Control of Gambel Oak with Three Herbicides

GORDON A. VAN EPPS

Highlight: *Fenuron, picloram, and 3 phenoxy compounds were applied to Gambel oak (*Quercus gambellii *Nutt.) to attain a complete kill of the plant. Spring treatments of fenuron applied to the soil at rates of 8 lb ae/acre or higher were effective as were fall applications. Picloram as a soil treatment was not effective. Foliar spraying with picloram and the phenoxy compounds at the higher rates killed oak crowns but not the plants. The herbicides varied in their injury to understory vegetation.*

This study in Central Utah was initiated to determine whether herbicides presently available would produce a complete kill of Gambel oak (*Quercus gambellii* Nutt.), which has been notoriously difficult to kill. Gambel oak is widely distributed in the central and southern Rocky Mountains as a deciduous shrub generally growing in clumps or thickets. The geographical distribution, ecology, and growth characteristics of this controversial species have been reported in more detail by Christensen (1949) and Brown (1958).

Changing of plant cover on watersheds in the Western United States has been suggested as a possible means to increase water yields. This process may improve the value of such areas for grazing, forestry, and recreation. In line with this, practical methods for eradicating those species throught to be high users of water would have to be known prior to initiating any changes in vegetation. Gambel oak is one of the species thought to be in this category because of its growth characteristics and its occupying large areas on important watersheds. Studies by Tew (1969), Marquiss (1969), and Grover (1970) have since borne this out. Grover et al. (1970) found that water yields in central Utah could be increased by 5.6 acre inches in 4 out of 5 years at elevations above 7,640 ft, if brush oak (Gambel oak and associated cover) vegetation was converted to a grass-forb type. Their preliminary data also indicated that aspen and sagebrush use water at a rate similar to that of Gambel oak. Working in the same geographical area, Tew (1969) found that moisture depletion was essentially the same in the upper 4 ft of soil, where either oak or grass were established. At the 4 to 8 foot depth, however, moisture loss from the soil was cut nearly 60% after complete eradication of the oak and establishment of grass. Tew (1967) found similar conditions prevailed with aspen (*Populus tremuloides* Michs.). The studies of Marquiss (1969), in Colorado, are in agreement with Tew (1969) in that there is no increase in soil moisture under Gambel oak unless the entire plant, including sprouts, is killed.

Several methods for controlling Gambel oak have been tried with varying results. Levels of plant injury desired may differ depending on area usage. Apparently, as mentioned above, the entire plant should be killed for water yield improvement, while killing top growth (crowns) and retarding sprouts (root and basal growth) may give effective control for increased grazing, as found in studies by Marquiss (1969).

Marquiss (1973) found that picloram and mixtures containing picloram not only provided the best kill of mature stems but also reduced root sprouting better than the usual phenoxy type herbicides. His use of fenuron pellets and picloram in bead and pellet forms at rates up to 2.5 lb/acre were ineffective in controlling mature oak. Heikes (1964) reported picloram applied at 1.5 lb/acre with a mist blower gave almost a complete kill of Gambel oak with little regrowth the year following application. Johnsen et al. (1969) used a number of herbicides on Gambel oak in Arizona, with variable responses. None of the studies show complete plant kill.

Methods and Procedures

Study sites on various exposures and soil types were selected on private land in central Utah. Oak stands were generally in scattered clumps on slopes of 5 to 20%. Total plots from all locations covered several hundred acres. Plots within replications at each location were similar in exposure and soil type. A plot consisted of a natural single clump which at the outset of the experiment was thought to be a single plant or clone. Later it was discovered that one to several clumps, some separated by more than 80 feet, could be part of the same clone. Thus several "clump plots" initially considered as separate clones were exposed to more than one herbicide because of extensive translocation. Individual plot size varied from 36 to 1,650 ft^2, depending on the size of the natural clumps. The average area was 479 ft^2 per plot. The differences in crown height, size, and number of trunks and sprouts were not evaluated in selecting plots though some observations were made. The species of plants, other than Gambel oak, growing in each plot were recorded.

Herbicides were measured, whether granular or liquid, according to the size of each individual plot and the specific treatment to be used. In the one liquid soil treatment, and all foliar treatments, water was applied at the rate of 100 gal/acre. This high water rate was used due to the small size of some plots for greater uniformity of coverage in applying the chemical. High rates of herbicide were included in hopes of insuring a complete plant kill.

The author was, at the time of the research, associate professor of plant science, Department of Plant Science, Utah State University, Logan. He is now stationed at Snow Field Station, Ephraim, Utah.

The report is a contribution of the Utah Agricultural Experiment Station as Journal Paper number 1769.

Manuscript received July 14, 1973.

A percentage scale was used in assessing the severity of injury, with 0 being normal and 100 being a complete kill. During 1967 and 1968, the three categories observed included the general condition of the oak clump, the understory other than oak sprouts, and the surrounding oak clumps.

Observations made from 1969-71 were more inclusive. Injury measurements for oak included the entire clump, the crown, and sprouts. The understory included the total plant population other than oak sprouts. Similar visual ratings were utilized for both the soil and foliar treatments.

Soil Treatments

A total of 156 Gambel oak clumps were given soil treatments. These consisted of seven spring and six fall treatments each with four replications. All treatments were applied at three locations. Each plot received a single herbicide treatment.

Site A has a western exposure located on a Clegg loam soil. The soil is deep, well-drained alluvium formed from limestone, sandstone, and shale of the North Horn and Price River formations. The elevation is approximately 6,200 ft, with annual precipitation of 14 to 16 inches.

Site B, located on eroded Borvant cobbly loam, has a southwestern exposure. The soil is 10 to 20 inches deep or eroded shallower and is underlain by limestone and calcareous shale of the Green River formation from which it is derived. Annual precipitation is approximately 16 inches at 6,400 ft. elevation.

Site C has a northeast exposure at approximately 6,200 ft with 16 inches of precipitation. The soil is classified as Manilla gravelly silt loam, and is deep, well-drained alluvium formed from the Indianola group of clastics composed of sandstone, shale, and quartzite conglomerate material.

The spring treatments were applied between April 15 and May 3, 1966, at or near bud break, depending on plant variation. Fall treatments were applied between October 21-28 after the leaves had frozen.

Herbicides[1], formulations, and rates applied in the spring and fall were: (1) The potassium salt of picloram (4-amino -3,5,6-trichloropicolinic acid) as Tordon 2K at 8 lb/acre; (2) Tordon 10K at 4, 8, and 10 lb/acre; and (3) fenuron (3-phenyl-1, 1-dimethylurea) as Dybar at 8 and 16 lb/acre. These were all supplied in the granular form and were broadcast uniformly through each plot according to the treatment. In addition to the above, a spring treatment of picloram, Tordon 22K at 2 lb/acre, was sprayed as a liquid in a 1-foot wide zone within the boundary of the plot. This approximated the drip line (outer branch spread) of the treated clump.

Foliar Treatments

Using a mist blower, herbicides were applied as a foliage spray to 180 plots at three locations. All vegetation within a plot was wetted. The 10 treatments, with six replications each, were applied on three dates as single applications to each plot. The dates were June 1-3, July 15-18, and September 22-29, all during 1966. Wind caused some delay in applying the chemicals. Climatic and soil data were obtained during the period preceding and the day of spraying. Injury symptoms occurring to the oak and understory were visually observed and noted annually during the 6 years following herbicide application. Soils and locations for foliar spraying were similar to those receiving the soil treatments.

Because of insect injury caused by the larva of the looper, *Lambdina punctata* (Hulst), which defoliated the oak clumps in the vicinity, Site A received only two replications of the June spraying. This looper has been reported by Minnock and Parker (1971). Sites B and C had eight replications apiece with each site having two replications sprayed in June, three in July, and three in September.

[1]Herbicides used in these trials were supplied by the Dow Chemical Company and E. I. DuPont de Nemours and Company. Trade names are used for clarification and do not constitute recommendation over comparable products.

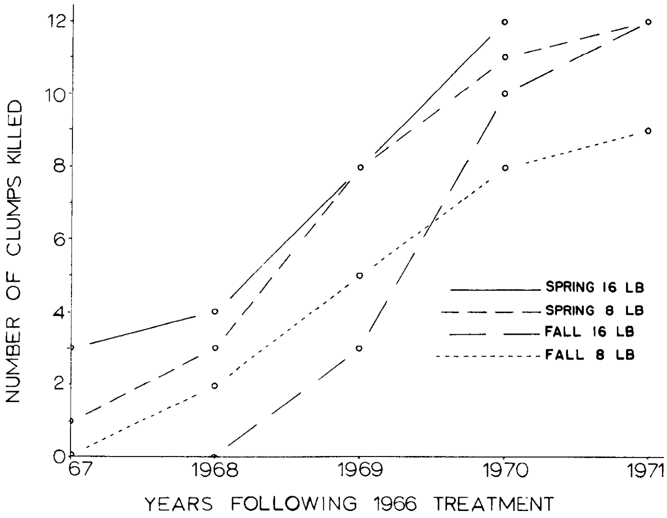

Fig. 1. *Accumulative rate by year in total kill of Gambel oak during the years following fenuron treatment showing variation between the 8 and 16 pound rates when applied in the spring or fall. Total of 12 clumps in each category.*

The herbicides, formulations, and rates applied were: (1) Picloram (Tordon 22K) at 2 and 3 lb/acre; (2) a mixture of picloram and 2,4-D (Tordon 101) applied at 2 lb of picloram and 8 lb of 2,4-D/acre; (3) 2,4,5-TP (Kuron) at 4 lb/acre; and (4) two other mixtures containing picloram with 2,4-D or 2,4,5-T. Tordon 212 contains 1 lb of picloram plus 2 lbs of 2,4-D and Tordon 225 is a mixture containing 1 lb each of picloram and 2,4,5-T per gal. These latter two mixtures were applied at 1, 2, and 3 lb/acre of picloram plus the various rates of 2,4-D or 2,4,5-T depending on the mixture.

Results

Soil Treatments

Injury was similar at all locations and seemed to be directly related to the various herbicides and rates of application, although there were some differences due to season of treatment.

Granular fenuron injury to oak

Fenuron was lethal to Gambel oak and produced the greatest injury to oak and the understory of all soil or foliar treatments. All plots treated at 16 lb/acre were killed, including the understory. The lower rate of 8 lb/acre applied in the spring was equally effective in killing all clumps treated. Spring applications were better than fall applications.

All but three of the 48 plots receiving fenuron were completely killed by the summer of 1971, 5 years after treatment (Fig. 1). The major injury was sutained during the third and fourth years following treatment. During this 2-year interval, two-thirds of the oak clumps died. The three remaining live clumps had received the 8-lb fall treatment. These were reduced to a few live ground sprouts which are now increasing in vigor and number. There was one living clump at each of the three locations.

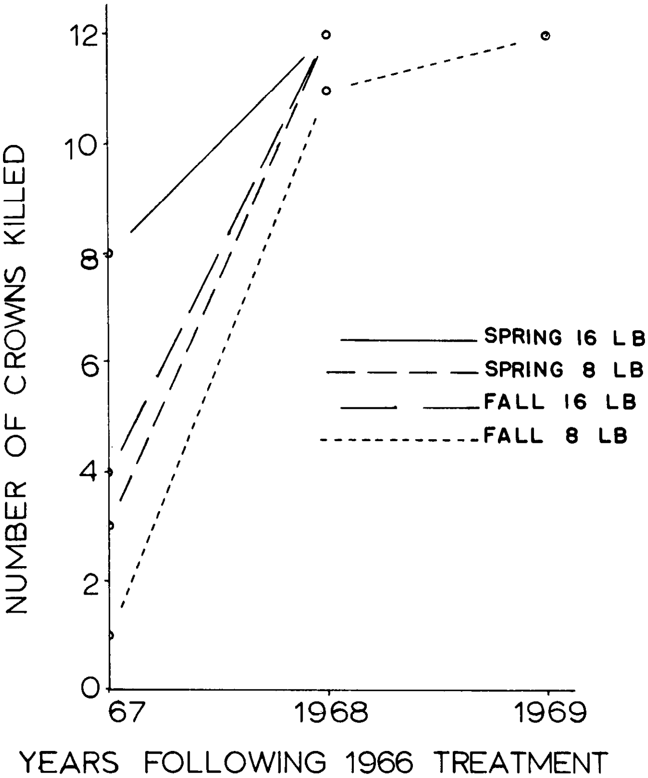

Fig. 2. *Accumulative rate of crown kill of a clump during the years following fenuron treatment showing variation between the 8 and 16 pound rate when applied in the spring or fall. Total of 12 clumps under each category.*

Crowns of the oak clumps showed the greatest injury during the first 2 years after the application of fenuron with a 100% kill (Fig. 2).

Injury symptoms were similar to those observed by Davis (1966) while working with fenuron on seedlings of shrub live oak (*Quercus turbinella*). Ashton (1965) found that light was necessary for injury symptoms to develop from phenylurea compounds. This probably accounted for leaf expansion on new sprouts before injury was manifested.

Granular fenuron injury to understory

Fenuron at both seasons and levels of application killed nearly all understory vegetation including perennial shrubs, forbs, and grasses, as well as the annual forbs and grasses. Many of the plots had a complete ground cover of Kentucky bluegrass (*Poa pratensis*), which was fairly well killed by the fall of the first year where spring treatments were applied, and all was killed by the second year. Rabbitbrush (*Chrysothamnus nauseosus*) was slower to show initial injury than big sagebrush (*Artemisia tridentata*), though both were ultimately killed. Broom snakeweed (*Gutierrezia sarothrae*) showed about the same susceptibility as rabbitbrush. Common hoarhound (*Marrubium vulgare*) and pricklypear (*Opuntia polyacantha*) were two of the more resistant plants. Plant re-invasion varied according to site and surrounding vegetation. The earliest annuals to grow in the previously sterilized area were the mustards (*Brassica* spp.), Russian thistle (*Salsola kali tenufolia*), flannel mullein (*Verbascum thapsus*), cheatgrass brome (*Bromus tectorum*), and others. Some of the first perennial seedlings were big sagebrush, rabbitbrush, broom snakeweed, common hoarhound, bluegrass, and others.

Plot boundaries are still plainly visible around most plots 6 years after fenuron treatments.

Granular picloram injury to oak

Picloram applied to the soil in granular form had little effect on the Gambel oak. Injury was slight even at the highest rates. Injury was mainly to the leaves and consisted of wilting, curling, browning, and premature shedding. Some twig and stem dieback was observed. A few clumps showed wilting and curling of the leaves on the ground sprouts. In 1971, 5 years after treatment, observable injury varied from 0 to 10%. Most clumps appeared normal. There was no noticeable difference between spring or fall application. No injury was observed from root translocation within the plant tissue and current data further substantiates it.

Granular picloram injury to the understory

A mortality in excess of 75% occurred to all understory perennial shrubs and forbs from picloram. Tordon 10K at 1 lb/acre was less injurious than the others. Grass was not affected by picloram at any of the rates. Annual forbs, as expected, were the first to become re-established within the treated areas. In some plots, the annual vegetation was more prevalent than before treatment. This was probably due to the death of the perennial shrubs and forbs, which allowed for a more favorable environment. Perennial seedlings of big sagebrush, rabbitbrush, snakeweed, and others are now re-invading.

Liquid picloram injury

No effect to the oak clump was observed in any of the plots where picloram was sprayed on the soil in a 1-ft band around the plot boundary.

The understory of various species within the soil sprayed zone were injured or killed where the material was sprayed directly on the plants. These mainly were big sagebrush, rabbitbrush, and broom snakeweed. These plants inside the sprayed area were normal.

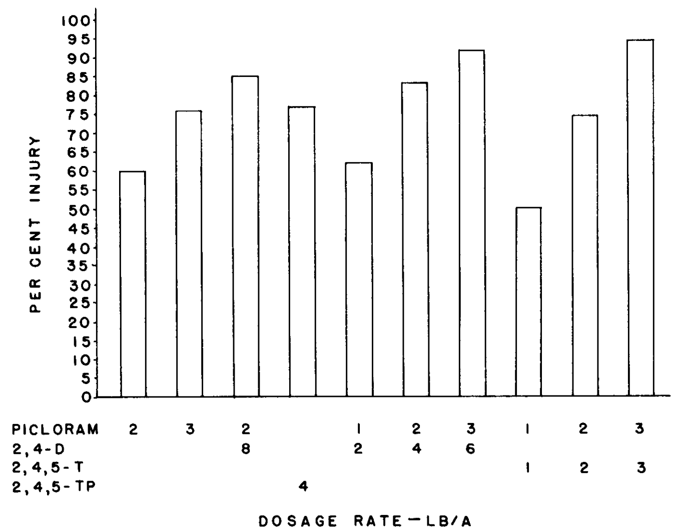

Fig. 3. *Injury to the understory of perennial shrubs and forbs (other than Gambel oak sprouts and grass) growing under Gambel oak clumps when exposed to several chemicals by foliar spraying at different rates. Average of 6 replications and 3 dates of applications —3 years after treatments.*

Table 1. Injury (%) to Gambel oak clumps observed 4 years after foliar treatment with several herbicides at various rates (lb ae/acre) and at 3 dates of application. Data is the average of 180 plots from 6 replications at 3 locations expressed in percent injury.

Date and formulation	Application rate				Crown[1]		Sprouts[2]	
	Picloram	2,4-D	2,4,5-T	2,4,5-TP	Average injury	Spread of injury	Average injury	Spread of injury
May 25-June 3, 1966								
Tordon 22K	2				22	0–70	7	0–10
Tordon 22K	3				34	0–95	13	0–50
Tordon 101	2	8			26	0–95	5	0–10
Kuron				4	32	0–100	7	0–20
Tordon 212	1	2			26	0–80	12	0–30
Tordon 212	2	4			28	0–80	15	0–50
Tordon 212	3	6			30	0–90	8	0–20
Tordon 225	1		1		27	0–80	13	0–40
Tordon 225	2		2		13	0–50	2	0–10
Tordon 225	3		3		47	0–100	25	0–50
July 15-18, 1966								
Tordon 22K	2				79	30–100	25	10–60
Tordon 22K	3				68	30–100	37	10–100
Tordon 101	2	3			77	50–100	36	0–100
Kuron				4	74	50–100	36	20–100
Tordon 212	1	2			72	50–100	12	0–20
Tordon 212	2	4			78	50–100	40	0–100
Tordon 212	3	6			82	60–100	50	10–100
Tordon 225	1		1		58	40–100	28	0–100
Tordon 225	2		2		70	30–100	40	10–100
Tordon 225	3		3		87	70–100	57	0–100
September 22-29, 1966								
Tordon 22K	2				15	0–30	5	0–10
Tordon 22K	3				29	10–80	17	0–50
Tordon 101	2	8			57	10–100	17	0–50
Kuron				4	38	10–60	12	0–40
Tordon 212	1	1			23	0–60	5	0–20
Tordon 212	2	4			78	40–100	30	10–50
Tordon 212	3	6			70	30–100	25	10–70
Tordon 225	1		1		33	10–80	10	0–30
Tordon 225	2		2		82	50–100	50	1–100
Tordon 225	3		3		83	60–100	25	1–40

[1] Crown includes the top growth or overstory of Gambel oak.
[2] Sprouts include new growth up to a few years of age originating from underground root sprouting or basal trunk sprouts.
[3] Spread includes injury observation between plots receiving the same treatment as compared to the average of 6 replications.

Foliar Treatments

Oak injury

Only nine clumps died out of 180 treated. Eight of those occurred from the July spraying, and covered eight of the 10 treatments, all in the same replication. These were on a fairly dry site on the slope of a bank stretching along a dry wash. Soil moisture may have been a major factor. Two non-lethal treatments within this replication were Tordon 22K at 2 lb/acre, which killed the crown, and the lowest rate of Tordon 212. The latter killed 80% of the crown with no visual effect to the sprouts. The only other clump killed was from the September spraying with Tordon 225 at 2 lb/acre. Variations in location, temperature, or soil had no noticeable effect on oak with the herbicides used other than this one replication.

Four other clumps sustained 90% or more injury. Twenty crowns were killed in addition to the above and 14 were injured over 90%. Tordon 212 and 225 at the two higher rates were generally the most potent. The July spraying accounted for the greatest injury with the spring application being the poorest. Table 1 shows the comparison of injury for oak crowns and sprouts with the various herbicides, season, and rates of application. Obviously, oak crowns are easier to kill than the sprouts.

Understory injury

Injury to the perennial understory shrubs and forbs varied from 0 to 100%. Average damage from the herbicides varied between 40-98%. Time of application had little effect. In general, the percent injury varied according to the dosage with little difference between chemicals (Fig. 3). New seedlings of the perennial shrubs and forbs in the plots were observed the year following treatment with increasing numbers each subsequent year. There was no injury to the grass understory regardless of formulation and dosage. Plant species were similar to those noted under the soil treatments.

Discussion

Fenuron was the only reliable chemical that killed Gambel oak at the rates used. A herbicide with its translocation potential and phytotoxicity would be highly desirable for Gambel oak control if there was a method of application that would prevent the sterilization of the soil and consequent elimination of desirable plants. However, its sterilization effect and long persistence makes it impractical for intended uses within objectives of this study.

The most striking revelation of the experiment was the distances fenuron is translocated within oak root systems.

Connected clumps 80 ft away from a treated clump, with no oak growth between, showed injury. This injury persisted for at least 6 years.

The results obtained from the July foliar spraying of picloram with mixtures of 2,4-D or 2,4,5-T at higher rates indicated promise in killing the crowns of Gambel oak. This would open up additional rangeland for grazing, but it would be of little value on watersheds for increasing water yields. Perhaps follow-up applications with picloram mixtures would have destroyed the total plant. Observations indicate that these herbicides are mainly phytotoxic only to those portions of the plant actually receiving the chemical. Translocation apparently is limited. The lack of injury to grass with the foliar sprays used is a desirable characteristic. This is true not only on rangelands, but for watersheds.

In a general foliar broadcast application, all other shrubs and forbs would probably be killed with the concentrations of herbicides necessary to control Gambel oak. In addition, the cost of chemicals used in this study coupled with dosages needed to obtain the desired results would be economically prohibitive at the present time.

Additional studies are needed in developing effective techniques for controlling Gambel oak.

Literature Cited

Ashton, F. M. 1965. Relationship between light and toxicity symptoms caused by atrazine and monuron. Weeds 13:164-168.

Brown, Harry E. 1958. Gambel oak in West-Central Colorado. Ecology 39:317-327.

Christensen, Earl M. 1949. The ecology and geographic distribution of oakbrush (*Quercus gambellii*) in Utah. MS Thesis, Univ. of Utah. 70 p.

Davis, Edwin A. 1966. The role of starvation in fenuron injury to shrub live oak. Weeds 14:10-17.

Grover, B. L., C. B. Campbell, and M. D. Campbell. 1970. A prediction for vegetation effects on water yield from watersheds in arid areas. Soil Sci. Soc. Amer. Proc. 34:669-673.

Heikes, Eugene E. 1964. Tordon and other herbicides field testing for the control of deep rooted perennial weeds in Colorado. Down to Earth 20(3):9-12.

Johnsen, Thomas N., Jr., Warren P. Clary, and Peter F. Ffolliott. 1969. Gambel oak control on the Beaver Creek Pilot Watershed in Arizona. U.S. Dep. Agr. Pub. ARS34-104. 8 p.

Marquiss, R. W. 1969. Studies on Gambel's oak at the San Juan Basin Station. Colo. State Univ. Exp. Sta. Prog. Rep. PR69-38. 2 p.

Marquiss, R. W. 1973. Gambel oak control studies in Southwestern Colorado, J. Range Manage. 26:57-58.

Minnoch, Maxine W., and Douglas L. Parker. 1971. Life history of a looper, *Lambdina punctata*, in Utah (Lepidoptera: Geometridae) Annals of the Ent. Soc. of Amer. 64:386-389.

Tew, Ronald K. 1969. Converting Gambel oak sites to grass reduce soil moisture depletion. U. S. Forest Serv. Res. Note INT-104. 4 p.

Tew, Ronald K. 1967. Soil moisture depletion by aspen in central Utah. U. S. Forest Serv. Res. Note INT-73. 8 p.

Wiltse, Mark G. 1964. Tordon herbicide as a soil treatment for brush control. Down to Earth 19(4):3-6.

Second Call for Papers

28th ANNUAL MEETING

February 10-14, 1975, México City, México

The objective of the Program Committee for the 1975 Annual Meeting is a stimulating program of important topics that will provide something of value and interest to all those who attend. To accomplish this objective, the format for the meeting will include both invited and volunteer papers; it will also provide a forum for airing controversial issues and the expression of ideas. The Committee solicits members—and nonmembers—to volunteer papers reporting their work, their research, and their ideas. *Although papers on any subject relevant to range science and range management—or the affairs of the Society—will be considered, papers representing new knowledge and fresh ideas are encouraged.*

The Program Committee will carefully screen all volunteer papers and select only those that provide reasonable assurance of meeting the standards of high quality that the Society expects. *The Committee will attempt to accommodate papers on any subject matter.*

Procedure: Those wishing to present papers at the 28th Annual Meeting should consider only topics that can be presented within an allocated time of 15 minutes. The author should provide the following: (1) title of paper, (2) name and affiliation of authors, (3) name of individual to present the paper, (4) name and address of author to whom correspondence should be addressed, (5) a preliminary abstract of not less than 250 or more than 500 words, and (6) a supporting statement indicating the significance of the offered paper and the subject matter area(s) under which he thinks his paper could be classified. For research papers, this statement should also indicate the relative amount of data supporting the paper (e.g., years of study). All illustrative materials must be adapted for use in Kodak 35-mm Carousel projectors.

Deadlines: Three copies of the preliminary abstract and supporting statement should be in the hands of the Program Committee chairman not later than **August 15, 1974** (October 5 for student papers). Authors will be notified of acceptance or rejection of their paper by October 1, 1974 (November 1 for student papers). Final abstracts for all papers must be received by the Program Committee by November 15, 1974.

Preliminary abstracts and correspondence relevant to the program should be addressed to: **Dr. Charles L. Leinweber, Director, Environmental Quality Program, Faculty Exchange, Box 119, Texas A&M University, College Station, Texas 77843.**