LANDOWNER'S GUIDE

DWARF MISTLETOE MANAGEMENT

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GAME TRAIL HOMEOWNERS ASSOCIATION

Buena Vista, Colorado

P. Charles Arnold, Jr.

30580 Timberline Drive
Buena Vista, Colorado 81211

email: carnold@dillon.com

The following information is intended to be a practical landowner's guide to managing dwarf mistletoe. It provides basic information on dwarf mistletoe and the chemical ethephon. It then goes through a step-by-step process for managing dwarf mistletoe based on the author's research and own experience. It covers everything from keeping track of what you're doing to a conversion table for liquid measure.

This guide was developed using a variety of university and federal and state governmental sources. Acknowledgment of these sources is listed in **Appendix A**, ***References & Acknowledgments***, and provides references for further research for those interested in doing so. The Management Plan itself is the opinion of the author based on the information obtained from these sources and his own experience, and adapted to the concerns of private landowners. The author is a fellow landowner interested in preserving the natural beauty of his home site to the extent practicable, and not a biologist or horticultural expert.

My thanks to Mike Schomaker, Colorado State Forest Service, Pathologist, Fort Collins, Colorado, and David W. Johnson, Supervisory Plant Pathologist, Forest Health Management Staff for the USDA Forest Service Rocky Mountain Region, for all of their assistance.

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INTRODUCTION

Private land owners are often reassured that dwarf mistletoe works very slowly and their trees will live for many, many years. And besides, you can't do anything about it anyway, right?

The first statement, about living for many years is true, sort of. It depends on how far the dwarf mistletoe infection has advanced in the owner's trees. In any case, if nothing is done to control the infection, an owner is ultimately condemning all of the specific tree species infected to death. The infected trees will eventually cease reproducing themselves, stop all younger trees from maturing and reproducing, and all will completely die out. It may take 60 years, but they will die out. At Game Trail, this generally means the loss of all or your ponderosa pine, the predominant tree at Game Trail, along with most, if not all, of your lodgepole pine.

The second statement, that you can't do anything about it, is entirely false. You can, in fact, get your dwarf mistletoe under control and at least set the stage for it to be entirely eliminated. That is what this manual is all about.

One additional note on taking action now: if your land is in an advanced stage of dwarf mistletoe infection, every additional year you wait to take action, about another 10% of your trees will reach the "point of no return" and move beyond recovery. "Advanced" means 50% or more of your trees are already infected. This means you have about 10 years before none of the infected species can be saved. On the other hand, if it is less than 50% or just on the edge of your land, you have a wonderful opportunity to prevent it from ever getting into most of your trees. And the old saying "An ounce of prevention is worth a pound of cure." is very, very true in the case of dwarf mistletoe.

DWARF MISTLETOE

Dwarf mistletoe is a parasitic plant that grows on conifers. It sinks roots into the branches and trunk of host trees, and draws its sustenance primarily from the host tree's nutrients. There are several dwarf mistletoe species and each is primarily specific to a corresponding tree species. For instance, the dwarf mistletoe species *Arceuthobium americanum* primarily infects the lodgepole pine. Although it spreads slowly and kills slowly, once dwarf mistletoe reaches an advanced stage in a tree, the tree will wither away in 7 or 8 years. Newly infected younger (shorter) trees will be crippled quickly and will wither away in only a few years.

Dwarf mistletoe causes more damage to pine forests than any other forest disease or insect including the pine beetle. In the last 5 years Game Trail has lost about 1,100 trees to pine beetle. In the next 10 years, Game Trail will lose, conservatively, 5,000 trees to dwarf mistletoe. About 135 million cubic feet of commercial lodgepole pine, the most widely distributed conifer in the West, are harvested annually. In comparison, about 275 million cubic feet of timber, twice the amount harvested, are damaged annually in the western United States. Almost 50% of the lodgepole pine and 25% of the ponderosa pine in Colorado are infected. In the last 50 years, damage from dwarf mistletoe has increased substantially due to public forest fire policy. Forest fires are the primary natural constraint on the spread of dwarf mistletoe.

Management

The only way to destroy dwarf mistletoe is to remove the infected branches. Despite substantial research by both public and commercial interests, no chemical treatment has so far been discovered that will destroy the dwarf mistletoe plant without also destroying the host tree. As a practical matter, in large public and commercial forest stands, the disease is primarily controlled by cutting the infested trees and, insome cases, by clear cutting, i.e., cutting down the entire infected forest stand. Branch pruning is too time consuming and therefore not economically feasible in public and commercial forests plus the risk of missing some of the infection is fairly high. Dwarf mistletoe seeds lie dormant or otherwise undetected for several years so containment by pruning requires continuous re-inspection and further pruning for complete eradication.

Clear cutting is generally impractical for the private landowner. While time is usually not a factor in public or commercial forest management, it is ***the*** major factor for the private owner. Clear cutting substantially reduces the quality of living and impairs property values for many years. However, dwarf mistletoe can be effectively managed ***on a small scale*** without just cutting down all the trees. Landowners can "micro" manage their land by re-planting while progressively removing infected branches and individual trees. Instead of remove and replace, you can replace and ***then*** remove. It's just that it's a lot of work.

Replacement of trees that will eventually be lost can begin immediately by re-planting with alternative immune species. Using other species has the added advantage of providing a long-term diversification of the landowner's forest stand that will greatly reduce the risk of future catastrophic losses to a single disease (such as dwarf mistletoe or pine beetle). However, to be successful, the immune species chosen must be reasonably suitable for the moisture, soil, altitude, and other local environmental conditions.

In the mean time, as with any disease, treatment involves trying to save an infected tree (or at least extend its life) while preventing that tree from infecting other trees. Prune infected branches. Spray with the chemical ethephon to inhibit the seeding process on the remaining infected branches of trees you don't want to cut down yet. Remove badly infected trees of any size, and progressively remove large trees that cannot be effectively pruned as each reaches a point of no longer being worth saving.

Plant, prune, spray, and remove.

Description

Dwarf mistletoe (*Arceuthobium*) is a small, flowering plant with leafless shoots of 1 to 5 inches. It is parasitic, attaching itself to trees of the pine family (*Pinaceae*) and drawing its primary nourishment from its host.

It is a dioecious plant, which means it has separate male and female shoots and flowers. Fruits develop on pollinated female flowers. At maturity, the fruits orient downwards at about a 45° angle, and a single, very sticky seed is ejected upwards out of the fruit at the point it breaks from the stem. The ejection is at speeds of up to 60 miles per hour and can travel up to 50 feet (about the width of a road). However, because they tend to shoot upwards, the seeds usually either strike the branches above them or arc and travel only about 15 feet or less. Birds and other animals (chipmunks, squirrels, even deer brushing against the branches) can also contribute to the dispersal because of the sticky quality of the seeds, but this is fairly limited.

It is an obligate parasite, which means it is only able to exist or survive on a live host. Pruning off a branch or cutting down the tree will cause the dwarf mistletoe to die. Any existing fruit will cease ripening so the removed branches or trees do not need to be burned or otherwise destroyed to prevent further infection.

The larger, leafy “Christmas” mistletoe is a different genus, *Phoradendron*, from the smaller, hence "dwarf," mistletoe, *Arceuthobium*. Christmas mistletoe hosts are primarily hardwood deciduous trees. The most common harvested for Christmas is *Phoradendron tomentosum*, grown in Texas on mesquite and hackberry. There is one *Phoradendron* found in Colorado, a leafless variety, *juniperinum*. It is, as the variety suggests, specific to junipers.

Chaffee County Species

There are 5 known species of dwarf mistletoe (*Arceuthobium*) in Colorado of which we have 3 in Chaffee County. Including the specific variety (var.) and subspecies (ssp.), these are:

Principal Host	Dwarf Mistletoe Species
Pinus ponderosa var. *scopulorum* **Rocky Mountain Ponderosa Pine**	*Arceuthobium vaginatum* ssp. *cryptopodum*

This has relatively large shoots with a dark orange coloring. It will occasionally cross over to lodgepole, limber, and bristlecone pine. Firs, Douglas-fir, spruces, and other pines are generally immune to it. This is the most common dwarf mistletoe species found at Game Trail.

Pinus contorta var. *latifolia* **Rocky Mountain Lodgepole Pine**	*Arceuthobium americanum*

This is a much more insidious species. It tends to have finer, yellow-green shoots. It often crosses over to ponderosa pine. It may occasionally also cross over to Douglas-fir, Engelmann and Colorado blue spruce, and bristlecone and limber pine. It is present on the western edge of Game Trail in the public forests.

Pseudotsuga menziesii **Douglas-fir**	*Arceuthobium douglasii*

This is generally specific to Douglas-fir only although it has been known (rarely) to cross over to firs and spruces. It has very small (¼“ inch) shoots and is very debilitating and lethal to the Douglas-firs. We have a single “vein” of this species running through Game Trail.

Other Colorado Species

Principal Host	Dwarf Mistletoe Species
Pinus edulis **Pinyon Pine**	*Arceuthobium divaricatum*
This is specific to pinyon pine only.	
Pinus flexilis **Limber Pine**	*Arceuthobium cyanocarpum*
This is an uncommon species, but does occasionally cross over to bristlecone pine, and (more rarely) to ponderosa and lodgepole pine.	

Appendix B, ***Dwarf Mistletoe Susceptibility Table***, lists the two most common dwarf mistletoe species in Chaffee County for which the principal hosts are Rocky Mountain ponderosa and lodgepole pine. It lists primary, secondary, and occasional-to-rare hosts susceptible to these two dwarf mistletoe species as well as known host species demonstrating immunity.

Life Cycle

From the time dwarf mistletoe fruit "goes to seed" in August or September, it takes ***3 to 4 years*** for about 2/3^{rds} of the seeds that germinate to ***begin to produce shoots***. The remainder takes up to 2 or 3 more years for shoots to appear. After sprouting, the new plant does not flower and produce fruit until spring of the following year. It then takes another year for the fruit to mature and go to seed. That is a total of 5 to 6 years at a minimum, and up to 9 years for some.

Year	Stage	Season	Activity
1	**Seeds**	August - October	Seeds disperse and adhere to host branch or trunk (bole).
2	**Germinate**	March - April	Seeds germinate.
		May - June	Germinated seeds produce radicle (holdfast).
		July - August	Radicle penetrates host and sinks roots. ***No external symptoms***.
3	**Endophytic System**		Plant establishes endophytic system. ***Swelling*** around point of penetration becomes visible.
4	**Shoots**		Shoots appear; swelling enlarges.
5	**Flowers**	April - May	Female shoots produce flowers, and fertilized flowers produce fruits.
6	**Seeds**	August - October	Fruits mature, and seeds disperse to begin new cycle.

Pathology

Endophytic System. After the radicle penetrates the bark, it grows down through the cambium layer of the host branch. The cambium is the outer vascular layer that the tree's water and nutrients pass through. The radicle then encircles the branch through the cambium layer with a cortical strand. The cortical strand extends roots (sinkers) just into the xylem. The xylem is the inner "tree ring" layer. The sinkers stop as they encounter the harder interior xylem (rings) of the branch. Each year, as a new xylem ring grows out, it grows around the sinker, and the sinker grows in the middle to accommodate it. This is the endophytic system or root structure of dwarf mistletoe. Once established, it is there for the life of the tree. The endophytic system can also extend itself up or down the branch (or trunk) for about 6 inches from the point of the radicle penetration, including into sub-branches and back into the trunk itself. Some dwarf mistletoe varieties, e.g. *A. douglasii* (Douglas-fir), are systemic, spreading into the trunk and extending the endophytic system throughout the tree, making *A. douglasii* very debilitating and lethal.

Witches' & Stimulation Brooms. One of the major characteristics of dwarf mistletoe infection is the related formation of "witches' brooms" on the infected tree. Infected branches grow at an abnormal rate to support the dwarf mistletoe. Such "witches' brooms" sometimes become as big around as the tree trunk itself. Because of the abnormal growth, the witches' broom usually becomes gnarly and "blackened" with a profusion of sub-branches. Basically, the typical witches' broom in ponderosa and lodgepole looks like a big, overgrown mutant limb. Birds and squirrels will build nests in them because of the excellent cover they provide. They are also a major fire hazard. In younger trees, the witches' brooms will form into multiple parallel stems (co-dominant stems), giving the tree the appearance of having several main tree trunks. In Douglas-fir the witches' broom is very different, actually looking more like a fireplace broom with a profusion of very small sub-branches.

Presence of a "broom," however, is not always a sure sign of dwarf mistletoe infection although in a generally infected area, you can count on it most of the time. Pine trees will occasionally form "stimulation" brooms that are very similar. Generally, only one stimulation broom, if any, will form on a given tree while an infected tree will continue to develop additional witches' brooms as the dwarf mistletoe progresses.

Damage. As the dwarf mistletoe spreads, a host tree will progressively deteriorate.

- Vigor, i.e., fullness of the branches (the crown) and needles is lost. For instance, on ponderosa, the branches will become shorter and sparser and the pine needles will become noticeably shorter and lose color.
- Height and diameter growth will be cut by about 2/3^{rds}. The tree just simply stops growing in favor of the witches' brooms which draw off water and nutrients from the tree.
- Cone and seed production eventually become non-existent so the tree can no longer reproduce itself.

In older, taller trees, the dwarf mistletoe will eventually begin to choke off the food supply to the top of the tree causing the top of the stem to die off, leaving it with a "spike" on top. From that point on, the tree will slowly die from the top down while the witches' brooms lower down become more and more pronounced. Eventually, the tree will become twisted and blackened with only a few withered branches remaining and, then, finally die.

When trees reach an advanced state of infection at a younger age (under 10 years), they will often form so many deformed witches' brooms that the entire tree becomes severely bent and misshapen in a few years, giving the appearance of a "bonsai" tree. Thus weakened, the younger trees never really mature, never begin to produce pine cones, are more susceptible to other pests like the pine beetle, and will quickly die off during drought conditions.

Where the dwarf mistletoe infection has reached the middle and upper branches of the taller, more mature trees (25 feet and higher), the forest stand enters into a self-destructive downward spiral. All of the new young trees below are infected by the taller trees, the taller trees die from the top down, and both

produce few or no new pinecones. This is accentuated even more where the forest stand is naturally less dense or has been thinned. The "wide open spaces" allow maximum dispersal of the shooting seeds from the taller trees.

The dwarf mistletoe also causes a change in the tree's cellular structure, making the tree unsuitable for commercial lumber. Consequently, when commercial interests thin or harvest an area, they take the good large trees and leave the infected trees. This explodes the spread of the dwarf mistletoe and condemns the remaining middle and lower canopy to a rapid deterioration. If you wanted to propagate dwarf mistletoe, this is an excellent way to do it.

Mistletoe infecting a trunk (bole) 5 inches or more in diameter at the point of infection has a much lower impact on the tree's vigor, growth, and seed production. This means that if all infected branches can be pruned off a tree, it will regain most of its vigor and growth even though its trunk is still infected. Dwarf mistletoe infections on the trunk are also less of a threat because they do not tend to produce seeds.

Finally, squirrels like to eat the swollen bark caused by the initial dwarf mistletoe infection, sometimes completely girdling the tree trunk or branch. There are indications that the squirrels may go deep enough to remove the initial setup of the endophytic system and actually eradicate that particular infection. However, squirrels and other critters will also nibble on uninfected bark, so finding such damage is not always indicative of a dwarf mistletoe infection.

ETHEPHON

Description

Ethephon is a plant growth regulator used to promote fruit ripening, abscission, flower induction, and other responses. Ethephon is registered for use on a number of food, feed, and nonfood crops, greenhouse nursery stock, and outdoor residential ornamental plants. It is also used in accelerating the ripening of fruits and vegetables. It is currently registered in the U.S. for use on apples, barley, blackberries, bromeliads, cantaloupes, cherries, coffee, cotton, cucumbers, grapes, guava, macadamia nuts, ornamentals, peppers, pineapples, rye, squash, sugarcane, tobacco, tomatoes, walnuts, and wheat. It is primarily used with cotton crops. There is a good chance you eat some ethephon treated fruits and vegetables every day.

Ethephon acts by liberating ethylene, a plant hormone, which is absorbed by the plant and interferes in the growth process. In dwarf mistletoe, the release of ethylene causes abscission of most (but not all) of the current external mistletoe shoots, flowers, and fruit. In plain language, they dry up and fall off. It does not kill the endophytic system, however, so the shoots will re-sprout in 1 to 3 years. It is not known what effect repeated sprayings every few years over several decades will have on either the dwarf mistletoe's endophytic system or the host tree's vigor.

Regulatory History

Ethephon was discovered in 1965, and was first registered as a pesticide in the U.S. in 1973. The EPA issued a Registration Standard for ethephon in September 1988 (PB89-109427), requiring toxicology, residue chemistry, and environmental fate and effects data.

Toxicity

Ethephon has the potential to cause severe skin and eye irritation, but otherwise is moderately acutely toxic. It is an organophosphate pesticide, which has the potential to cause cholinesterase (ko-li-nes-ter-ace) inhibition. Simply put, it can cause rapid twitching of some muscles. It is classified as a Group D carcinogen because there is insufficient weight of evidence regarding its cancer-causing potential. Ethephon is ***not*** persistent in the environment, exhibiting rapid degradation and moderate to low mobility in soil. Ethephon is expected to have minimal effects on birds, mammals (including you), fish, freshwater invertebrates, and marine and estuarine organisms.

Trade Names & Use Restrictions

The active ingredient ethephon is found in a variety of commercial herbicides. Trade names for products containing ethephon include Arvest, Bromeflor, Cerone, Etheverse, Etherel, Flordimex, Flordimex T-Extra, Chipco Florel Pro and Prep, and Monterey Florel. The ethephon chemical, itself, is produced by Rhone-Poulenc who holds the patent.

These products are not all classified the same by the EPA and the Colorado Department of Pesticide Regulation. The brand **Monterey Florel** is a 3.9% concentration. It is classified as a General Use Pesticide (GUP). The brand **Ethrel** is a 21.7% concentration. It is classified as a Restricted Use Pesticide (RUP) in Colorado because of the higher concentration.

"General Use" can be purchased at retail whereas "Restricted Use" means the pesticide must be purchased from a distributor by a certified applicator. Under EPA regulations certification can be obtained as a *Commercial Pesticide Applicator* or as a *Private Pesticide Applicator*. The *Private Pesticide Applicator* certification allows an individual to use, or supervise the use of, restricted use pesticides on land owned or rented by the individual or the individual's employer. To obtain certification, an individual must review a 100 page *Private Pesticide Applicator Training Manual*, and complete a 17-page test at home. Check the EPA Region 7 website (http://www.epa.gov/rgytgrnj/programs/wwpd/pests/geninfo.htm or http://ianrwww.unl.edu/ianr/pat/training.htm) for more information on the Training Manual and test.

Sources

The ethephon brand **Monterey Florel**, a 3.9% solution, can be obtained in a quart size at a retail price of about $25. It is available locally at the Pleasant Avenue Nursery. It can also be special ordered in gallon sizes (4 gallons/case) at a considerable savings, but a nursery may want a guarantee that an individual or group will purchase all 4 gallons. In the initial year of the author's dwarf mistletoe control program, the author used four 4-gallon tanks of spray. One 4-gallon tank uses about 1 quart of Monterey Florel so the author used about 1 gallon all together. This was on a 2-½ acre lot with 75% of the trees infected. In subsequent years, the author has used less than 1 tank each year.

The brand **Ethrel**, a 21.7% solution, must be obtained from a distributor and the buyer must have a commercial or private applicators certificate. While a gallon costs twice as much as Monterey Florel, it will actually cost less than half as much because of the much higher concentration.

MANAGEMENT OF DWARF MISTLETOE

Landowner's Approach

As mentioned earlier, a landowner's approach to manage a dwarf mistletoe infestation will differ considerably from the approach taken by public and commercial forest managers. Because of economic constraints, professional managers must completely eradicate the area of forest infected by the dwarf mistletoe and allow 40 or 50 years for reforestation, in effect substituting time for cost. Private landowners, on the other hand, will generally want to trade cost for time. They can provide the labor and bear the expenses required to micro-manage a relatively small residential track of only a few acres, but cannot afford to wait 40 or 50 years because of both property values and the age constraints of landowners themselves.

To quote Frank G. Hawksworth and David W. Johnson in *You Can Save Your Trees From Dwarf Mistletoe*,

> "Control of dwarf mistletoe does not require eradication of the parasite. Not all infected trees have to be cut; instead, the aim of control should be to reduce the amount of mistletoe to a low level. By cutting heavily infected trees and pruning or chemically treating lightly infected ones, your trees can continue to live for many years, providing shade and enhancing the beauty of your home site."

Priorities

1st - Protect uninfected trees, especially big ones.

- Prune, spray, or remove trees within reach.
- Keep “guard” trees.
- Long term – plant immune species around them.

2nd - Stop the seeding.

- Prune off all branches with seeds on trees up to about 20 ft.
- Remove badly infected big trees (over 20 ft).
  - The bigger the tree, the bigger the risk.
  - Must spray large infected trees every year initially and every 2nd or 3rd year after that until removed. If you stop for a few years, everything will become re-infected.
  - But also keep in mind:
    - The bigger the tree, the longer to replace.
    - Removal opens the area and allows seeds from remaining infected trees to go further.
    - A tree may have many more years with proper care.
- Spray what you can’t prune and won’t remove.
  - ***Temporarily*** stops the seeding.
  - Can only prune so much off in one year so may need to combine with spraying.
  - Costs a lot to power spray large trees year after year so need to strike balance between removing worst trees and spraying some bad trees for several years.
  - Probably not 100% reliable.

3rd - Save infected trees.

- Can save trees up to about 20 ft.
- Although you can prune lower branches and greatly restore vigor, you can't save upper big trees because you can't reach branches above about 20 ft.

Planning Factors

Life Cycle. It is important to understand that the life cycle of dwarf mistletoe is very, very long because it will have an impact on your planning. You may have many other dwarf mistletoe infections on your trees that have not even shown swelling not alone shoots. Therefore, it will take 5 or more ***continuous*** years of effort before you have eliminated the latent dwarf mistletoe. You will probably not be able to detect infections from seeds dispersed in the fall of this year until the spring of the year after next, and then only if you look carefully for the swelling. It will be at least another year before the initial shoots make it more obvious. And 1/3rd of the seeds probably won't show up until after that. So once you start working on your dwarf mistletoe, you need to keep working on it for several years, or your work will have gone for naught. It will come right back on you. This is not for the faint of heart.

Uninfected Trees. In the author's case, at least 4 pockets of uninfected ponderosa and lodgepole pines were found, usually composed of 4 to 8 trees each. It is possible that some or all of these trees are naturally resistant. However, the pattern of infection around them would suggest that the dwarf mistletoe seeds had not reached them yet. There are two ways to protect these trees. First, remove (through pruning, spraying, and outright removal) all infection within 50 feet of the uninfected pocket. Tall, badly infected trees pose the most serious threat. Second, and obviously a very long-term approach before it becomes effective, plant a series of immune species as a barrier between the infected and uninfected areas. This will also help prevent re-infection at a later date.

Density of Crowns & Forest. The higher the density, the slower will be the spread of infection. Seeds ejecting in a dense crown will tend to hit the branches immediately above them, and, therefore, never escape the tree. However, once a crown is thinned out by pruning, it is much more likely to successfully eject seeds to surrounding trees. It is also more susceptible to receiving additional infection from other trees as well. Similarly, dense stands of trees tightly packed together are less likely to infect nearby stands and the rate of additional infection within the stand will be slower. But a dense stand has less vigor, is consequently less healthy and more susceptible! One of the worst things to do is to thin a dense stand while leaving dwarf mistletoe in the tops of remaining trees: it will spread "like wildfire" after that.

Neighbors. A 2-acre lot has about 87,000 square feet. The 50-foot perimeter around a 2-acre lot represents an additional 73,000 square feet! This means that owners have almost as many trees bordering their lots within infectious range as they have trees on their own lots. Long term you can re-plant your lot lines with resistant or immune species to act as a barrier. But short term, concerted action by all lot owners with dwarf mistletoe infections is needed.

Timing. Dwarf mistletoe "goes to seed" for 3 to 4 weeks some time between the beginning of August and late October depending on the altitude, climate, and other growing factors. It appears to the author that the dwarf mistletoe fruit at Game Trail ripen and eject their seeds during the last 2 weeks of August, but that may vary depending on the weather in future years. A good target date to have all control steps completed would be August 1st.

Preparation

Assessment. An initial inventory or assessment of the degree of dwarf mistletoe infection on your property is essential to planning your control program. You can be very formal using a survey form and tree tags (see **Appendix D**, ***Work Sections & Tree Tags***, and **Appendix F**, ***Survey Form***), or you can simply draw a rough map of your lot and record approximate counts on some kind of a grid of your property. But, either way or some place in between, you need to start out by walking every foot of your property, look at every tree, and look for mistletoe ***before you do anything else***.

When considering what to do, keep in mind the following points:

- Assessing the extent of infection before beginning will provide a good basis for planning specific activities: where to replant, what to remove, etc.
- Sectioning off areas and marking trees, either singly or in groups, is probably essential just to keep track of what you are doing, what you have already done, what you have remaining to do.
- Keeping some record will provide a basis for evaluating the success of your program from year to year.

Hawksworth Scale. A simple scale to assess dwarf mistletoe infestation developed by Frank G. Hawksworth has become the standard used by governmental forestry departments. The scale sections off a tree, more specifically, the living portion of the crown, into 3 parts: bottom, middle, and top. It then assigns a dwarf mistletoe infestation rating of 0, 1, or 2 to each section. The scale may, therefore, range from 0 to 6 in total for a tree (see **Appendix F**, ***Survey Form***).

0 = no infestation.
1 = less than half the branches are infested.
2 = more than half the branches are infested.

For trees that are already so badly damaged by the dwarf mistletoe that only a small misshapen crown remains at the top of the tree, assign a full 6 rating to the tree on the basis that this is a tree that should be evaluated like other trees rated 6.

Remaining Life. A table was also found in the literature that related the Hawksworth Scale and tree diameter to the probable remaining life of the tree. It is a very basic scale that should probably only be taken as a general indication. For instance, in taking into account tree diameter, and thereby relating to the size and age of the tree, the table breaks down into only two sizes: under and over 9 inches (at chest height). But it will give you some idea as to what to expect.

Remaining Life

	Hawksworth Scale		
	Light 2-3	**Moderate 4-5**	**Heavy 6**
Diameter < 9”	30 years	17 years	7 years
Diameter > 9”	60 years	25 years	10 years

This table has also been included on the survey form included with **Appendix F**, ***Survey Form***.

Schedule

December - January	Order nursery stock from Colorado State Forest Service.
Mid May - Early June	Plant nursery stock.
Mid June	Survey trees for dwarf mistletoe infection and request approval to remove badly infected trees.
Late June - Early July	Prune.
Mid July	Hand spraying.
2nd half July	Remove badly infected trees.
End July	Commercial spraying.

The first year you will need to start your survey in early June and start your pruning and the rest of the schedule as soon as possible. The reason is that everything will take longer the first year. However, the dwarf mistletoe is much more apparent in late June so you will find more than you surveyed when doing your pruning.

Basic Plan

Save the trees that can be saved, and forestall removal of those that can't be saved for as long as you can.

1) **Plant** as soon as you can to replace the trees you are going to remove now or in the future.

2) **Prune** off as many infected limbs as you can each year from the trees you are ***not*** going to remove that year.

3) **Spray** the remaining infected limbs of those trees with ethephon to keep them from seeding and help the host tree get over the shock of pruning and regain its vigor.

4) **Remove** the worst trees.

Plant, prune, spray, remove.

Getting Started

Appendix E, ***How To Get Started***, lists initial steps to start your management program.

PLANT

There are two great times to plant trees: the first was 20 years ago - the other is now.

Unfortunately, all of your trees with advanced dwarf mistletoe infections are probably going to die. It's just a question of when. Those that have already reached a 5 or 6 on the Hawksworth scale will mostly be gone or seriously deteriorated within 7 to 10 years. This especially applies to your big trees that already have substantial infections in the top 2/3^{rds} of the crown. If you use a rough "rule of thumb" of 1 foot of growth per year, that will give you some idea of how long it will take to replace your trees.

Thinning

You don't necessarily have to replace all of the trees lost to dwarf mistletoe (or other infestations for that matter). To some extent, your property may need thinning anyway. When a stand becomes too thick, the trees don't grow as fast because of the competition for water, nutrients, sunlight, etc. They also are weakened by the competition and become much more susceptible to not only dwarf mistletoe, but also other pests, such as the pine beetle, and diseases. So when you select badly infected trees to remove the first year, start with ones that are too close to other trees and need to be thinned out anyway.

A good rule of thumb is to leave at least 15 feet between trees. The actual rule is 7 plus the diameter (at chest height) of the tree in inches. So a 10 inch diameter tree should have 7+10=17 feet of space surrounding it.

Re-Planting with Host Species

The host species, in this case primarily ponderosa pine, has already demonstrated an otherwise natural suitability to the site. So the best thing to do to get the highest survival rate would normally be to re-plant with the host species. However, that is only going to work if you first remove all of the infected trees and/or branches.

Re-Planting with Immune Species

If you want to forestall cutting down all of your trees at once, but still want to start planting for the future now, you need to plant other species that are both suitable to your site and immune to your dwarf mistletoe variety. Looking at **Appendix B**, ***Dwarf Mistletoe Susceptibility Table***, you will see that the immune species for ponderosa dwarf mistletoe are basically your non-pine conifer genera: true firs (*Abies*), Douglas-fir (*Pseudotsuga*), spruces (*Picea*), and junipers (*Juniperus*).

White Fir	*Abies concolor*
Subalpine Fir	*Abies lasiocarpa*
Douglas-fir	*Pseudotsuga menziesii*
Colorado Blue Spruce	*Picea pungens*
Engelmann Spruce	*Picea Engelmannii*
Rocky Mt. Juniper	*Juniperus scopulorum*
Eastern Redcedar	*Juniperus virginiana*

As mentioned earlier, lodgepole dwarf mistletoe is much more insidious with only the true firs being completely immune. Douglas-fir dwarf mistletoe generally only infects Douglas-fir. So, your best bets in Chaffee County are firs, spruces, junipers, and pinyon pine. In general, firs and spruces need more moisture and shade such as north slopes; junipers and pinyon pine are better adapted to drier, sunnier locations such as south slopes and lower elevations. However, make sure you check a planting guide for any specific species, as this is ***only*** a generality. Additional information on the suitability of specific varieties to your location (soil, weather, moisture, altitude, etc.) is available on the Internet at:

http://www.colostate.edu/Depts/CSFS/suitability.html

Seedling Tree Conservation Program

The Colorado State Forest Service has an excellent conservation program that provides seedling trees and shrubs at a very reasonable cost. Our local Salida District office has about 50 varieties generally adaptable to the Upper Arkansas Valley environment. Some are available as bare rootstock in lots of 50, and others as 1" and 2" seedlings in lots of 30. To help maximize the seedling survival rate, the Forest Service also offers a variety of planting aids including items to minimize moisture requirements and protect against wild life damage.

The Forest Service also provides planning and planting services as part of the Seedling Tree Conservation Program. This gives property owners who are non-resident, or physically "challenged" (unable to physically do the work), or "forestry challenged" (unable to determine what is suitable for their location or successfully plant it) a good alternative at a reasonable cost to start re-planting.

However, this ***is*** a state conservation program. The plants must be used for conservation purposes only such as reforestation (including replacement of trees lost to pine beetle, dwarf mistletoe, and other infestations), erosion control, windbreaks, wildlife habitat, etc. Use for homeowner "ornamental" planting or other landscaping is not allowed. You must own a minimum conservation area of 2 acres, and you are not permitted to resell the plants.

Order forms for the following spring are available from the Salida District office in late fall. Orders (including payment) can usually be placed from early December. Seedling quantities are limited, so the earlier you order, the better. Also, you should have a 2nd and even a 3rd choice in mind in case you are too late for the specific variety you initially ordered. The Forest Service will notify you in late April when your order is ready, and you need to pick it up within 2 weeks.

The Salida District office is at 7980 W. Highway 50, Salida, Colorado 81201.

Phone: 719-539-2579
Fax: 719-539-2570
Email csfssal@chaffee.net

Additional information on the Seedling Tree Program is available on the Internet at:

http://www.colostate.edu/Depts/CSFS/csfsnur.html

Planting Aids

Expect to spend (a lot) more on planting aids than you do on the plants themselves. In planting bare rootstock and seedlings, the author has found the planting supplies recommended by the CSFS to be very helpful. In particular at Game Trail, where outdoor use of water is prohibited, the polymer to enhance the soils retention of water, weed barriers to inhibit competitive plants, and rock mulch to retain moisture are essential. Both the polymer and the weed barrier are offered by the CSFS. The weed barrier is offered in 3' wide roles or pre-cut in 3'x3' squares. The pre-cut squares are well worth the extra 10 cents each. If you use rock mulch, you will not need the ground staples to hold the weed barrier down. The rock mulch (called leach rock) is available by the ton from ACA Products (395-3790) out by the Buena Vista Airport. Since there is a delivery charge, you may want to buy enough for several years. Figure 1 ton per 50 trees or shrubs.

When planting:

- Mix some peat or other soil enhancer in with the soil you dig out of the hole, but not more than a third. More than that and the roots will tend to turn in rather than venture out of the initial hole into the native soil.
- Leave rocks in the dirt. Again, the roots need to be acclimated to dealing with rocks before reaching the native soil outside the initial hole.
- Dig your holes in April when the ground is still wet from the snow. Once it dries out, you will need a pickax to dig your holes.

PRUNE

Prune off at the trunk every infected branch you can reach, but do not prune off more than 50% of the branches (crown) in any one year. If you can't prune off all the infected branches in a given year, prune off those with fruit first. Then spray with ethephon until you can prune them off in later years to prevent the remaining infected limbs from seeding and help restore vigor.

As mentioned earlier, dwarf mistletoe is an obligate parasite - once cut off, the mistletoe will die so you do not need to remove or burn the slash to prevent further spread of infection. However, while the dwarf mistletoe ruins the wood for lumber purposes, it is quite suitable for firewood. In addition, the pruned branches, especially "witches' brooms," are a fire hazard so they do need to be hauled off or cut up for firewood.

Cut Outs

One of the saddest things to find is a young tree with a trunk infection. Branches you can prune off, but once in the trunk, you've basically lost the young tree. You may as well remove it and make space for the healthier trees surrounding it. However, the author has observed a number of trees that have had a substantial section of trunk on one side eaten down to the xylem layer. This has presumably been done by squirrels attracted by a dwarf mistletoe infection on the trunk. The author has also observed branches chewed on the same way, but usually the branch is girdled and dies. Generally, the dwarf mistletoe does not reoccur around the edges of the damage site indicating that the squirrel "licked the bowl" so to speak and got all of the endophytic system at that point.

Taking a queue from the squirrels, the author tried a new procedure in 1999: an arceuthobiumectomy. Using a sharp hunting knife, single, new infections on the trunks of young trees (up to about 10 feet) were cut out using basically an upper and lower cut into the infection, creating a wedge that could be removed. The wound was then inspected for signs of remaining dwarf mistletoe roots (little black specks), and a little additional whittling was done if found. In all, 35 trees had cut outs. It is still too early to evaluate the success of the program, but upon inspection in 2000, it appears to be about 80% successful so far. The other 20% shows signs of new shoots emerging around the edge of the cut out.

Tools

The author uses pruning shears, lopping shears, a small bow saw, a 6 ft. pole pruner, a 15 ft. extendable pole pruner, and a 20" chainsaw. While larger branches, over 3" to 4" in diameter, could be pruned with the pole pruners, the chainsaw was pretty much a necessity given the number of trees being pruned (and removed). Taking off a witches' broom with a pole pruner is a *lot* of work. The extendable pole pruner was especially useful for higher branches that were too dangerous to reach with the chainsaw.

Pruning Procedures

Conifers may be pruned any time of year. Pruning during the dormant season (late fall, winter) will minimize sap and resin flow, and reduce the risk of invasion by other pests while the wound is healing itself. However, it is much more difficult to spot the dwarf mistletoe outside of it's prime growing season (June-July), and you will also be allowing branches bearing fruit to go through the seeding period (August-October).

Don't actually prune flush to the trunk. There should be about a ½" to 1" stub. When "pruning off at the trunk," you should prune just outside the *branch bark ridge* that grows on the topside between the trunk and the limb, and the *branch collar* that grows on the underside at the base of the limb. A good cut should start just outside the branch bark ridge and angle down and ***away*** from the trunk.

When using a saw, support the branch with one hand while sawing. If the branch is too large to support by hand, or if using a chainsaw (which requires two hands), **always** do a 3-cut prune.

3-Cut Prune

1st Cut 5 or 6 inches outside the branch collar, make a shallow notch on the **underside** of the branch. The bigger the branch, the deeper the notch should be and the farther away from the branch collar, but not so deep as to bind the blade of the saw. This will prevent the limb from ripping back into the trunk when it is cut off with the 2nd cut.

2nd Cut From the **topside** of the branch, and **outside** the 1st Cut, cut the branch completely off, leaving a long stub.

3rd Cut Cut the long stub off just outside the branch bark ridge as you would normally do in a single-cut prune.

Chainsaw Safety

The author is not a professional or particularly experienced chainsaw operator, but would like to offer the following in the interest of everyone's safety. If uncomfortable with using a chainsaw, you may want to hire a professional to come in and do the work for you.

- When using a chainsaw, be very, very careful - they are very unforgiving.
- Always be conscious of where your feet are when cutting low - chainsaws are even better at cutting human limbs than tree limbs.
- Keep other people outside of your "swing distance."
- Keep it oiled and keep it sharp.
- Don't overtax yourself - that's when most accidents occur.
- It is strongly recommended that somebody else be around when you are using the chainsaw. If you have an accident, there is a good chance you won't be able to get help yourself.
- The author would not go higher than the 3rd step of a stepladder when using a chainsaw, and then only with some trepidation. The author also always had somebody steady the stepladder from the side opposite the branch being pruned, and always turned the chainsaw off before descending the ladder - even one step. Because you need 2 hands for a chainsaw, using an extension ladder is very difficult.
- Witches' brooms tend to be incredibly heavy, and, therefore, unpredictable and dangerous. Consequently, when cutting witches' brooms, you will generally need to cut them off in pieces before you make the final 3-cut prune at the trunk. Make sure your helper stays out from under a witches' broom when you are working on it.

SPRAY

Objectives

The primary objective of spraying with ethephon is to stop trees infected with dwarf mistletoe from going to seed and infecting other trees. Due to the long life cycle of dwarf mistletoe, fruit should not reappear until at least the 2nd year after spraying, and seeds will not be ready for ejection until at least the 3rd year.

As mentioned earlier, the taller trees are the most dangerous because they have the widest dispersal from their upper branches. These will require commercial spraying (with power equipment) that can reach up to 50 feet because hand sprayers will only reach about 20 feet. Saturation levels will be lower than with the hand spraying. It is also more difficult to saturate overgrown witches' brooms. Consequently, continuous annual commercial sprayings for several years will be necessary in order to "get the parts" that were missed by earlier sprayings. In addition, when you first start, there will be seeds in place in various "pre-sprout" stages because of the long life cycle. So, between the missed "parts" and the "invisible" seeds, repeated sprayings will be needed for the first 4 to 5 years. After that, you can probably go to every other year.

The second objective of spraying with ethephon is to reduce the drain on the host tree's nutrients by the dwarf mistletoe. Theoretically, if you have caused most of the external dwarf mistletoe to dry up and fall off, there is that much less parasite to be supported by the host tree's food system - at least for 1 to 3 years until the dwarf mistletoe shoots grow back. There should be a substantial impact on the tree's vigor. However, it appears that there has been very little study of the long-term effect of using ethephon on dwarf mistletoe, so the long-term impact on vigor is unknown. Removing witches' brooms will have a much more pronounced effect on vigor.

Equipment

For hand spraying, the author used a 4-gallon backpack sprayer. It was a Solo brand sprayer, Model 425 with a piston pump for about $80 that worked quite effectively. In addition, the author also replaced the 2 ft. plastic wand and standard nozzle that comes with the sprayer with a 5 ft. brass wand and adjustable brass nozzle at a cost of an additional $28. The 5 ft. wand is essential for reaching the tops of 15-20 ft trees. The adjustable nozzle is essential for adjusting "on the fly" from mist spraying dwarf mistletoe clusters within reach of the wand to directed stream spraying the tops of the 15-20 ft. trees.

Personal Protective Equipment (PPE)

EPA regulations specify that applicators and other handlers must wear long-sleeved shirts and long pants, waterproof gloves, shoes plus socks and protective eyewear. In addition, the author used a cheap plastic poncho, an old wide brimmed hat, and a simple workshop breathing filter over the nose & mouth. In practice, the goggles and breathing filter were sometimes difficult to use when the humidity was unusually high because it would fog up his eyeglasses. The author also always showered and changed clothes immediately after completing a spraying session.

Commercial Spraying

Infected trees over about 20 ft. require commercial power spraying equipment to reach the higher branches. Initially having some 53 infected trees in this category, the author contracted with Jetco Service & Supply in Nathrop to power spray the trees. The spraying took about 2 ½ hours or about 20 trees/hour. The commercial rate per tree is very similar to the rate for pine beetle spraying, somewhere in the $10 per tree range.

Mix

Manufacturer's recommended application rate for dwarf mistletoe is 2,700 ppm (parts per million). However, in US Forest Service tests, they found no discernible difference between 2,700 and 2,200 ppm. The author therefore used the 2,200 ppm rate for both the hand spraying and the Jetco commercial spraying. However, since a 1-quart bottle conveniently makes up one 4-gallon tank, the author reverted to the recommended 2,700 ppm after the first year “just to be safe.” Likewise, Jetco preferred to use the recommended mix as well so as to insure they were not shorting their customers. Also, half the 2,700 ppm rate is recommended for Douglas-fir because the higher rate may result in excessive needle drop. Detail mix requirements for both Monterey Florel and Ethrel along with a Liquid Measure Table are included in **Appendix C**, ***Spraying Mix***.

Surfactant

It is also recommended that a surfactant, or "spreader-sticker," such as Ortho X-77 Spreader or Hi-Yield Spreader Sticker, be added to the mixture to increase spread, absorption, and adhesiveness. The amount required is pretty minimal when used with a defoliant like ethephon: about 1 oz. per 4 gallons so 1 pint (16 oz.) should be more than enough for several seasons.

Application & Usage

The application rate varies quite a bit between shorter trees (up to 15 to 20 feet) that can be done with a hand sprayer, and taller trees (up to 50-55 feet) requiring commercial spraying. For shorter trees, the author averaged about 8 trees per mixed gallon or .125 gallons per tree. For taller trees, Jetco averaged about 2.1 gallons per tree or about 17 times more per tree than the hand spraying. This is partially because of the geometric increase in crown volume as the tree becomes taller. Effectively, a 50 ft. tree crown has 310 times the cubic feet of a 7 ft. tree.

Tree Height	Crown Area (in cubic feet)	Ratio
7	17	1
15	262	15
35	1,178	69
50	5,278	310

The higher commercial usage is also because the hand spraying is done directly to each mistletoe plant found on a tree while the application to the taller trees is a general spraying for saturation from opposite sides of each tree.

Weather

The manufacturer's instructions specify that the ethephon product should be applied at temperatures between 60° and 95° F. Spraying sessions have sometimes been done just prior to rainfall. In general, it appears that the rain had little effect, probably due to the use of the surfactant plus a tree's natural ability to shield the interior of the crown from rain. Given daily mountain weather cycles in July (rain in the afternoon), the most opportune time for spraying will usually be in the morning as soon as it warms up a little (above 60°).

Effect

The ethephon takes 1 to 2 weeks to work. The shoots literally dry up and fall off. You can physically see a lot of dead shoots lying around the base of each tree after several weeks. Besides destroying the shoots and the fruits, it also considerably improves each tree's appearance. Because of the 2 weeks required to do its work, the ethephon needs to be applied by late July to provide a safe interval before the start of the seeding process.

REMOVE

Selection

The initial decision to remove a tree can be done the first time you walk through the property. The overall removal plan can then be reviewed for strategic considerations such as proximity to uninfected groups, and value as a barrier to infected taller trees and neighbors' trees. The condemned trees can then be re-evaluated when pruning, again when spraying, and again when finally removing the selected trees. As noted earlier, chopping down a tree is pretty final. As long as you get them down before the 1st of August, it doesn't otherwise matter whether you take them down first or last. But, if you take them down last, you will probably find that you will change your mind on some of the more borderline trees, if only to delay removing them for another year or two.

Also, you need to get approval from the Homeowners Association at Game Trail before you remove any tree over 3 inches in diameter at the base. By identifying the trees you want to remove at the start of the program, you will then have time to go through the approval process while you complete the rest of your program.

Cutting Procedures

The following is mostly an excerpt from the Colorado State Forest Service's booklet, *Landowner Guide To Thinning*.

As with earlier admonitions about chainsaws, cutting down trees is **dangerous**! Don't overtax yourself or your chainsaw. For very large trees, you should probably hire a professional to do the removal.

Step 1 - Determine where you want the tree to fall.

This is the side on which you will make your "falling notch" described in **Step 4** below. A leaning tree or a tree with branches mostly on one side (especially witches' brooms) may fall only one way. If that is an unsafe or threatening direction (house, fencing, utility modules, etc.), you may need to significantly prune off the unbalancing branches to get it to fall in a safe direction. If the problem branches cannot be safely reached for pruning, or if the tree is very large (bigger than a 12" to 15" diameter), you should probably consider having a professional tree remover come in to do that particular tree.

Step 2 - Clear your cutting area.

Cut off limbs that are close to the ground so they won't snag your clothes or hinder your cutting. Trim back any brush overhanging your work area.

Step 3 - Escape route.

Always have an unhindered escape route that you can take when the tree begins to fall. It should be well away from the tree's falling direction and back to one side, but ***not*** directly behind the tree. Trees can have a pronounced "kick back" in the opposite direction after they fall when they complete the break off at the stump. Don't ever stand directly behind the tree as it falls - even lumberjacks have had their chests (or worse) stove in from making that mistake. If the tree is falling at 12 o'clock, your escape route should be around 4 o'clock or 8 o'clock.

Step 4 - 3-Cut.

1st Cut **Flat cut** into at least 1/3rd of the tree's diameter no more than 4" above the ground on the side you want the tree to fall. Two inches is probably about as low as you are safely going to get with a chainsaw.

2nd Cut Above the 1st Cut, **slant cut** at a steep angle (about 60°) into the flat cut to form your "falling notch." A lesser angle will compress too soon and will not control the tree's falling direction. This can compensate a little for an unbalanced tree, but not very much. Generally, a tree is going to go where the big witches' brooms are regardless of where you put the notch.

3rd Cut From the opposite side of the tree, **back cut** (also a flat cut) a minimum of 2" **above** Cut 1.

Timber! Take your finger off the chainsaw trigger, and head out your escape route.

Step 5 - Hang-ups.

Trees may get stuck on other trees as they are falling. Like a "kick back," these "leaners" can also be very dangerous because they may fall suddenly. Sometimes rolling the tree will prompt it to fall. A safe way to handle a difficult one is to winch or pull the tree with a chain and vehicle until it comes free and falls.

Appendix A

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Appendix B

DWARF MISTLETOE SUSCEPTIBILITY TABLE

	Ponderosa	Lodgepole
Dwarf Mistletoe Species	***Arceuthobium vaginatum*** ssp. ***cryptopodum***	***Arceuthobium americanum***
Principal Host	Rocky Mountain Ponderosa Pine *Pinus ponderosa* var. *scopulorum*	Rocky Mountain Lodgepole Pine *Pinus contorta* var. *latifolia*
Secondary	None	RM Ponderosa Pine *Pinus ponderosa* var. *scopulorum*
Occasional To Rare	RM Lodgepole Pine *Pinus contorta var. latifolia* Bristlecone Pine *Pinus aristata*	Douglas-fir *Pseudotsuga menziesii* Engelmann Spruce *Picea Engelmannii* Colorado Blue Spruce *Picea pungens* Bristlecone Pine *Pinus aristata* Limber Pine *Pinus flexilis*
Immune	White Fir *Abies concolor* Subalpine Fir *Abies lasiocarpa* var *arizonica* Douglas-fir *Pseudotsuga menziesii* Colorado Blue Spruce *Picea pungens* Pinyon Pine *Pinus edulis* Rocky Mt. Juniper *Juniperus scopulorum* Eastern redcedar *Juniperus virginiana*	White Fir *Abies concolor* Subalpine Fir *Abies lasiocarpa* var lasiocarpa

Appendix C

Spraying Mix

Adjusting Mix For % Concentration & PPM

The table below lists ounces of a 1% ethephon solution required to be mixed with 1 gallon of water to achieve 2,700 ppm and 2,200 ppm. To adjust to other % concentrations like Monterey Florel's 3.9%, divide the ounces required for a 1% solution by the active ingredient percentage of the brand being used. For instance, for Monterey Florel at 2,700 ppm, divide 31.2 oz./gal by 3.9% to determine the mix *rate* of 8 oz of Monterey Florel per 1 gallon of water. To determine the mix *ratio*, divide 128 oz. (1 gallon) by the 8 oz. of Monterey Florel to determine a ratio of 16 parts water to 1 part Monterey Florel.

Per 1% Ethephon Solution	
2,700 ppm	31.2 oz/gal
2,200 ppm	25.4 oz/gal

Ethephon Brand Mix

	Ratio	**Per 1 Gallon**	**Per 4 Gallons**
Monterey Florel - 3.9%			
2,700 ppm	16.0 to 1	8.0 oz.	32 oz. (1 qt.)
2,200 ppm	19.6 to 1	6.5 oz.	26 oz.
Ethrel - 21.7%			
2,700 ppm	89.0 to 1	1.5 oz.	5.75 oz.
2,200 ppm	109.3 to 1	1.2 oz.	4.7 oz.

Liquid Measure Table

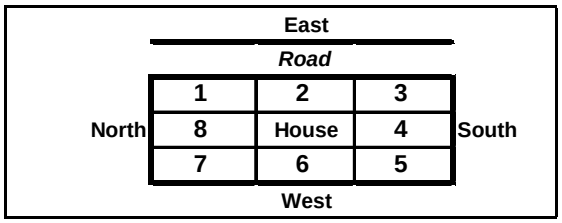
Ounces (oz)	**Equals**	**Equals**
.167	1 teaspoon	
.500	1 tablespoon	3 teaspoons
1	1 fluid ounce	2 tablespoons
8	1 cup	8 ounces
16	1 pint	2 cups
32	1 quart	2 pints
128	1 gallon	4 quarts
512	1 tank	4 gallons

Appendix D

Work Sections & Tree Tags

Work Sections

It is easier to find trees and plan work if you break your lot up into workable sections. The author used a simple system that sectioned off the lot into a 3X3 grid using the road and the house as basic reference points.



The author also used the driveway as a natural dividing line between sections 2 and 3-4. Other natural features of your lot could also be used.

Tree Tagging

Actual tagging of each tree made it a lot easier to keep track of each tree and will make it a lot easier in future years to evaluate the effectiveness of the management program. However, it is also a lot of work. In the author's case, the author realized after about the first 20 trees that he already did not have a clue as to which trees he had already surveyed and which tree belonged to which Hawksworth count. Since there turned out to be over 350 pine trees on a little over 2 acres (which was much greater than the author would have ever guessed), stopping and tagging the trees before going any further turned out to be very worthwhile despite the time it took. Only pine trees over thigh high were tagged. Smaller trees and all deciduous trees were not included in the survey.

However, if you are dealing with a lot fewer trees, or otherwise would prefer not to tag your trees, as an alternative, you might try tagging only every 5th or 10th tree, or only one tree in each cluster or group (Section 1, Cluster 1, etc.).

If you do want to tag, a variety of tree tags at various costs is available from Forestry Suppliers, Inc. (you'll *love* their catalog!) 1-800-647-5368. www.forestry-suppliers.com The author selected 1¼" round aluminum tags that were pre-numbered from 1-1000 and then used the 100's for Section 1, the 200's for Section 2, etc. Try to start at a logical place in each section so it is easy to find tree #101 in Section 1, tree #201 in Section 2, etc. Then proceed to methodically move through the section, e.g., left to right, back to front, etc.

Appendix E

How To Get Started

1) Survey your lot.

a) If there is no house on the lot, you need to start by deciding the general area for house location.

b) Generally identify
- § Locations of both Infected and healthy trees.
- § Where you need to thin and about how many.

c) Evaluate those trees for
- § Badly infected – 5's & 6's.
- § Most valuable trees, infected or healthy
- § Infected trees that pose a threat to healthy (including lightly infected) trees.
- § Neighbors' infected trees that pose a threat.

2) Remove & Spray.

a) Remove immediately:
- § All topped out trees.
  - Ø By definition, these really can't be valuable trees – they will continue to deteriorate, becoming more and more unsightly, and be dead within 7 to 10 years, possibly less.
- § Infected "Loners" around healthy trees.

b) Progressively remove over a period of years:
- § All remaining 5's & 6's that pose a threat.
  - Ø Starting with least valuable and finishing with most valuable.
  - Ø Spray remaining 5's & 6's each year until removed.
- § Excess trees where thinning is needed – remember the 15 ft. rule.

3) Plant.

a) Estimate trees that need to be replaced.
- § This should be the total infected trees less those that need to be thinned anyway.

b) Plant at least 30 trees per year until replacement estimate reached. 30 is the minimum CSFS seedling order.

4) Prune.

a) Witches' brooms on 5's & 6's not being initially removed, starting with most valuable.

b) Witches brooms on all other trees.

c) All infected limbs with fruit on them that you can reach.

d) All other infected limbs.

e) Spray all infected limbs not removed each year.

Appendix F

Survey Form

The following Dwarf Mistletoe Survey form provides columns and lines to record basic information and the actions taken on each tree. It also includes a Location Grid, Hawksworth Scale, and Remaining Life Table.

Some suggestions on using the columns provided:

Location - Enter whatever identifier scheme you decided upon: 101, 102, A1, A2, etc.

Species - A single letter abbreviation is suggested for each type of conifer. Ponderosa, lodgepole, and Douglas-fir are the primary species threatened by dwarf mistletoe at Game Trail. Other conifer species are optional, but you may want to know the locations of other species as well when planning your re-planting or just for your own information. Figuring out what they are can be half the fun.

Circumference - It was much easier and more accurate to measure the circumference (chest high - about 4½ feet) than the diameter. This will be very helpful in assessing the vigor of the tree in future years. Infected trees will generally be much shorter than other uninfected trees of similar circumference.

Diameter - The formula for converting circumference to diameter is $D = C/\pi$ where $\pi = 3.1416$. The author set the survey up on an Excel spreadsheet, which made applying the formula even simpler. Also note that removal of trees over 3" in diameter (at base) requires the prior approval of the Game Trail Homeowners Association.

Height - A range of heights was used rather than estimates or actual measurements (which would require a surveyor's theodolite). The author used height primarily to determine trees requiring commercial spraying, and to look at the overall characteristics of a stand (how many young trees, how many tall trees, etc.). For these purposes, ranges worked quite well. A range is actually more consistent than estimates with the naked eye, and actual measurements would have been very time consuming even if the author had the necessary surveyor's equipment.

The author used a simple range using his own height and the height of the house as reference points. The house reference point was a little fuzzy since the author's lot slopes quite a bit from back to front, but it still provided a standard, comparative measurement.

Range	Height
1	Under 6 ft. – eye level.
2	6-15 ft. - still reachable with extension wand on hand sprayer.
3	15-30 ft - tall, but lower than the house.
4	30 ft or more - higher than the house.

Other Damage - This column was used to note trunk damage from squirrels, spiked out trees, trees that were "98%" dead, evidence of other infections, etc.

Take Out - The author used a simple "**x**" in this column to indicate trees to be removed. On removal, a second "**x**" was placed in the column.

Ethephon Applied - X's were also used in these columns.

PB - Sprayed for pine beetle. Since the trees were all labeled, this was a simple way to use the survey to keep track of which trees were also sprayed for pine beetle.

Dwarf Mistletoe Survey

Name________________________ **Date** ______________

Lot________________________

Work Sections

	Road	
1	2	3
8	House	4
7	6	5

P	Ponderosa
L	Lodgepole
Y	Pinyon
D	Douglas-fir
S	Spruce
F	Fir

1	Under 6 ft
2	6-15 ft
3	15-30 ft (Lower than house)
4	30 ft or more (Higher than house)

Hawksworth Mistletoe Infestation Scale

Branches Infested:		Less	More
Crown	**None**	**Than 1/2**	**Than 1/2**
Top	0	1	2
Middle	0	1	2
Bottom	0	1	2
	0	3	6

Remaining Life (Years)

Hawksworth	Light	Moderate	Heavy
Diameter	**2-3**	**4-5**	**6**
Under 9"	30	17	7
Over 9"	60	25	10

					Hawksworth 0-2				Other	Remaining	Take	Ethephon Applied		
Location	**Species**	**Circum**	**Diameter**	**Height**	**Bottom**	**Middle**	**Top**	**Total**	**Damage**	**Life**	**Out**	**Hand**	**Service**	**PB**

Sprayed for Pine Beetle PB