals would have us believe that they are the result of man-made activities. Actually, algal blooms were in existence long before civilization reached this planet. Otherwise our vast areas of peat and muck soils would not have come into existence. Nourishment for the algal blooms that caused these deposits came chiefly from virgin forest, in the main, but also from prairies. Here's what Dr. Cecil Wadleigh of the USDA said about one aspect of eutrophication in a recent talk:

*"The State of Minnesota is essentially a monument to the process of eutrophication. Seven and one-half million acres of the state are comprised of peat and muck. This is 1/7 of the surface area. These peats are the organic residues from the massive eutrophy that prevailed in the area over past thousands of years. This*

(Continued on Page 8)



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## CREDIBILITY GAP

(Continued from Page 1)

most of these cases, sports managers who have "switched" will never know whether top management might have produced satisfactory playing turf. It certainly has for golf, which is even more exact and precise in its turf grooming requirements.

### CREDIBILITY GAP #2 THE COST MYTH

A second point of credibility involves statements which overlook the fantastic initial cost of artificial turf substitutes (up to \$250,000 for a football field). Proponents of the artificial surfaces quickly emphasize that the high cost will be recovered over a period of ten years. Again, this is strictly speculation because, to my knowledge, no field of artificial substitute has existed under playing conditions for anything like ten years. The Astrodome in Houston and a municipal gridiron in Seattle have less than five years experience with synthetics. And, of course the Astrodome is not comparable to outdoor conditions because it is covered and air conditioned. But these are the oldest regulation facilities under actual playing conditions. On what basis, then, can the proponents of synthetics logically (or honestly) even suggest a longevity of ten years??? The real proof of their conviction is in their guarantee period. To my knowledge, the longest guarantee period is three years.

In addition to the high initial cost, regular maintenance is also required on artificial fields. The field has to be vacuumed instead of mowed, drained instead of irrigated and mopped to clean off soiled matter. Then there are renovation problems such as repair of burn damage (some of the plastic surfaces are subject to cigarette and other burns), and repair of the hard undersurface such as the problem of asphalt bleed-through reported at the University of Tennessee.

So, it is ridiculous to assume less maintenance than real turf. In fact, we might find that before the ten year period is up, upkeep for synthetics will be higher than for real turf. I'm sure that was the case in the Tennessee Stadium where the asphalt base bled through.

### CREDIBILITY GAP #3 THE SAFETY "MYTH"

Finally, there is the safety issue. Promoters of artificial substitutes keep

plugging safety features of their products. Player injuries always receive much concern and publicity. Hence it is a sensitive area to prey on and promote (I hesitate to use the term "exploit").

There is increasing talk by the artificial material proponents about player injuries being caused by poor turf. They infer that artificial materials would have surgery which benched him for the remainder of the season. The prominence of Sayers and the seriousness of his loss for the season prompted some to blame the turf and to claim that he would have avoided such injury had the game been played on artificial materials.

Apparently Sayers himself did not believe such inferences. On November 20, 1968 the New York Times quoted him as saying that "... it wouldn't have made any difference what kind of cleats I had on, what kind of field I was playing on — grass or artificial. He (Kermit Alexander of the 49ers) hit the knee and that was it. That's football . . ."

And so it is. It's a tough sport and the players know it. Certainly we should do everything possible to provide the best and safest playing surface possible for all sports (amateur and professional). Every good turf man also knows that top management is essential to maintain the best turf in the best playing conditions. But somehow I can't quite understand how concrete or asphalt layers underneath artificial materials are going to cushion knee crush impact as will the resilience of a well established and maintained field of real grass. In fact, TURF-GRASS TIMES published an article in 1967 entitled "Grass for Player Safety" (September-October issue). The author discussed research pointing out that football injuries could be reduced by using the proper turf-grasses and specified turf maintenance practices. The article stressed the resilience and impact resistance provided by a well established cushion of growing grass.

#### An Artificial Golf Course

While attending a meeting of the American Society of Golf Course Architects in January, 1968 at Boca Raton, Florida, I learned details about a golf course near Knoxville, Tennessee, that was to be constructed using artificial turf on greens and tees. This course (to be known as Four Seasons Golf Course) was apparently a test case by a prominent manufacturer of artificial turf. To my knowledge at least, this was the first regulation golf course to fully use synthetics on greens and tees.

The idea of this trial promotion was met with much mixed reaction by architects and others attending the 1968 Meeting at Boca Raton. Most of us professed great curiosity. We knew of specialized uses of synthetic materials

on driving ranges, in locker rooms and pro shops — even on walkways — but on such critical facilities as golf greens???

#### Never Lasted The First Year

At that time I made plans to visit the Tennessee development in about a year to evaluate appearance, wearability, player reaction and general conditions. That trip never developed because the course closed within the year. There are prevented such injuries. A case in point is the injury of Gayle Sayers, brilliant runner of the Chicago Bears. He suffered a serious knee damage in a game last November (1968) and required rumors as to why the course closed. One rumor indicated that the manufacturer removed the artificial surface because of non-payment. Another story inferred that the course closed (and apparently payment contract was not completed) because golfers did not care for the manner in which the artificial material affected the game and hence did not return to support the venture. Golf World Magazine (October, 1968 issue), reporting on the Tennessee experiment, indicated that the players would not accept the artificial turf due to failure of the greens to hold the approach shot.

It does seem odd, based on the outcome of the Tennessee trial, that there is more and more open promotion of synthetics for golf courses.

One particular advertisement lists many prestige golf courses across the country where artificial turf is in use — suggestively on regulation greens and tees. In this regard, I talked with one leading golf course superintendent whose club was mentioned in the ad. It turned out that the only artificial turf on that facility was on a bridge crossing.

Another ad suggests that synthetics can do away with the need for men, mowers and materials now used in turf management. Again, doesn't it seem a little odd that it didn't work out that way in Tennessee. This is what I mean by the credibility gap in artificial turf.

#### In Conclusion

TURF-GRASS TIMES finds no fault with exploration of new concepts and products. After all, this is the space age, and today's ideas may become tomorrow's practices. Without question there are sports complexes where wear is so intense and weather so adverse that real turf can no longer answer the need. There are other special applications where a non-turf type of cover may be useful and acceptable.

At the same time, the Turf-Grass Industry has become accustomed through the years to objective processes of evaluation. New products come through a long chain of testing and validation, concluding with recommendations from our highly respected State Agricultural Experiment Stations. To

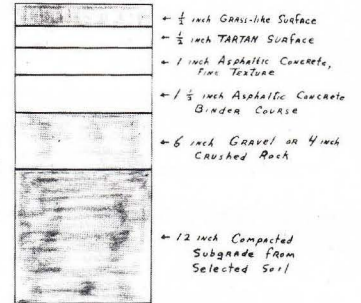


# CONSTRUCTION OF ARTIFICIAL T

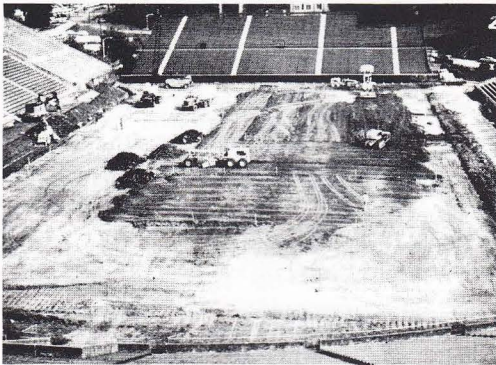
## Football

University of Tenn.

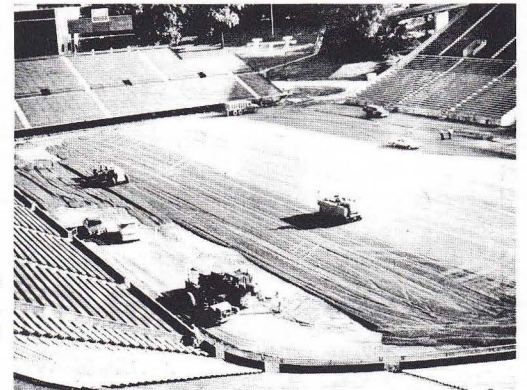
"PROFILE OF ARTIFICIAL TURF INSTALLATION, UNIV. OF TENNESSEE GRIDIRON



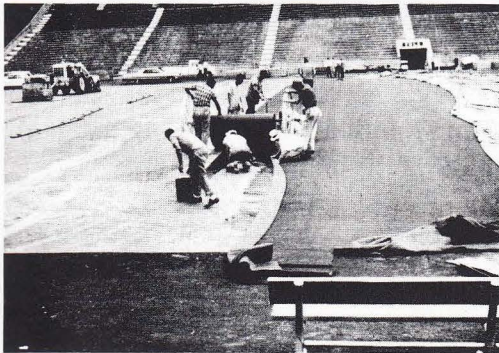
Profile of "Tartan-Turf", artificial turf construction as installed on the varsity gridiron at the University of Tennessee in 1968. (Photo credit University of Tennessee)



Old sod and soil are removed and the field excavated to allow for the 21-inch foundation of materials underlying the final layer of artificial turf. Then, as seen in this University of Tennessee photo, selected soil is added, contoured and compacted. (Photo credit—University of Tennessee)



The 6-inch gravel blanket is added on top of the 12-inch sub-grade, and then compacted. (Photo credit—University of Tennessee)



After the asphalt layers have been poured and the special half-inch layer of Tartan adhesive surface installed, the artificial turf is layed and rolled. In the case of the University of Tennessee Stadium (installed prior to the 1968 football season) difficulty was encountered when the asphalt sub-layers bled through the artificial turf. Cost of installation was reported to be approximately one-quarter million dollars. (Photo credit—University of Tennessee)

date, I have seen none regarding artificial materials as turf substitutes.

It might be good for the artificial turf manufacturers to realize that high flying

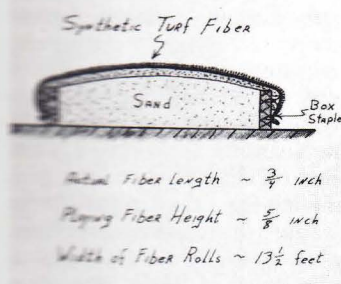
promotions might get one reception on Madison Avenue. Their reception in the Turf Industry so far has not met the credibility test. We wish to grant them

# TURF IS INVOLVED AND EXPENSIVE

Four Seasons Golf Course

**Golf Course**

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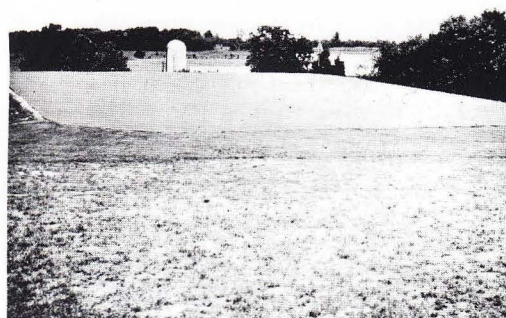


Profile of "Astro-Turf Golf Surface", the artificial turf as installed at the Four Seasons Golf Course, Knoxville, Tennessee.

(Photo credit—University of Tennessee)

View of table-top type construction of putting green covered with artificial turf at Four Seasons Course in Tennessee. Undoubtedly this was first regulation golf course to fully install the artificial substitutes on greens. Cost of material was between \$2.00 and \$2.50 per square foot.

(Photo credit—University of Tennessee)



The artificial turf was stretched and tacked over a boxed frame containing compacted sand. Soil was then filled in flush around the boxed frame to provide a level approach to artificial green surface.

(Photo credit—University of Tennessee)

Double layers underlying synthetic turf in Houston Astrodome. The artificial material comes in rolls 14-feet wide which are laid on the felt-like matting and attached by large zipper fasteners. For the inside story of the Astrodome—and the real grass controversy—see TURF-GRASS TIMES article "Grass Under Glass?" (September-October 1966 issue). (TURF-GRASS TIMES Photo)



every right and privilege to introduce and prove their products. We do not grant them the right and privilege to falsely promote or insinuate that arti-

ficial or synthetic turf will serve as the utopian replacement for the Turf-Grass Industry. There simply is no proof of such fancy. ●

(Continued from Page 3)

*historic process is still going on as one can readily see by flying over Minnesota's lakes today. One can observe all stages of development of aquatic plant growth—from completely clear water through every degree of plant accumulation to recently formed bogs. One can readily observe serious eutrophication taking place in many of these lakes even though they are quite remote from any farmland.*

*"Minnesota's known reserves of air-dried peat are estimated to be 6.8 billion tons. Think of the fantastic plant growth that must have taken place in the waters of Minnesota long before any farming or domestic animals came upon the scene!"*

The 6.8 billion tons of peat in this one state alone fixed more than 340 million tons of nitrogen, or more than 50 times the amount of all nitrogen fixed by commercial processes in the U.S. since the beginning of the nitrogen industry. Even today, the Minnesota deposits contain at least 100 million tons of nitrogen, according to Dr. Wadleigh.

Nobody knows how much nitrogen from Minnesota's peat beds gets into underground aquifers, but no doubt thousands of tons a year move into water channels, and after a period of several centuries some of the nitrogen may now be showing up hundreds of miles distant.

Another interesting sort of fairy-land picture has been painted by such statements as this:

*"In a balanced natural system, the amounts of organic nitrogen and nitrate dissolved in water remain low, the population of algae and animals is correspondingly small, and the water is clear and pure."*

To me, the picture is quite different by reason of the pre-civilized conditions and natural situations I have already cited, but beyond those I wonder how one could say "clear and pure" under a natural system such as prevailed in the Midwest as recently as the days of the buffalo. From accounts I have read, there were millions of these creatures grazing the grass into the ground and wallowing in every stream and pond, and that Indians and settlers going through the area could never find a decent place to get a drink of water. Certainly, the Midwest has much more clear and pure water today than in the days of the buffalo. Just as an added note about our great prairies, I have been told by people who should know that trout never thrived in the central part

of this continent, from Canada down into the United States, in the region of tall and short native grasses, because the nutrient content of the streams was too high.

### Soil Loss Great

When considering decline in productivity of soils as our ancestors moved westward in early USA, one key point may be overlooked. It's easy to credit this productivity decline to the process of nutrient removal by crops, whereas the top soil too often was washed away by rainstorms and floods, taking the nutrients downstream. Even today, with our advanced farming methods, heavy rains carry vast quantities of sediment into our streams, river, and lakes. Those sediments (about four billion tons a year, half of which comes from farms and ranches) contain valuable plant nutrients, and should be kept on the land.

Cost of getting the soil out of lakes and streams is 20 times the cost involved in keeping it on the land in the first place.

But, we cannot deny that our agriculture, up until very recently, was one of extensive soil mining and nutrient depletion. It is only within recent years that farmers in the USA have given serious attention to replenishment of nutrients to their lands and this has largely been forced on them by their struggle to maintain economic crops and livestock production.

### Early Experiments

In the early days, while knowledge of fertilization and plant nutrition was being developed, even the top research people made great errors. A common one was to supply soils with an increasing amount of one nutrient, such as nitrogen, while holding the others constant, or applying such an amount of a nutrient as we removed in the grain harvested. There was a serious problem, especially with respect to phosphorus. Crops starved because the applied phosphorus was tightly fixed by moist soil.

This criticism can be made of the early Sanborn Field experiments in Missouri. Indeed, crop growth was limited and roots were shallow, thus the organic matter content of the subsoil, and even of the top soil, declined to very low levels. When ample nutrients were supplied, later on, these same plots readily responded and produced top yields in the very first year of proper treatment.

Documented experiments on the

Morrow plots in Illinois, under cultivation since 1876, tell a similar story. Dr. M. B. Russell, director of the Agricultural Experiment Station in Illinois, published an article in 1956 entitled, "All The Way Back in One Year."

Results of Dr. Russell's modernized treatments, where nutrients were applied according to need, indicate that prior yield differences associated with long years of previous management practices largely were removed by the application of fertilizer. His results showed that soil physical condition had not limited yields but, instead, it was the nutrient supply in the soil.

Similar studies have been made and reported from the historic Jordan plots in Pennsylvania, and, likewise, from the oldest of all, the Rothamsted plots in England. Actually, the amount of aeration, and consequently oxygen supply, while important, probably seldom is a limiting factor in agriculture. It must be kept in mind that plants can grow in water if it contains proper quantities of dissolved nutrients, with only a minimum of aeration. In fact, plants can grow for days at a time without any aeration being provided. It is quite likely that most of the oxygen required for respiration under these circumstances is provided by the nitrate molecule.

The Rothamsted experiments in England date back to 1843 and are the oldest known continuous agricultural research plots in the world. One plot never received any fertilizer, while a second was treated with 14 tons of barnyard manure a year, and a third received no manure but was fertilized with chemical fertilizers equivalent to the nutrients supplied by the manure. The plot that never was fertilized produced an average of only 13 bushels of wheat a year over the first 120 years. The second plot that got the manure averaged 35 bushels of wheat per acre, and the plot that got the chemical fertilizer also produced 35 bushels per acre.

Thus, in 120 years there was never any difference in whether organic matter or chemical fertilizer was the source of the nutrients. Also, there was never discernable difference in the quality of the grain produced.

### "Back-to-Nature"?

Lawes and Gilbert, often considered the fathers of soil fertility research, began a "back-to-nature" experiment at Rothamsted in the 1880's. For this, a field of wheat was fenced off and the plants were allowed to go on reseeding themselves. In one year

the crop of wheat was reduced by half. In the fourth year, the field was completely taken over by weeds. Only three stunted wheat plants could be found. The lesson here is that food production ceased when nature took over.

Thousands of experiments around the world have firmly established the value of fertilizer in helping to provide man's basic needs. Essential production of food and fiber is becoming more and more dependent on man's ingenuity in devising ways and means to thwart the adverse effects of nature. Advancing technology, so vital for civilized progress, never has been, is not now, and never will be in accord with nature. These are not my words, but rather those of Dr. Cecil Wadleigh, USDA. Nature could not sustain the world's population—not in food—not in clothing—not in shelter.

### The Fate of Fertilizer Nitrogen

It is interesting to consider the following and often overlooked facts relating to the nitrogen cycle. Each person in the U.S. consumes about 92 grams of protein a day, about two-thirds of which comes from animal sources. In terms of nitrogen, this is equivalent to about 14.7 grams per day, with 4.3 grams coming from plant sources and 10.4 grams coming from animals. For each gram of animal protein nitrogen, there must be supplied to animals 10 grams of nitrogen as plant protein or urea. Adding this all up means that in the U.S. we are consuming 8.7 million tons of nitrogen per year from proteins in our food.

This 8.7 million tons does not include nitrogen ingested as amides or amino acids. It does not include nitrogen in foods exported to other countries. It does not include nitrogen consumed in production of fibers, such as cotton, wood pulp and timber. It does not include nitrogen used on lawns or ornamentals. It does not include the high losses of nitrogen occurring by denitrifying processes in soils. These are the figures of Dr. Wadleigh, whom I have already mentioned, and those of Dr. W. H. Allaway, director of the U.S. Plant Soil and Nutrition Laboratory, Ithaca, N.Y. These individuals are among the world's authorities in soil chemistry and plant nutrition.

Since little of the 8.7 million tons of consumed protein nitrogen finds its way back onto our field, we might say that the approximate seven million tons of chemical nitrogen used in fer-

tilizers even fall short of balancing this outlet of nitrogen from the system.

### Nitrogen Losses Great

Another internationally known soil scientist, Dr. George Stanford, of the USDA, has calculated that cultivated soils in the United States, over the past 100 years, have lost 35 billion tons of organic matter from the surface 40 inches. This is equivalent to 1.75 billion tons of nitrogen. Most of this loss has occurred through mineralization and denitrification since the turn of the century. According to Dr. Stanford, this means that during the last 70 years of our agricultural history, loss of organic nitrogen has approached 20 million tons a year. How long will it be until we are applying enough commercial nitrogen to half-way balance such a loss? In any event, such a big annual loss of nature's own reserve of nitrogen casts doubt that the present use of seven million tons of it a year can be doing very much to inflate the nitrogen reserves in our soils. Also consider that the total amount of nitrogen being removed by crops from soils in the U.S. now is about two million tons greater than the quantity applied in fertilizers.

Soils have tremendous natural processes for decomposing and nitrifying organic sources of nitrogen. Inorganic sources of nitrogen, such as ammonia and urea, when added to the soil, are likewise nitrified. The end product is  $\text{NO}_3$ , the most critical nutrient form limiting growth of microorganisms in the soil. Additions of nitrogen rapidly stimulate biological activity and multiplication of all life in the soil. This life has the capacity to "fix" large quantities of nitrogen every year. Of course, about the same amount is mineralized and made available during a favorable growing season as is fixed into bodily protoplasm, but during these processes plant roots must compete with the soil organisms for available sources of nitrate. Often, plant roots cannot find a sufficient supply for optimum plant growth because these organisms are assimilating most of the  $\text{NO}_3$ .

### Nitrate Movement

It is my belief, based on lysimeter experiments, that where plants are actively growing, little nitrate escapes below the root zone. But, when plants are not actively growing and absorbing nitrate, such as is the case in California where native vegetation in the

valleys may grow only part of the year, some of the nitrate will move deeper into the soil as water may move. It is interesting to observe that Drs. Stout and Burau, of the University of California, found, from an extensive study of uncropped soils, that there can be high nitrate concentration throughout the soil profile down to the watertable, at depths of 20 feet or more. Concentrations of more than 100 ppm were quite common in their studies. The source of this nitrogen is given as "biological conversion of plant residues and nitrogen fixation." They explain a mechanism by which the underground water reservoir receives percolating water containing 133 ppm of nitrate directly from the soil as a result of vegetative cover and climatic sequences, without any fertilizer contribution whatsoever within the last five years.

In further reference to the work of Stout and Burau, they report that through many observations, it is commonly accepted that the legume plant covers will fix in the order of 150 pounds of nitrogen per acre per year, while a good grass cover will fix about 15 pounds per acre through free-living nitrogen fixing microorganisms, including algae. Under equilibrium conditions the gains of nitrogen will be about the same from year to year, as will the losses. They conclude that some legume covers have the capacity to provide 150 pounds of nitrogen to percolating waters year after year. By the same reasoning, a pure grass stand provides about 15 pounds of nitrogen. Based on this, they have developed an equation from which one can calculate rather simply the equilibrium conditions when a few reasonable assumptions are made. The equation is:

$$C = (19.6) (N_f) / [(P_i) (L_p) / 100]$$

Where  $N_f$  is pounds of nitrogen fixed per acre per year,  $P_i$  is inches of rainfall,  $L_p$  is inches of water leached below the root zone in terms of percentage of rainfall, and  $C$  is the potential nitrate concentration in the leaching water.

Consider the use of this equation in this example: Under an established grass sward fixing 18 pounds of nitrogen per acre per year, and receiving 36 inches of rainfall in a temperate climate, where 65 per cent of the water goes to evapotranspiration or run-off, and 35 per cent percolates downward through the soil, the potential nitrate concentration of the leachate becomes 28 ppm.

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# Opponents Call It Danger to Environment; Killer of Many Life Forms

# DA

By Dr. CHARLES WURSTER, JR.

Dr. Wurster is assistant professor of biological sciences at State University of New York at Stony Brook. He was recommended by the office of Sen. Gaylord Nelson as one of the leading authorities on DDT.

**D**URING the past quarter-century, man has subjected his environment to an increasing variety of chemical insults in the form of pollutants with molecular structures never before encountered by living organisms. Of these contaminants, the chlorinated hydrocarbon insecticides (those, such as DDT, that contain chlorine, carbon, and hydrogen) are probably more widely distributed than any other synthetic chemicals and have become one of the world's most serious pollution problems.

Residues of DDT and some of its relatives seem to be almost everywhere—in soils never treated with the chemicals, in birds and seals that never leave the Antarctic (although DDT has never been used on that continent), in most other animals and probably all humans, in the air, even in remote parts of the world, and even in the rain. Yet, after 25 years of use, the physiological mechanism of action for the chlorinated hydrocarbons is poorly understood, and we are only now discovering some of its environmental effects. We are, in a sense, conducting a biological experiment of colossal proportions, using the entire world as a laboratory.

How will it all come out? No one knows. Clearly some parts of the experiment have gone sour, and the

flow of bad news increases as the data come in. Not all is mystery about these chemicals, however, for there is a great deal we do know about them.

DDT was first made in 1874, but its insecticidal properties were not discovered until World War II. With a high toxicity, great persistence, and side effects that were neither of concern nor well understood at the time, DDT was the miracle insecticide that played a heroic and glamorous role in the war, saving thousands of lives that would otherwise have been lost to malaria, typhus, and other insect-borne diseases. After the war it became a panacea for all insect problems, and its usage was greatly expanded.

While DDT has been the most widely used and extensively studied, and its residues are the most widespread within the environment, most other chlorinated hydrocarbons have similar properties and should be expected to have comparable ecological effects. These include dieldrin, aldrin, endrin, heptachlor, chlordane, lindane, and others commonly used against insects under a host of circumstances, including gardens, farms, and forests.

### Properties Cause Unique Problems

In order to understand the movement and consequences of these materials within the natural environment, it is first necessary to know something of their properties. The chlorinated hydrocarbons present a relatively unique environmental problem because they combine four important characteristics in the

same molecule:

**1 Broad Toxicity and Biological Activity**—Rather than having a toxic action that is limited to insects, as is popularly supposed, the chlorinated hydrocarbons are toxic to a broad spectrum of living organisms, including most of the animal kingdom and all vertebrates. All are nerve poisons. They cause instability or spontaneous "firing" of nerve cells, and increased doses result in tremors or convulsions—typical symptoms of acute poisoning that can occur in organisms ranging from houseflies to man. In general, if an organism has nerves, the chlorinated hydrocarbons can kill it.

Recent studies have uncovered other, more subtle, yet probably more important, mechanisms of action. At sublethal concentrations, organisms show increased nervousness, hyperactivity, and various behavioral abnormalities. We now know that most chlorinated hydrocarbons are enzyme inducers, i.e., they can induce enzymes in the liver that modify the steroid sex hormones, thus changing their biological activity and affecting vital physiological processes. At the same time, some members of the DDT family can function as estrogens, thus perhaps further upsetting hormone balance. Very recent work now suggests that DDT may inhibit carbohydrate metabolism, that it may affect the genetic material to influence future generations, and that it may be carcinogenic; each of these mechanisms needs further research.

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# Defenders Say Environment —And Especially People— Endangered Without It

**A** BILL has been introduced before Congress to ban the nationwide sale of DDT.

Sen. Gaylord Nelson of Wisconsin has forced upon our elected representatives the necessity of making a decision.

They must decide who shall have priority of protection—people, or certain birds and fish.

The decision should be easy.

There is even a question of whether defeat of the bill would mean defeat (much less doomsday) for the birds and fish. There is strong evidence, however, that banning DDT could eventually impose death or a life sentence of misery upon literally thousands of people around the world.

Lawmakers will be weighing the merits of the case against DDT with the findings of a recently completed 18-month study conducted at the request of the U.S. Department of Agriculture.

Fifteen scientists of the National Academy of Sciences and National Research Council heard 83 principal witnesses. These spokesmen included authorities from scientific and conservation organizations, industry, universities and government agencies.

A full report of their study may be obtained from Press Service, Office of Information, USDA, Washington, D.C. 20250. A summary of the committee's conclusions and recommendations follows:

#### Conclusions

1. Persistent pesticides are contributing to the health, food supply,

and comfort of mankind, but, in the absence of adequate information on their behavior in nature, prudence dictates that such long-lived chemicals should not be needlessly released into the biosphere.

2. Although persistent pesticides have been replaced in some uses and are replaceable in others, they are at present essential in certain situations.

3. No decrease in the use of pesticides is expected in the foreseeable future. On a world basis, increased use is probable.

4. Although the use of DDT has decreased substantially, there was no important change in the use of other organochlorine insecticides in the United States during the 10-year period ending June 30, 1967.

5. Available evidence does not indicate that present levels of pesticide residues in man's food and environment produce an adverse effect on his health.

6. Registration requirements for persistent pesticides appear to provide adequate safeguards for human health, but continuing attention must be given to accommodating new knowledge and insuring against subtle long-term effects.

7. Residues of certain persistent pesticides in the environment have an adverse effect on some species of wild animals and threaten the existence of others.

8. The availability and low cost of effective persistent pesticides have slowed the development and adoption of alternative methods of control.

9. Work on nonchemical meth-

ods as alternatives to persistent pesticides has been emphasized in recent years, and continued support for this work is needed.

10. Inadequate attention and support are being given to developing pesticidal chemicals and to improving techniques for using them.

11. Persistent pesticides are of special concern when their residues possess—in addition to persistence— toxicity, mobility in the environment, and a tendency for storage in the biota.

12. A few organochlorine insecticides and their metabolites have become widely distributed in the biosphere, appearing in the biota at points far from their places of application.

13. The biosphere has a large capacity for storage of persistent pesticides in the soil, water, air, and biota, but little is known concerning amounts of persistent pesticides and of their degradation products that are stored in the biosphere.

14. Knowledge is incomplete concerning the fate and degradation of persistent pesticides in the environment, their behavior in the environment, the toxicity of the degradation products, and the interaction of these products with other chemicals.

15. Present methods of regulating the marketing and use of persistent pesticides appear to accomplish the objectives of providing the user with a properly labeled product and holding the amounts of residue in man and his food at a low level. However, they do not appear to insure the prevention of environmen-

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# DDT Is 'Compound of Extinction'

DDT Harm  
to Trout  
Claimed

Falcon, Eagle Decline Blamed on Variation of DDT

UW Wildlife Expert Links  
DDT With Decline of Birds

## DDT Opponents . . .

(Continued from Page 10)

**2 Mobility**—Unfortunately, these insecticides do not remain where they are applied, dispersal through the environment being facilitated by a variety of transport mechanisms. Obviously the chemicals can travel about within living, mobile organisms, though this mode of transport seems minor. Despite low water solubilities and vapor pressures, large amounts can be carried by vast quantities of moving water and air, and dispersal is further facilitated by the tendency of these materials to form suspensions in both air and water. Since many insecticide application procedures intentionally produce atomized droplets or particles, substantial amounts are thereby passed into the atmosphere. Less than half the amount sprayed from a plane may reach the ground. Once in the air, these materials can circle the globe in a few weeks; fallout from the air probably contributes about the same quantity of pesticides to the oceans as do major river systems.

The chlorinated hydrocarbons also readily adsorb to particulate matter like soil particles, which are carried away by wind and water. Escape into the air is further aided by the process of codistillation, whereby the chemicals pass into the vapor state associated with evaporating water. Thus a wet field will release pesticides into the air much more rapidly than will a dry one. It is clear, then, that these insecticides can be transported about much of the earth to points far distant from the original application site by currents of water and air, as well as by mobile organisms.

**3 Chemical Stability**—In the environment, the chlorinated hydrocarbons are very stable compounds; they probably have a half-life of many years or decades, but exactly how long they persist we do not know. Mechanisms for effectively metabolizing or breaking down

these exotic materials apparently have not evolved, although certain tissues, particularly liver, can bring about gradual breakdown. DDT is slowly metabolized into DDE, DDD, and eventually other compounds, but unfortunately most of these, too, are toxic and induce liver enzymes. DDE, apparently more stable than DDT, is probably the world's most widely distributed synthetic organic chemical.

Treated areas show declining residues during subsequent years, but this "disappearance" is sometimes falsely equated with decomposition. The two are not the same. Increasing evidence indicates that much of these materials have simply gone elsewhere in their original, or slightly modified, form, retaining their biological activity.

**4 Solubility Characteristics**—DDT is insoluble in water—almost. DDT saturates water at only 1.2 parts per billion (ppb), making it one of the most insoluble organic substances known. Conversely, the chlorinated hydrocarbons are soluble in lipids (fats or fat-like materials). They are, therefore, invariably more soluble in any biological material, living or dead, than in water, since all organisms contain lipids. If we divide the biosphere into the inorganic (nonbiological) and the organic (biological), we must always expect the chlorinated hydrocarbons to flow from the former into the latter. Organisms, therefore, remove these chemicals from their environment and retain them.

### DDT Travels Far

These four properties mean that biologically potent chemicals will contaminate non-target organisms far removed by both time and space from the site of application.

Chlorinated hydrocarbons may be absorbed by organisms through the gills, the skin, from the diet, and from the air via the lungs. Muds and other solids that hold these chemicals by absorption serve as

reservoirs, feeding the chemicals into the water as they are absorbed by organisms. Living organisms accumulate these residues and become contaminated, often from an environment that may appear relatively "clean." For this reason some measurements of environmental quality are misleading. One must analyze living organisms, rather than water, to monitor water quality. Water and air are the transport media, but they contain only minute amounts of these chemicals.

### Biological Concentration Occurs

Once these insecticides get into food chains, something else happens—the phenomenon of biological concentration, often called biological "magnification." Each organism eats many organisms from the next lower trophic level, i.e., the next step down in the food chain. A robin, for example, eats many earthworms, and a large fish eats many smaller fish. These food organisms are digested and excreted, but the chlorinated hydrocarbons are retained. The chemicals remain in biological material and therefore accumulate, the concentration depending on rates of intake, breakdown, and excretion.

The use of DDT in attempted control of Dutch elm disease is a clear and relatively simple example of food chain contamination. Since DDT is sprayed when the elms are leafless, only a small fraction remains on the trees. The rest is either lost into the air or settles to the earth. That retained by the tree eventually also reaches the ground. Earthworms and other organisms that work the soil accumulate the DDT and become contaminated. Many species of ground-feeding birds eat the soil organisms, concentrate the DDT further, receive a lethal dose, and die with tremors.

Flying insects also become contaminated by contact with the trees and soil, especially those emerging from soil dwelling larvae. Insectiv-

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DDT Hearings In Spotlight

## The Case for DDT

# Up With People

And Down With the Venomous Foes of Chemical Pesticides

California Scientist Gives Warning

## Scientist Testifies

### DDT Defenders . . .

(Continued from Page 11)

tal contamination.

16. Public demand for attractiveness in fruit and vegetables, and statutory limits on the presence of insect parts in processed foods, have invited excessive use of pesticides.

17. The National Pesticide Monitoring Program provides adequate information about residues in man and his food, but it does not provide adequate information about the environment generally, because it can detect changes in residues only in selected parts of the biosphere.

18. Contamination of the biosphere resulting from the use of persistent pesticides is an international problem. Changes in techniques for

using these pesticides and the substitution of alternatives here and abroad are questions of immediate concern to all mankind.

#### Recommendations

The Committee recommends—

1. That further and more effective steps be taken to reduce the needless or inadvertent release of persistent pesticides into the environment.

2. That, in the public interest, action be increased at international, national, and local levels to minimize environmental contamination where the use of persistent pesticides remains advisable.

3. That studies of the possible long-term effects of low levels of persistent pesticides on man and

other mammals be intensified.

4. That efforts to assess the behavior of persistent pesticides and their ecological implications in the environment be expanded and intensified.

5. That public funds for research on chemical methods of pest control be increased without sacrifice of effort on nonchemical methods.

6. That the present system of regulation, inspection, and monitoring to protect man and his food supply from pesticide contamination be continued.

7. That the objectives and procedures of the National Pesticide Monitoring Program be reviewed and that the feasibility of obtaining data on quantities of persistent pes-

(Continued on Page 14)

## USDA Pesticide Suspension Order No 'Confession'

USDA's suspension from use of nine pesticides should not be interpreted as an "admission" that these chemicals are harmful to wildlife and people, a Department spokesman told WTT's editor shortly after the announcement was published in mid-July.

One of the pesticides is DDT, which Sen. Gaylord Nelson of Wisconsin is seeking to ban nationwide through a bill now before a congressional subcommittee.

Questioned about the timing and effect of the USDA suspension with regard to this legislation, the spokesman spelled out USDA's position generally on chemical pesticides:

*"We are categorically not in favor of any action that represents an across-the-board ban on DDT or any other pesticide. Any action that's taken should be on a case-by-case basis."*

The spokesman added that he did not believe the Nelson bill would pass.

The suspension on the use of nine chemicals isn't necessarily permanent, the spokesman pointed out. Rather, it is for the duration of the review, expected to be completed within 30 days.

"Some programs may require a quick decision and be reinstated before 30 days," he said. "On other programs, the review (and suspension) may need to be extended."

The review was initiated, the spokesman explained, just to "show response to the NAS (National Academy of Sciences) study and recommendations and the request of wildlife conservationists."

A report by NAS and the National Research Council had recommended that "further and more effective steps be taken to reduce the needless or inadvertent release of persist-

ent pesticides into the environment."

The spokesman said the review is to see if in fact there are more effective steps that could be taken on those programs carried out by USDA.

"Basically, we'll be looking for effective alternatives," he said, since, repeating the words of the release, "USDA programs in the past have been carefully planned and carried out to insure maximum safety to man, animals and our natural resources."

It is the Department's intention, he said, to carry out the review so that it "won't unduly delay" critical programs.

The suspension order affects programs of the Agricultural Research Service and the Forest Service involving any planned applications of DDT, dieldrin, endrin, aldrin, chlordane, toxaphene, lindane, heptachlor, or BHC.



## Bills Ask DDT Ban; Pesticide Commission

Summaries of Wisconsin Senator Gaylord Nelson's two bills affecting DDT follow.

Bill 1753 would amend the Federal Insecticide, Fungicide and Rodenticide Act by adding Sec. 17. The paragraph would make it unlawful for any person to distribute, sell, or offer to sell, DDT in the U.S. after June 30, 1970. It also would be unlawful to receive DDT from any foreign country.

Bill 1799 would establish a National Pesticide Commission. Under provisions of this bill, the President would appoint three representatives from government agencies, three from the scientific and medical professions, two each from conservation and agricultural organizations and two from private enterprises for a term of three years.

The commission would be responsible for:

1. Determining and evaluating the present usage of pesticides;
2. Reviewing existing limitations on pesticide use and



Senator  
Gaylord  
Nelson

current labeling requirements;

3. Recommending standards of safety for pesticides in water;

4. Developing a continuing monitoring program for pesticides in the soil, air, water, wildlife, fish and humans;

5. Fostering research in the development of less persistent, less toxic pesticides;

6. Initiating basic research into the degradability of pesticides;

7. Conducting research on the effects of pesticides on the environment, fish and wildlife and humans; and

8. Making recommendations on the elimination or limitation of use of certain pesticides to the President and Congress.

### DDT Defenders . . .

(Continued from Page 13)  
ticides in the biosphere be studied.

#### No Danger to Humans

The strange aspect of the DDT controversy is that the cry for a total ban on usage comes at best on the basis of questionable evidence of damage to wildlife. And this absolute position is taken without apparent regard for the consequences that people would suffer.

Evidence to the contrary is too strong for opponents to contend that DDT is a threat to human life.

The summary of a study conducted by the National Communicable Disease Center at Atlanta, Ga., states:

"A study was made of 35 men with 11 to 19 years of exposure in a plant that has produced DDT continuously and exclusively since 1947.

"Findings from medical history, physical examination, routine clinical laboratory tests, and chest X-ray

attributable to exposure to DDT. film did not reveal any ill effects. It was estimated that the average daily intake of DDT by the 20 men with high occupational exposure was 17.5 mg per man per day as compared to an average of 0.04 mg per man per day for the general population."

Dr. Thomas H. Jukes, a biochemist at the Space Sciences Laboratory at the University of California, described recently the greatest "experiment" with DDT. It took place in India with American assistance. It began in 1953 and was stepped up in 1958.

The success of the program "depended upon the fact that DDT is a residual insecticide," said Dr. Jukes.

"At the start, there were 75 million cases of malaria in India, and life expectancy for Indians was 32 years. By 1962, 147,593,270 pounds of DDT had been used, and life expectancy had jumped to 47 years. By 1967, there were fewer than 100,-

000 cases of malaria in India.

"DDT is safe, and has been studied more than any other pesticide for its effects on human beings," Dr. Jukes said.

"Without pesticides, there wouldn't be enough food to go around. Most important DDT is needed by the millions of people because it is a cheap, safe residual pesticide."

At one time malaria killed two million people and left millions of others debilitated from the disease each year, another biochemist testified recently.

#### Ban would Be 'Disastrous'

Dr. Wayland J. Hayes, former Chief of Toxicology for the U.S. Public Health Service and now a professor at Vanderbilt University, Nashville, Tenn., said that while malaria isn't a threat to public health any longer in the U.S., it remains a major killer of people in many parts of the world.

"DDT still remains the most important single tool for control of malaria," he said.

A ban on DDT would prove "disastrous," as undoubtedly there would be a resurgence of malaria without it.

There would be a particularly adverse effect on the control of malaria in emerging nations which look to the U.S. for leadership.

Dr. Hayes said he feared people in other countries would feel that if DDT were banned in the U.S., it would not be safe for use in their countries, and that many human lives would be needlessly lost.

Dr. Jukes, agreeing, cited an article that predicted the campaign against pesticides could cause deaths and sufferings greater than those of World War II.

#### DDT Does Break Down

Dr. Hayes testified at public hearings on a proposal to impose a state ban on DDT in Wisconsin. Other witnesses questioned the very basis of Dr. Wurster's position against DDT that it is permanently stored and that the buildup is now endangering certain species of wildlife.

"I know of no natural situation where DDT is not degraded," stated Dr. Paul E. Porter, an associate member and consultant to pesticide commissions of the International Union of Pure and Applied Chemistry.

In addition, Porter said DDT does

not build up in plant life, soil water, fish, or mammals, beyond a naturally reversible plateau. When this level is reached, he said, it remains balanced between intake and dissipation.

Porter said DDT is broken down by nature in soil and degraded to far less toxic compounds by the action of micro-organisms present. On vegetation, it is broken down by sunlight and is additionally dispersed by rain and evaporation.

Since DDT adheres to soil particles it is not readily moved by water, making the compound relatively stable, he advised. However, what remains of DDT and its metabolites disappears at an approximate rate of 20% per year, regardless of concentration.

In streams, lakes, and ocean waters, DDT and its metabolite DDE are absorbed on matter which is present, with a considerable portion sinking to muddy water beds.

In mammals and birds, studies reported degradation of DDT through internal chemical action and excretion. A portion of the chemical components are stored in fat, but here again a stored level is reached, Porter testified, with no additional buildup of DDT residues in the animal.

Abnormally high levels of DDT residue reportedly found in many wildlife species may have been inaccurately measured and exaggerated, said Francis B. Coon, chief of the Wisconsin Alumni Research Foundation's chemical department.

"PCBs," polychlorinated biphenyls, Coon pointed out, are compounds that produce an almost identical picture to DDT when analyzed on a gas-chromatograph, an analytical

instrument which "fingerprints" chemical compounds.

Until this confusion between DDT and PCBs was recently discovered, most gas chromatographic assays overstated the amount of DDT above that actually in the sample, due to the presence of the PCBs.

#### Birds Not Affected

DDT-fed pheasants, testified Dr. Frank Cherms, University of Wisconsin professor of poultry science, have exhibited no changes in reproduction rates.

In other tests, turkey and quail were fed 200 parts per million of DDT. The pesticide intake, Cherms said, resulted in no changes in the thickness of egg shells.

Many other factors found in the environment, he continued, could affect differences in shell thickness of wild bird eggs. If birds are frightened, by being chased, or disturbed by cars, dogs barking, horns, or jet airplane sonic booms, thinner egg shells can be the result.

In any experiments in wild birds to ascertain causes of shell alterations, it would be necessary to negate other genetic, disease, and environmental factors before DDT could be ruled the cause of egg failures, Dr. Cherms testified.

In denying that DDT is a threat to wildlife, William F. Gusey, wildlife specialist, noted that "the mammal population on a country-wide basis is in a 'sound state,' and thrifty; big game has increased in numbers for the past 30 years; and population of small game and upland game birds has been quite favorably maintained—as well as many song birds, including robins."

Gusey is a former assistant division chief of the U.S. Department of Interior's Bureau of Sport Fisheries and wildlife.

Dr. Jukes, the California biochemist, strengthens the "sound-state" appraisal of the bird populations by citing a comparison of Audubon Society Christmas bird counts for 1941 and 1960, before and after the widespread use of DDT.

"The greatest increases are in grackles, redwing blackbirds, cowbirds, starlings and robins—up 11-fold to 131-fold.

"I think by far the greatest effect of DDT on birds is to kill mosquitoes that carry serious diseases of wild birds, including malaria, Newcastle disease, fowl pox and encephalitis."

#### Ban Too Drastic

Banning DDT could bring many lesser adverse effects upon people, not the least of which include predictions that food prices would rise and many more Dutch elm diseased trees would fall, because substitute chemicals are more costly and less effective.

It is vital to realize that DDT still is an essential chemical for which there is no comparable substitute for certain afflictions.

American technology inevitably will solve the problem to the satisfaction of all of us. But to impose an outright ban on DDT at this time would be far more serious than to have outlawed the horse as a mode of transportation before the automobile was invented.

—Reprint from  
*Weeds, Trees and Turf, August, 1969*  
Vol. 8, No. 8

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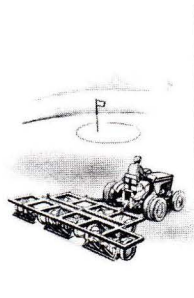
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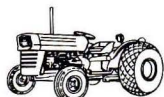
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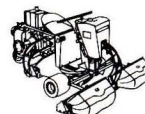
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## DDT Opponents . . .

(Continued from Page 12)

ous birds of the treetops thereby also become involved in this mass avian mortality. In some treated areas, robin mortality has been virtually complete and birds of all species have been reduced by as much as 90 percent.

Wide areas of the coniferous forests of North America have been sprayed with DDT during the past decade to control the spruce budworm. In New Brunswick, Canada, where excellent salmon streams include the Miramichi River, DDT applications have caused severe and widespread losses of salmon, trout, and other fish. After an application of DDT in 1954, not a single salmon fry was seen that year. Harmful effects extended 30 or more miles below the spray zones and lasted for several years. And effects were not limited to fish. A single treatment changed the insect ecology of the area for at least three to four years.

### Concentrations Eventually Kill

Since the chlorinated hydrocarbons are concentrated as they ascend the food chain, carnivorous birds at the top of this pyramid reach the highest concentrations and face special problems. Death sometimes occurs.

In North America, reproductive success of the osprey has declined sharply. A colony in Connecticut, its habitat and other factors apparently unchanged, declined from 200 pairs in 1938 to 12 pairs in 1965. Their eggs contained 5.1 parts per million (ppm) of DDT residues and productivity was 0.5 young per nest, while Maryland birds with 3.0 ppm produced 1.1 young per nest and normal productivity was 2.2 to 2.5 per nest. Ospreys are fish-hawks and DDT residues in the fish eaten by Connecticut ospreys proved to be five to ten times higher than in the food of the Maryland birds.

Studies of the peregrine falcon in Europe reveal a widespread and rapid population decline which began during the early 1950's. The decline was characterized by egg breakage and egg eating by parent birds, abandonment of nests, and other abnormal breeding behavior, and it coincided geographically and in time with the use of chlorinated hydrocarbon insecticides. Tissues and eggs of the peregrine contained DDE, dieldrin, and heptachlor epoxide.

A highly significant, sudden, and widespread decrease in eggshell

thickness and calcium content occurred during 1946-48 in several British birds of prey, including the peregrine falcon. Shell thickness and calcium content were stable from 1900 to 1946, then declined by 7 to 25 percent within a few years with no subsequent recovery. The years of decline coincided exactly with the introduction of DDT into the world environment.

### DDT Biological Makeup

But what do eggshells have to do with DDT and reproduction? Quite a lot. In birds, increased absorption of calcium from the diet, decreased excretion, and deposition of calcium in bone marrow are all mediated by estrogen, a steroid sex hormone. The calcium in the marrow is later transported to the oviduct where it becomes part of the eggshell. A subnormal estrogen level interrupts this crucial chain of events in the reproductive cycle.

Recent studies showed that DDT, DDE, and dieldrin induced liver enzymes to break down steroid sex hormones in pigeons, and caused mallards and sparrow hawks to lay thin-shelled eggs and have a lower reproductive success.

In aquatic environments, the chlorinated hydrocarbons may contaminate virtually all organisms at all levels of the food pyramid. This has happened to the Lake Michigan ecosystem. DDT residues in bottom muds averaged 0.014 ppm, but amphipods contained 0.41 ppm, nearly 30 times that of the mud. Several species of fish carried residues 10 times higher than the amphipods, and herring gulls at 99 ppm were 20 to 30 times more than the fish. The gulls showed low breeding success and behavioral abnormalities, and could not withstand stress. When starved, the birds developed tremors and died of DDT poisoning while less contaminated gulls easily withstood the same treatment. (Starvation depletes fat reserves that store DDT residues, thus releasing the toxins into vital tissues.)

### Fish Accumulate Residues

The Coho salmon, being a top carnivore, also accumulated residues in Lake Michigan and these were passed into the eggs. Recently almost 700,000 salmon fry died shortly after hatching. The fry were poisoned by residues in the egg yolk during final absorption of the yolk sac. Heavy mortality of trout fry occurred similarly in several New York lakes. For several years, mortality of fry from Lake George was 100 percent.

Clear Lake, California, offers another classic example of biological concentration in action. Additions of DDT to the war in an attempt to control gnats, the last in 1957, were followed by the dying of western grebes, reduction of the nesting colony from 1,000 to 30 pairs by 1960, complete nesting failure among survivors for several years, and 500 to 1,500 ppm of DDD in grebe fat. In 1967, ten years after the last treatment, the grebes still averaged 544 ppm of DDD in their fat, and the colony of 165 pairs still had very poor nesting success.

Effects are by no means limited to the top of the food pyramid. A few ppm of DDT in the water can decrease photosynthesis in marine phytoplankton. These single-celled algae are the indispensable base of marine food chains and are responsible for more than half of the world's photosynthesis. Interference with this process could have profound worldwide biological implications.

The nature and movement of the chlorinated hydrocarbons indicate that they will be transferred from the earth's treated land areas to its ocean basins, where they will accumulate. Being so insoluble in water, however, we cannot expect them to "get lost" in the oceans; they will be picked up by its living organisms. Recent analyses of fish and birds from both the Atlantic and Pacific Oceans indicate that this process is occurring.

The Bermuda petrel is a rare oceanic bird of the North Atlantic that has no contact with any continent or area treated with insecticides. Yet its eggs and chicks average 6.4 ppm of DDT residues, and reproductive success has declined significantly since 1958. Only from its oceanic food chain could this bird become so contaminated.

There are more data from the Pacific, but the story is the same.

Clearly the chlorinated hydrocarbon insecticides cannot continue to be used in the natural environment without serious degradation of the world ecosystem. Fortunately we have a choice. Many biological techniques exist for controlling insect populations, and numerous other less stable, more specific insecticides are available. These alternatives are highly effective. Man's control of pests requires ecological sanity. Which way will we go?

(Continued from Page 9)

Similarly, if one considers a legume cover fixing 150 pounds of nitrogen per acre per year, the nitrate concentration potential of the percolating water becomes 233 ppm.

The work of these outstanding California scientists convinces me that legume stands can contribute nitrate to percolating waters, at least in a climate where growth is dormant part of the year, and thus I must disagree with statements specifying that under natural conditions, or under legume stands, practically nothing is lost to underground drainage. Actually, I believe the losses just cited are probably far greater than under conditions where crop plants are harvested from the land.

#### Tillage Releases Nitrogen

The California scientists say that "tillage of native soils is probably one of the most significant factors in releasing nitrate to underground waters because of the enormous store of nitrogen in the organic matter of most soils and the speed with which nitrate is released from organic matter when oxidation is increased by tillage."

They further cite a generalized case for the grassland soils of the Prairie regions of the United States where organic matter content is so high that the top acre-foot may contain as much as 32,000 pounds of nitrogen. Converting this over to its nitrate equivalent, the figure is 140,000 pounds of  $\text{NO}_3$  per acre-foot. If only one-half of this is lost over a 100-year period, the average annual loss could amount to 360 pounds of nitrate per acre per year. In a situation where 12.6 acre-inches of water would pass below the root zone annually, weighing 2.8 million pounds, the loss of nitrate would be 360 divided by 2.8, or 129 pounds per year.

The California report goes on to say that where fertilizers and irrigation are involved, the same kind of accounting can be used for determining the potential nitrate concentration in the leaching waters, but in these circumstances one must further take into account the nitrogen imported as fertilizer and exported in crops. Also, denitrification losses become important.

The points to be made here are (1) that the amount of nitrogen already in most soils is vastly greater than any amount now contemplated to be added for crop production, and (2) already in nature there is an appreciable loss to underground waters.

The points to be made here are  
1. that the amount of nitrogen already in most soils is vastly greater than any amount now contemplated to be added for crop production, and  
2. already in nature there is an appreciable loss to underground waters.

Although the soil is the best natural filtering system in nature, it is scientifically established that nitrate does pass through that medium, and that significant quantities have been doing so for ages prior to the advent of civilization. This is at least one reason why in the Prairie regions of the Midwest, long before the days of fertilizer use, there were rural health problems associated with nitrate in drinking waters. To our knowledge, this situation has not been accentuated due to the recent use of fertilizers in that area. Certainly, there are fewer cases of cyanosis or blue babies than was the case in the 1940's and early 1950's. This is evidence that better sources of drinking water are available now than was true in the 1930's and 1940's.

#### Plant Growth Important

Data from a lysimeter experiment in South Carolina shows the importance of keeping something growing on the land. Lysimeters which were completely fallowed and received no nitrogen fertilizer whatsoever, released 154 pounds of nitrogen per acre to the leachate over a five-year

period, whereas lysimeters receiving high levels of nitrogen fertilizer but where crops were kept growing, released very little nitrogen to the leachate over this same five-year period. It would be difficult to conclude from this, and from the results of many other lysimeter experiments around the United States, that adding fertilizer to a cropped field will contribute much nitrate to the leachate.

This is further confirmed to me by conversations with some of the key soil scientists in the State of Florida. It happens that Florida is the only state in the United States where the use of nitrogen fertilizer is what one would call high (approx. 240 pounds per crop acre), and the scientists there believe that very little nitrogen is reaching underground water tables because of the fact that plants are growing during much of the year. Too, crops occupy less than five per cent of the land in Florida. Thus, if there were any problems they likely would be quite local in scope, and would have become evident before now.

Only two states have over 50 per cent of their land in crops. These are Illinois and Iowa with 60 per cent in crops. Average use of nitrogen in Illinois is only about 55 pounds per crop acre and in Iowa is only about 40 pounds. This is a very small amount, on the average, in comparison with what is already in the soil.

Of course, surface run-off is something different, and can carry soil and its organic nitrogen into streams. But, here again one must observe that the fertilizer application is so small as to be insignificant in comparison with what enters streams from urban sources, and livestock manure, and the organic matter in the soil sediment that erodes in heavy rains. Too, we must not completely overlook waste products from sources such as dogs, cats, and other pets and wildlife. Their contribution to pollution must indeed be great, not to mention the unsanitary conditions people so "graciously" contend with in their front yards, neighborhood streams and park areas.

#### Nitrogen Storehouse Great

In addition to the large accumulations of nitrogen in soils already cited, let's take a look at some of the other of nature's vast stores of nitrogen. There certainly were many powerful forces in nature which gave rise to nitrates long before the advent of man. Large natural nitrate deposits are located in many parts of the

(Continued on Page 20)

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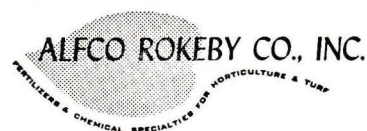
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(Continued from Page 18)

world. For example, nature deposited about 250 million tons of nitrate of soda on the plateau of Tarapaca in Chile. There are significant deposits of nitrate in the Amargosa Valley, Inyo County, California. In fact, nitrate deposits have been found in soils or geological formations in all of the 11 western states. Several deposits are known in the State of Texas. Most of the states entering into the Ozark and Appalachian plateaus have natural nitrate accumulations in caves or geological deposits. Nitrates from these caves served as sources of black powder for explosives during the Civil War. Many soils have surface accumulations of sodium nitrate. Historically, these have been known as "nitre spots."

To get the total storehouse of the world's nitrogen we must add to these the vast quantities of nitrogen contained in igneous rocks, coal, peat beds and muck soils and all the world's organic matter, both living and dead, plus that in sedimentary rocks.

The result is startling to most people. The great bulk of the earth's

nitrogen is *not* represented by nitrogen gas in the air, contrary to some statements that have been made. Actually, the reverse is true, and here I want to confirm it by quoting soil biochemist, Dr. D. R. Keeney, University of Wisconsin:

*"The great bulk (about 98 per cent) of the earth's nitrogen is in combined form in the lithosphere, the atmosphere contains only about two per cent of the earth's nitrogen. The nitrogen cycle, where only a few inorganic forms exist in comparison to large numbers of organic forms, is certainly the rule rather than the exception in nature, as a brief look at carbon, phosphorus and sulphur cycles will attest."*

(For those wishing further information on the 98 per cent-two per cent ratio, see page 4 of the book, *Soil Nitrogen*, by the American Society of Agronomy, 677 S. Segoe Road, Madison, Wisconsin.)

One final point should be noted before closing. There was implication made recently that the town of Elgin, Minn., had to develop a new water system on account of fertilizer use in the area. Dr. William P. Martin,

head, Department of Soil Science, University of Minnesota, reports that use of fertilizer was in no way associated with the new water system.

If we are to continue a fruitful discussion of basic issues, let's get all the facts, where we do not have them, and refrain from positive declarations until we have them. Even then, the matter of interpretation must be carefully scrutinized, else we will fall into grave error.

### Conclusion

This is a brief review of what allegedly has been happening to the nitrogen cycle since man brought civilization to earth. Actually, I believe man's adverse impact to date has been quite small, and one might even say almost negligible in terms of nature's storehouse of nitrogen. Except for lack of population control, atmospheric smog, and waste disposal problems, things, in general, look pretty good to me. At any rate, man is living longer than ever before, and I think he possesses the knowledge, or knows how to get it, in order to upgrade his environment. □

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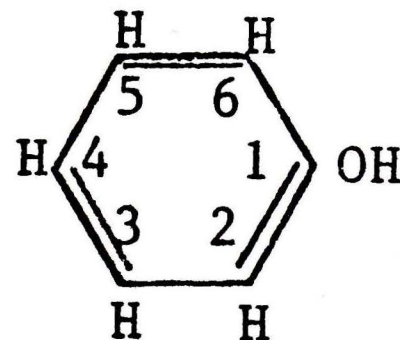
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Extension Specialists, Plant Physiology  
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*Weeds, Trees and Turf*, July, 1969  
Vol. 8, No. 7

## What Type 2,4-D To Use?



**TO USE** 2,4-D or not to use 2,4-D. That is only part of the question. Another consideration is what type of 2,4-D would be best suited for the job.

All kinds of the chemical have the same basic weed-killing ingredient, but are formulated for different purposes. They can be divided into major groups: acids, salts, amines, esters (high and low volatile), and oil-soluble amines.

In addition to 2,4-D, there are several other closely related compounds considered as derivatives of phenol and hence named phenoxy herbicides. These include 2,4,5-T, silvex MCPA, 2,4-DB, and others.

Comparing the molecular structure of 2,4-D with that of phenol (Fig. 1), you can better visualize how the chemical name is developed.

The phenol ring is numbered for convenience. Each angle of the ring represents a carbon atom. By observing the two molecules you can see the chlorine atoms have been substituted on the ring at the 2 and 4 position and a 2 carbon unit (acetic acid) has been added. 2,4,5-T is identical with 2,4-D with the exception of an additional chlorine atom substituted at the 5 position of the ring.

Growth-regulatory and weed-control potentials of 2,4-D were discovered in the early 1940s. Early in-

formation on the use of 2,4-D was classified during the war.

Although a tremendous amount of research has been conducted with 2,4-D, it still is not clear how 2,4-D kills plants or why it is selective for broadleaf plants.

Studies have shown that many plant processes are affected by 2,4-D. Respiration, food utilization, cell division and cell enlargement are all increased after application.

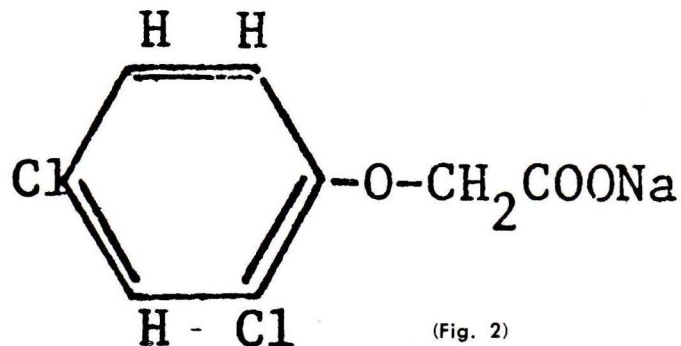
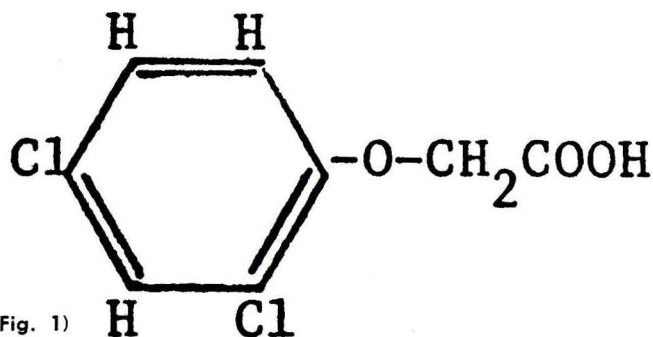
Recent work would indicate that it has a more basic action which is an effect on the nucleic acids of the cells. The nucleic acids contain the information for directing cell processes. Disrupting this system can cause many side effects.

The common expression that 2,4-D causes a plant to grow itself to death may be as near the truth as any present scientific explanation.

The 2,4-D applied to a plant leaf must gain entry to be effective. Once inside, it may be moved through the plant. This movement is called translocation and is responsible for the root kill of many deep-rooted plants.

Movement occurs in the living tissue, which carries food throughout the plant. When excessive rates of 2,4-D are applied or other materials added to give a contact burn, living tissue is destroyed and translocation into the root system is reduced or prevented.





Thus, addition of oil to a foliar spray of 2,4-D and/or 2,4,5-T will hasten top kill but excessive re-growth may occur.

2,4-D also is used as a pre-emergence herbicide. Again its action is primarily selective for broadleaf weeds. Under ideal conditions, some control of emerging grasses may be realized. Duration of 2,4-D in the soil is short and usually does not exceed four weeks. Loss from the soil is primarily by the action of soil micro-organisms.

#### Formulations of 2,4-D

The pure acid of 2,4-D has very low water solubility but may be dissolved in various solvents or suspension agents that can mix with water. Amchem's Weedone 638 is an example of an acid formulation of 2,4-D.

Various salt formulations of 2,4-D are on the market. These appear as white powders that dissolve in water. Fig. 2 is the sodium salt, but others include the potassium, lithium, and ammonium salts.

Amines and esters are by far the more popular formulations. The amines are more accurately known as amine salts, since they combine an amine grouping with one of the above salts.

Amines are ammonia ( $\text{NH}_3$ ) derivatives with hydrogen atoms replaced

by alcohol groupings. Methanol ( $\text{CH}_3\text{OH}$ ) and ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) are common substitutions. Fig. 3 is a common commercial formulation, triethanolamine salt of 2,4-D.

Amine salts are quite soluble in water and form true solutions when added to a spray tank. The amine salts as well as the salt formulations dissociate in the spray tank as shown in Fig. 4.

Thus if other salts (calcium and magnesium in hard water, or others in liquid fertilizer) are present, reactions may occur which will result in insoluble precipitates. Such precipitates can clog sprayers and are extremely difficult to remove.

Amine salts and salts are nonvolatile and do not evaporate after reaching the plant or soil surface. Where high temperatures (excess of 80 degrees) are expected or when applications are in close proximity to actively growing sensitive plants, the amines should be used in preference to ester formulations.

A disadvantage of the amines is their water solubility, which allows them to be washed from the plant surface by rain. As a rule, the majority of the applied 2,4-D which is going to enter the plant will have done so in the first six hours. Thus if an amine salt formulation remains on the plant for at least six hours prior

to rain, no serious loss of effectiveness should occur.

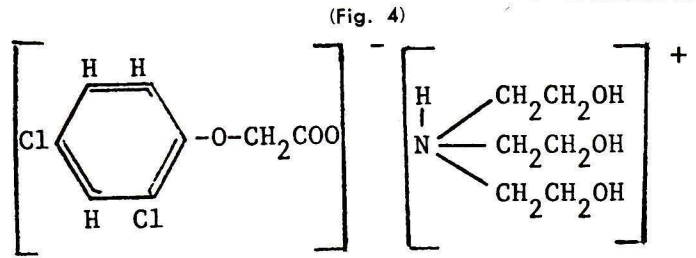
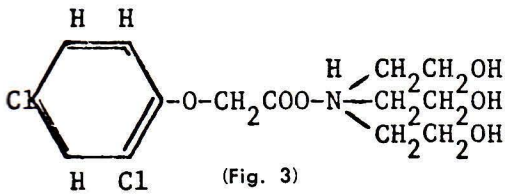
An ester is formed by combining an alcohol with an acid. The resulting ester receives its name from the alcohol used. Thus 2,4-D acid combined with butyl alcohol yields butyl ester of 2,4-D as shown in Fig. 5.

Esters are soluble in organic solvents and nearly insoluble in water. Commercial ester formulations are dissolved in oil carriers with an emulsifier. When added to water in the spray tank, they form emulsions of tiny oil droplets (containing 2,4-D) dispersed in water. Such a dispersion creates a milky appearance rather than the clear (but colored) solution which results when an amine salt is added.

When esters are sprayed on a plant surface, the water evaporates and leaves a thin film of oil containing 2,4-D. As esters are oil soluble rather than water soluble, they do not wash off as readily during rain.

Esters are also considered to have greater killing power than amines on certain plants. (On some woody species, the amines may be superior to esters.) This is thought to be partially due to the presence of the oil carrier, which permits increased penetration of esters.

Leaf surfaces are covered by a waxy substance called cutin. The oils containing 2,4-D can conceivably dis-



solve their way into or through the waxy layer.

#### Volatility of Esters

Many individuals do not understand the difference between volatility and spray drift. Volatility is the evaporation of the 2,4-D ester molecules from the plant or soil surface after application.

Spray drift is the physical movement of tiny spray droplets at the time of application. Spray drift is dependent upon wind velocity, droplet size, and distance to ground. Droplet size is primarily controlled by pressure, nozzle size and design, and nature of material being applied.

Most cases of injury are from spray drift, and not volatile vapor drift. All formulations can result in spray drift when misused.

Ester formulations vary widely in their degree of volatility. Volatility of 2,4-D esters is primarily controlled

by the length of the carbon chain that composes the alcohol portion of the 2,4-D ester molecule. Four of the common ester formulations in decreasing order of volatility are shown in Fig. 6.

When the alcohol portion exceeds four carbons in length, the ester is considered to be low volatile. Thus the isopropyl and butyl esters are sold merely as "ester" while the butoxyethanol and isooctyl esters are sold as low volatile esters.

The high volatile esters have been outlawed in many states. At temperatures in excess of 100 degrees, volatilization of the low volatile formulations becomes significant.

As leaf or soil temperatures exceed air temperatures, we suggest that low volatile esters not be used when air temperatures exceed 80 degrees.

#### Oil-Soluble Amines

Esters may be superior to amines

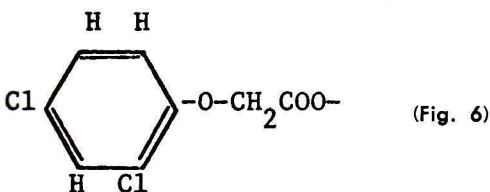
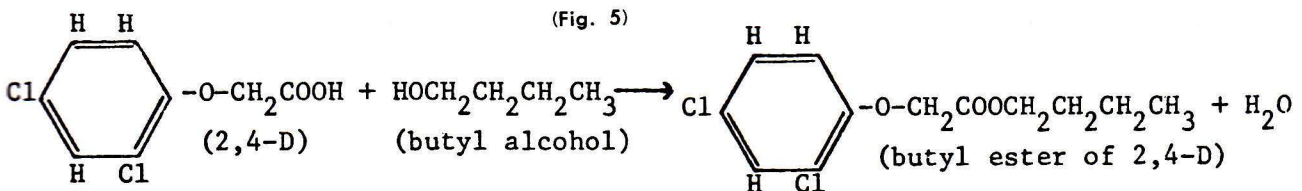
because they do not readily wash from the plant surface and because of their possible increased penetration.

The amines, however, are superior to the esters by virtue of nonvolatility. Oil-soluble amines were formulated to combine the benefits of both into a single formulation.

Dacamine (Diamond-Shamrock) and Emulsamine (Amchem) are examples of oil-soluble amine formulations of 2,4-D.

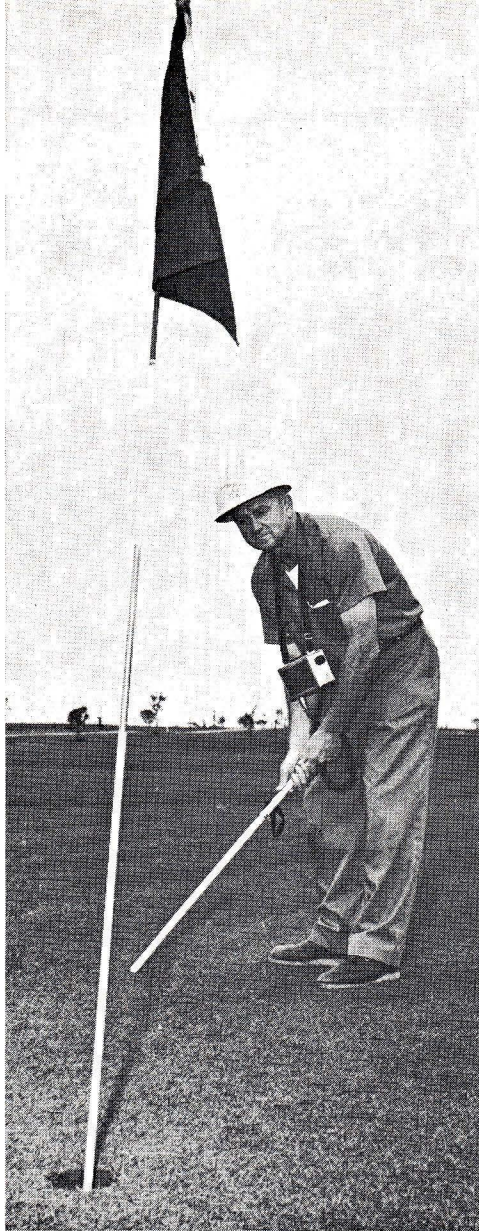
The disadvantages of the oil-soluble amine formulations are their higher cost and syrupy consistency which makes them difficult to pour from containers at cool temperatures.

Data comparing drift potential of oil-soluble amines with that of water soluble amine or ester formulations are not available. However, drift potential is anticipated to be equal to that of other formulations.



- $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH} \\ | \\ \text{CH}_3 \end{array}$  (isopropyl)
- $\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  (butyl)
- $\text{CH}_2\text{CH}_2\text{-O-CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  (butoxyethanol)
- $\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\underset{\text{CH}_3}{\text{CH}}$  (isooctyl)

—Reprint from  
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OAKLAND ELECTRICAL Dept. Electrician Al Delinger found a conductor break in sprinkler control circuit in Galbraith Municipal Golf Course in one hour.

## Irrigation Circuit Break Pinpointed in One Hour

A City of Oakland, Calif. electrician scored a hole-in-one here recently by electronically trouble-shooting in less than one hour the precise location of a break in a public golf course's buried sprinkler control circuit.

Electrician Al Delinger's feat took place on Oakland's Galbraith Municipal Golf Course, a par 72, 6,750-yard layout. Although it was the first use of the City Electrical Department's new electronic cable fault locator, the hole, which was dug immediately for repairs, uncovered the outage-causing break in the conductor.

According to department Foreman Jack Overby, "This single use of the troubleshooting instrument more than saved the purchase cost in labor alone. Time was of the essence, too, since the electrical breakdown oc-

curred during the area's annual windy, dry spell. The number of days required for old fashioned pot-holing and ohmmeter readings could have allowed the turf to be seriously damaged."

### Course and Sprinkler Details

Clarence Langlow, Gabraith course foreman, describes the San Francisco Bay-side layout as follows:

Size: 18-hole, par 72, 6,750 yards (over 200 acres; 100 acres of turfgrass).

Course opened October, 1966. Used to be the site of a sort of garbage dump, where people could go and dump old tires, paint . . . all kinds of junk. The area was filled in with top soil, but this is only a couple feet deep in some areas and the underlying junk has given us problems when we have to dig down for any reason.

Sprinkler system is Buckner, consisting of some Johns-Manville Transite 6 in. pipe; most of it, though, is 4 in. plastic pipe with lateral pipes of 2 in. to 1¼ in. plastic.

Sprinkler heads are Buckner Pop-Ups #1360.

Twenty automatic electric clocks control sprinkler which can be set to operate anywhere from 1½ minutes to one hour at a time.

The 24-volt automatic sprinkler control circuit at the new Galbraith Golf Course is a single conductor, No. 10 AWG, buried to a two-foot depth.

### Fault Locator, Operation

The 20-pound system consists of a self-contained transmitting unit to generate a 990-Hz signal (pulsed at 7 Hz) through the cable, and highly sensitive hand-held probes to detect these electrical signals through

earth, asphalt or concrete pavement. The battery-powered, solid-state device is known as a Delcon (Division of Hewlett-Packard Co.) 4900 series Buried Cable Fault Locator.

In troubleshooting a faulted circuit, the electrician first de-energizes the circuit. Access for the Cable Fault Locator is gained at the valve box closest to the fault section. One of the transmitter output leads is clipped to the conductor, the other lead to ground.

After solid ground contact is made, an automatic transmitter control establishes the proper output signal level for such various factors as soil condition, moisture, cable length, etc. A flashing light informs the craftsman of the proper setting.

With the circuit established, the electrician is ready to locate the precise underground course and also the depth of the cable at any point. His tools consist of a lightweight three-foot-long probe, and a 35mm camera-sized receiver unit which reproduces the pulsed signal through a loudspeaker and indicates changes of signal intensity on a meter. The tip of the Search Wand probe contains a specially designed pickup element which is sensitive to the inductive field above the cable. When the Wand is pointed down directly over the course of the buried cable, the receiver unit registers only a null (or sharply reduced) signal. Moving the probe to either side of the precise course of the underground cable produces a distinctly audible signal. Thus, the electrician can describe the entire course as fast as he can walk.

### Determining Depth

Since the inductive probe senses a null when pointed directly at the cable, the depth can easily be determined by moving the probe at a 45° angle away from the cable path. When a null effect is reached with the probe at this angle, the craftsman need only measure the surface distance between the two points, which equals the cable's depth.

Because of the pronounced nature of the faults common to dig-in damage, the Search Wand alone pinpoints faults within a shovel-width. An immediate and unmistakable fall in signal intensity isolates its position. In instances of multiple faults on a single circuit (such as caused by gophers), the electrician repeats the Search Wand process from the other end of the circuit.

### The Trouble at Galbraith

"In the Galbraith troubleshooting job we followed the conductor, which controlled five separate circuits, along a service road. There, mature trees had been planted to serve as fairway dividers," Delinger recounted. "The trees were held upright against the prevailing winds by guy wires connected to metal anchor stakes. One of these stakes had been driven right through the conductor."

The City of Oakland electrical department now uses the 4900A instrument as its fault locator on all extraordinary assignments and plans extensive use in troubleshooting street lighting circuits in plastic conduit now gaining favor by subdivision developers.

The Fault Locators are available from the Delcon Division of Hewlett-Packard Company, Mountain View, California. The 4900A costs \$655. ●

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