cept concerning the principles that underlie natural phenomena. While all this is well known, it is nevertheless an extremely rich and memorable experience to be able to watch at a close distance in a single instance the mutual influence and the subsequent growth of these two factors—the concept and the observation. It is, indeed, a privilege that I have this opportunity to tell you part of this experience in the recent developments concerning the nonconservation of parity and the weak interactions.

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Science, Industry, and the Abuse of Rights of Way

Frank E. Egler

The problem of improving the present unsatisfactory methods of controlling brush and other vegetation on our national rights-of-way is a fine illustration of the more general problem of getting industry to accept and act upon established scientific principles. The right-of-way domains are those narrow threads of land which serve for transportation and communication of men and materials. They include highways, railroads, electric power and telephone lines, and pipelines for gas, oil, and coal. The rights-of-way of the utility corporations alone comprise an acreage greater than all six New England states combined.

The fundamental scientist traditionally has observed, recorded, and interpreted the facts of the world about him and in doing so has usually remained aloof from society. He has been unconcerned about the discoveries of his science and indifferent about whether they are used for good or evil. In recent years, however, these discoveries have been of enormous import. More and more do we hear of a "Scientific Revolution" that may prove more challenging to the development of the human race than the Industrial Revolution from which we are just emerging. There are three significant recent events which, though differing greatly in magnitude, emphasize the contemporary trend of science toward integrating itself into society.

The first of these events was seen during the last political campaign for the Presidency of the United States. For the first time in our history, a scientific issue became a major feature. I refer to the problems of radiation hazard and of continuing H-bomb tests. Unfortunately the issue became a political football and then was left in the field, deflated. The second event occurred at the annual meetings of the American Association for the Advancement of Science. This august and distinguished body, representing organized science in America, broke with its traditional aloofness relative to the social effects of scientific discoveries. For the previous year, an Interim Committee under the chairmanship of Ward Pigman had been studying the subject, and the report has been distributed as evidence of the committee's interests and activities. The AAAS Council has voted to continue the existence of this committee. In a measure, therefore, science has begun to show a sense of responsibility to provide professional guidance on how to manage and control the revolutionary potentials that it is creating. The third event directly involves our present discussion. For the first time in the 10-year history of commercial herbicidal brush control, a utility corporation presented a system-wide policy that drew upon the common pool of biologic data. At the meetings of the Northeast Section of the Wildlife Society, a leading New England power corporation offered a paper which—in its statements—was scientifically sound. Furthermore, the opinions are in accord with a joint policy statement released at the same time by the Connecticut State Board of Fisheries and Game and the Connecticut Botanical Society.

Following a general review of the problem, I shall consider four of its aspects. The first is a definition of terms. The second is the question of "brush control—for whose benefit?" The third involves the authority of the scientific statements here made. The fourth and last is a short survey of specific factors that have become critical in the actual programming of brush control.

The author is a consulting vegetationist in Norfolk, Conn. This article is based on an invited paper presented at a panel discussion on "Programming Brush Control on Utility Rightofways," Northeastern Weed Control Conference, 11 Jan. 1957.

Review of the Problem

I believe there will be agreement when I state that any brush-control program must aim for "the lowest costs for the most years." I would like to add to that slogan "with the highest good to society," although I realize that there are many who are, by nature, indifferent to this facet of our American economy or of that of the One World which may yield peace. Programming must essentially be a three-cornered cooperative venture, even though triangles are known to be sources of trouble. This particular venture involves a utility engineer, a biologist, and a brush-control contractor.

The utility engineer and the needs of the utility come first and foremost. The needs are simply stated. For electric power, the right-of-way must be adequate, free, and open for patrol, for maintenance, and for repairs. From the standpoint of vegetation, these needs mean permanently low vegetation below the wires, and no trees at the sides that will grow into, or fall into, the wires. Flammability of vegetation, such as grassland, is often an additional factor.

The biologist, with a knowledge of plant species and of plant-communities, is the one to indicate which plants it is desirable to save in a discriminate brush-control program. He can predict the post-treatment vegetation, how many years it will last, or how rapidly it may be invaded by undesirable trees. It is the biologist who has been missing, ignored, or ridiculed at the council tables of the programmers. I use the word *biologist* guardedly, for there is much confusion about the term and the field. If the biologist is consulted at all, the engineer is likely to choose him and to expect him to be—as we used to consider the family physician—a jack of all related trades.

Some companies have employed biologists. All too often, however, they have chosen foresters, agriculturists, agronomists, biochemists, or plant physiologists —men who may be competent in their own fields but who, in making recommendations on this subject, are under the same handicap that a surgeon would be under if he were asked, and forced, to treat an emotional disturbance. In other instances, a competent biologist is "neutralized" by an engineer of higher echelon. More often, no biologist is consulted. For example, one of the world's largest corporations (which, in one division alone, spent $3.5 million spraying 200,000 acres in eight years and is still spraying) does not have a single botanically trained individual to judge the effects of its nation-wide spraying program. Although this corporation spends millions of dollars a year on research through a laboratory of deserved renown, not one dollar goes to the study of the effects of chemicals on the plant-communities. What little research is done is concerned only with specifications for the herbicides themselves.

In a second instance, another mammoth corporation in the chemical manufacturing field finally appointed one of its entomologists to carry through a costly and time-consuming investigation of vegetation management on rights-of-way. By good fortune, they chose a remarkably fine individual, with an unusual hobby-interest in botany. I have a letter from the company indicating essential approval of all aspects of that program (with which I was then affiliated). His final report was nearing completion when an unexpected heart attack took his life. To my knowledge, the investigation was shelved, and I am not aware that there has been any significant change in the policy of the company. It took courage to do what this man was doing.

The third and last of this irregular triangle is the line-clearance contractor. It is he who knows the various mechanical and chemical techniques for brush control and who can estimate the relative costs of the different approaches in the light of the biologist's and engineer's recommendations and needs.

Outside of the triangle, but often manipulating thought within it with consummate dexterity, is the chemical manufacturer. Chemical herbicides are assuming an ever-increasing role in commercial brush control, and they deserve to. The chemicals used are generally derivatives of 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid, commonly known as 2,4-D and 2,4,5-T. Ammonium sulfamate is also used. It must be understood that these chemicals have no known adverse effects on any animals. If used unwisely, they do have an extremely detrimental effect on wildlife habitat, and this, in its way, is far more disastrous than any killing of the animals themselves. An animal reproduces readily; habitat does not.

In the use of these herbicides, many practices are followed. Much of the so-called controversy revolves around two common and antithetical procedures. One is indiscriminate, blanket, summer-foliage spraying with power equipment. The other is discriminate basal-bark spraying at various seasons, usually with small or hand-powered equipment. For the first procedure, water-borne sprays of low concentration are used; for the latter, oil-borne sprays of high concentration. Much of the discussion that follows is based on the different biological and economic effects of these two techniques, although it must not be assumed that either, or any, technique can be adopted to the exclusion of all others.

"Brush Control"—the Term

It is my sober opinion that the rational management of vegetation on the rights-of-way of this nation will never be established on a sound basis as long as the problem is referred to as "brush control." Both words in the term are heavily laden with factual error and with insidious emotional connotations.

The word *brush* for example—"brush" refers to any woody vegetation, including trees and all shrubs, even those under one foot in height. To many engineers—and I speak from my experience with them—there are but two kinds of plants, brush and grass. Brush grows up into trees; engineers do not want it. Grass stays low; they want it. *Brush* has actually become a dirty word, and advertising campaigns have been very effective in promoting the idea that no brush can be tolerated on a right-of-way. When sales and marketing divisions bring modern motivational psychology to bear on this thought, the result is very impressive. Therefore, the accepted scientific fact that many types of brush—that is, the low shrubs—not only can be advantageously saved but may be extremely valuable with respect to the future control of trees is a statement contrary to common belief in the industry. The maenads of Madison Avenue have prevailed over the soberness of science.

The word *control* involves even worse problems, for it has been used so much that electrical engineers have become satisfied with repeated control and do not recognize that "elimination" is often a scientific possibility, especially where tree roots are involved and where invading seedlings do not occur. On the other hand, we should be realistic and recognize certain psychologic facts. Those who are in the business of "controlling" are rarely interested in "eliminating." This is true in industry as well as in philanthropic and scientific activities. I am sure that some social workers would be deeply

grieved if underprivileged and problem families suddenly ceased to exist. I recall also a discussion I once had with a pathologist, whom I was trying to impress not with the importance of controlling a forest disease but with the possibility of furthering an already natural trend toward developing a resistant strain of the tree species. The hour was late, and other factors contributed to an unusual element of frankness in his words. "But Frank," he finally confided, "don't ask me to eliminate the disease. I like diseases. It is my job and my profession. All that I want to do is to control them." And so it is with many in this industry. I accept the fact that they may just want to "control" brush. But when science can eliminate undesired brush and thereby effect an economy for society as a whole, the scientist will say so.

Brush Control—for Whose Benefit?

Brush control is a business, a profession, an art, and a science. Any reasonable discussion of programming brush control should recognize the fact that different people are interested in it for different reasons. What I must now say may offend some readers. However, these are not personal opinions but are based on factual experiences and expressed with the impartiality of a sociologist. I seek neither to convince some of you nor to alter the unalterable but to generalize from the variety of contacts in my own background.

For our purposes, the people interested in brush control can be segregated into four groups. The first group includes the chemical manufacturers and the spray and line-clearance contractors. In this case, I do not see why we should not all face the fact that more brush means more business for these organizations, and thus that any science-based program recommending the elimination of brush will not be welcomed. For example, at a conference in the summer of 1952 it was reported that an owner of a local and successful spray business, after hearing a talk on long-term, lost-cost vegetation management, commented to another group in the evening that "all this talk about stable low brush cover may be good enough. But I have a son coming up in years, and when I retire I want enough new brush around so there will be business for him. What better way than to spray, so that the trees will come back in again."

It is my opinion that this philosophy, though rarely so bluntly and honestly admitted, is nevertheless widespread. I have, for example, no evidence that any chemical manufacturer has incorporated scientific data concerning the relative stabilities of different types of post-spraying vegetation in their sales and marketing literature. Almost all line-clearance contractors have studiously avoided the subject also, although I know of two that are outstanding exceptions. They act on the philosophy that, although there may be less brush per acre in the future, there are many brush-covered acres. These are small organizations, however. That they are not among the largest is possibly an indication of the disadvantage of espousing a minority viewpoint, even if it is scientifically correct. Furthermore, there are problems inherent in selling a new approach. When sales representatives have long been in the habit of taking orders for what a consumer has been conditioned by others to demand, even if it is morphine, they are unwilling to sell, and incapable of selling, an idea, and thus, through poor salesmanship, can undermine their own corporation.

The second group involves the utility corporations themselves. The rights-of-way of these corporations include railroads, pipelines, electric power lines, telephone lines, and roadsides; my personal experience has been mainly in the field of the electric utilities. Among the utilities we must accept the fact that within any one company there can be remarkably diverse reactions to the different aspects of brush control. The engineering departments are directly concerned with the construction, maintenance, and repair of the rights-of-way and the lines upon them. Very often these departments find themselves already committed to programs that disregard certain scientific knowledge. I say without rancor, and with complete sympathy and understanding of their individual problems, that such departments, when confronted with certain scientific evidence, are primarily concerned with saving department funds, department jobs, department face, and individual faces. Of these, the last leads all the rest. Five large power corporations strikingly exemplify this situation—a reality which we must all accept.

Public relations departments, on the other hand, have an extremely different approach to the subject. They are highly sensitive to public opinion and are often in a far freer position to evaluate the voice of science. Indeed, this sensitivity can be a disadvantage. I myself find that I can present, coldly and with dignity, the facts of accumulated scientific literature and the results of a decade of field research without accomplishing as much as can one irate conservation-committee chairman of a local garden club, who tosses off a perfumed letter that all but singes itself. Furthermore, whether or not the lady in question is scientifically correct may be irrelevant to the state of her temperature and to her effectiveness. Scientists should recognize the value, and the danger, of such thermal bombs.

And finally, in addition to engineering and public relations departments, there is top management. We must recognize that top management may be open to suggestions and to developing views of its own. Although generally it does not wish to be bothered with activities that traditionally have been handed down to departments, time and time again I have found only in top management (and not always here) a respect for science and a concern for company economies. Within the three aspects of this second group, in particular, I see little prospect for permanent relief unless we can establish a higher standard of scientific literacy than now exists. By "scientific literacy" I do not mean a knowledge of technical details equivalent to that of the professional expert. I do mean an awareness of the complexities sufficient to distinguish the voice of authority from that of fraud and quackery. The urgent need for such literacy was obvious during the course of the panel discussion for which this paper was originally prepared.

In the third group, which may or may not benefit from brush control, is the forgotten person in this entire program. It is doubtful whether he was represented in the audience at the time the panel discussion took place. I refer to the man who is the owner of this land in a free democracy, to the man who has all rights and prerogatives on these 50 million acres except as they concern the transmission and distribution of the commodity involved. I doubt whether any utility corporation involved in brush control has presented an impartial and factual account of the varied and multiple methods of accomplishing such control, all economically feasible but differing greatly in owner benefits. (In personal discussion, at the original conference, one utility representative admitted frankly that his company delib-

erately tried to keep owners uninformed about different spraying techniques. If there was any questioning, the company had a policy of sweeping away opposition with claims that theirs was the "only proven way"—a policy which he thought excusable even if not correct. Another company representative seemed to agree that the owner was the forgotten factor and implied that he should stay forgotten, for, "after all, what the owner wants, we do—regardless!")

Here is a striking instance of the power of an owner in my own state. A woman happened to be at home when blanketeering operations started on her property. Single-handedly, with no scientific knowledge but with a large measure of common sense, an effusion of Latin blood, and the vigor of a chick-defending mother hen, she cowed a large force of laborers. The result, today, is the finest single example on the lines of this company of vegetation that is best for the company and best for society. It is in striking contrast to the rest of the blanketeered right-of-way in the town—a town whose active sportsmen's association was ineffective in dealing with the company. This corporation has persistently destroyed more wildlife habitat than the state game department has produced in its entire history, despite the fact that scientific information has been repeatedly brought to its attention by many groups since 1947.

Fourth and last comes the "general public." By this I mean neither the owners nor the land management, but "society," which has an indirect stake in these lands. I refer to the forestry profession, which may be involved with alternating hosts of forest diseases. Members of the wildlife profession and sportsmen have a large interest, for the vegetation can serve as habitat, as food, and as cover for game populations which will breed here and then spread to other lands. Berry pickers, hikers, bird watchers, and other recreationists often utilize these rights-of-way. Then there are the naturalists and scientists, who often find on these lands rare and unusual plants and animals and biotic communities. In some ways the general public has one of the largest stakes, but it does not know about it. One reason for this lack of knowledge on the part of the masses is that this subject has been neglected or openly avoided by almost all federal and state agencies. Such agencies are traditionally concerned with the conservation of timber, forage, wildlife, crops, soil, and water, on public and wholly private lands. For reasons that are understandable, however, if not entirely excusable, the natural resources in a very sizable area of our nation have been left defenseless against overzealous commercial exploitation.

Programming—Whose Scientific Opinions?

To the best of my knowledge, the items I will be mentioning in the fourth part of this article are not personal opinions, are not matters of controversy among scientists in this field, and may be considered reasonable scientific generalizations in the light of existing data (*1*). I am not aware of any contrary generalizations emanating from those scientists who are now involved in related research or practice.

At the present time there are three national organizations that have committed themselves to an interest in these 50 million acres. The Wildlife Management Institute has commissioned a booklet on the subject, has sponsored a questionnaire that has been sent to almost 1000 electric utility corporations, and is aiding one of the largest corporations in launching a "rightofway vegetation management" program. The Boy Scouts of America National Council has a project in their Del-Mar-Va camp, for purposes of Scout education. The Garden Club of America, national Conservation Committee, was instrumental in furthering a project in central New York which, in turn, would aid member clubs in handling local problems. Furthermore, the federal Fish and Wildlife Service has stated its official policy, by request of the editor of *Public Works* magazine. This policy appeared in the issue for April 1955.

Two state conservation departments have issued definitive policies: the Connecticut State Board of Fisheries and Game and the Pennsylvania Department of Forests and Waters. One state scientific society, the Connecticut Botanical Society, has an active Rightofway Vegetation Committee. This committee is associated with certain representative projects in its territory, including those of an Audubon Society chapter, a college arboretum, a sportsmen's club, a foundation, a land owner, and a corporate sanctuary. Essentially the same ideas are expressed in a U.S. Forest Service foreman's manual for roadside spraying in Region Seven. The national Committee for Brush Control Recommendations for Rightofways is associated with approximately 20 projects, extending from Florida to northern New England. There is no basic difference in the scientific or economic approach of these projects or groups. I am sure there are many other organizations that should be included here, but I have no published evidence of their policies.

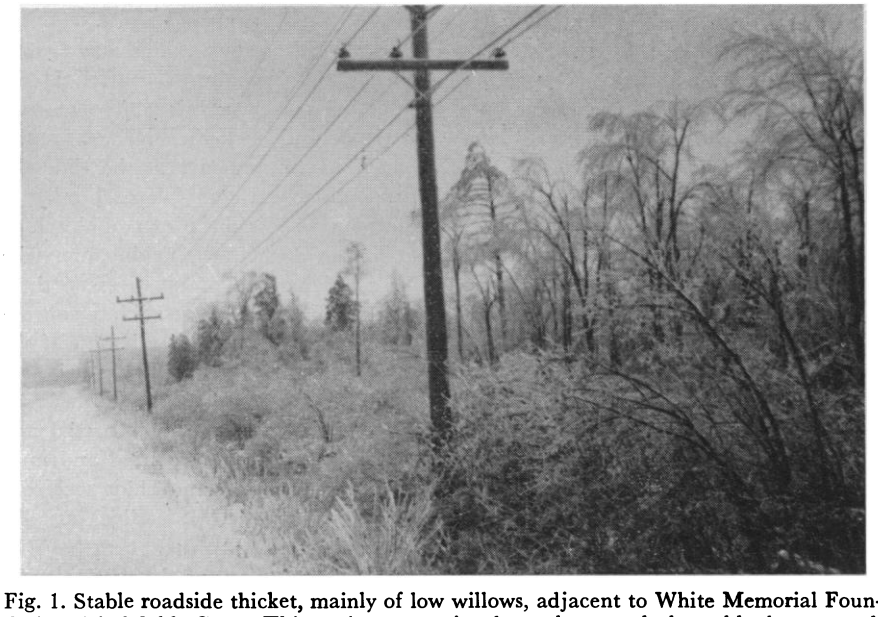

Fig. 1. Stable roadside thicket, mainly of low willows, adjacent to White Memorial Foundation, Litchfield, Conn. This entire vegetation has subsequently been blanket-sprayed. [Photograph by Gordon Loery]

Brush-Control Programming

In the following and final paragraphs, specific factors will be discussed which, as the biologist's contribution to a sound vegetation management program, have been found to be of critical importance. These will be discussed in five categories,

Fig 2. A type of right-of-way grassland that is misleadingly attractive (in Pennsylvania). It is a thin vegetation of poverty grass—a relative desert for wildlife—and will be costly to maintain because of invading pines.

pertaining respectively to applied phytosociology, herbicides and plant-kill, commercial brush control, conservation intests, and the general idea of research and development.

Applied Phytosociology

If any biological generalizations are to be made, the leading idea is that, in most mixtures of shrubs and trees, the trees are of the same age as, or older than, the associated shrubs. Tree seedlings are relatively unusual among most shrub covers. There are exceptions, especially in the tropics, and these must be carefully evaluated. Root systems are frequently much older than aboveground parts, and this fact plays an important part in low-cost management.

Another generalization concerns the relative stability of upland grasslands and shrub covers. In most cases shrub communities retard reforestation more successfully than do grasslands. Rhododendron, laurel, and hazel are notorious in this role (Fig. 1). Pines are eminently successful in invading grasslands; so are ashes, elms, maples, and birches (Fig. 2). Sound vegetation management involves the encouragement of that plant-community which is most stable through the years. A community that goes to forest twice as quickly as another does is twice as expensive to maintain, and some communities (including some produced by blanket-spraying) advance 20 times as quickly as others.

Sound brush control should start with initial clearing of the line. Too often there is unnecessary destruction of valuable cover at this time, cover which would mean future savings (Fig. 3). Much of such destruction is accompanied by soil-baring, which the forester often purposely effects in order to increase reforestation.

"Construction" of a suitable seminatural vegetation should be clearly differentiated from "maintenance" of that vegetation once it is attained. These two costs should receive the same consideration as comparable construction and maintenance costs of poles and towers. The situation is analogous to that of separating the construction cost of your home from its continuing maintenance costs.

Vegetation is highly variable, from town to town, county to county, and state to state. As in the case of other vegetation management procedures, such as forestry or range pasture and wildlife management, a knowledge of existing local variations is essential, and economically sound, as a prerequisite to a rational program.

The botanical aspects of the program can be planned in terms of the length of the life of the line itself, be that 25, 50, or 75 years. There is adequate botanical literature on the stabilities of vegetation types, some of which involve communities that have perpetuated themselves for several centuries. This aspect of the problem seems to be particularly mystifying to engineers, one of whom arrogantly refuted during the course of the panel discussion on "Programming Brush Control on Utility Rightofways" all such knowledge, even when it involves stability of only a few years' duration.

Herbicides and Plant-Kill

Past chemical treatments must be clearly evaluated in several different respects. The easiest to observe is "top-kill" or kill-to-ground. I estimate that 95 percent of the companies of this nation are judging their brush control in these terms. As "kill," it is comparable to mowing the lawn, which is not done to kill the grass. Less easy to observe is root-kill, which cannot be adequately judged until at least two years after treatment. I know of only half a dozen companies who are properly judging root-kill. The economic importance of this distinction should be quite obvious, for root-kill techniques may cost up to twice as much as one "chemical mowing," and yet some companies are top-killing for the fifth go-around. The third item in evaluation is a consideration of the vegetation that remains after treatment. I know of no company that has any policy on this aspect of vegetation management. The fourth and last item involves reinvasion of the postcontrol vegetation by new tree seedlings. Here also I know of no company which is employing the technical know-how to estimate this all-important economic factor. Although they may mention certain new brush as being composed of reinvading seedlings, the species they mention (most frequently aspen) indicates the error of their judgment. I estimate that over 90 percent of commercial brush control is judged purely in terms of these four factors, based on engineers' estimates of the numbers of above-ground stems.

Commercial Brush Control

Indiscriminate blanket-spraying leaves a bright brown swath in midsummer that has often evoked adverse criticism from the public. In itself, this situation cannot be considered undesirable, provided this is the cheapest technique for achieving the highest general values. On the other hand, I have not yet seen the brown-out, except for local stretches of several spans, which I would recommend. Furthermore, evidence is abundant that such blanketeering techniques more readily kill the low, desirable shrubs (which do not return by reseeding) and tend not to kill the undesirable tree roots (Fig. 4).

One of the most unfortunate theories, and one that has regrettably gained widespread acceptance because of a superficial rationality, is that of the desirability of an initial blanket-spraying followed by later years of selective spray-

ing of what is left. To the average engineer, the vegetation in the summer is a jumbled and confused mass of verdure. He cannot distinguish shrubs from trees. With a vigor that approaches a neurotic compulsion, he wants "to get rid of all that brush." After that, he promises to selectively spray out the trees. More often than not, observations in the dormant season would indicate that there are far more desirable shrubs than intermixed trees. Very frequently I have seen long stretches blanketed with spray when there was but a handful of young trees—trees that could have been cheaply root-killed by hand equipment. Furthermore, these initial foliage sprayings, wholly unwarranted on biologic grounds, frequently have very little root-kill effect on the tree component. In the subsequent selective spraying for eliminating the surviving trees, the cost may be just as high as if this were done in the first place, while conservation values have been permanently lost.

Of all the right-of-way spraying I have observed in recent years, I would judge that more than 50 percent has been done from 1 to 20 years too soon. Furthermore, there is empirical evidence indicating that taller unwanted brush is often more easily root-killed than is younger brush. In addition, each year postponed means lower average costs. On the other hand, I recognize the economic forces that favor early spraying. Any contractor is constantly pressuring the utilities for these premature jobs, knowing full well that if he does not get the contract, his competitor will. There is no force, even within his own company, to aid the utility engineer to withstand this pressure.

In judging these sprayed rights-of-way of the nation, I would estimate that over 75 percent of them have already had a definite loss of vegetation "capital" because of indiscriminate blanket spraying. The act is comparable in many ways to throwing the baby out with the bath water. This loss will continue, until the validity of biologic knowledge is recognized.

A rational program of vegetation management is definitely a multitechnique procedure. It involves a combination of mechanical and spraying techniques, depending on the local and predominating vegetation conditions. I realize that my name has been linked with one particular technique, largely because I was associated with some of the original research on that technique a decade ago. I accept the fact that, among engineers, there is an overpowering tendency to tie one to a technique rather than to a biological end-result. The technique they can understand; the end-result can be accepted only in relation to that scientific literacy previously mentioned. In my own experience, I no sooner squirm out of one technique tie-in than I am pulled into another. I cannot emphasize too strongly that, in the last analysis, the vegetation, not the engineer, should determine the technique.

Another unjust and unwarranted claim is that selective power spraying is a far more efficient procedure than knapsack spraying (where a biologist recommends knapsack spraying) and that it can pinpoint out the undesired trees without undue harm to the surrounding shrubs. One electric utility corporation in particular has tried to placate the wildlife interests by extolling this claim. Whether or not such selective power spraying is generally feasible is yet to be proved. In the case of this company, it was found that patches of shrubs 30 feet in diameter would be ruined in the course of spraying a single small tree. It is doubtful, anyway, whether such trees were root-killed by such treatment, and, even if they were, they would not have been critical to the maintenance of the line for many many years to come. Surely common sense, rather than scientific knowledge, is needed in such instances as these.

Bulldozing and discing, except in certain very limited instances, are not indicated as suitable techniques for long-term vegetation management. Such procedures are widely known to encourage reforestation, and those few companies that have prematurely endorsed them will eventually realize the problems they are creating for themselves. One company, operating on borrowed federal money, purchased its own bulldozers and carried to completion a bulldozing operation on 5000 acres, including an excellent demonstration area on a federal experimental forest. Finding that brush is returning after this bulldozing, the company is now purchasing a helicopter for a program of aerial spraying. This decision was made without regard for existing biologic knowledge, which strongly indicates the inadvisability of such a procedure.

It is not my intent to imply that the needed biological advice for the programming of right-of-way vegetation management is either expensive or difficult to obtain. Suitable specialists exist in a dozen American universities, and there are several national organizations, and their branches, that would cooperate. It is my opinion that adequate recommendations, based on field surveys, could be prepared at the absurdly low cost of 25 cents per acre per year, plus expenses, for three years, beyond which time the program would be self-maintaining. In view of the fact that some companies have spent $200 per acre, or more, within two years, and on a treatment that involves a capital loss, many people have a right to feel disturbed.

Conservation Interests

At times, the wildlife profession has disregarded its own interests by a too-ready admission that any right-of-way, even of legume-killed poverty grass, is better than closed forest. This is true, but certain industrial interests have jumped the statement, through under-

Fig. 3. View of willow thicket (in mid-background), stable for several decades, that has been unnecessarily destroyed (foreground) for right-of-way sides (White Memorial Foundation, Litchfield, Conn.). [Photograph by Gordon Loery]

standable misunderstanding. If no right-of-way produces x animals, and a sprayed-out grassland produces $2x$ animals, one would choose the poverty grass—if those were the only two alternatives. The choice, however, includes a third—mixed edge effects that can produce $10x$ animals. Even if one has been a coal miner, he should not stoop to pick up garnets if diamonds are also present!

Among the multiple-use aspects of these right-of-way lands, that of providing food and cover for game and other forms of wildlife seems to be of greatest importance. During the course of the panel discussion, there was one supercilious claim that the shooting of insulators by trigger-happy hunters makes it impossible for utility corporations to cooperate with sportsmen. I am amassing considerable data that are pertinent. Apparently this destruction is almost always a local problem, traceable to delinquents of various ages. One rural electric cooperative in the Southeast solved the problem effectively and permanently by apologizing to its customers for the disruption of service and asking for their aid in locating the guilty party. (He was quickly found.) Moreover, there is a difference between habitat lands and shooting lands. I know of no professional wildlife manager who demands these lands primarily for shooting. In some instances, however, corporations have knowingly constructed their rights-of-way through state game lands, with foreseeable results.

Fig. 4. Spray-induced grassland below a telephone line, open to invasion by pine seedlings (in Virginia). Unmowed roadside grass is a fire hazard. Present spray policy is to reach out under the adjacent forest, killing out desirable food and cover shrubs and leguminous herbs.

Research and Development

One further word should be said about the role of recent and future research and development. The terms *research* and *development* have an aura of respectability and dignity that can be unwarranted. Far more often than I would like to admit, the claim for additional activity of this kind is a cloak, somewhat diaphanous, for ignorance, confusion, laziness, unmitigated procrastination, or sheer cowardice. I can document that strong statement, but I trust I am not forced to do so. This is as true in science as it is in industry. Within this discussion, I wish to emphasize very strongly that marked improvement can be made in the existing commercial practices without additional phytosociologic research and development. The need today is for the amalgamation into those practices of the common fund of scientific knowledge—knowledge which can no longer be accredited to any one individual, certainly not to myself. I refer to the literature on the nonforest areas that existed at the time of the white man's arrival and that still exist—areas such as the balds and slicks of the southern Appalachians and the blueberry heaths of West Virginia. I refer also to commonly accepted forestry practices, such as scarification of the soil, and destruction of the hazel brush of the Lake States and of the Appalachian rhododendron thickets in order to favor tree regeneration. It is not additional knowledge of this kind that is needed. The problem is for industry to catch up with what is already known.

And, finally, I wish to say that the cheapest means of achieving brush control for the future is by the encouragement and utilization of *other plants*. Such plants often already exist on the land and can be saved by discriminate programs of brush control. I accept the fact that this biologic means of control is distinctly alien to the thinking of—and therefore largely ignored by—the industrial sponsors of the Northeastern Weed Control Conference.

In conclusion, I wish to apologize if I appear to have unduly criticized certain facets of industry for the failure to utilize scientific knowledge. The fault is definitely two-sided. If science has not claimed respect, it is the fault of science. If science is ridiculed at conferences of this type and not one scientist stands up in defense, those scientists present are at fault. If scientific fact is blatantly overridden, there may be something wrong with the science professors in the engineering colleges. If scientists are invited to adorn industrial conferences and then are discarded when they do not sing the proper song, then scientists should seek some other way to influence the national economy. If industry-sponsored research is prematurely taken from the ivory tower and deliberately distorted for marketing purposes, the scientist who aids and abets this is the one to be blamed.

The integration of scientific fact into our society, for the general good of that society, is not to be accomplished without a broad and general understanding, on the part of all its citizens, of the nature of the different sciences. It is not accomplished without some facets of that society being temporarily and locally dislocated. In this connection I would say that our little problem of achieving scientifically sound right-of-way vegetation management, involving an area greater than all of New England, is one typical facet of the general problem—the problem which dominated recent meetings of the American Association for the Advancement of Science. That problem recognized the urgent need for scientists to abandon their traditional impartiality and to provide professional guidance in the integration of

their discoveries into our way of life. I do not, in this instance, have the answer for this segment of industry, but if I have brought some of its traps and hazards to your attention, I shall have accomplished my aim.

Reference

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News of Science

Snyder Statement on Education Legislation

Laurence H. Snyder, chairman of the AAAS Board of Directors and retiring president of the Association, recently appeared before the Senate Committee on Labor and Public Welfare, which has been holding hearings on proposed legislation for additional Federal support for education, especially science and language education. For an analysis of the two major bills under consideration, S.3163 and S.3187, see Dael Wolfle's "Science Education Legislation for 1958" on page 389 of the 21 February issue of *Science*. Snyder's statement to the committee follows.

"As a representative of the American Association for the Advancement of Science, I welcome the opportunity to discuss with you some of the problems of improving science and education in the United States. These problems have for long been of concern to this committee. They have long been of concern to my Association also. As two rather widely separated examples, I might cite the fact that the presidential address of one of my predecessors a century ago was one of the first public statements of the need for a National Academy of Sciences, a proclamation that President Lincoln heeded a few years later in establishing the National Academy, and that a decade ago the American Association for the Advancement of Science prepared the material on science education that was included in the report of the President's Scientific Research Board in 1947—the report that is usually known as the Steelman Committee report.

"Three years ago the Association greatly increased its attention to the problems of improving education in science and mathematics. This we did because we agree completely with the authors of both S.3163 and S.3187 that the primary requirement in education today is to improve the quality of education, especially education in science and mathematics. We need more and better school buildings. We need to pay our teachers more adequate salaries. We need to overcome the handicaps that prevent some bright students from attending college. But above all, we need to offer education of higher quality to the students who will be the teachers, the statesmen, the scientists, and the leaders in business and other fields of tomorrow.

"Let me explain why we put such stress on quality. There are two reasons. The first lies within the educational system. During the past three quarters of a century, the population of the United States has increased threefold. During those same years the population of our schools has increased a hundredfold. The nation's teachers have done an excellent and devoted job of meeting this rapidly expanding load. But note what we ask them to do. We want them to take care of practically every child in the land from the age of five or six to the age of sixteen or older. We want them to help the retarded and handicapped child; to serve the needs of the average; and to develop the talents of the gifted. Seventy-five years ago, most of the students who graduated from high school went on to graduate from college. It was appropriate then for the high schools to concentrate on preparing their students for college. Now, under the weight of a majority of students who will not, and in many cases should not, go to college, the high schools can no longer concentrate on college preparation. In the course of these changes, some of the virtues of intellectual rigor, of preparation for more advanced work, and of high quality education for the students of highest ability have been submerged under the burden of other claims on educational facilities and teachers' time. In science and mathematics, the problem has been particularly acute because industry and government have been able to outbid the schools in recruiting college graduates with training in science and mathematics. Consequently, there have been some special difficulties in securing an adequate number of well-trained teachers of science and mathematics, and instruction in those vital subjects has suffered more than in other fields.

"The second reason for our emphasis on the importance of improving the quality of education comes from within science itself. Less than 15 years ago the first atomic bomb was exploded. During these 15 years man has learned of the tremendous potentialities of nuclear energy and has witnessed a number of other dramatic technological developments. Atomic fission and fusion, satellites and space exploration are important in themselves, but in a larger sense they are merely symbols of a scientific revolution that we are entering. We are on the verge of vastly greater power over the forces of nature than we have ever held in the past. The evidence is already dramatically evident: compare the power of atomic fusion with the power of TNT, or the speed and range of Explorer with the speed and range of an airplane. Throughout the sciences discovery is accelerating. Astronomy, astrophysics, geology, and geophysics are greatly expanding our knowledge of the world, and of the universe. Chemistry is creating new marvels. In genetics, in pharmacology, in biochemistry, in neurophysiology, we are conducting experiments that were inconceivable five or ten years ago. We are getting close enough to some of the secrets of living matter so that scientists of all fields understand, and many agree with, Vannevar Bush's statement last month that if he were starting his career now he would be a biologist.

"We may be frightened or gladdened by this scientific revolution and its consequences. But like it or not, we cannot escape; we cannot stop the rush of scientific developments of which I speak.