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INVESTIGATION OF SPRAY PROJECT NEAR GLOBE, ARIZONA

INVESTIGATION CONDUCTED FEBRUARY 1970

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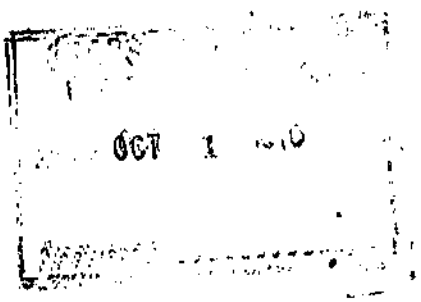

INTRODUCTION

In 1965 the U.S. Forest Service began a land improvement program in the Pinal Mountains near Globe, Arizona. The program called for spraying an area of chaparral with herbicides to accomplish the objectives of multiple land use. The area was sprayed in 1965, 1966, 1968, and 1969.

Adverse comments and complaints about the spraying began during and immediately after the 1969 spray treatment. The complaints included damage to vegetation off the spray project area, deformed animals, and human illnesses. In response, two investigating teams were established by the Forest Service to survey the area and investigate the various allegations of damage. These two teams were designated as Task Force I and Task Force II. Their reports were submitted to the Forest Service and distributed to interested parties. Many of the local citizens were dissatisfied with the reports and the case continued to fester.

In February, 1970, the Globe affair attained national attention. Television newscasts showed deformed animals alleged to have been caused by the herbicides used for spraying chaparral in the Pinal Mountains. Because of the continuing problems associated with the use of herbicides near Globe, a Government Interdepartmental Panel of scientists was selected to conduct a third investigation.

The Interdepartmental Panel to investigate the allegations of damage to plants, animals, and humans in and near Globe, Arizona, was established by the Office of Science and Education, U.S. Department of Agriculture. Members of the panel were selected to provide a broad and diverse range of background experience and expertise so that the nature of the alleged damages could be properly assessed. The talents represented on the panel included the effects of herbicides on plants, monitoring soil and water for pesticide presence or absence, plant pathology, air pollution, fisheries and wildlife, toxicology, and teratology. In addition, two observers assigned to the Panel increased the range of talent to include range management practices and entomology.

The panel members arrived in Phoenix, Arizona, on Sunday, February 15. February 16 was devoted to briefings for the panel by the U.S. Forest Service, Salt River Project, Arizona State Land Commission, Arizona State Department of Health, and the Arizona State Department of Game and Fish. These briefings provided backround information essential to subsequent phases of the investigation.

February 17, 18, and 19 were spent in and near Globe conducting onsite inspections of the spray project area on the Tonto National Forest and adjacent private properties, discussions with local residents, interviews with physicians and officials of the Gila County Health Department, and collecting samples of soil, human and animal blood, animal tissue, vegetative tissue, and the herbicides used in the spray project. The samples were collected for future analysis.

February 20 was devoted to a review of the voluminous notes taken and a determination of tentative conclusions possible with the information at hand as of that time. A more complete assessment was not possible until after the results of laboratory analyses were received, analyzed, and interpreted.

THE KELLNER CANYON-RUSSELL GULCH SPRAY PROJECT

The Kellner Canyon-Russell Gulch spray project is located on the Tonto National Forest, principally in T1S, R15E (Fig. 1). A small portion, about 200 acres, is located in T1S, R14E. Herbicide treatments on the area were applied in 1965, 1966, 1968, and 1969. The objectives, as stated by the Forest Service, were as follows:

1. Improve water quality and yield through reductions of the potential for sedimentation following wildfire and through reductions in evapo-transpiration losses where modification of existing vegetation is proper.

2. To enhance the scenic value of the chaparral zone through development of varied patterns resembling the natural variety sometimes found in unprotected chaparral; these patterns range from savannah-like grass and forb areas to newly regrowing chaparral, to relic stands of mature chaparral.

3. To improve wildlife habitat through creation of additional edge effect and through maintenance of vigor and new growth in desirable species.

4. To reduce the high costs of protecting chaparral from wildfires through the establishment of breaks in heavy fuel continuity, making it more possible to avert fires of conflagration proportions.

5. To increase forage production for wildlife and livestock through the release of native grasses and the establishment of new grass stands.

6. To improve access for both the observer of wildlife and the hunter through a system of near-primitive roads to strategic fire control locations and through the openings that will result in treated areas.

The herbicides used in the project are specified in Table 1. An additional note is needed about the herbicides used in 1969. Silvex, 2,4-D, and 2,4,5-T are listed in Table 1. However, silvex was the principal herbicide, accounting for about 97 percent (3,680 lbs) of the total used. Thirty gallons of 2,4,5-T manufactured by Hercules Chemical Company accounted for most of the remaining 3 percent. The

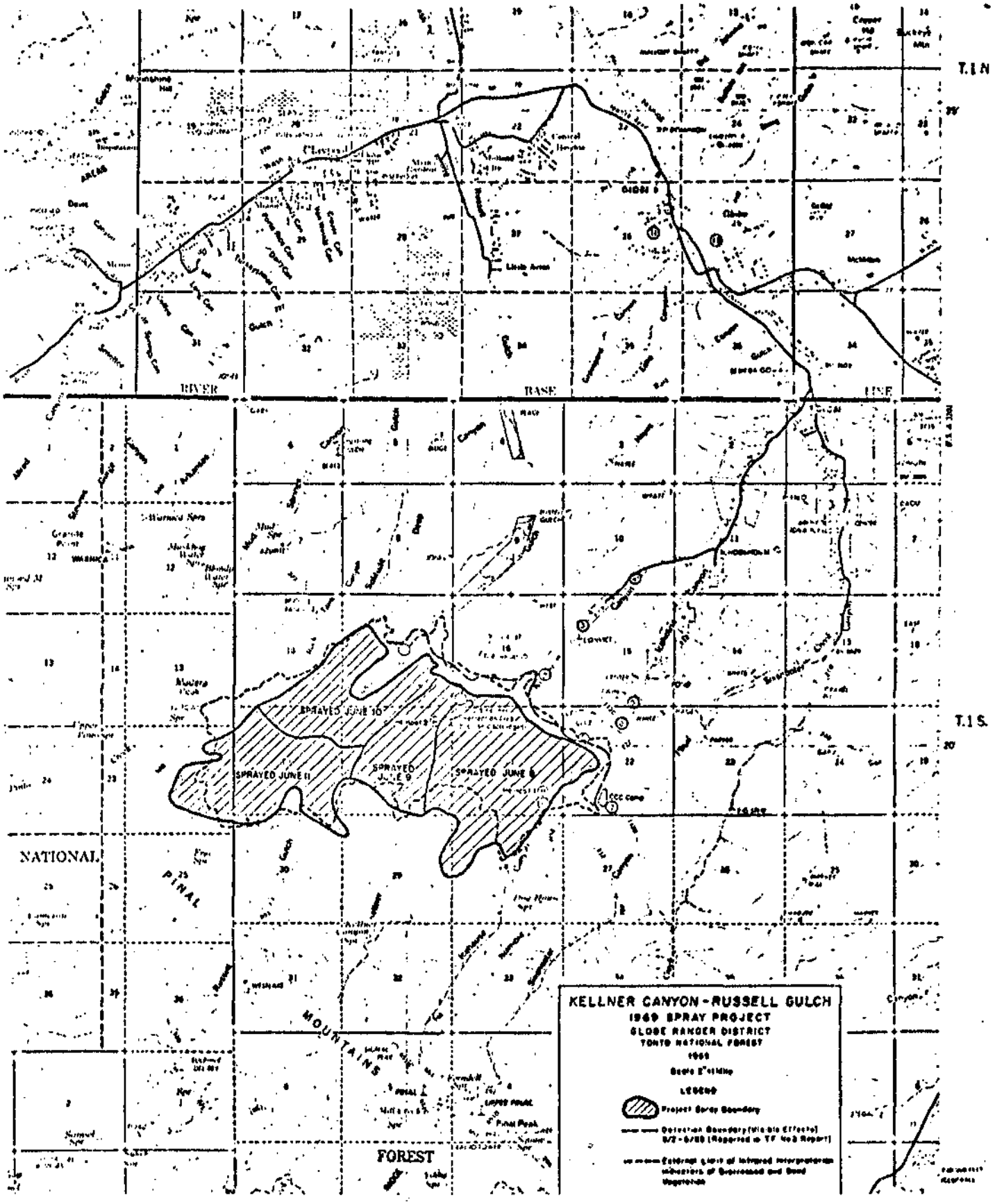

Fig. 1. Map of Kellner Canyon-Russell Gulch Spray Project.

2,4-D and 2,4,5-T of Monsanto and Thompson-Hayward represented only an insignificant fraction of the total. The Monsanto and Thompson-Hayward products had been used in a project sprayed immediately before the Kellner-Russell project and some diluted spray solution remained in the mixing tank. If one assumes 24 gallons of solution remaining in the tank, then the 8 gal/A volume and 2 lb/A herbicide rate would mean that only 3 lbs each of these materials was used.

Although some complaints by local residents about the Kellner-Russell project relate to all four years of treatment, the focus of complaint seems to be centered on the 1969 treatment. Thus, more attention is devoted to it than to treatments in previous years.

Comments have been made to the effect that the Forest Service erred in 1969 by mixing the herbicide in water instead of an oil:water emulsion as had been done in previous years. As we understand the comments, complainants feel that the water would evaporate more rapidly than would oil:water, and thus, the spray droplets would contain a higher concentration of the herbicide. There is no requirement that phenoxy herbicides be mixed with an oil:water emulsion. An oil:water emulsion is commonly used because such a solution is usually somewhat more phytotoxic than is water alone used as a carrier for the herbicide. The comment about higher herbicide concentration in a water droplet is an spurious issue because the total amount of herbicide applied per unit area is the key point - not the concentration of the herbicide in the spray droplet. In addition, oil in the spray solution would reduce the surface tension of droplets which would in turn result in more small droplets and thus, more drift.

The 1969 treatment began on June 8 and ended on June 11. Wind speeds during the operation are reported to have been taken at the heliport with a pocket anemometer, but the actual wind speeds were not recorded. Records were maintained of when spraying was shut down because of winds exceeding 10 mph (Table 2). It was not possible for us to determine, after the fact, actual wind speeds at the site of application. Official records from the Globe Fire Weather Station would not be applicable because it is too far away from the project area and wind speed is recorded only at 1300 hours. The unrecorded measurements made by the Forest Service Project Air Officer would not provide a true picture either, because winds at a specific application site would not necessarily be the same as at the heliport. Residents adjacent to the project area reported "gale winds" one evening during the spraying operation. Gale winds, as defined by the U.S. Weather Bureau, have a velocity of 39 to 54 mph. While it is doubtful that winds of that force occurred while spraying, we cannot discount the possibility of wind velocity exceeding 10 mph at some location where the helicopter was spraying at some time during the spray operation.

Table 1. Record of Herbicides Applied to the Kellner Canyon-Russell Gulch Project.

Year	Chemical Name	Manufacturer	USDA Reg. No.	Lbs Acid Equivalent per Gal. of Mixture	Application Rates lbs Acid Equivalent/A
1965	2,4-D isooctyl-ester	Monsanto	524-115	6	1 lb
	2,4,5-T isooctyl-ester	Thompson-Hayward	148-431	6	1 lb
1966	2,4-D, isooctyl-ester	Monsanto	524-115	6	1 lb
	2,4,5-T isooctyl-ester	Thompson-Hayward	148-431	6	1 lb
1968	Silvex, propyl-eneglycolbutyl-ether ester	Dow	464-162	4	2 lbs
1969	Silvex	Dow	464-162	4	2 lbs
	2,4-D, isooctyl-ester	Monsanto	524-115	6	1 lb
	2,4,5-T, isooctyl-ester	Thompson-Hayward	148-431	6	1 lb
	2,4,5-T, butyl ester	Hercules	891-46	4	2 lbs
	2,4,5-T, 2-ethyl-hexyl ester	Hercules	891-45	4	2 lbs

Table 2. Records of Spraying shut-down time on the Kellner-Russell Project, June 8-11, 1969.

Date	Time	Remarks
8 June 69	1505	Shut down, wind exceeds 10 mph
	1703	Resume operations, wind below maximum
	1935	End operation for day
9 June 69	1018	Shut down, wind exceeds 10 mph, end operation for day
10 June 69	1115	End operation for day
11 June 69	1250	End operation for day

HERBICIDE DAMAGE TO PLANTS OFF PROJECT AREA

A comprehensive assessment of plant damage resulting from the herbicides used on the project was not possible. Many plant species are defoliated from natural causes at this time of the year (February). The assessments of plant damage made by Task Forces 1 and 2 are more meaningful than those we were able to make, with respect to ocular estimates of damage to foliage.

Although we could not accurately evaluate certain specific reported instances of plant damage on private properties, some general conclusions are possible.

Herbicidal damage to some plants on private properties was observed. Whether that damage was caused by drift from spraying on the project area, or whether there was a direct overflight by the helicopter while spraying, could not be determined. Some residents claim a direct overflight was made, others mention only drift. Our general consensus is that most of the damage caused by herbicides on private properties resulted from drift. In only one case, the Mikeworth property, was the degree of damage such that a direct overflight would be suspected.

Although there was some herbicide damage to plants on private properties adjacent to the project area, we are equally certain that other causes were operating as well. There is adequate evidence to show that disease, insects, and air pollution from smelter operations have caused plant damage ranging from light to severe. Thus, an unhealthy plant does not necessarily mean that its condition was caused by a herbicide. Disease, insects, drought, and air pollution can cause conditions similar to, and equally as drastic as, those caused by herbicides. The effects of disease and air pollution are discussed in greater detail in other sections of this report.

PLANT PATHOLOGY

Previous investigating teams had mentioned considerable damage to plants on private properties caused by factors other than a herbicide. Because our objective was to investigate causes of damage, considerable attention had to be given to moisture stress, disease, and insect attack as possible explanations for the damages reported.

Moisture Stress - Rainfall was below normal in 1969, at least for the first eight months of the year. Drought conditions are supported by official weather records and by most of the local residents. The nearest first-order weather station to Globe is at Phoenix, 90 miles away. In the months after January, and through July, Phoenix had below-normal precipitation in 5 of these 6 months. Temperatures were above normal in 4 of these 6 months.

The second-order weather station at Globe, near the sprayed area, showed below-normal precipitation for each of the 8 months, from January through August 1969 with the largest deficit, -1.33 inches in July, which is the month following the spraying (Table 3). For the entire year, monthly rainfall in 1969 exceeded the 55-year mean only in September and November.

Table 3. Inches of Rainfall at Globe, Arizona, in 1969.

Month	Mean[1/]	1969
January	1.62	1.34
February	1.38	1.35
March	1.27	1.07
April	0.65	0.29
May	0.34	0.27
June	0.41	0.40
July	2.61	1.28
August	2.60	2.47
September	1.26	1.27
October	0.92	0.64
November	1.04	1.60
December	1.65	1.15
Total	15.75	13.13

1/ Based on 55-year record

Almost all plants seemed under moisture stress in Sixshooter Canyon, Kellner Canyon, Icehouse Canyon, and Russell Gulch, until one got up the mountains into the ponderosa pine type.

The yards of most of the complainants visited, e.g., the McKusick's, Lewises', and Steinke's were mainly bare of vegetation. The soil was either compacted, or loose and dry, with little attention given to vegetation care except around a few fruit trees or a small garden.

Our observations support those of "Task Force No. 2", with regard to the general drought conditions.

The canyons southwest of Globe are often dry, to such an extent that many families haul their water in barrels. The growing season of 1969, with below normal precipitation for all but one month, put all plants under additional stress that year. The generally poor condition of the horticultural, woody vegetation in the canyon areas

around Globe is undoubtedly due in part to the extra stress imposed by drought.

Diseases and insects - February was a poor time of year to observe foliage pests. However, abundant damage from many twig insects was easily apparent. Hackberry trees, wherever we saw them, were heavily damaged by the gall psyllid, which caused swellings up to 3/4 inch on petioles, and much foliage died as a result. There were also many gall wasp tumors on the native oaks.

Sycamores close to canyon bottoms looked generally vigorous although there was some evidence of anthracnose twig blighting. Anthracnose is a common leaf and twig disease of sycamores throughout the U.S.

Richard Lewis (Kellner Canyon) and others had some 3 to 6 inch d.b.h. Chinese elms. Some were riddled with thousands of sapsucker or woodpecker holes. Others, without holes, were dead, having died from the roots upward. The symptoms were typical of that caused by root rot. Texas root rot (caused by the fungus Phymatotrichum omnivorum) is reported to occur widely in the canyons and gulches of the Globe area. Mr. Lewis, himself, attributed much of this killing of introduced trees in this area to what he called root rot, which he said was known to be common in the area.

We also saw what was a small vegetable garden of the Lewis family. Mrs. Lewis raised tomatoes, lettuce, radishes, and a few other plants. Mr. Lewis says the whole garden died after the spraying. He says the helicopter did not fly over his place, but could be seen circling over the hill behind his place. He has a "paradise tree" in fine condition, some peach trees that had some dead terminal branches, but otherwise were in fine condition, and a very small, dead, year-old peach replant that died, apparently of transplant shock. Lewis says that the evening he saw the circling helicopter there was almost a gale wind blowing down the canyon from the spray area.

Mr. Lewis and Mr. Steinke had elderberry trees growing near the creek that were reported by them to have suffered some shoot dieback, possibly from the herbicide spray, but these trees had already leafed out strongly (week of February 15) and will suffer no permanent damage.

Mr. McKusick (Kellner Canyon) had an 8 inch walnut tree (Juglans major) that he claimed was killed by herbicide. This tree very likely died of root rot. The roots and much of the base were rotten, deeply checked, and punctured up to 3 inches deep with borers. The tree was in a bare, dry, trodden situation, scarred, and wrapped with fence wire. Some life had remained in the top through a tenuous bit of remaining cambium, but in 1969 that slight living "bridge" died, and so the top died. The stool was a plethora of hacked, rotten stumps of earlier multiple stems. Although a herbicide may have contributed to the ultimate death of the tree, other factors as described above are believed to have been the principal cause.

Superintendent McKittrick of the Boyce Thompson-University of Arizona Arboretum at nearby Superior said he saw some plant damage at the Shoecraft's (Icehouse Canyon) after the spray (he did not know the date).

He says he saw other herbicidal damage after the spraying in other canyon properties above Globe, mostly to vegetables. Mr. McKittrick said he told Mrs. Shoecraft that much of her tree damage could "just as well be due to cumulative air pollution."

Mr. Belcher (Icehouse Canyon) has fruit trees (pear, peach, plum, apricot, blackberry, currant) on his property and also had garden vegetables at the time the spray was applied. He saw no herbicidal effect on either fruit trees or vegetables. He observed some wilt on tomato vines, but said that wilt occurred every year. Mr. Belcher pumped water from a stream in Icehouse Canyon into a well on June 8, 9, and 10, 1969. The well water was then used to irrigate his vegetable crops. There was no indication of herbicidal damage to the vegetables after irrigation. Mr. Belcher observed damage to hackberry in 1969 and in previous years which he attributed to air pollution from the nearby copper smelters. According to Mr. Belcher, the smelter smoke problem was worse in 1969 than in previous years.

Texas root rot fungus (Phymatotrichum omnivorum) attacks more kinds of woody plants than any other plant pathogen in the world. It occurs only in the American Southwest, including Arizona. It occurs in the southern half of the state, mainly in the larger valleys. It is reported from the Globe area, probably occurring only in local spots. Peach is moderately susceptible. Trees usually survive long enough to be of some use in the root rot belt. Apricot is rated highly susceptible according to J. J. Taubenhaus and W. N. Ezekiel (Texas Agricultural Experiment Station Bulletin 527, 1936), which means that from 30 to 80 percent of the plants exposed to root rot may die the first year in infested areas. All species of walnut (Juglans) are rated by Taubenhaus and Ezekiel from highly to extremely susceptible. Chinese elm (Ulmus parvifolia) is also susceptible.

Dead trees, each several inches in diameter, of species of Juglans, Prunus, Ulmus, all known to be susceptible to root rot, showed evidence of attack by P. omnivorum, whereas hackberry and sycamores, known to be resistant to root rot, did not show signs of this disease. Root rot has undoubtedly killed some of the dead woody horticultural plants seen in the Globe area.

Soil properties - An inventory in plant ills in the canyons of the Globe area would show a large number of symptom complexes aside from those due to moisture stress, air pollution, disease, and insects. Native species would be expected to do reasonably well, but residents of the narrow canyon bottoms in the Globe area are attempting to raise, in addition to small gardens, a variety of fruit and ornamental trees unsuited to the dry, alkaline, low organic matter soils that characterize the area. Mineral excesses and alkaline soils that lead to iron and manganese deficiency in plants are problems in the low-rainfall parts of the West. Agricultural scientists who have visited the Globe area have called attention to chloroses (yellowing) and other striking symptoms of debility in trees, that have been identified in the canyon drainages involved in this report.

Soil samples taken by us (composite of 6 grab samples in a part of Sixshooter Canyon), showed a pH of 7.6, an alkalinity level than can be expected to lead to the yellowings of fruit trees found on the canyon properties, and certainly to problems with roses, which are known to require acid soils (in the range of pH 5.0 to 6.0).

Our investigation was conducted 9 months after spraying, and at a poor time of year to assess plant damage. Nevertheless, we feel that the combination of (1) rigorous conditions for plant growth (except for native adapted vegetation), (2) introduction of species not suited to the environment, (3) soil moisture deficits, (4) mineral excesses and deficiencies, (5) root rots, other fungus, and insect attacks, and (6) air pollution from a nearby copper smelter, would make it highly likely that any list of plant ills, such as those in the list of complaints we were shown, would include many not associated with the localized drift from the spray program of 1969. Undoubtedly, this drift was responsible for some damage to horticultural plants and garden crops in properties close to the sprayed area, but many of the cases cited in the list of complaints were not due to the spray.

In attempting to assess the role of factors other than herbicide damage in this case, it may be significant to cite some of the additional information obtained about plant responses.

Mr. McKittrick, Superintendent of the Arboretum near Superior, was shown partly dead or dying grapevines on the Shoecraft property. He told us he then found that the Arboretum's grapevines, at least 25 miles away from the Shoecraft's, were in a similar condition.

Mrs. M. H. Webb of Sixshooter Canyon is listed among those offering complaints as a result of the spray. The statement attributed to her that, "Large pine tree many years old in yard. It is dying and discolored" is incorrect. The pine proved to be a deodar cedar (Cedrus deodora) in excellent color and health. Mrs. Webb denied making the statements attributed to her, and asked to have her name removed from the complaint list. Her rose bushes had some death of terminal shoots of undetermined cause.

Task Force No. 2's report contains a picture of a healthy grapevine, reportedly taken on the McKusick property. Mr. McKusick insists that the picture was not of his grapevine. The vine we were shown had deep fissures in the main stem, suggesting that it had been unhealthy or dead for some time.

AIR POLLUTION

Travel from Phoenix to Globe, Arizona, reveals extensive air pollution from cooper smelters in the region. It is well-known that the smelting of cooper ores results in the production of toxic pollutants, particularly sulfur dioxide and sulfur trioxide. The latter is usually present in low concentrations because it is converted to sulfuric acid droplets soon after entry into the atmosphere. The visible pollution from smelters can be attributed primarily to this acid aerosol. In terms of sulfur equivalent, the sulfuric acid mist is considerably more irritating to humans than is sulfur dioxide.

The Inspiration Consolidated Copper smelter at Miami is less than five miles from Globe and from the Forest Service project area involved in herbicide spraying. Information from several sources indicated about 400 tons of sulfur dioxide is released per day from this smelter. Production of copper has increased about 60 percent in the past ten years. Thus, stack gas emission of sulfur dioxide has increased by a similar amount, unless specially designed control devices were installed.

A report by C. R. Hosler (Monthly Weather Review 89:319-339, 1961) indicates that South Central Arizona, including Globe, has frequent temperature inversions. Temperature inversions may be at various heights and are associated with slow wind speed, air stagnation, and the accumulation of pollutants. Inversions with a ceiling at or below 500 feet above the station elevation occur about 55, 40, 35, and 50 percent of the days in winter, spring, summer, and fall, respectively. The Globe area as well as the valley around Phoenix had a severe air pollution episode lasting for about 10 days during the latter part of December 1969. Visibility was reported to be down to two miles as a result of air pollution.

Little information is available on concentrations of sulfur dioxide in air in the Globe area. However, the odor threshold for many persons is about 0.5 ppm. One of the residents living in Kellner Canyon near the herbicide project area stated that occasionally he could not only smell the sulfur but even taste it. He had not, however, associated any injury to plants with the sulfur fumes. Injury to a number of sensitive plant species follows exposure to 0.5 ppm of sulfur dioxide for 4 to 8 hours. Some pines can tolerate far less sulfur dioxide. Leaf markings have been produced on some plant species with 0.25 ppm sulfur dioxide. (Sheffer, T. C. and G. C. Hedgcock, U. S. Department of Agriculture Forest Service Technical Bulletin 1117, 1955.)

Needle injury attributable to either sulfuric acid aerosol or to sulfur dioxide was observed on ponderosa pines located on an area adjacent to the spray project which may have received some herbicide spray. The numerous small yellow markings were on the rounded, upper side of needles, especially the older ones. The same type of injury was observed on ponderosa pine in an unsprayed area located about 1.3 miles above the sprayed area toward the summit of Pinal Mountain. Some of the ponderosa trees seemed to be more sensitive to air pollution than did other trees, as is known to occur with oxidant injury on ponderosa and white pines. This is the first known observation of probable air pollution injury to ponderosa pine growing in the Pinal Mountains. There was only a slight amount of insect chewing and lesions caused by fungi on the pine needles.

Deciduous trees and most other vegetation were in dormant condition at the time of examination, making it impossible to diagnose air pollution injury to species other than pine. It can be stated, however, that the sycamore leaf shown as Figure 9 of Task Force Report No. 2 suggests air pollution injury rather than the sycamore anthracnose disease. Also, Figure 14 in Task Force 2's report shows some "fruit tree" leaves with a marginal necrosis said to be not typical of herbicide damage. This is true. The leaves appear to be of the genus Prunus, possibly peach or apricot. We know that the sulfur dioxide injury pattern on Prunus is a marginal necrosis

rather than the intercostal browning typical of SO_2 injury to most tree leaves. The injury shown in Figure 14 closely resembles leaf damage to Prunus around SO_2 sources in Pennsylvania and Tennessee.

Vegetation samples analyzed for sulphur content support the concept of air pollution being a cause of plant damage near Globe. A sample of Ponderosa pine (Pinus ponderosa) about 10 miles from the Globe smelter contained 0.10 percent total sulfur. A sample of shrub live oak (Quercus turbinella) from Payson, Arizona (an area remote from sulfur air pollution) contained 0.08 percent total sulfur. In contrast, a sample of shrub live oak from Sixshooter Canyon near the McKusick property contained 0.32 percent total sulfur, four times that found in an area free of sulfur air pollution.

The 0.10 percent sulfur content in pine is not high enough to be certain that pitting of needles was caused by sulfur fumes, but it is likely that the pitting was caused by sulfuric acid aerosal which washed off after causing the pitting. The high sulfur content in shrub live oak in Sixshooter Canyon is clearly much higher than that normally found and must be responsible for much of the damage observed.

We learned that the valley known as Wheatfields located northwest of Miami, along Route 88, was once a productive agriculture area. Apparently, because of air and water pollution from the nearby smelter, there is little agricultural activity remaining. The reported injury to six mulberry trees near the home of Mr. Bill Byrne in Wheatfields, which is several miles from the Forest Service sprayed area, is far more likely caused by sulfur dioxide fumes than herbicide as claimed. Mulberry is listed by Barrett and Benedict (report of Arizona State University and Stanford Research Insitute) as among 10 kinds of trees "generally considered to be sensitive to sulfur dioxide." Sulfur dioxide fumes may well be the cause of some of the reported injury to vegetation on other properties, especially those farthest away from the herbicide spray project.

TOXICOLOGY AND TERATOLOGY

The chlorophenoxy herbicides used in the Kellner Canyon-Russell Gulch Project are widely used in weed and brush control. These herbicides have been used throughout the world with notably few authenticated incidents of poisoning of man, domestic animals, or fish and wildlife. Although safe use-experience cannot be taken as anabsolute guarantee of safety, it is one of the best indicators available in the evaluation of hazard.

Toxicology of the phenoxy herbicides - Although the mammalian pharmacology and mode of action of silvex, 2,4-D, and 2,4,5-T are not well characterized, the clinical toxicology of these compounds has been extensively studied. These studies include evaluation of acute and subacute toxicity in sheep, dogs, mice, rats, steers, cattle, guinea pigs, chicks, rabbits, fish, oysters, and even man himself. As a general rule, the oral LD_{50} of these herbicides range from 300 to 1000 milligrams per kilogram (mg/kg) of body weight in species tested. The dog with an oral LD_{50} of 100 mg/kg

appears to be more susceptible than the other species. However, dogs fed 2 to 10 mg/kg of 2,4,5-T for 90 days showed no detectable symptoms nor pathology. Such findings were similar in sheep fed 100 mg/kg of 2,4,5-T for 35 days. Silvex is similarly low in toxicity having an acute oral LD_{50} of 650 mg/kg for rats.

The acute oral toxicity of these herbicides to chicks is quite low. The LD_{50} for the acid is of the order of 300 to 500 mg/kg. However, the esters of these compounds are even less toxic, having an oral LD_{50} to chicks of 1000 to 2000 mg/kg. Chicks have been fed 2,4-D daily at a dosage of 280 mg/kg for 28 days with no detectable effects.

Hazards to man are more likely to occur from exposure to the concentrated herbicide before dilution and from inhalation of spray during application. Workers with occupational exposure from manufacturing of from spraying have the greatest potential risk, yet there are very few reports in the literature of poisoning of man by these compounds. Furthermore, cumulative effects in tissue have not been observed. It is generally accepted that these herbicides do not present a direct toxic hazard to man or his environment when correctly used for weed or brush control.

When the exposure is sufficiently high to produce acute poisoning by these compounds, a characteristic toxic syndrome appears, particularly in the dog. Death may be delayed two to nine days and is precipitated as cardiovascular failure. If death is delayed, the symptoms involve a progressive apathy, depression, muscular weakness of the hind limbs, periodic clonic spasms, and finally, coma and death.

It is important to recognize that the toxicology of the phenoxy herbicides has been determined on the basis of the product and its contaminants, not on the basis of a pure product.

Toxicology of dioxin - Much attention has been focused recently on contaminants in phenoxy herbicides. The contaminants are a family of compounds called chlorinated dibenzo-p-dioxins. Of particular concern, because of its high toxicity, is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The oral LD_{50} in mg/kg is 0.0006 for guinea pigs, 0.022 for male rats, and 0.045 for female rats. The toxicity of other chlorinated dioxins is not known, but is generally recognized as being appreciably less than for TCDD.

TCDD is formed during alkaline hydrolysis of 2,4,5-trichlorophenol at high temperature during the manufacture of 2,4,5-T and silvex. TCDD is known to occur in commercial 2,4,5-T and silvex. It has not been found in 2,4-D, nor is it expected because a different manufacturing process is used.

In man, the most sensitive indicator of subacute exposure to dioxin appears to be a swelling of the eyelids and a dermal irritant effect. This dermal irritant effect takes two forms. The first and less severe form is a skin rash at the primary site of exposure. The second is the appearance of a systemic chloracne which may or may not develop at the site of primary exposure. Chloracne has been described as a form of occupational acne which develops as a result of intoxication with certain chlorinated aromatic compounds. In the case of 2,4,5-T and silvex, chloracne has been found to be produced by contaminants in these herbicides. Although there are several contaminants, the chloracne activity appears to be

due mainly, if not exclusively, to TCDD.

The chloracne which develops on exposure to TCDD involves mainly the regions adjacent to hair follicles. "Comedones, resulting from a follicular hyperkeratosis predominates and frequently are so numerous that hardly a single follicle remains untouched and the affected region of the skin obtains a dirty-gray appearance." Large sebaceous cysts, inflammatory nodules, and pustules, can appear as well as large spots or patches of pigmentation in regions exposed to light.

Teratology - Studies by the Bionetics Research Laboratories suggested that 2,4,5-T was teratogenic in mice and rats. Shortly after the results of the Bionetics study became known, a suggestion was made that perhaps the sample of 2,4,5-T used by Bionetics contained impurities. Analyses showed that the Bionetics sample of 2,4,5-T did indeed contain TCDD at a concentration of 27 $\pm$ 8 ppm. Tables 4 and 5 summarize the work done by Bionetics (Courtney, et. al., Science 1970, Vol. 168:864-866).

With the finding that the sample of 2,4,5-T used by Bionetics contained such a high concentration of TCDD, the question was immediately raised as to whether 2,4,5-T, TCDD, or both caused the terata. Studies by Dow Chemical Company and by the National Institute of Environmental Health Sciences (NIEHS) have established that TCDD is indeed a teratogen. Further studies by Dow Chemical Company and NIEHS with a "purified" sample of 2,4,5-T showed that the purified 2,4,5-T was not teratogenic in rats, but was teratogenic in mice at a dosage level of 100 mg/kg. "Purified" in the preceding sentence means that the 2,4,5-T was recrystallizied to remove the TCDD, but all of it could not be removed. Similar results were obtained with technical 2,4,5-T containing less than 1.0 ppm TCDD.

In recent studies by the U.S. Department of Agriculture, pregnant ewes were fed an acid and este of 2,4,5-T at a dosage of 100 mg/kg. The herbicide was mixed with 0.5 lb ground alfalfa and administered by stomach tube daily from days 14-36 of gestation. Ten ewes fed the acid formulation gave birth to full-term, normal lambs, one ewe was not pregnant. Of the ewes fed the ester of 2,4,5-T, seven gave birth to full-term, normal lambs, two were not pregnant, and two died in the 35th and 36th day of gestation. Fetuses of the ewes that died were normal.

Table 4. Teratogenic evaluation of 2,4,5-T in mice.

Compound	Vehicle	Dose (mg/kg)	No. of litters	Average no. of live fetuses/ litter	Percent fetal mortality/ litter	Percent abnormal litters	Percent abnormal fetuses/ litter	Percent of fetuses per litter with: cleft palate	cystic kidney
C57BL/6 Strain treated days 6-14									
Non-treated	none	none	72	5.8	26	38	11	<1	1
Control	DMSO	+	106	5.5	29	42	12	<1	2
Control	Honey	+	32	7.1	15	41	14	0	1
2,4,5-T	DMSO	21.5	6	7.7	3	50	12	0	0
2,4,5-T	DMSO	113.0	18	4.4	42	86*	57*	22*	41*
2,4,5-T	Honey	46.4	6	8.5	8	100**	37**	2	33*
2,4,5-T	Honey	113.0	12	4.8	47*	100*	70*	23*	48*
C57BL/6 Strain treated days 9-17									
Non-treated	none	none	8	5.1	36	71	31	0	7
Control	DMSO	+	10	6.1	23	30	8	0	0
2,4,5-T	DMSO	113.0	10	7.7	11	100*	77*	29*	60*
AKR Strain treated days 6-15									
Non-treated	none	none	58	7.1	16	19	5	<1	<1
Control	DMSO	+	72	6.9	15	24	4	<1	<1
Control	Honey	+	12	8.8	9	0	0	0	0
2,4,5-T	DMSO	113.0	14	6.9	23	71*	29*	28*	1
2,4,5-T	Honey	113.0	7	5.3	42**	100*	55*	55*	0

* Statistical Significance Level p=0.01; ** Statistical Significance Level p=0.05; + 100 µl/mouse

Table 5. Teratogenic evaluation of 2,4,5-T in rats.

Compound	Vehicle	Dose (mg/kg)	No. of litters	Average no. of live fetuses/ litter	Percent fetal mortality/ litter	Percent abnormal litters	Percent abnormal fetuses/ litter	Percent of fetuses per litter with: enlarged renal pelvis	cystic kidney
Non-treated	none	none	7	9.9	11	43	9	9	0
Control	Honey	+	14	8.7	1	57	12	12	<1
2,4,5-T	Honey	4.6	8	8.2	12	88	36*	18	21
2,4,5-T	Honey	10.0	7	7.1	28**	86	46*	17	30*
2,4,5-T	Honey	46.4	6	2.7	59**	67	60++	27	33++

* Statistical Significane Level=0.05; **Statistical Significance Level=0.01; + 200 ul/rat
++ The sample size was possible too small to show a significant difference.

RESIDUES OF PHENOXY HERBICIDES

The phenoxy herbicides are not considered to be persistent by comparison with many of the chlorinated hydrocarbon insecticides. Residues have been found in soil, water, air, plants, and animals, but they persist for only a short time. The data available suggest that residues resulting from recommended rates of application are not of sufficient magnitude to justify concern as potential health hazards.

Soils - Persistence of residues in soils vary widely depending on soil type, temperature, moisture, and microbiological populations. Generally, residues persist from one to six or eight months; 2,4-D being least persistent and silvex most persistent. The persistence of residues seems to be independent of the rate of application.

Certain species of bacteria have been reported to use phenoxy herbicides as a source of energy and carbon. The relatively rapid degradation in soil suggests that accumulation from one season to the next is highly unlikely.

Water - Considering the large areas treated with phenoxy herbicides each year, some contamination of surface water will inevitably occur. Whether the contamination occurs from direct application or from drift determines the amount of residue. In most cases, the herbicide is intercepted by vegetation. Because the compounds are metabolized by plants, little, if any of the parent molecule would be expected to reach water following death and decomposition of the organic material.

At an application rate of 2 lb/A the residue in a body of water 3 inches deep would be only 3.0 ppm. As depth is increased the concentration would decrease. At a concentration of 3.0 ppm, a 400 kg cow drinking 40 liters of water per day would ingest only 0.3 mg/kg/day.

Herbicides could, and probably are, washed into water, especially after heavy rainfall. Residues of 2,4,5-T have been found in rivers of the West, but the concentrations were always low, ranging from 0.1 to 0.7 ppb. Studies conducted under controlled conditions in North Carolina gave similar results. In one test an amine salt of 2,4-D was detected in flume water at concentrations of 0.003 to 0.005 ppm for about 2 months after an application of 2 lb/A. The authors could not be certain that these values were authentic, however. Residues of an ester of 2,4,5-T in the same test could not be detected in the flume water. In a second test 2,4,5-T was applied at 4 lb/A and the maximum 2,4,5-T concentration detection was 0.48 ppm.

Plants - Substantial residues can occur in forage plants treated at a rate of 2 lb/A. Animals grazing on treated forage will ingest these residues. However, toxic effects on grazing animals have not been reported and residues found in the FDA market basket survey have been rare, and at low levels when found. Several studies have shown that residues in forage grasses decrease at a fairly regular rate and it is doubtful they would persist for more than 4 or 5 months.

Animals - Studies on residues of phenoxy herbicides in mammals show that they are eliminated rapidly in the urine. Total diet studies by the Food and Drug Administration showed that about 2 percent of dairy products and 1 percent of meat, fish and poultry contained residues of 2,4,5-T at average amounts of less than 0.002 and 0.0005 ppm, respectively for the 1964-68 period. This lends added support to the concept of lack of residue accumulation of phenoxy herbicides in animal tissue.

Little can be said about the persistence of TCDD in the environment. Studies on persistence in soil are underway, but not enough time has elapsed to get results. We do know that TCDD is degraded by sunlight when in solution, with a half life of about 5 hours. Studies on the behavior of TCDD in the environment are continuing.

FISH AND WILDLIFE

Direct observations and discussion with Arizona Game and Fish Department personnel who are familiar with area wildlife did not indicate any wildlife damage which could be attributed to the spray operation. Aquatic habitat is scarce. It consists of a few isolated stock tanks and very short stretches of permanent water in Kellner and Icehouse Canyons. No fish species were observed in the streams and none was known to exist prior to spraying.

The small stream section adjacent to Kellner Canyon Recreation Area was examined for aquatic biota. The stream is only a few yards from Helispot 2 but reportedly was avoided during the spray operation. Normal runoff resulting from rain would be expected to carry some herbicide from the plants and soil into the stream. Residues would not be expected in the flowing stream 8 months after application. The small amount that might occur would not be harmful to the aquatic organisms. At the time of our visit, larval forms of stone flies, caddis flies, and Diptera were noted. Adult water striders, water beetles, and midges were present in abundance. Heavy growths of filamentous algae were noted in flowing water. A lush growth of a sphagnum-like moss covered the vertical face of a six-foot high dam in the stream. Stream flow was estimated to be less than 50 gallons per minute.

Permittees who hold cattle allotments within the project area and adjacent to it report that fish and water dogs (Ambystoma) are present in some of the dugout stock tanks. Fish, mostly bluegill sunfish, are stocked in some of the tanks by local children who like to fish these small bodies of water. It was reported that water levels in these tanks commonly decline during late summer accompanied by a rise in water temperature. These factors combine to create favorable conditions for a fish die-off. Such a condition is common each year. If a fish kill did occur, the cause could not be determined at the time of our visit.

One permittee, Mr. Sheppard, had 49 head of cattle on the area when it was sprayed in 1969. He has had the cattle allotment for many years and has visited the area almost daily. His observations were that wildlife was not adversely affected by the spraying. He stated that coyotes and

jackrabbits were more numerous the last two years than the previous five. Cottontail rabbits were as plentiful as ever. Quail were more numerous in 1969 than they had been for several years. Deer with normal, healthy fawns were common. He has observed no dead or unhealthy wildlife of any kind. Two other permittees, Mrs. Anderson and Mr. Lewis, made similar observations. Mrs. Steinke, who occupies property within one-quarter mile of the spray boundary in Kellner Canyon, reported observing fewer sparrows, skunks, and ground squirrels since the 1969 spraying, but did not see dead animals of any kind.

Mr. Pat O'Brien, local Wildlife Ranger for the Arizona Game and Fish Department, stated that he has received no substantiated reports of fish or wildlife injury in or near the project area. Latest deer classification counts were made in February 1970, and were considered normal. Mr. Robert Jantzen, Director, Arizona Game and Fish Department, and staff assistants, stated that they would not expect any of the herbicides used to cause adverse effects to wildlife. Departmental personnel have monitored thousands of acres of similar brush removal projects in other areas of the State and observed no injury to fish and wildlife. Such common chapparal bird species as the Spotted (Rufus-sided) Towhee and Arizona Jay would normally tend to avoid the areas following drastic alterations of the habitat. White-tailed deer, on the other hand, tend to be attracted to the open areas created by herbicide spray operations.

The Colorado Cooperative Wildlife Research Unit at Colorado State University recently completed a four-year study designed to evaluate the effects of 2,4-D when used to control the growth of sage over large areas. A total of 4000 acres was treated with 2,4-D at the rate of 2 pounds per acre during 1965. There were no noticeable effects on sage grouse reproduction nor was there any observed mortality during the four year post spray study. Histological examinations were conducted on six grouse and no atypical symptons were noted. Traces of 2,4-D were found in breast muscle and the brain but its effects were not determined.

During the period 1964-1969, 2,4,5-T and silvex were periodically used to control weed problems on nine National Wildlife Refuges in Southwestern United States. The maximum area treated was in 1965 when all or parts of 2,577 acres received 2,4,5-T or silvex treatment. Since 1964 a total of 1,500 gallons of silvex and 2,4,5-T has been applied in all listed projects on these nine refuges. These refuges are all staffed with professional wildlife biologists. A recent poll of the nine refuge managers revealed that no animal distress or mortality was recorded or observed as a result of use of the two chemicals.

The herbicide 2,4,5-T is only moderately toxic to warm-blooded animals and no mortality to wildlife would be expected in the immediate area of application at recommended dosage rates. Studies have shown that it does not significantly concentrate in animal tissues. The major effect on wildlife would be in the destruction of the habitat. Such has been reported in Montana, Idaho, Wyoming, Colorado, and Utah mainly as affecting willows for moose browse or sagebrush for winter deer range.

As to streams or ponds, some of the 2,4,5-T esters are moderately toxic to fish. An application directly to water might cause some mortality to sensitive species of fish. Runoff from treated areas could possibly have an effect on sensitive life history stages although this has never been verified by any study. As with wildlife, the major effect would likely be from change in environmental conditions.

As a result of information made available to the panel, and a study of the literature pertaining to biological effects of the herbicides 2,4-D, 2,4,5-T and silvex on fish and wildlife, we conclude that the spray project in question did not produce any significant adverse effects on local fish and wildlife populations.

HUMAN HEALTH ASPECTS

This section reports on alleged ill effects to human health as a result of spraying silvex, 2,4-D, and 2,4,5-T near Globe, Arizona. The information was obtained by interviewing many of Globe's citizens with health complaints and nine of the Globe physicians, as well as by direct observation.

Case histories and a brief summary of the symptoms of many of the involved individuals are included. In addition, the impressions of the nine M.D.s, and evaluation of other observed public health problems are discussed.

1. Family A (as told by Mrs. A). Son-in-law and daughter and their children living in Kellner Canyon all experienced diarrhea after eating apricots from a tree on private property near the spray project. The tree was in fruit at the time of spraying. Husband was out of work for about one month because of diarrhea. Mother-in-law was quite sure the fruit was washed before eating. Two of the children have had difficulties with allergies since the 1969 spraying and the frequency of respiratory infections has increased.

2. Related by Mrs. A. Mrs. A. and her daughters, ages 17 and 15, who live in Kellner Canyon, began having irregular and painful menstrual periods following the 1969 spray job. They had previously been quite regular. This was a stressful time in their lives, however, reports Mrs. A, because of a death in the family and preparations for a trip. The irregularity has been largely resolved, but the menstrual flow continues to be quite heavy in the daughters. (The number of pads used is 2X normal.) Menstruation in the daughters also continues to be painful and one daughter has passed out several times.

Mrs. A reports also that her asthma condition has worsened and she has had some increase in chest pains and numbness in her arms.

A son has had excessive muscle spasms in his legs and arms, and has lost weight.

3. Family B in Kellner Canyon (as related by them individually). Male, about 30 years of age, has lost his sense of taste and smell since the spraying. He has also experienced a worsening of an allergy condition characterized by nasal stuffiness.

Female, about 30 years of age, has had two miscarriages: one in April 1969, and the other in December 1969. She was quite frightened about attempting to have additional children. She also related an increase in

cramping and vaginal bleeding during menstruation.

Female, about 30 years of age, was four months pregnant and quite fearful that she would have a deformed child. She reported a lot of lower abdominal cramping but no spotting.

Male, about 70 years of age, has had an increase in muscle spasms, some chest pains, and an increase in headaches since the spraying.

4. Related by adult male, age about 50, with an attorney present. He became ill in December 1968 with a chest cold and flu-like illness. He apparently recovered until two to three weeks later when he experienced an episode of severe, crushing chest pain, and shortness of breath. He was rushed to the hospital where he reportedly had a lot of numbness on the left side of his face. He apparently recovered rapidly the same evening and was told by the attending physician that he could go home. However, on the way home he experienced a similar episode (chest pain and dizziness). He returned to the hospital and was admitted. An EKG and other laboratory studies were normal and he was discharged.

Since that time (January 1969-February 1970) he has had numerous episodes of chest pain and dizziness. The chest pains were limited primarily to the left side and frequently involved the back. He stated that fatigue and visits to the spray sites precipitated the attacks. He has visited M.D.s in the Globe and Phoenix area. These include Drs. Meneaff, Sussman, Tamberek, Collopy, Matheson, C. Lewis Parker, and Hooper (Osteopath). The therapy which appeared to have been most successful was the injection of a local anesthetic in the left back region by Dr. Hooper. The pain, however, would recur when the local anesthetic had worn off. Despite obtaining some relief, subject has continued visiting different physicians and being treated with different medications. These have been primarily pain and nerve medications. Finally, in December 1969, at the suggestion of Mr. McKusick, he called a Dr. Morton Biskind in Westport, Connecticut, who after hearing the subject's story over the telephone, suggested the diagnosis of herbicide poisoning and recommended a visit to Dr. Granville Knight on Wilshire Blvd. in Santa Monica, California. This was done on January 29, 1970. Dr. Knight, after several tests, including a fat biopsy (results not available), told subject that he quite likely had herbicide poisoning. He was then given the following therapy: Soya Lecithin (2 teaspoons daily); Sclerex RX; E-Feral Succinate; ascorbic acid; Rex Wheat Germ; Cerophyl and Haliver oil capsule. Subject was apparently told that his recovery would be prolonged, and he continues to have the severe pain.

His only exposure to the spray area was apparently in either May, June, or July of 1968 when he spent several weekends working on a house in Kellner Canyon. He at no time saw spraying or smelled any spray. His only other medical condition is an atopic dermatitis which he has had since 1953.

5. Female, about 50 years of age, living in Icehouse Canyon, interviewed in presence of attorneys. Subject also visited Dr. Knight in California where she had a fat biopsy which reportedly showed 2,4-D. The attorneys have refused to release the remaining lab results. At least one of the labs doing the study was G.H.T. Laboratories in California. Subject apparently has had numerous physical complaints

and has visited many local physicians. Dr. Randolph reported a visit at which she said to him: "Do whatever is necessary to prove that I have herbicide poisoning."

6. Family in Kellner Canyon (as related by parents in the presence of Attorney Murphy). Dr. Bishop is the family physician. Their one-year old son has been reportedly quite ill and a summary of his medical history follows. Pregnancy and delivery were normal. On July 1, 1969, he had an eye infection which lasted 2-3 weeks. Since the spraying he has had frequent upper respiratory infection, ear infections, and episodes of vomiting and diarrhea. His father also reports a respiratory and cardiac arrest of the one-year old son at home, from which the father was able to successfully resuscitate him. However, the local physician did not consider hospitalization necessary at this time, nor was he seen by a physician. Son has also apparently been somewhat anemic, is receiving gamma globulin shots, and is currently being treated with phenobarbital for nervousness. His growth and development, however, has been normal and he has not been hospitalized.

The exposure of the family to the spray reportedly occurred in June of 1969 in Kellner Canyon where they were working on their house all day on June 8 and on the evenings and mornings of the other spray days. Father, about 35 years of age, also reports steam-cleaning the herbicide barrels for the Forest Service in 1967 and 1968. He reported eye irritation and a skin rash following the spraying in 1969. In addition, he has had continuing episodes of severe chest pain. He also stated that he has had muscle spasms and numbness in his fingers and toes since the spraying.

Blood samples were obtained from the following individuals to be analyzed for silvex, dioxin, 2,4-D, and 2,4,5-T. Jack Creilin and W. J. Fleishman, both Forest Service employees, who were on the Kellner Canyon-Russell Gulch project (as well as several others) and had high exposure to the spray. In addition, blood samples were obtained from seven members of a family living in Kellner Canyon.

The individuals mentioned above are those who have been most vocal in their complaints. Other individuals may have been overlooked. The complaints as a group include recurrent respiratory infections in children, irregular menstruation, heavy vaginal bleeding during menstruation, episodes of chest pain, miscarriages, diarrhea, and eye and skin irritation in one subject.

Nine of the approximately 13 physicians serving the Globe area were contacted. They were asked these three questions:

1. Have you been aware of any disease which could be related to herbicide spraying?
2. Have you noted any increase in the incidence of miscarriages since the spraying?
3. Have you noted any increases in any other human illness, such as birth defects, unusual skin rashes, or muscular weakness during this time?

The physicians contacted were Drs. Bosse, Bishop, Harper, Randolph, Collopy, White, Tamarek, Ruesch, and Matheson. Only Dr. White did not comment, saying that his experience was too limited. To the first question, all physicians answering said, "No", except Dr. Matheson who attributed several episodes of severe chest pain and vague female complaints to the herbicide

spraying. To questions two and three, all the physicians replied in the negative. Dr. Collopy did note an increase in the number of complaints as the emotions of the citizens became aroused.

Most of the individuals with complaints lived just below the spray area and had private wells. When the well water became low they would haul in city water and pour it in the well and then pump it into their homes. These wells were generally quite shallow and located about 50 feet upstream from a septic tank. Both the wells and septic tank were not far removed from a small stream which runs down the canyon and is frequently used by livestock and other animals. The county health sanitation officer reported frequent high bacterial counts in these wells. This appeared to be a definite health hazard and possibly related to the episodes of diarrhea.

The copper smelters in Globe which emit sulphur oxides and particulate matter are an additional complicating factor. Medical evidence obtained from epidemiological studies (Speizer, F. E. Jour. Air Poll. Cont. Assoc., Vol. 19, No. 9, pp 647-655, September 1969; and HEW, Nat. Air Poll. Cont. Adm. Publ. No. AP-50, 1969.) indicates that there is an increase in the incidence of respiratory infection and chronic respiratory disease associated with high atmospheric levels of SO^2 combined with smoke and/or particulate matter. An epidemiological study has not been done in Globe, and it is not known that there has been any general increase in respiratory illnesses. Nevertheless, the respiratory complaints should be evaluated in this context.

Significant in evaluating the Globe situation was the emotional peak of its inhabitants. The complaints offered were those occurring in normal populations, with many of them (especially in the adults) being quite subjective. With the exception of the skin rash and eye irritation experienced by one subject, it is highly unlikely that the ailments described above were related directly to the spraying. However, the psychosomatic effect of an aroused public very likely has played a role.

It is also important to note that except for three subjects all of the complaints dated only from the June 1969 spraying, despite the Forest Service having sprayed the same area three other years.

Despite the above impressions, it will be quite important to study this situation further and attempt to rule out or verify any human contamination by the spray products. Therefore, Dr. Clifford Roan of the University of Arizona, and heading the U.S. Public Health Service Community Pesticides Program in Arizona, suggested the following:

1. An epidemiologic study of the hospital records.
2. A thorough medical work-up on all volunteers including pesticide analysis of serum and urine, and chromosome studies.
3. Request the sacrifice of reportedly afflicted animals and their mothers when possible to collect adipose tissue and liver for analyses.
4. Sample adipose tissue for pesticides (dioxin, 2,4-D, and 2,4,5-T) during elective surgical procedures on consenting patients.
5. Analyze liver and fat for pesticide residues following postmortem examination.

DOMESTIC ANIMAL HEALTH ASPECTS

The investigation of possible adverse effects to domestic animals resulting from the spray program involved interviews with livestock owners and a local veterinarian, and a direct examination of some animals. Blood samples taken from six of Mr. McKusick's goats were analyzed to determine if either the herbicide or dioxin was present. These samples were also analyzed for enzootic abortion, vibrosis, and brucellosis.

Dr. F. I. Skinner, the local veterinarian, states that, to his knowledge, no animals were directly affected by the spraying operations. He had numerous calls asking him about herbicide poisoning in animals and suggested to the people calling that they should bring the animals to him for examination. None of the inquiring persons submitted his or her animals for examination. He said he had treated an increased number of dogs with respiratory disorders which came from the entire Globe area during the past year.

Grazing Permittees - Cattlemen have grazing permits on the Jones, Parker, and Ranger Station allotments, which fall within the sprayed area. Calf crops for the last five years ranged from 71 to 100 percent (Table 6). No abnormal loss of calves, noticeable increase in disease, or birth defects were observed following the spraying operations.

Table 6. Percentage calf crops of permittees with grazing animals on the Kellner-Russel Project area.

Year	Allotment					
	JONES		PARKER		RANGER STATION	
	Cows,No.	Calf Crop,%	Cows,No.	Calf Crops,%	Cows,No.	Calf Crop,%
1965	133	88	28	89	34	94
1966	139	71	28	82	33	100
1967	142	77	33	82	35	89
1968	146	77	31	88	37	92
1969	133	81	29	90	40	92

The cattle of these permittees grazed the range areas before and after spraying and had been on the range continually since the 1969 treatment. All animals were routinely vaccinated for blackleg and sprayed for lice annually. Of the three permittees, two feed supplement during the winter months. All provide block salt for animals throughout the year.

We had an opportunity to observe five head of Hereford cattle grazing within the sprayed area during the inspection. All animals appeared strong, vigorous, alert, and in good condition. One cow was nursing a calf which had made excellent growth.

Lewis Family - Mrs. Lewis had two stray, orphan dogs (approximately two months of age) at her home. One of the dogs died shortly after she took them in. The other developed enlargement of the abdomen, lost condition, and died about 2 months after the spray application. The decline in condition

occurred over a two-month period. The dog was approximately two years old when it died in 1969. It showed some respiratory discharge at time of death.

Steinke Family - Mrs. Steinke reported that chickens just coming into production appeared to lose weight and ultimately die. One or two died suddenly. Several birds showed paralysis of legs, wings, and distorted neck. The description of the affected birds is identical to Avian Leucosis Complex. She also reported that other people had similar conditions in their poultry flocks. When her pullets first began laying, she found several soft-shelled eggs. This is a common condition found in pullets coming into production.

A heifer calved recently and, following nine milking periods, produced milk having a "bitter" flavor. Mrs. Steinke said there were no flakes or mastitis. Mrs. Steinke also said the cow's udder was swollen before calving. Approximately three weeks after calving, the cow got out of the yard and went up on the side of the hill where Mrs. Steinke said there was drift from the spray. Subsequently, a red color was observed in the bottom of the milk jar after it had set overnight, which produced string-like attachments from the bottom of the container up into the milk. This condition is a common result when unsterilized milk containers are contaminated with the bacteria Serratia marscens, which produce a red coloration when allowed to grow in milk.

She also had a beef animal which developed a labored breathing condition. The animal had a characteristic "grunt" upon exhalation, did not appear sick, eyes were bright, ate hay without hesitation. No treatment was given to this animal. After two to three weeks, the animal seemed to recover. In the fall, the animal was slaughtered for meat. One lung was much smaller in size, gray in color, and adhered to side of thoracic cavity. This condition, as described by Mrs. Steinke, is typical of pulmonary emphyzema found in many regions in the fall of the year. It is not associated with herbicides. She reported that all other organs appeared normal. The liver of this animal, which reportedly was immediately frozen, and a shoulder roast frozen one week after slaughter, were obtained in a frozen state for chemical analysis.

McKusick Family - McKusicks had a number of goats and a several varieties of chickens. All animals had free access to the yard and adjacent hillsides. The general husbandry practices left much to be desired. All vegetation in the yard was excessively grazed by the goats. Snakeweed (Gutierrezia spp), a poisonous plant growing in the far end of the yard, was also heavily grazed. We were told the goats were supplemented with a dairy mix containing 10-12% protein. It was also reported that hay was fed, though no hay was observed at the time of our visit. All animals were in poor flesh except one aged wether.

The goat shown on television was in extremely poor condition. She had a long, pendulous udder with one enlarged teat and was trying to nurse three young kid goats. This animal had an arched back, stiffness of all legs, and seemed to be in considerable pain. It would frequently raise its right foreleg and extend it forward. She had calluses on both knees, indicating she had previously been unable to walk on front feet. This condition was a typical case of malnutrition. A condition of stiffness in

leg joints and general emaciation, is commonly found in sheep and goats at times when the body is utilizing excessive amounts of phosphorous, and phosphorous is not being supplemented in sufficient quantities. This animal was said to be born in December of 1968, which would make it about 14 months of age when examined. However, its mouth contained a full set of permanent incisors with the center pair showing slight wear. This indicates without doubt that this animal was at least five years of age (Exhibit 1). The condition of this animal was caused by a nutritional deficiency, not by herbicide poisoning.

It was reported by Mr. McKusick that a number of kids died at birth. There was no organized breeding program, and with the one billy with females at all times, marked inbreeding was unavoidable. This often results in high morality of offspring. One completely dried aborted fetus, about 8-10 inches in length, was examined. No skeletal deformity could be identified in this dried specimen. The eyes were properly located and ears and face appeared normal.

One duck given to the family in June 1969 was reportedly hatched in Central Heights, a community four miles from the sprayed area. This duck had a slipped tendon when given to the McKusicks. This is a common condition in fowl suffering from choline deficiency. Other than the leg condition, the duck appeared in good health. If the reported date of hatching is correct, the slipped tendon could not have resulted from the herbicide. Spraying occurred on June 8-11, 1969. The incubation period for ducks is 28 days. Thus, exposure to the herbicide would have occurred after incubation had started, so the herbicide could not possibly have been the cause of the deformity.

McKusicks also own a varied breed of fowl, some of which were reported to have died from symptoms that suggest Avian Leucosis. The entire husbandry operation was unsatisfactory for raising healthy animals of any species.

The deformed goat and the duck with slipped tendon had been shown on television with the inference that the conditions were caused by exposure to the herbicides used on the Kellner-Russell project. These cases were clearly misrepresented. The duck was crippled when given to the family, and at that time already suffered from slipped tendon. The goat was born before any herbicide was applied on the Kellner-Russell project. We do not believe the goat was born deformed. Its condition is typical of severe nutritional deficiency. The consequences of that deficiency were intensified by nursing those kids.

ANALYSES OF SAMPLES

A number of samples were collected for analysis while we were in Globe. The samples included human blood, animal blood, animal muscle and liver tissue, fruit, soil, and herbicide. Our intent was to have all samples analyzed to determine the content of the herbicides used on the Kellner Canyon-Russell Gulch project in 1969 and also to determine the dioxin content. Unfortunately, not all of the analyses we intended could be carried out, because reliable analytic methods have not been developed. The results of the analyses that were possible are given below.

Herbicides - The silvex and 2,4,5-T used in 1969 were analyzed for herbicide content and for dioxin. The samples were taken from sealed containers so there was no danger of cross contamination when the samples were taken. The results were as follows:

			Equivalent ester, percent	
Chemical	Reg. No.	Label Claim, %	Lab 1	Lab 2
Silvex	464-162	67.9	65.5	28.9
2,4,5-T	148-431	90.2	86.4	61.0

TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) in silvex and in 2,4,5-T was reported to be 0.5 ppm by Lab 1, and none detectable by Lab 2. The low levels of TCDD found in two laboratories is supported (for the silvex product) by the production standards of Dow Chemical Company. The trichlorophenol manufactured by Dow is reported by them to contain less than 1.0 ppm, which would be the equivalent of less than 0.33 ppm in the silvex. Thus the principal herbicide used on the Kellner Canyon-Russell Gulch project, which accounted for about 97 percent of the total, contained only a small amount of TCDD.

The lower values for percent equivalent ester by Lab 2 may be due to the method of esterification used. A 2 minute esterification using BF_3-MeOH does not always give quantitative conversion to the methyl ester (Woolson & Harris, Weeds 15:168-170).

Soil - Three soil samples were collected from the heliports used for the spraying operation. These samples were analyzed for TCDD content and all were found to contain less than the minimum detectable levels of TCDD. The minimum detectable level varied among samples because of interfering substances in the three samples. TCDD content could not have been more than 0.2 ppm, 0.002 ppm, and 0.0002 ppm for samples 1, 2, and 3 respectively. The values cited do not mean that TCDD was indeed present; they do mean that if any TCDD was present, the amount was less than the specified values.

Such low values are not unexpected. If the content of TCDD in silvex is 0.5 ppm, there would be 0.23 mg of TCDD in each pound of silvex. To provide 0.2 ppm of TCDD in the upper 3 inches of soil would require 0.2 pound (90,720 mg) of TCDD per acre. Thus, an equivalent of 394,430 pounds of silvex per acre would be required on the spot from which the sample was taken to provide 0.2 ppm in the soil.

No 2,4,5-T was detected in the soil samples. Silvex was present in amounts of 5,500, 129, and 1.8 ppm for samples 1, 2, and 3 respectively. The amounts correspond closely to the limits for TCDD detection. The more silvex present, the more interfereing substances present that raised the detectability level. The amounts of silvex found also explain why TCDD was not detected. The 5,500 ppm of silvex in soil samples 1 would mean that 0.0027 ppm of TCDD would be present if there were 0.5 ppm of TCDD in the silvex herbicide, 0.0027 ppm is 100 times lower than the stated limit of detection (0.2 ppm) for the sample.

Analyses of blood, fruit, and animal muscle and liver were not successful. Reliable methods for the analysis of TCDD in tissues have not yet been developed. Until reliable methods are developed, any reported results would be subject to severe question. This is especially true for the extremely small amounts of TCDD that would be expected on the basis of the TCDD content in the silvex.

Analysis of the animal tissues to determine the presence or absence of 2,4,5-T and silvex was inconclusive. Neither herbicide was detected in the liver or the shoulder roast. The reported results for the animal blood were too variable to permit definite conclusions. There was high variability among animals for a given herbicide. In addition, 6 of 14 samples showed less silvex than 2,4,5-T, 4 samples showed more silvex than 2,4,5-T, and neither herbicide was detectable in the remaining 4 samples. The fact that 6 samples contained less silvex than 2,4,5-T is not reasonable because about 97 percent of the herbicide applied was silvex. Thus, much higher residues would be expected for silvex than for 2,4,5-T. This problem and the extreme variability among samples, does not permit a conclusion as to whether the herbicides were or were not present in the animal tissue.

As reported previously, the blood samples from the McKusick goats were negative for enzootic abortion, brucellosis, and vibrosis.

CONCLUSIONS

At the conclusion of its on-site investigation of the Kellner Canyon-Russell Gulch spray project, and the allegations of damage that resulted from that project, the Interdepartmental Panel of Scientists issued a press release that summarized their findings at that time. The text of that press release is quoted below.

> "The panel is carefully examining the evidence collected during its visit. The study will continue and will include analyses of the numerous samples of blood, soil, water, fruit and plants for the herbicides, a possible contaminant (dioxin), as well as various agents producing disease in man, animals and plants. However, to date, we can summarize a few of our findings as follows:
>
> 1. The application of herbicides in the Pinal Mountains near Globe, Arizona was made by the Tonto National Forest starting in 1965. The most recent application of the herbicide was made by helicopter on June 8, 9, 10 and 11, 1969.

2. The materials used in the treatments in 1965, 1966, 1968 and 1969 included 2,4-D, 2,4,5-T, and silvex. These chemicals came from different sources. In 1969, 30 gallons of 2,4,5-T produced by the Hercules Chemical Company and 935 gallons of silvex produced by the Dow Chemical Company were used. The silvex is reported by Dow Chemical Company to contain less than 1 ppm of the dioxin. Analyses will be made of silvex and the other herbicides for dioxin and the active herbicide ingredients.

3. There are reports of the aircraft flying over private properties but not spraying; and other reports of the herbicide being applied just outside the project area. There is clear evidence of drift of the herbicides on a number of plants on some of the nearby properties.

4. Human illnesses have been reported by several residents in the Globe region. Many of the residents with complaints were interviewed by a medical member of the panel. These are complaints that commonly occur in the normal population; the eye irritation in one individual may be related to the spraying. Nine doctors serving the area of Globe were interviewed and there was general agreement that there had been no significant increase in human illness related to the spraying. However, blood samples were obtained and additional studies are planned to verify or rule out this possibility.

5. Reports from the wildlife specialists indicate no significant effects on birds, deer, and other wildlife. There are reports of reductions of birds on a few properties but there are other reports that bird and other wildlife populations in and near the project area are normal.

6. Information obtained from owners of livestock and observations of animals did not indicate any illnesses that do not commonly occur in other regions. It is doubtful that the spraying of the herbicides or dioxin caused the afflictions in the goat and duck because the goat was born before the treatment and the duck was hatched about 4 miles away from the treated area.

7. There was evidence of woody plant mortality from root rot, and also visible damage to certain yard trees from several kinds of insects and woodpeckers or sapsuckers. Other plant injuries were observed that appeared to be caused by low soil moisture, air pollution and unusual soil properties.

8. The phenoxy herbicides following normal use do not usually persist for more than 8 months in soil and water. Additional analyses are in progress to determine the presence or absence of herbicides."

At the time of the press release, the Panel realized that certain conclusions might have to be modified if chemical analyses showed that the herbicides used contained a high level of the toxic contaminant TCDD. Chemical analyses by two laboratories have shown that the concentration of TCDD in the silvex used on the spray project was less than 0.5 ppm.

As a result, we see no need to modify any statement in the press release issued at the conclusion of our on-site investigation. Indeed, subsequent investigations have supported and strengthened the tentative statements made previously.

A few additional comments are in order. Air pollution by sulfur oxides must be seriously considered as a significant contributor to the plant and animal damages, which were alleged to have been caused by the herbicides. Some plant damage off the spray area was obviously not caused by herbicides, and still other plant damage existed only in the imagination. Specific instances of plant damage due to the herbicides used on the spray project are given in the reports of Task Forces I and II. A precise determination of the relative importance of the many factors contributing to plant damage would require an intensive and extensive effort.

The low level of toxicity of the phenoxy herbicides, and the proven low concentration of TCDD in the principal herbicide used on the project, can only lead us to the conclusion that any effects on animal populations were not a direct result of the herbicides. It is possible that habitat modification by the herbicides had an effect on populations of some native animals, but there is no evidence to either prove or disprove that thesis. Populations of game animals surveyed by the Arizona Game and Fish Commission were reportedly not affected. Some non-game bird species may have had reduced populations as a result of the spray, but there are no data on which to base a reliable conclusion.

The deformed goat and duck alleged to have been caused by the herbicides used on the spray project, were obviously not caused by those herbicides.

The human illnesses reported were those that commonly occur in a normal population. The only human illness that may be related to the herbicides used on the spray project is eye irritation experienced by the individual who steam - cleaned the empty herbicide containers in years before 1969. Although his symptoms are not identical with those experienced by workers in manufacturing plants, we cannot rule out the possibility that irritation of the eyelid may have been caused by a small amount of TCDD contained in the phenoxy herbicides used on the spray project.

TCDD could not be detected in soils, even in places where considerable spillage had occurred. This is consistent with the exceedingly small amounts found in the silvex used in 1969.

It is unfortunate that reliable methods have not been developed for the analysis of TCDD in animal tissues. A positive on the presence or absence of TCDD in animal tissues would be most helpful, and would permit a more sophisticated interpretation of possible consequences. But such a statement was not possible. At the same time one must question whether TCDD could be found in animal tissues when it could not be detected in soils where there was known concentration due to spillage.

DAIRY GOAT HUSBANDRY

AND

DISEASE CONTROL

By

C. E. LEACH

FIRST EDITION

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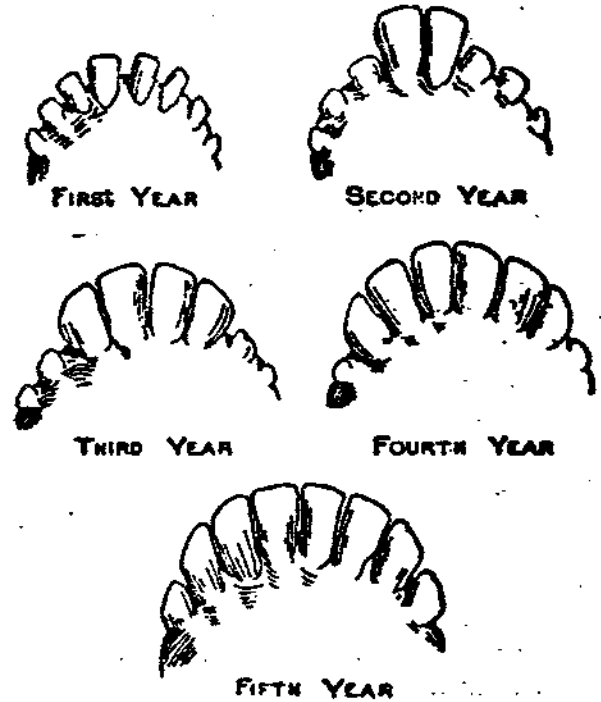
back to health. In most cases the organ will require rest. Particularly is this true of the digestive tract. It might be serious to place the animal on a long fast, but the organs of digestion can be given a rest by feeding easily digested foods. Other organs may get sufficient rest by keeping the goat quiet and comfortable.

I have been speaking of internal medicines. There are frequent cases where external medication is necessary. These cases are more obvious and usually do not present the complex problems that are presented by internal maladjustments.

Age of a Goat By Its Teeth



A general guide for telling age of goats by their teeth. It is not too dependable, as there is quite a variance in tooth development