Guidelines for Aerial Spraying Mesquite in New Mexico

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Preface

This report is a modification of a similar report prepared for the Upper Colorado River Authority by Ecological Restoration and Management Consultants 7662 Wren Road, San Angelo, Texas 76901. The original report was entitled “Guidelines to Assure that Aerial Spraying of Mesquite is According to Program Specifications and an Acceptable Level of Mesquite Mortality is Achieved.” It was authored principally by Dr. Darrell Ueckert and Dr. Allan McGinty. These brush scientists spent much of their professional careers with the Texas A&M University Agricultural Research and Extension Center at San Angelo.

This document also compliments earlier reports conducted in New Mexico related to aerial spraying mesquite with a mixture of clopyralid and triclopyr herbicides. This treatment is most useful on moderate-to-dense mesquite infestations and for maintenance control of the shrub following initial treatments. This report addresses the advantages and disadvantages, cost, efficacy, risks, and potential for adoption of aerial spraying for mesquite control. General specifications for aerial spraying mesquite are given relative to the herbicide application rate, appropriate spray carrier and adjuvants, appropriate spray volume, weather conditions, spraying equipment, and aircraft speed. Important environmental factors considered include soil temperature, plant growth stage as related to carbohydrate translocation, foliage damage due to insects, hail, or disease, and off-target drift of spray. This report details the specifications that should be used for aerial spraying mesquite in Public-funded brush control projects and provides suggested guidelines to help assure that aerial spraying of mesquite is done according to program specifications and in a manner to improve the probability of successful mesquite control. The guidelines are based upon our experience, the existing knowledge base, the scientific literature, and specimen labels for clopyralid (Reclaim®) and triclopyr (Remedy Ultra®) herbicides. Recommendations by the manufacturer of these herbicides, and other information obtained from other publicly funded projects is also considered.

Guidelines for Successful Aerial Spraying for Mesquite Control

Aerial spraying with a mixture of clopyralid + triclopyr can be a highly effective method for controlling moderate-to-dense infestations of mesquite on rangeland if the treatment is applied properly. For this relatively expensive herbicide combination to be cost effective, it must be properly applied and result in a very high level of mesquite canopy reduction and whole plant mortality. While most landowners could quickly discern poor workmanship by mechanical brush control contractors, most would not be aware of inadequacies in aerial spraying of mesquite for 1 to 2 years after the work was completed. Less than acceptable results can occur when mesquite is aerially sprayed if proper attention is not focused upon the condition of the target plant, soil temperature, environmental conditions, and the technical aspects of preparation and application of the herbicide spray. There has been speculation that some commercial aerial applicators are not qualified or simply do not have the time to evaluate the conditions critical for determining the proper timing of application of aerial sprays for mesquite control. The high costs of clopyralid and triclopyr may create a temptation among some applicators to apply a lower rate than contracted. Diligent efforts need to be made to assure that taxpayer dollars are used wisely in any Public-funded brush control program. For aerial spraying with a mixture of clopyralid + triclopyr to successfully achieve a high level of mesquite canopy reduction, plant mortality, and obtain full value for each dollar of public funds spent, the following criteria must be met:

- Clopyralid and triclopyr herbicides must be used and properly mixed with all other spray ingredients. These herbicides are sold as an acid, ester, or salt formulations under various trade names. The most common trade names purchased for mesquite control in New Mexico and Texas are Reclaim® (clopyralid) and Remedy Ultra® (triclopyr) (Manufacturer: DowAgrosciences). However, generic products are now available and they can also provide acceptable mesquite control provided they are formulated in the same manner as Reclaim® and Remedy Ultra®.

- The herbicides must be applied at the correct rate

- The proper total volume of spray per acre must be applied with appropriate spraying equipment

- The spray mix must include the recommended spray carrier and adjuvants

- Applications must be made when the weather conditions are conducive to maximize deposition of spray droplets onto the mesquite leaves and absorption of herbicides into mesquite leaves

- Mesquite plants must be in the proper phenological phase to facilitate the translocation of a lethal dose of herbicide to the basal meristems and roots of the plant

- Soil temperature and mesquite growth conditions at time of application must be appropriate to facilitate the translocation of a lethal dose of herbicide to the basal meristems and roots of the mesquite plants.

The specifications for aerial application of herbicides for mesquite control **that should be mandated** in Public-funded brush control projects are presented below, along with suggested guidelines to help assure that aerial spraying of mesquite is done according to these specifications. The specifications are based upon our personal knowledge and experience, the scientific literature, and the recommendations of the manufacturer of clopyralid and triclopyr, Dow AgroSciences (formerly known as Dow Chemical Co. and DowElanco.)

The guidelines presented below to help assure that aerial spraying of mesquite is done according to specifications follow the policies currently adhered to by other publicly funded programs in which herbicides are aerially applied for mesquite and saltcedar control or insecticide is aerially applied. These

programs include: the Natural Resource Conservation Service Environmental Quality Incentives Program,Wildlife Habitat Incentive Program or Riparian Buffer Program (contact: NM State Range Conservationist, Albuquerque, NM, phone 505 761-4421); the U.S. Department of Interior -Bureau of Land Management's mesquite control program in New Mexico (contact: Russell Fox, Bureau of Land Management, Roswell Field Office, Roswell, NM, phone 505 627-0229).

Specifications for the Proper Rate of Application, Spray Volume, and Spray Ingredients:

The spray mixture shall include 0.25 lb acid equivalent (a.e) clopyralid + 0.25 lb a.e. triclopyr per acre and shall be applied in a total volume of at least 4 gal/acre in a 1:5 diesel fuel - water emulsion carrier. This is equivalent to 2/3 pint of Reclaim® herbicide + ½ pint of Remedy Ultra® + 2.56 qt diesel (= 0.08333 gal Reclaim + 0.0625 gal Remedy Ultra + 0.64 gal diesel fuel + 1 gal water/acre). One ounce of emulsifier, such as Triton X-100® or Sponto 7® shall be added to each gallon of diesel fuel used in the spray mixture to assure that the water and diesel molecules adhere and form a stable, milky-colored emulsion. A drift control additive or spray deposition aid such as Nalco-Trol® or StaPut® shall also be added to the spray mixture at the rate of 6 fl oz/gal to increase the mean spray droplet size, which: 1) maximizes deposition of spray on the target area; 2) maximizes the time the herbicide remains on the leaf in the liquid phase; and 3) minimizes the lateral displacement (drift) of fine spray droplets off the target area by air currents. The correct amounts of Reclaim®, Remedy Ultra®, diesel fuel, emulsifier, drift control additive, and water that shall be included for various batch sizes are shown in Table 1.

Table 1. Proper amounts of Reclaim®, Remedy Ultra®, diesel fuel, emulsifier and water for various batch sizes.

Batch size (gal)	Acres to be treated[1]	Reclaim® (gal)	Remedy® (gal)	Diesel fuel (gal)	Emulsifier[2] (oz)	Drift control (oz)	Water (gal)
100	25	2.08	1.56	16	17	6	80.2
200	50	4.17	3.13	32.1	33	12	160.3
300	75	6.25	4.69	48.1	50	18	240.5
400	100	8.33	6.25	64.1	67	24	320.7
500	125	10.42	7.81	80.2	83	30	400.8
600	150	12.50	9.37	96.2	100	36	481.0

[1] Based upon a total spray volume of 4 gal/acre, but slightly fewer acres would be actually sprayed if one swath is applied for "trim" at each end of the pasture where the parallel swaths began and ended.

[2] 1 oz./gal of diesel fuel.

Specifications for Materials:

Commercial aerial applicators shall deliver to the loading site all herbicides, diesel fuel, control and deposition aid additive, and emulsifier in original unopened containers (with the exception of the herbicides in the event the agency provides these materials).

Active Ingredient(s):

a. Reclaim®
Clopyralid (3,6-dichloro-2-pyridinecarbolixylic acid)
Monothanolamine salt……40.9%

Inert ingredients……..59.1%
Acid equivalent: 3,6-dichloro-2-pyridinecarboxylic acid – 31% - 3 lb/gal
E.P.A. Reg. No. 62719-83

b. Remedy Ultra®
Triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid)
Butoxyethyl ester……...61.6%
Inert Ingredients……38.4%
Acid equivalent: 3,5,6-trichloro-2-pyridinyloxyacetic acid – 44.3% - 4lb/gal
Contains petroleum distillates
E.P.A. Reg. No. 627 19-70

Specifications for Tank Mixing Clopyralid, Triclopyr, and Other Spray Ingredients:

Read the product labels and carefully follow all applicable directions during the tank-mixing process. Tank mixes shall be prepared according to the following procedure:

- Add half the needed water to the mixing tank
- Add the required amount of Reclaim® (a water-soluble herbicide) to the mixing tank
- Prepare a premix consisting of diesel fuel (No. 2 fuel oil or kerosene can be substituted for diesel fuel), 1 fl oz of emulsifier such as Triton X-100 or Sponto 71 2 per gallon of diesel fuel and the required amount of Remedy Ultra®. Slowly add the premix to the mixing tank using agitation to prepare an oil-water emulsion [Note: a thick "invert"(water in oil) emulsion may form if water is added to or leaks into the premix or oil-soluble herbicide. An invert emulsion may also form if the premix or water-soluble herbicide are put into the mixing tank before the water is added. Invert emulsions are very difficult to break
- Add the remaining water, along with a drift control and deposition aid such as Nalco-Trol or equivalent, needed to bring the mixture to the required volume. Maintain a 1 oil-to-water ratio when preparing the oil-water emulsion. This ratio is critical to ensuring optimum herbicide performance in aerial applications
- Maintain agitation in the spray tank during application.

Specifications for Application of Aerial Sprays for Mesquite Control:

- Pilots of spray planes must be New Mexico Department of Agriculture-certified commercial aerial applicators
- Aircraft used shall be capable of applying herbicide at 120 mph maximum air speed or slower speeds
- Aircraft shall be equipped with a boom and nozzles appropriate for delivering stable

herbicide droplets in the range between 250 and 500 microns in diameter uniformly within the effective swath at a boom pressure of 18 to 22 psi

- Round booms shall be positioned even with and 4 to 6 in. behind the trailing edge of the wing, and the ports should be directly to the rear of the boom in flight

- Airfoil or streamline booms shall be positioned 4 to 10 in. below and 4 to 6 in. to the rear of the trailing edge of the wings, and ports should be tapped along the trailing edge of these booms

- Nozzles shall be attached to a street that attach to a 90° street “L” that attach to 2-in. nipples or shut-off valves that attach to the ports on the boom to remove the nozzle from the area of air turbulence immediately behind the trailing edge of the boom.

- Nozzles shall be equipped with diaphragm check valves (e.g., Spraying Systems 4664, Delavan 34560). Optional spray tips that fit Spraying Systems 34560 nozzle bodies include the Spraying Systems Multee Jet (dial), the Smith-Faire (dial) and the Delavan Raindrop. No. 46 or No. 56 core plates should be used in Spraying Systems 4664, Delavan 34560, and Raindrop nozzles (the No. 45 core plate is not recommended)

- Nozzles shall be oriented to the rear of the boom and generally downward 10" for aircraft that travel at high speeds 120 mph) to as much as 45" downward for aircraft that travel at slow speeds

- Eight-to 12-in. long rigid drop nozzles shall be used to avoid releasing herbicide sprays in areas of air turbulence such as prop wash, automatic flaggers, and wing struts

- Usable boom length shall not exceed 3/4 of the wing span of the aircraft

- If the boom extends beyond the last functioning nozzle, a bleed line should connect the last outboard port on the boom to the last functioning nozzle to prevent fluctuation in system pressure caused by air trapped in the ends of the boom

- Swath width shall not exceed 1.25 times the width of the aircraft

- Flight height shall be 10 to 15 ft above the mesquite canopies, low enough to achieve proper distribution of herbicide across the entire swath and uniform coverage of spray onto the mesquite foliage

- Flight passes shall be perpendicular to the wind so that there is considerable overlap of the spray pattern from adjacent swaths (this lateral displacement is not considered to be "drift" of the herbicide droplets off the target area)

- Maximum aircraft speed during herbicide application shall not exceed 120 mph

- Herbicides shall not be applied when relative humidity is less than 50%

- Herbicides shall not be applied when air temperature is greater than 95° F

- Herbicides shall not be aerially applied when wind speed is less than 2 mph or greater than 10 mph;

wind speed should be 5 to 10 mph where the mesquite foliage is very dense

- Aircraft shall be equipped with an operational Differentially Corrected Global Positioning System (DGPS) and appropriate software.

Specifications on Soil Temperatures, Mesquite Growth Stages, etc.:

The efficacy of aerially applied herbicide sprays is a function of the physiological, morphological, and phenological stage of the target plants and the environmental conditions under which the plants are growing. If all these conditions are not optimum, aerial sprays will not usually produce sufficient levels of canopy reduction and whole plant mortality to meet management objectives in State-funded brush control projects. After herbicides like picloram, clopyralid, and triclopyr are absorbed by the leaves of susceptible plants, they are then translocated to other parts of the plant in the phloem with photosynthates (carbohydrates) that are produced in the leaves via the process of photosynthesis. Plants like mesquite, which have the ability to form dormant basal buds following treatments which kill the aerial portions of the plants, must be sprayed when the herbicides will be translocated to the roots and basal meristem regions of the plant. The ultimate success of an aerial spray application to mesquite is directly related to achieving high levels of absorption of the herbicides into the leaves and downward translocation of a sufficient amount of the herbicides into the mesquite bud zone to kill the dormant basal buds. Maximum control with aerially applied herbicide sprays occurs only when soil water is not limiting and soil temperature is conducive for root activity. Although we have learned that mesquite can be effectively controlled with hand spraying a high-volume foliar spray of clopyralid + triclopyr throughout most of the summer and into the early autumn no research has been conducted specifically to determine the optimum periods for applying aerial sprays of clopyralid + triclopyr for mesquite control. Brush control scientists in Texas and NewMexico generally agree that the specifications addressed in this report are the best available recommendations. Therefore, the specifications for aerial spraying with clopyralid + triclopyr relative to soil temperature, mesquite phenology, and foliage conditions are:

- Aerial sprays shall be applied for mesquite control only after the soil temperature at a depth of 12 to 18 inches exceeds 75°F and is preferably 80°F or higher

- Aerial sprays shall be applied for mesquite control only after all mesquite leaves on tree canopies have changed from a light, pea-green color to a dark green color

- If the two conditions above have been met, in years when the trees produce many flowers the first optimal period for aerial application of herbicide sprays for mesquite control shall be during the 21-day period from 42 to 63 days after the leaf buds break (the date when small leaves have emerged on most mesquite trees in the target area) [Note: In an exceptionally dry year when few flowers are produced, the first optimum spray period might be 1 week earlier]

- Aerial sprays shall not be applied for mesquite control during the period from day 64 through day 71 after the leaf buds break if new pods (beans) are present and elongating from the 2-in. length to the 8-in. length

- If the first two conditions have been met, the second optimal period for aerial application of herbicide sprays for mesquite control shall be during the 13-day period from 72 to 84 days after bud break [Note: if the mesquite trees have produced only a few flowers the second period might be 1 week earlier]

- Aerial sprays shall not be applied during any period when light, pea-green leaves are present in the tree canopies, when the mesquite flowers are white, or when mesquite pods (beans) are immature (not fully

elongated) because carbohydrates are being translocated upward during these growth stages to support these forms of plant growth

- If mesquite pods (beans) are present, aerial sprays shall not be applied until after the pods are fully elongated (pods do not have to be filled out and mature)

- Aerial sprays shall not be applied to mesquite regrowth that appears after trees have been topkilled by mowing, other mechanical treatments, herbicidal treatments, or fire until the new growth is at least 4 feet tall so that there will be sufficient leaf surface area to assure absorption and translocation of a lethal dose of herbicide into the old, established crown and root system

- Aerial sprays shall not be applied when more than 25% of the mesquite leaves have been lost or damaged by insects, hail or disease

- Aerial sprays shall not be applied for about 3 weeks after significant rainfall events (2-3 in.) that have stimulated the growth of light, pea-green new leaves in the upper mesquite canopies

- Aerial sprays shall not be applied to mesquite that is obviously drought stressed, as evidenced by the presence of sparse foliage, chlorotic (yellow) leaves, or necrosis of leaves (dead or dying tissue on the leaf margins).

Anticipated Results

Root kill of mesquite in several large-plot experiments in eastern New Mexico with aerial sprays of clopyralid and triclopyr exceeded 80% when environmental and plant growing conditions were optimal at the time of treatment (McDaniel and Duncan, 1986. Five year summary of range brush control research-demonstration trials in New Mexico. RITF Report 21. NMSU). It is not realistic to expect to kill all the mesquite plants on a target area with a single broadcast application of clopyralid and triclopyr. A substantial amount of variability in mesquite root kill with this treatment should be expected, not only among applications on different ranches, but also among applications within a ranch applied at different dates within a year or in different years. Mesquite plants within a range site are never fully synchronized relative to growth stage and some plants growing in close proximity may support flowers, while others support pods that are still elongating. On other shrubs they may have pods that are fully elongated, and a few may have light, pea-green leaves in their upper canopies. These factors all contribute variability in mesquite mortality following application of aerial sprays.

Mesquite growing on sandy or shallow, rocky soils are much easier to kill with aerial herbicide sprays than those growing on deep, heavy clay soils. On a given day, soil temperatures can vary substantially among range sites within a pasture. Sandy soils as well as shallow, rocky soils warm up much faster than deep, heavy clay soils because they have a much lower water-holding capacity. Deep, heavy clay soils may also remain cooler than shallow, rocky soils because they support heavier canopies of mesquite and more herbaceous vegetative cover, both of which shade and insulate the soil from the full heating impact of sunlight. Significant rainfall events, even during the summer, can result in a substantial drop in soil temperature and reduce the temperature below the minimum level for successful mesquite control with aerial spraying.

Suggested Guidelines to Assure that Aerial Spraying of Mesquite is According to Program Specifications and an Acceptable Level of Mesquite Mortality is Achieved

Pre-certification of mesquite growth stage, foliage conditions, and soil temperatures on target areas by agency representatives:

A "Checklist to Determine Mesquite Conditions for Effective Herbicide Control" was prepared by Dr. Darrell Ueckert, and this checklist has been routinely used by Soil Water Conservation District personnel in Texas (see Appendix A). Completed checklists become a permanent record in the contracts of participating landowners to verify the rationale for decisions on aerial spraying. New employees involved with Public-funded brush control programs should be involved in educational or certification workshops for mesquite control. Ideally, each spring, other employees should also receive an annual "refresher" training course in evaluating the suitability of the mesquite conditions and soil temperatures for aerial spraying. District employees who have used the checklist should critique this document and offer suggestions for improvement. Administrators of Public-funded brush control projects should consider developing a written policy for conducting pre-certification of mesquite targeted for aerial spraying and for informing landowners and aerial applicators of the results of these surveys.

Establish legal contracts with aerial applicators:

"Verbal"agreements between landowners and aerial applicators may not effectively communicate the program specifications to participating landowners to commercial aerial applicators and thus may leave the details of aerial application largely to the discretion of the aerial applicator. Procedures must clearly and concisely define all the necessary specifications for aerial spraying of mesquite with clopyralid + triclopyr, as outlined in this report, to either the landowner or the commercial aerial applicator.

The agency administering Public-funded brush control projects, rather than the participating landowners, should establish legal contracts with aerial applicators for aerial spraying with clopyralid + triclopyr. The specifications for aerial spraying mesquite, as provided in this report, should be included in the contracts so that commercial aerial applicators will clearly understand the treatment specifications. All responsibilities of the agency and the applicator, as well as performance standards should be clearly delineated in contracts. A copy of a contract currently used by the Bureau of Land Management in New Mexico is provided in Appendix B.

Use agency representatives as inspectors at herbicide mixing and loading areas:

A representative of the agency administering Public-funded brush control projects should be at the airport or landing strip at all times during mixing and loading of herbicide sprays and take-offs and landings by the aircraft applying aerial sprays for mesquite control to serve as the "Airport Recorder"(AR). A copy of the "Airport Recorder Instruction Manual" and "Daily Aircraft Record Form 802" used in the Texas Boll Weevil Eradication Program is an excellent example that can be adapted to Public-funded brush control programs. The AR serves under the direct supervision of the Brush Control Project Supervisor and performs a range of delegated assignments in accordance with written instructions and established procedures. The

primary function of the AR is to observe and record all activities that occur at the airstrip or landing area while aerial spray operations are in progress. The AR should maintain and provide an accurate Daily Aircraft Record and furnish the aerial applicator with a copy. His responsibilities include overseeing operations to assure the contractor and his employees abide by the contract, the Brush Control Project Supervisor immediately if problems cannot be resolved or suspending operations in the event the Supervisor is not immediately available until he can be located and contacted. The AR will check aircraft spray systems to include:
Checking nozzles, hoses, booms, and hopper for leaks

- Checking systems for compliance with contract specifications, such as nozzle size and type, shut-off valves, by-pass lines, etc.

The AR will also supervise loading of the aircraft, to include:

- Determining the amount of herbicide to load before takeoff
- Determining the amount of herbicide remaining in hopper upon landing
- Comparing amount of herbicide used with acreage treated to assure correct sprayer calibration
- Observing actual loading and metering of all spray ingredients (does not physically assist in handling or loading of fuel herbicide into the aircraft)
- Keeping inventory of herbicide and other spray ingredients (if the agency purchases and furnishes these items)
- Documenting that the meters used to measure water, diesel fuel, and herbicides have been checked by the New Mexico Department of Agriculture for accuracy, and confirming the accuracy of meters at the airstrip by metering out small volumes of each liquid into containers of known capacity
- Maintaining adequate supplies of herbicides and other spray ingredients by informing the Project Supervisor when reserves get low enough to warrant additional delivery (if the agency purchases and furnishes these items).

The AR will complete the Daily Aircraft Record form by:

- Recording all requested information
- Using forms to maintain herbicide usage records
- Documenting routine daily operations, including noting delays and reasons for delays, acres treated and gallons sprayed, and times of all pertinent events start and end of daily operations, aircraft takeoffs and landings, etc.)
- Documenting problems and unusual events that occur during spray operations, including accidents, safety violations or unsafe practices of the contractor or his personnel, herbicide spills or dumps, and leaks in either the aircraft spray system or bulk tank storage systems
- Documenting complaints, and recording visits and telephone calls from the public regarding project activities.

The AR will also maintain communications with the Project employee stationed at the spray target area to:

- Monitor weather conditions, including wind, temperature, and relative humidity conditions at the spray site, watching for approaching rain and storms, monitoring fog or haze at the spray site, watching for temperature inversions, etc.

- Track progression of the spray operation, including advising Project personnel at the spray site when the aircraft leaves and returns to the airstrip, making changes on the Application Log when need recording spray sites missed or sprayed inadequately, and notifying the Project Supervisor if a herbicide spill occurs.

Use agency representatives as inspectors at field locations during aerial herbicide applications:

An employee of the agency administering Public-funded brush control projects should be present at the spray site (within the target area) at all times during spraying operations to serve as a Field Inspector (FI). The duties of the FI should be to:

- Assure that the herbicide treatment is being applied to the correct area and to the entire area designated to be treated, and to report problems to the pilot and Airport Recorder

- Assure that buffer zones adjacent to drainages, dwellings or susceptible plants and areas designated to be left untreated for wildlife are not sprayed

- Record air temperature, relative humidity, and wind Speed/direction and report these data to the Airport Recorder and to the pilot

- Advise the pilot and Airport Recorder when spraying should cease because of excessive air temperature or wind speed or inadequate relative humidity

- Check for ground fog (signs of a temperature inversion) and report this to the pilot and Airport Recorder

- Observe the aircraft for abnormalities during the spraying operation, including functioning nozzles, leaks, etc. and report these to the pilot and Airport Recorder.

Require constant communications capability between field inspectors and aircraft pilots:

Aerial applicators should be required to furnish 2-way radios so that the pilot can be in communication constantly with the Field Inspector while spraying and with the Airport Recorder while to and from the airstrip so that problems can be reported and so that spraying can be terminated for weather or spraying system problems.

Agency should purchase the herbicides or require commercial aerial applicator to deliver herbicides to mixing and loading site in new containers that have not been opened:

Products to be used should be delivered to the site undamaged and in original, unopened containers with the manufacturer's name, Lot number and brand designation and contents legibly indicated. Airport Recorder should inspect all herbicide containers. Any herbicide delivered to the airstrip by the commercial aerial applicator appears to have been diluted with water or diesel fuel or otherwise altered should not be used. The agency administering State-funded brush control projects should investigate purchasing herbicides directly from the manufacturer as a means to reduce brush control costs and for eliminating the chances for product alteration [Contact District Sales Manager, Dow AgroSciences, phone 936 273-9369 office.].

Summary

For aerial spraying with clopyralid at 0.25 + triclopyr at 0.25 lb/acre to be successful in achieving a high level of mesquite canopy reduction, whole plant mortality, and getting full value for each dollar of public funds spent, the spray must be:

- Properly mixed
- Applied at the correct rate
- Applied in the proper total volume of spray per acre
- Applied with the spray carrier and spray adjuvants recommended by the herbicide manufacturer
- Applied in the proper manner with appropriate spraying equipment
- Applied when the weather conditions are conducive to maximize deposition of spray droplets onto the mesquite leaves and absorption of herbicides into mesquite leaves
- And applied when the soil temperature and mesquite growth conditions are appropriate to facilitate the translocation of a lethal dose of herbicide to the basal meristems and roots of the mesquite plants.

Specifications for achieving these critical elements that should be mandated in Public-funded brush control projects are presented in this report. Assurance that aerial spraying operations are conducted according to these specifications and in a manner to improve the probability of achieving an acceptable level of mesquite mortality can be achieved if the agency responsible for State-funded brush control projects will:

- Certify that mesquite growth stage and foliage conditions and soil temperatures are acceptable prior to spraying
- Adopt strict specifications for aerial spraying
- Establish legal contracts with aerial applicators
- Place inspectors at herbicide mixing and loading areas and at sites being sprayed reduce brush control

costs and for eliminating the chances for product alteration.

- Require constant communications capability between inspectors and aircraft pilots
- Purchase the herbicides or require commercial aerial applicators to deliver herbicides to the mixing and loading site in new containers that have not been opened.

Appendix A
Checklist to Determine Mesquite Condition for Effective Herbicide Control

Ranch_____ Date_____

Range Site_____ Pasture #_____

MESQUITE CONDITIONS

1. Current foliage volume as a percentage of "normal"_____% <75%.

"RED FLAG" Foliage has been damaged, removed, or reduced by_____% (Circle appropriate agents that have caused damaged, removed, or reduced foliage volume):

a. INSECT and ANIMAL DAMAGE. Symptoms include: leaflets removed, leaves tied together by webs, insect frass on soil surface, and larvae under loose debris. Lower bark on branches and stems gnawed or removed.

b. HAIL DAMAGE. Symptoms include: leaves on soil surface, foliage "ragged".

c. FREEZE DAMAGE. Symptoms include: yellowing or chlorosis of leaflets and leaf drop.

c. DISEASE. Symptoms include: leaf chlorosis, orange dots on lower leaf surfaces, and leaf drop.

d. DROUGHT. Symptoms include: necrosis of leaf tips and margins, chlorotic leaves, pale green leaf color, or leaf drop.

2. General foliage color. (Circle appropriate color)

a. Dark green
b. Pea green **"RED FLAG"**
c. Intermediate green (Between dark green and pea green)

3. Is there light or pea green foliage in upper tree canopies and on twig tips? (Circle appropriate response.) YES NO YES = **"RED FLAG"**

4. Flower color if present. (Circle appropriate answer)
a. Yellow
b. White **FLAG"**
c. None

5. Pod (bean) growth stage. (Circle appropriate answer)
a. Not present
b. Green and less than fully elongated **"RED FLAG"**
c. Green but fully elongated
d. Ripe
e. Ripe and fallen

6. Notes: Record observations such as the percentage of the trees that appear "normal" and likely susceptible to broadcast sprays, and where these trees occurred (in draws, along roads, in low-density mesquite areas, etc.)

Soil temperature at 18 inches _____F°
Estimated rainfall within previous week_____inches
Estimated rainfall within previous month_____inches

"RED FLAG"= CONDITION FOR POOR SUSCEPTIBILITY TO BROADCAST SPRAYS

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