Symposium on Rodent Control Research in the Direct Seeding of Forest and Range Lands

In the five papers which follow on the problem of rodent damage to direct seedings, the benefits from close cooperation in research among forestry and wildlife agencies are apparent. The papers point up salient features of the problem, explain the requirements of a good seed repellent and how it is developed, and give results obtained in three distinct areas—the Pacific Northwest, the Black Hills in South Dakota, and game ranges in southwestern Idaho.

The scope of the cooperative investigation is extensive, involving as it does field tests at eight research centers and ten operational units of the U. S. Forest Service; five forest districts of the Bureau of Land Management; three state forestry departments; the British Columbia Forest Experiment Station; eight of the largest lumber companies in the United States and Canada; and three sections of the U. S. Fish and Wildlife Service. Obviously, only representative papers could be used, but other reports in more detail will follow.

Seed loss to rodents is a well-known problem to foresters and wildlife managers. Poisoned bait, usually grain, scattered over the area to be seeded has been the time-honored control method. But this method, never wholly satisfactory when blanketed over extensive areas, is very often less effective when applied to small areas as typified by the modern staggered clearcut. A new approach was required which has been achieved through the outstanding cooperative effort cited here. It consists of giving the seed itself, at little or no detriment to germination, a quality of repellency or toxicity to rodents.

Because the program is still in developmental stages, it can be assumed that continuous research will almost certainly disclose other and more effective seed protectants.

Rodents and Direct Seeding

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The fate of seeds broadcast over denuded forest and range land is precarious indeed. Not only is the seed bed unprepared, from a nurseryman's point of view, but there is little or no opportunity to modify the fertility of the soil, lessen the plant competition, or relieve drought; furthermore, the soil is often impoverished by fire or erosion that has destroyed its "A" horizon. Important as seed bed and climate may be, feeding by numerous small rodents, birds and insects on the seed and germinating seedlings reaches such proportions at times as to completely mask the other factors.

Formerly lacking effective means to protect seed broadcast in the field, the forester developed large nurseries where thrifty seedlings were grown under full protection and subsequently transplanted to field areas. This approach is still the backbone of reforestation programs, but the advance in labor and material costs in recent years is creating renewed interest in direct seeding. Numerous and intermittent studies envisioning only the killing of offending species with poisoned baits have occupied the Fish and Wildlife Service and other investigators for at least the past four decades. Valuable contributions in new rodenticides and bait application techniques[1] have further advanced direct seeding for reforestation and range improvement. For example, two new rodenticides, thallium sulphate and sodium fluoroacetate, properly formulated and distributed on a cereal grain bait will achieve 95 percent control or better of the resident rodent population. This procedure, however, fails to give lasting protection to subsequently sown tree seed for the following reasons:

1. The few rodents that survive are free to feed on the untreated tree seed, and it has been determined that as few as six deer mice (Peromyscus) per acre can largely nullify a program in which Douglas-fir seed is broadcast at the rate of one-fourth pound per acre.

2. Deer mice rapidly repopulate an area from which the resident population has been removed by poison. An area of 100 acres or less may regain its former rodent density by invasion from surrounding areas within as short a time as one month in the summer

[1] Citation and review of these past studies is not practical in this brief paper, which emphasizes seed treatment rather than rodent elimination.

and three months in midwinter. Many of the invading rodents survive despite residues of poison grain still on the ground, and repeated applications only partially correct the difficulty.

3. An effective rodent poisoning program must precede distribution of untreated seed by only a few weeks, and in late fall would find several species in hibernation, chipmunks (Eutamias), ground squirrels (Citellus), pocket mice (Perognathus) and jumping mice (Zapus). Their emergence the following spring makes necessary another application of poison bait.

A more logical approach is to have the seed carry its own rodenticide or repellent. In the case of rodenticide, only those mice survive that leave the seed alone after sublethal feedings. In such instances the rodent may associate the unpleasant physiological effect of sublethal dose with the food that bears the chemical rather than with the taste of the chemical itself. Thus, clean untreated seed may be avoided following an experience with treated seed of the same plant species.

Paradoxically, more of the seed remains to germinate when an effective non-lethal repellent rather than a rodenticide is used for seed treatment. This phenomena of "replacement of decimated populations" becomes increasingly evident as the size of the seeded area decreases. For example, on a 5 acre tract in southern Arizona there was a resident population of only 15 gray-tailed antelope squirrels (*Citellus harrisi*), but 119 were trapped and removed over a 10 month period. On this same area there were 107 white-throated wood rats (*Neotoma albigula*), but regular bi-weekly trapping for 10 months removed 682 of these rodents. A non-lethal seed treatment would be expected to "educate" the resident rodents against further feeding, but leave their populations intact to occupy the area and prevent intrusion of new individuals from the outside.

Also of importance is the fact that treatment of the seed is a more economical procedure since it avoids the added operation of bait distribution.

The first satisfactory chemical for seed treatment discovered in the course of this project was "tetramine" (Tetramethylene disulpho tetramine).[2] Field tests during the past 3 years have proven it effective in overcoming seed loss to rodents.

Tetramine was patented in August 1953 (U. S. Patent No. 2,650,-186) as a rodenticide by Farbenfabriken Bayer of Leverkusen, Germany. It is a light, fine, white powder that is only slightly soluble in water, alkalies and dilute acids and moderately soluble in acetone and glacial acetic acid. Although pharmacological and toxicological studies of tetramine are incomplete, available information indicates that it is at least five times more toxic than any other poison used in rodent control. The lethal dose (LD 50%) for most mammals appears to be between 0.1 and 0.3 mg/kg.

The hazardous nature of tetramine is recognized as an unfavorable characteristic of no small importance. Precautions against breathing any dust arising from tetramine formulations or bringing seed-treating solutions in contact with skin or clothing must be rigidly observed through the use of respirators and rubber gloves. The treated seed must be handled and planted only with the protection of rubber or gum-dipped gloves. In stored sacks or bulk quantities the tetramine-treated seed could be hazardous to livestock, poultry and game, but properly broadcast it is unavailable in quantities hazardous either to domestic livestock or game animals.

Most pine seed (Pinus) and a few shrubs such as antelope bitterbrush (*Purshia tridentata*) can be treated by immersing dry seed in a one percent acetone solution of tetramine for one hour and then drying for at least 24 hours before planting or applying moisture. Acetone solutions may not be reused when treating resin-bearing seed. The viability of many seed species including spruce (Picea), hemlock (Tsuga) and Douglas-fir (*Pseudotsuga menziesii*), in fact, any species of coniferous tree seed having a high moisture content, may be severely impaired by acetone. Tetramine is unusual in that it produces its effect in very minute quantities, making it possible to employ a seed coating rather than attempt seed impregnation. Thus, the recommended formulation for all coniferous tree seed is to coat the seeds with a suspension of the finely pulverized tetramine in a 20 percent aqueous solution of yellow dextrin. The amount of tetramine in this coating solution varies with the size of the seed to be treated. With seed the size of Douglas-fir or larger, the ratio of tetramine to seed, by weight, should be 1/1000; with smaller seeds such as western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), the amount of tetramine should be doubled. While the newly coated seed is in the mixer and still moist, aluminum flake or finely powdered pigment is added to give it a brilliant color as a deterrent against bird feeding.[3]

While it is an extremely poisonous compound, tetramine has marked warning characteristics at sublethal levels. For example, caged deer mice will consume an average of 17 tetramine-treated Douglas-fir seeds when this treated food is offered the first time in unlimited quantities. All those eating more than 5 seed will be killed. If, on the other hand, the seed are offered one at a time at short intervals (duplicating the slow feeding that takes place in the field on broadcast seed), the average acceptance drops to 3½ seed, and only 20 percent of the mice die. Ear-tagging studies in the field have shown that as high as 50 percent of the small mammals may survive their

[2]As the JOURNAL goes to press, notice of a change in the manufacturer's plans makes tetramine currently unavailable.

[3]For further information on the treatment of seeds not mentioned here, requests may be directed to the U. S. Fish and Wildlife Service, Wildlife Research Laboratory, Building 45, Federal Center, Denver, Colorado.

contact with tetramine-treated seed.

Another favorable characteristic of tetramine is that it is translocated from the treated seed to the germinating seedling. In laboratory studies, deer mice refused to feed on conifer seedlings grown from treated seed. Meadow mice (Microtus), whose food consists largely of succulent growing vegetation, were killed by feeding on these tetramine-bearing seedlings, any time during the first month after germination.

Despite tetramine's almost equal toxicity to all animals on a weight basis, little hazard appears to exist for domestic pets and beneficial furbearers that might eat poisoned rodents. As in the case of rodents picking up scattered grain, the intake of tetramine from poisoned rodents that the predator eats is so gradual that sublethal warning symptoms develop. In the laboratory, predators of several species were offered all the tetramine-killed mice they would eat, and, although some of the test animals became ill, none died.

Tetramine is but the first introduction as a seed protectant under this project, and the search continues for other and less hazardous chemicals. The progress of these efforts, now well underway at the Service's Denver Laboratory, is discussed by Nelson B. Kverno.

Development of Better Seed Protectants

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THE WILDLIFE RESEARCH LABORATORY at Denver, Colo., a U. S. Fish and Wildlife Service station, engages in chemical, biological, and ecological research into economic wildlife problems. Late in 1950, two members of the staff, both ecologists, were assigned full time to study the rodent factor in reforestation and range restoration. This action reactivated a project of long standing at the Laboratory. The objective was to find a chemical, rodenticide, or repellent, that could be applied directly to the seeds of trees and shrubs, a comparatively new approach to the problem. Necessarily, the investigation began with test tubes, caged native rodents and electrically controlled germination and seedling production tables. The results of this study have been the seed-treatment formulas that are the basis of the field tests reported in this symposium.

Since 1946 the Patuxent Research Refuge at Laurel, Md., another Fish and Wildlife Service laboratory, has solicited from private companies, universities, and the National Research Council, candidate compounds that might be useful as rodenticides or rodent repellents. The compounds are evaluated by feeding tests in which caged white rats are used. By January 1, 1954, a total of 4,585 compounds had been screened of which the most promising materials had been forwarded to the Denver Laboratory for further tests against native field mice. Because deer mice (Peromyscus) appear to be the principal offenders with respect to direct seeding, these mice have been used by the thousands in cage studies. In the later investigative stages of any candidate compound, other rodents found on the reforestation areas have been trapped and used in cage studies. These include meadow mice (Microtus), red-backed mice (Clethrionomys), chipmunks (Eutamias), harvest mice (Reithrodontomys), wild house mice (Mus) and a scattering of larger forms.

To qualify as a satisfactory chemical for seed treatment, the candidate compound must meet certain requirements.

1. It must:

a. Reduce the amount of seed consumed by mice by a minimum of 80 percent on first contact.

b. Be chemically stable so that seed protection is imparted over prolonged periods (6 to 12 months).

c. Be non-phytotoxic so that little or no reduction in viability results at the recommended level of seed treatment.

d. Be cheap enough, together with its formula additives, to permit economical use.

2. It must not:

a. Seal the seed against exchanges of oxygen and moisture either through its own action or that of its carrier.

b. Endanger domestic livestock and beneficial wildlife if used in field exposures.

c. Be unduly hazardous for the human operator to formulate and handle.

The term "repellent" is used in this text in a broad sense which requires definition. Strictly speaking, a repellent is something that tends to keep the repelled object at a distance without actual contact —for example, the action exhibited by opposite poles of a magnet. In this sense, tetramine and many other candidate compounds are not actually repellents, but in another sense a rodent is repelled after learning to avoid the chemical through an unpleasant experience with it.

In the preliminary evaluation of candidate repellents, wheat, which has been moistened with a 20 percent dextrin solution, is coated with a 2 percent concentration of the chemical. Twenty-five kernels of the treated wheat are then offered to each of 10 individually caged rodents for at least 5 consecutive days. A sustaining ration also is available in the cage so an animal is not force fed. Those compounds that reduce consumption of seed by 70 percent or better are then subjected to further investigation as follows:

1. The seed treated with the 2 percent compound is planted in electrically controlled germination tables to determine any loss in viability.

2. Wheat treated with the candidate chemical at several levels under 2 percent is bioassayed, using caged mice.

3. Tree seed having an outer inedible hull is coated with a 2 percent compound of the candidate material and bioassayed.

4. Tree seed having an outer inedible hull is impregnated with the candidate chemical in solution, which deposits the repellent on or in the edible endosperm. Seed so treated must be both bioassayed and checked for loss of viability.

5. Whenever the candidate chemical is water-soluble (even to fractions of 1 percent) tree seed is impregnated during moist cold stratification.

There are two reasons for desiring to get the repellent inside an inedible hull. First, the compound will withstand more weathering with less loss of repellency, and second, it will better withstand rodent attack—the rodent with his large protruding incisors can cut through and discard the outer hull with only small amounts of a repellent coating coming in contact with the mucous lining of the mouth. By contrast, wheat has a very thin, closely adhering bran coat that is often consumed along with the endosperm, in which case coatings are as effective as impregnation of repellent chemicals. Of 16 compounds that caused a pronounced aversion when applied to wheat, only 1 produced any aversion when coated on the inedible hull of Douglas-fir seed. Each compound or seed has different characteristics and merits special treatment—an adhesive or solvent that works for one will not necessarily work for another.

Not all rodents are seed eaters—some are foragers that damage newly germinated seedlings. However, seedlings grown from tetramine-treated seed are not readily damaged by rodents because some of the chemical is apparently translocated into the vegetative portion of the seedling. For this reason, seedling acceptance tests are conducted to investigate further the potential of each new compound before it is released for field testing. Also, growing seedlings are kept under observation to determine whether or not the compound produces new latent abnormalities.

In some areas more seeds are taken by birds than by rodents. Experiments have shown birds to be so sensitive to color that they usually avoid unnaturally colored objects. In contrast, rodents apparently show no aversion to colored objects. The losses to birds can be minimized by dyeing the seed a brilliant unnatural color, another step in the final formulation of a seed treatment.

As an example of the slow and tedious work involved in the development of seed treatments, 185 new chemical compounds were received within a six month period in 1953 that rather effectively repelled the white laboratory rat. Rescreened on deer mice only 48 proved to be effective on this species. Only 13 of the 48 new compounds proved to be non-phytotoxic when applied to the seed. Extended studies of these 13 new compounds have eliminated all but three, that possess qualities justifying even the beginning of field experimentation.

Direct Seeding in the Pacific Northwest

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REFORESTATION by direct seeding in the Douglas-fir region was first tried by the U. S. Forest Service as early as 1908, but nearly all of these early attempts failed because mice ate most of the seed before it germinated.[2]

These discouraging results led foresters to resort to planting nursery-grown seedlings as a more positive method of regeneration. Hand planting costs about $25.00 per acre, for it is slow, arduous work. A skilled tree planter can cover hardly more than an acre a day. Furthermore, planting requires large investments in nurseries, careful planning, considerable administration, and close supervision of field crews. Nevertheless, it has become our most widely accepted method of artificial regeneration. By 1953, more than 410,000 acres in Oregon and Washington were in forest plantations. By contrast, only 54,000 acres have been seeded.

In the Douglas-fir region there are two distinct types of reforestation problems: (1) Large clearcut areas or extensive burns, such as Tillamook, where no seed source remains; (2) small clearcuts where rapid recovery of the brush may preclude the establishment of Douglas-fir if logging does not happen to coincide with a good seed year.

But now, with the advent of helicopters and more effective means of rodent control, direct seeding under favorable conditions

[1]Unit of the Pacific Northwest Forest and Range Experiment Station, Forest Service, U. S. Dept. Agric., Portland, Ore.

[2]Pacific Northwest Seeding and Planting Committee. Recommended Reforestation Practices and Techniques. Western Forestry and Conservation Association. pp. 69. 1953.

shows increased promise as a quick, yet inexpensive, method of getting trees on the land again. However, this cannot be regarded as a panacea for all our problems. Vegetative competition, high temperatures on blackened surfaces in new burns, unfavorable sites or exposures, and extremes in weather conditions also influence seedling establishment. Many of these limiting factors likewise affect survival of nursery-grown planting stock.

Rodent Problems

Small mammal populations on nonstocked cut-over lands in the Pacific Northwest vary widely, but have been found to range from a low of 6 to more than 50 per acre. A deer mouse (*Peromyscus* spp.) will consume as many as 200 Douglas-fir seed in a day, even when other foods are available. But perhaps more important, they collect and hoard properly sown Douglas-fir seed, thus making serious inroads on seed in a brief period. Consequently, direct seeding without effective rodent control is seldom successful.

Foremost among treatments currently used for rodent control is cereal grain bait, usually wheat, poisoned with thallium sulphate or sodium fluoracetate, commonly called 1080. A light, broadcast application of poisoned bait about two weeks before seeding kills mice on treated areas, but often requires repeat baiting in the spring, as well as treatment of ¼-mile buffer zones, which is impractical on areas of less than 100 acres.

Tetramine

In 1951 the Wildlife Research Laboratory in Denver introduced for restricted experimental use a revolutionary new compound, tetramethylene disulpho tetramine, commonly called "tetramine." This chemical (primarily a rodent repellent, but also a lethal poison) is used as a direct treatment on the seed itself, thus eliminating the need for poison grain bait.

Federal, state, and private agencies in the Pacific Northwest are completing the third consecutive year of tetramine field tests. These experiments were conducted in 20 different locations. They include a wide variety of sites, high altitude as well as sea level "fog-belt" areas, and range in size from ¼-acre to 100-acre blocks. Although Douglas-fir has been the predominant seed species, tests have also included ponderosa pine, Sitka spruce, western hemlock, sugar pine, and Jeffrey pine. Methods used were fall and spring broadcast seeding, either by helicopter or by ground crews using cyclone seeders, and some spot-seeding (planting).

Results.—Field tests of tetramine, generally, have given encouraging results. For example, in 1953 a 17-acre test under favorable conditions near Mayfield, Wash., showed 13 times as many Douglas-fir seedlings on the tract where tetramine was used as on the untreated check area. At the end of the first growing season, one pound per acre of tetramine-treated seed produced 10,397 seedlings per acre, in contrast to 793 seedlings per acre for untreated seed.

Even on areas as small as ½-acre, tetramine treatment gave excellent rodent protection as evidenced on a test near Randle, Washington in 1953. Here a pound to the acre of Douglas-fir seed produced 8,100 seedlings per acre. Eighty-nine percent of the mil-acre plots were stocked with one or more year-old seedlings. This is highly significant, because by the standard bait method of rodent control it is difficult to prevent reinvasion of small treated areas.

On the Tillamook Burn in Oregon, 100 acres were helicopter seeded in 1951 with tetramine-treated Douglas-fir at ½-pound per acre. This was an adverse site and weather was unfavorable, yet 544 seedlings per acre were produced. Tests near Olympia, Wash., on an old non-stocked clearcut, seeded at one pound per acre, resulted in 885 Douglas-fir seedlings at the end of the second growing season, even under adverse conditions.

Costs

The low cost of seeding by helicopter can be illustrated by citing the Forks Burn reforestation project covering 1,133 acres on the Olympic Peninsula. Here, cost of helicopter service alone for a single coverage was approximately $1.00 per acre.[3] On smaller projects, cost per acre, of course, increases.

To cite another example, under entirely different conditions, a 100-acre tract on Capitol State Forest near Olympia, Wash., was helicopter-seeded with tetramine-treated Douglas-fir at a total cost of $10.34 per acre, which is less than half the cost of hand-planting.[4] Total flying time for a single coverage of the square 100-acre block was only 7 minutes.

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[3]Shaw, Elmer W. Direct seeding experiments on the 1951 Forks Burn. Research Paper No. 9, Pacific Northwest Forest and Range Experiment Station. 19 pp illus. December 1953.

[4]Shaw, Elmer W. Effects of tetramine used for rodent control in direct seeding of Douglas-fir, Research Note 89, Pacific Northwest Forest and Range Experiment Station. 7 pp. August 1953.

The Use of Tetramine in Bitterbrush Revegetation[1]

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FORAGE PRODUCTION on many important big game winter ranges in Idaho has been seriously reduced as a result of fire, insect depredation of overuse by livestock and/or big game. Formerly productive browse ranges are now dominated by cheatgrass (*Bromus tectorum*) and other low value annuals. Depletion on these ranges has been so severe or complete that natural recovery is unlikely for generations. More rapid restoration of forage species is needed. The possibility of accomplishing this by artificial measures of revegetation has received a great deal of attention and stimulated much interest.

In 1949 the Idaho Fish and Game Department undertook a project to restore browse on principal winter ranges of southwestern Idaho. Bitterbrush (*Purshia tridentata*) was used because of its known adaptability to existing site conditions and because the seed was plentiful and easy to handle.

Seeding bitterbrush in the fall has to date proved more practical than spring seeding and was used in all operations. However, it posed a serious problem—that of exposing the seed to adverse natural factors for a period of four to six months.

Use of Untreated Seed

Results of the early seeding efforts were poor. Seedlings emerged from less than 5 percent of the seed hills. Roden depredation was observed but its degree of seriousness was not readily apparent. To further determine the extent of rodent activity, hills of seed were planted in several locations within a general area where reseeding was planned. Disturbance, to the extent that hills were dug into and most or all of the seeds removed, was heavy in all areas. Within 48 hours after seeding, from 60 to 90 percent of the hills had been disturbed and in six days 98 to 99 percent had been dug into. Snap trapping revealed that the rodents present were primarily deer mice (*Peromyscus maniculatus*), with some pocket mice (*Perognathus* spp.) and harvest mice (*Reithrodontomys* spp.).

Use of Poison Bait

Control of these rodents was tried by applying two different poisoned baits. One application of sunflower seed treated with thallium sulfate was made before seed planting and another of steam-rolled oats treated with 1080 was made in late fall after seed planting. These treatments did not prove effective as a great deal of mouse disturbance still occurred. The complicated conditions of weather, terrain and accessibility made it impossible to apply these poisoned baits in the most efficient way or at the most effective time. This procedure also involved two operations entirely independent of the actual seeding and each application cost $1.50 to $2.50 per acre. Some other more efficient rodent control measure was surely needed.

Use of Tetramine

Assistance from the Wildlife Research Laboratory of the Fish and Wildlife Service was requested in solving this problem. They suggested the possible use of a tetramine formulation applied directly to the seed and cooperated in a program to test the compound for protecting bitterbrush reseeding. In this introductory field trial bitterbrush seed was treated with tetramine in an acetone solution. Electric plant table tests were made to determine the effect of tetramine treatment on the seedling production capacity of the bitterbrush seed. Results averaged 87.2 percent for the treated seed and 87.7 percent for the untreated seed. Another comparison was made under typical field conditions on a winter range near the mouth of Mores Creek about 15 miles east of Boise. On December 2, 1952, 21 pairs of hills were planted, with 10 seeds per hill. One hill of each pair was planted with treated seed and the other with untreated seed. Each hill was protected by a mouse-proof wire dome. Again, no material difference in seedling production capacity was indicated. Seedlings emerged from 51 percent of the treated seeds or 90 percent of the hills as compared to seedlings from 57 percent of the untreated seed or 95 percent of the hills.

On the same date, 20 acres in the area mentioned above were seeded with tetramine-treated seed and a one-acre control plot 300 yards away was seeded with untreated seed. The seeds were planted three-quarters of an inch deep in hills at regular intervals throughout both areas, with 5 to 15 seeds planted per hill. Approximately two months after seeding, examination of several hundred hills in both areas disclosed that only one hill of treated seed had been disturbed by rodents whereas *every* hill in the control had been dug into. Near the single excavation of treated seed only one seed was found and the seed coat of that had been opened by rodents and only a minute portion of the embryo eaten away. This was in contrast to findings near planted spots of untreated seed where numerous seed coat fragments were discovered from which all the embryo contents had been removed. Near many of the excavations in the control area no seed coat fragments were found, suggesting that whole seeds had been exhumed and carried away.

At the peak of emergence during the following spring a check

[1]A contribution from Pittman-Robertson Project 88-D, Idaho Fish and Game Department in cooperation with the Wildlife Research Laboratory, United States Fish and Wildlife Service. The cooperation of Milton O. Robinson, Branch of Predator and Rodent Control, Idaho District, of the Fish and Wildlife Service is gratefully acknowledged.

showed seedlings in 86 percent of the hills of treated seed and in only one percent of the hills of untreated seed.

Livetrapping operations indicated that tetramine, although a deadly poison, did not eliminate the rodent population in the treatment area. In five nights of trapping during late October, five weeks before seeding, 39 mice of the three species mentioned previously were taken, tagged and released. During three nights of trapping in December, two weeks after seeding, 20 mice were taken, three of which had been tagged in October. Then again in March, three and a half months after seeding, trapping was carried on for three more nights. A total of 52 mice was taken this last time, of which five had been tagged in December and three in October. There were 95 live traps used each night of trapping.

In summary, tetramine was demonstrated to have no material effect on the germination of bitterbrush seed. Preliminary field work indicates that treating with tetramine affords a definite protection to bitterbrush seed where otherwise near total rodent damage would occur. Practically no treated seeds were damaged even though there was a continuous population of mice. A portion of this population was known to be resident throughout the period of seed availability. These facts suggest possible repellent qualities of tetramine.

Because of these encouraging results, the program of further testing tetramine for protecting range reseeding against rodent damage is being continued and expanded this current growing season, exploring the use of new treating techniques and the effectiveness of use in other localities.

Ponderosa Pine Seeding in the Black Hills

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REFORESTATION of burns has been an objective on the Black Hills National Forest since its establishment in 1898. The forest has always been plagued with extensive burned areas, lacking in pine (*Pinus ponderosa*) reproduction—the principal conifer in this forested area.

Beginning as far back as 1905, direct seeding was used in the reforestation of the Black Hills. As a contrast with nationwide experience in direct seeding of forest species, efforts in the Black Hills have met with unusually high success. For example, of the 9,911 acres seeded to ponderosa pine through the period 1905-1916, 55 percent were classified as successful plantations. Perhaps the outstanding factor favoring seedling survival in the region is the light but often well-distributed moisture received in the wet spring snows and summer showers. This, coupled with periods of low rodent population, no doubt played an important part in the early success of direct seeding.

Although much direct seeding has been done in the Black Hills, primary reforestation effort in recent years has been the planting of 1-1 and 2-1 ponderosa pine seedlings. Spring spot seeding costs about $10 per acre or about one-fifth the total cost of hand planting. This is reason enough to shift from hand planting to direct seeding if the hazards of seeding can be reduced.

The above factors of rainfall and rodent pressure are quite variable from year to year. The purpose of present studies has been to reduce the element of "chance." It appeared that the rodent problem could be solved by using a protective chemical seed treatment and that some of the adverse factors of seed bed and drought could be avoided by improved seeding techniques.

At the request of the Black Hills National Forest, the Wildlife Research Laboratory at Denver, Colorado, joined in a cooperative program to field-test new seed protectants in 1952.

The Study

The 10-acre experimental seeding plots were established on three ranger districts located near Pactola, Nemo and Sundance (Bearlodge). Prior to the seeding program the rodent population was checked with snap traps. In the area of heaviest rodent population, near Nemo, 100 trap nights took 59 deer mice, 1 chipmunk, 1 meadow mouse and 1 red-backed mouse. Checks in the other seeding plots showed that rodent populations there were high enough to destroy most of the unprotected seed.

The test plots in 1952 proved without doubt that tetramine treated seed gives very adequate protection to seed during the period of germination. On all three ranger districts stocking of seed spots, in which tetramine treated seed was used, exceeded 50 percent and ranged upward to 80 percent. On these plots stocking was well in excess of that found on plots where untreated seed had been protected by pre-baiting the area with tetramine treated wheat and strychnine treated oats. On the latter plantation, 5 pounds of strychnine-treated oats were used per acre in an unsuccessful effort to wipe out the rodent population.

The seeding tests were continued in 1953. Although the previous year's experiments used pine seed treated with tetramine acetone as the protective agent, in 1953 a portion of the seed was given an overcoat of tetramine in yellow dextrin. This is a cheaper method, because of the reduced amount of tetramine required and, although dextrin is water soluble, it can be

TABLE 1.—SEEDLING PRODUCTION OF SPRING-PLANTED PONDEROSA PINE ON THE BLACK HILLS NATIONAL FOREST

District	*Control*		*Tetramine-Acetone*		*Tetramine-Dextrin*	
	Seed spots (1 or more seedlings)	Total seedlings	Seed spots (1 or more seedlings)	Total seedlings	Seed spots (1 or more seedlings)	Total seedlings
Nemo	0%	0	64%	233	76%	292
Bearlodge	4%	4	65%	187	87%	291

used for spring spot seeding in the Black Hills. No trap lines were run in the 1953 tests. However, a 5-acre control plot with the attendant loss of unprotected seed clearly demonstrated the presence of a damaging rodent population. The results of the 1953 season were even more impressive to local forest personnel. It was apparent that tetramine protected seed would germinate under field conditions where most unprotected seed was destroyed by rodents. It was also found that better results were obtained by using tetramine-dextrin treated seed. Table 1 gives the 1953 germination results, based on weekly examination of staked seed spots.

The 1954 spring seeding program included spot seeding on 335 acres of burns. All seed had been treated with tetramine dextrin paste. On planting sites where soil was very thin, the selection of seed spots was made with care to take advantage of the most favorable growing sites. These included areas of deepest soil and, on south and west slopes, shade protection to the seedlings by locating seed spots on the north side of stumps, down logs, and shrubs.

The tetramine treated seed studies for the Black Hills which have been reported were concerned exclusively with spot seeding of ponderosa pine seed in the spring. Other fall tests have been made using both broadcasting of seed and spot seeding in aspen and hazel brush stands but results are not conclusive.

Summary

1. Light, but well distributed moisture during the spring and summer favors ponderosa pine seedling survival in the Black Hills. However, rodent pressure is a serious factor in successful germination of seed.

2. Tests run in 1952 on three experimental seeding spots using tetramine-acetone treated ponderosa pine seed proved that this seed treatment gave good protection to seed. Results obtained were much better than on plots where clean seed had been spot seeded in areas prebaited with tetramine treated wheat and strychnine treated oats.

3. Tests in 1953 used two methods of tetramine application to ponderosa pine seed. They were tetramine-acetone and tetramine-dextrin. Seedling production was greatest where tetramine dextrin was used and seedlings germinated on 76 percent and 87 percent of the Nemo and Bearlodge plots.

TREE IMPROVEMENT SPECIALISTS in the Southeastern and Southern Forest Experiment Stations at a 2-day conference at Lake City, Fla., during which research at other centers and the newly created Southern Institute of Forest Genetics was considered. Those pictured are: (*front row l. to r.*) K. B. Pomeroy, H. A. Fowells, K. W. Dorman, W. H. D. McGregor, and B. W. Henry. (*Back row l. to r.*) R. E. Schoenike, C. E. Ostrom, P. C. Wakeley, R. M. Allen, J. C. Barber, François Mergen and P. E. Hoekstra. The Plantation is a 9-year-old progeny test of high-gum-yielding slash pines pollinated by Dorman in 1944.