FUEL REDUCTION OPTIONS FOR LANDOWNERS AT THE WILDLAND-URBAN INTERFACE

Technical Paper

for

Master of Forest Resources & Conservation

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Introduction

The wildland-urban interface can be defined as the area where flammable wildland fuels are adjacent to homes and communities (Long and others 2005). The tranquility and natural setting of wildland areas are characteristics that are appealing to many who desire to leave the congestion and fast pace of the city. These appeals, coupled with the need to grow due to increases in population, have resulted in an urban sprawl that has placed many homes at the interface. A primary threat to these homes is damage or destruction from wildland fire.

Fire is a natural occurrence in many plant communities across the South. In fact, some plant species depend on fire to complete or maintain their life cycles (Figure 1). Ecosystems that burn regularly rarely encounter catastrophic fires, because the fuels on the forest floor, and shrubby vegetation, do not accumulate to hazardous levels. Periodic fires, caused by either lightning or prescribed burns, consume most of these surface fuels. As people and homes migrated to rural areas, regular fires were suppressed to reduce risk to structures. This suppression allowed vegetative growth to go unchecked and to amass fuel loads capable of supporting intense fires.

Figure 1. Wiregrass, *Aristida beyrichiana*, is a fire dependent species. This photo was taken just two days after a prescribed fire in Waldo, FL. Notice the new shoots emerging. (Photo by D. Doran)

Fuels, in a wildland situation, are defined as plant materials that can ignite and support a fire (Bond and van Wilgen 1996)**.** They can originate from an abundance of sources but are primarily living and dead material from grasses, vines, shrubs, and trees. In many southern forests, substantial amounts of fuel accumulate every five to six years (Wade and Lunsford 1989). The reduction of fuels around structures will greatly reduce the risk of damage caused by wildfire (Cohen 2000).

Vegetative fuel reduction is a principal component of most wildfire hazard mitigation plans (Florida Division of Forestry 2000). However, conducting fuel reduction practices can be complex for individual landowners, especially for those owning parcels greater than one acre in size. Many interface properties are either too small or are in unsuitable locations to perform the fuel management techniques that are typically used on larger landholdings. The primary goal of this report is to investigate fuel management techniques that are suited for small landowners living in the wildland-urban interface. Prescribed fire, herbicide treatments, mechanical treatments, and the utilization of livestock for fuel reduction will each be reviewed for their effectiveness and associated costs.

A study has been initiated that will compare the effectiveness, cost, and longevity of three vegetation management techniques. Prescribed fire, mechanical mowing and herbicide applications have been conducted on research blocks in the Austin Cary Memorial Forest. The vegetation was sampled prior to each treatment and a control site was left in each block. As the study progresses, information regarding the lasting effect of each treatment will be acquired, providing landowners with the necessary information to make a reasonable estimate of the treatment that best suits their needs. This study is described and documented in Appendix 3 in this report. Additionally, two extension publications have been drafted that will assist landowners in choosing fuel management techniques and in selecting and maintaining fire-safe plants. The two drafts are also appended to this report (Appendices 4, 5).

Prescribed Fire

Prescribed fire is the controlled application of fire over a predetermined area to achieve a specific set of objectives (Florida Division of Forestry 2000). A prescription is usually written for each fire that includes a set of environmental conditions required before ignition can occur. Prescribed fire is a tool that has been used for fuel reduction since the early 1900's (Wade and Lunsford 1989).

Other beneficial uses for fire include: increased accessibility to stands, nutrient cycling, wildlife habitat improvement, ecosystem maintenance, increased palatability of vegetation for grazing animals, and site preparation for reforestation. In the South, over four million acres are burned annually using prescribed fire (Haines and others 2001). Due to increased populations at the interface and other social factors, that statistic is expected to decrease in the future.

In interface situations, the most common objective of prescribed fires is the reduction of hazardous fuels. Given that objective, prescriptions vary based on season of burning, existing fuel loads, and current weather conditions. On sites that have not had fire within the previous 8 to 10 years, initial burns should be conducted during the cool season (Campbell and Long 1998, Sackett 1975).

There are many elements to consider when preparing for a prescribed burn. Firelines must be created to disrupt fuel continuity around the boundaries of the proposed burn area. These lines, created by tractors, displace fuels on the ground leaving bare soil in an effort to contain the fire by removing the fuels. In some southern States, it is required that mangers contact and obtain a permit from local forestry agencies in order to legally perform a prescribed fire. Permits may or may not be available depending on current weather conditions. Burning without a permit may result in a citation and/or a fine. Burn plans are also required in many southern States. Managers write burn plans that include: fire weather, expected conditions, desired conditions, fuel type and loading, and the basic plans to carry out the burn. Contingency plans are often included in the event that a fire may escape the desired boundary. Many other elements such as proximity to nearest water source and fire services should also be considered.

A number of firing techniques exist for conducting prescribed burns. In sites with heavy fuel accumulations, backing fires are the most common. A backing fire is set on the downwind side of the desired burn unit; because the fire moves against the wind, flame heights remain low (Figure 2). This is the slowest firing method, moving 60 to 200 feet per hour, but it is the safest in areas with heavy fuels (Wade and Lunsford 1998).

Figure 2. A prescribed burn near Waldo, FL designed to reduce hazardous fuels. (Photo by A. Behm)

Head fire and strip-heading fires are set on the upwind side of a burn area, which allows the wind to "push" the fire in the direction of the fuel (Figure 3). They are more intense and faster moving than backing fires, and they usually consume a greater percentage of available fuel (Wade and Lunsford 1998). For fuel reduction burns, head and strip-head fires should be used carefully and when fuel loads are low. Due to differences in fuel moistures, fuel loads, dominant vegetation, and other variables, the results of a prescribed burn may not be uniform across a burn unit. Burn areas should be thoroughly evaluated, both before and after the fire, to determine the effectiveness of the treatment in accomplishing the stated objectives of the fire (Wade and Lunsford 1998).

Figure 3. A prescribed fire with short interval strip head fires used for fuel reduction at Austin Cary Memorial Forest near Gainesville, FL. (Photo by D. Doran)

Prescribed fires must be repeated in order to maintain safe fuel loads. Sackett (1975) determined that a three-year burn interval is optimum for minimizing wildfire potential and damage. Also suggested was the use of back fires when initiating a burn program, especially in areas that contain heavy rough. McNabb (2001) suggests that cool season backing fires can be conducted every two to five years. A twelve-year study in Florida determined that one year after a burn, the total amount of accumulated litter was 4,339 pounds per acre (ovendry). After the second year that number increased to 5,930 pounds per acre (ovendry). At the end of the fourth and twelfth years, accumulated fuels were 8,092 and 13,847 pounds per acre (ovendry), respectively (Sackett 1975). After 8 years, the fuel accumulation began to level off. The same study determined that the understory increased in height as well as weight. Gallberry measured 15 inches in height in the first year but grew to 42 inches by the twelfth year. Palmetto had a similar response, growing from 26 inches to 45 inches over the same time period. Height growth directly affects fire behavior, increasing the amount of available fuel and the height of the flaming zone (Sackett 1975). In another study, a February prescribed fire reduced gallberry coverage by five percent and litter coverage from 17.7% to 8.7% (Moore et al. 1982).

In 2002, the overall cost for prescribed burning in the South decreased 19% over the previous two years (from $17.70 in 2000 to $14.41 per acre in 2002). The cost of three different burning treatments ranged from $13.25 to $18.07 per acre (Dubois et al. 2003). The range of costs reflects differences in objectives, fuel loads, burn unit size, and other variables. Private companies or consultants plan and execute prescribed burns for a fee. Private landowners can also get assistance from state agencies to carry out prescribed burns. Often, the state assistance is free if the objective of the burn is wildfire hazard reduction. For example, in areas where private vendors cannot provide the service, the Florida Division of Forestry will assist landowners burning up to 250 acres per year. They will contract burn for $10.00 per acre for the first 50 acres or less and $6.00 per acre for additional acreage. In addition, they will construct fire lines at a rate of $50 to $80 per hour (Florida Division of Forestry 2000).

There are inherent risks associated with prescribed burning. The obvious risk is that a fire will escape its intended burn area and cause human casualties and property loss. Smoke management also generates a large amount of concern. Smoke can greatly reduce visibility on roads and near airports (Winter et al. 2002). There are also health issues involved with the dispersion of smoke in populated areas. Individuals with respiratory problems are most affected. Particulates in the smoke complicate their existing ailments and can create problems for healthy individuals. Also, the particulates can aggravate individual's eyes causing discomfort and reducing their ability to see clearly.

Many of these risks can be mitigated by comprehensive planning. The most important factor to consider is the weather. If current weather conditions do not correspond with the desired conditions as indicated in the burn plan, then ignition patterns should be altered or the burn should be postponed until a day when desirable weather is present. Humidity, wind speed and direction, and fuel moisture influence fire behavior greatly and should be given special attention throughout the day of the prescribed burn. When weather conditions deviate from the plan, then the fire should be immediately extinguished. Smoke management is also based on wind speed and direction. By identifying areas that are sensitive to smoke, burning can be conducted when wind will disperse smoke in an acceptable direction. Pay special attention to hospitals, major roads, airfields and other sensitive areas. By contacting surrounding property owners days before the burn, those with health issues may decide to leave for the day, reducing the risk to their health. Properly constructed firelines interrupt the continuity of fuels around the borders of the burn area and are essential to prevent escapes.

Prescribed fire is an effective tool in the management or reduction of hazardous fuels. Objectives for a fire must be set ahead of time, and proper methods should be used to achieve those objectives and ensure safety. In the South burning should be repeated every two to five years to keep fuel loads at manageable levels. Prescribed fire is often the most efficient method of fuel mitigation when conducted in a professional manner. However, not every situation allows for the use of fire. When potential risks outweigh the benefits of a burn, alternative methods of fuel reduction may be necessary.

Herbicide Treatments

The use of herbicide to reduce hazardous fuels is one alternative available to private landowners living at the wildland-urban interface. Herbicides are chemicals that have been developed to control or kill specific groups of plant species. Plants such as gallberry and saw palmetto, that are considered to be fire hazards in the South and rapidly resprout after prescribed burns, can be controlled or eliminated by using herbicides.

Three primary types of herbicide exist: foliar active, soil active, and those that are both foliar and soil active. Herbicides that are foliar active enter the plant through the leaves and occasionally the stem. Soil active herbicides are taken up through the roots of the plant. The herbicides are distributed through the plant by moving through the phloem, or with water through the xylem (McNabb 1996). Each herbicide contains an active ingredient that dictates the species that the herbicide will effectively control and the specific metabolic process that is affected. Common forest herbicides and their active ingredients are listed in Appendix 1.

Three important components of an herbicide prescription are: the proper product to use, the rate at which it is applied, and the season or time of year for the treatment. Common prescriptions can be found in Appendix 2. These three considerations depend solely on the objective of the treatment or the target species.

A number of methods are available for applying herbicides. Each method is directly related to the size and species composition of the area where the application is to take place. On large parcels of land, tractors rigged with spray equipment and aerial applications (helicopter and airplane) are common (Figure 4). There are a number of methods that are available for owners of smaller properties. A variety of hand and backpack sprayers are available that are sufficient for applying herbicides. These sprayers typically hold from one to three gallons of herbicide. Using a hand pump, air is forced into the container. When the wand is directed toward the target plant, a handle is pulled, releasing the herbicide. These sprayers can cost from $35 to $150. Hypo-hatchets are also used effectively for the removal of unwanted trees. These tools allow users to specifically treat individual targets. A small container is connected to a hatchet by tubing. The herbicide in the container moves through the tubing as the user swings the hatchet. During this process, the herbicide is introduced through holes in the head, placing the herbicide directly into the cambium layer of the target species. These tools range in cost from $30 to $100. All terrain vehicles can be fitted with sprayers, allowing the user to move quickly and easily through the target area. Wand and boom attachments are available for these systems allowing for the careful selection of target species or covering the entire area a boom passes over. ATV's range in cost from about $2,000 to $6,000 and the spray systems cost up to $500.

Figure 4. A farm tractor with spray rig applying herbicide treatment at Austin Cary Forest near Gainesville, FL.

Herbicides are most effective when used in accordance with a sound prescription. A single treatment provides long-term reduction of hazardous live fuels and changes in species composition, but the effect on total live and dead fuels is not immediate. In a study conducted in Florida, Brose and Wade (2002) reported that shrub fuel loads changed little during the first year after an herbicide application. After one year, there were 8.54 tons per acre of one-hour fuels and 2.06 tons per acre of ten-hour fuels. However, the amount of live woody material was reduced from 2.96 to 0.18 tons per acre during the first year. Dead vegetation remained standing during the first year, contributing to this trend. In the beginning of the second year, the dead material began to decompose and the fuel loads were greatly reduced; the forest floor also became more open. One-hour fuel loads continued to decline over time with 7.87 tons per acre recorded after three years and 5.32 tons per acre after six years (Brose and Wade 2002). These results suggest that a properly applied herbicide treatment could last as many as eight to ten years before reapplication is needed. This is one of the major advantages of herbicides compared to burning or mechanical treatments-a longer period of fuel reduction.

The cost of herbicide treatments is dependent on the management objectives and the specific nature of the application. In the period between 2000 and 2002, average treatment costs increased from $68.12 per acre to $70.18 per acre (Dubois et al. 2003). However, these figures were reported for forestry applications. Smaller landowners may expect to pay more per acre due to the small size of the area treated and associated costs of moving equipment. Treatments applied for a recent study on five acres outside of Gainesville, FL cost $86.50 per acre. These treatments were conducted in conjunction with a larger application that helped offset the price. The highest bid for the same application was $112 per acre. One reason for the high cost of herbicide treatments is the cost of the herbicide itself. Products range in cost from $55 per gallon to near $450 per gallon. Private individuals should be aware that a special permit is required to purchase some forest herbicides (eg. Tordon/picloram). All herbicide labels should be read and studied before their use. It is illegal to use herbicides in a manner that is not consistent with the label.

A few risks are associated with the use of herbicides. The primary problem is the social acceptance of the method. Many people are unaware that most herbicides target specific species, and they incorrectly assume that herbicides kill everything that they touch, both plants and animals. Herbicides work by targeting different processes of a plant's metabolism. This ensures that animals and plant species with differing metabolic processes are not affected by herbicides. In fact, most herbicides have very low toxicity levels, often lower than products that humans consume (eg. coffee).Most of the risk incurred when dealing with herbicide treatments is to the applicator and such problems are avoided by taking the necessary precautions.

Herbicides are a useful fuel mitigation tool for landowners at the interface. Private consultants can provide assistance to landowners, from start to finish, creating the prescription and seeing it through to completion. An important task in the development of an herbicide prescription is the determination of the appropriate application method. To meet the specified management objectives, the treatment should be applied in accordance with the prescription and special care should be taken to follow label instructions.

Mechanical Treatments

Mechanical treatments are becoming one of the most popular methods for fuel reduction. There is less risk involved in conducting a mechanical treatment than prescribed fire. Mechanical treatment utilizes a piece of equipment to reduce fuels. Examples of commonly used equipment include an axe, tree cutting machines, chippers, a tractor pulling a roller chopper, or mowers. The selective removal of individual trees to reduce overall tree density is called thinning and can also be considered a mechanical treatment of hazardous fuels. Social acceptance of thinning as a mechanical treatment is threatened because some of the public perceive it as simply a way to harvest timber (Winter et al. 2002).

Most of the equipment used in mechanical fuel reduction is expensive; therefore, purchasing the equipment is not a viable option for most landowners. Large tractors are needed to pull and/or push many of the currently available implements. The two primary types of mowers are flail and rotary. A flail mower, in most cases, fits on the front of a tractor. A barrel fitted with small knives or chains rotate in the direction that the tractor is moving, cutting vegetation to ground level. Rotary mowers are pulled behind the tractor or mounted on the front and have rotating blades that cut the vegetation (Figure 5). Roller choppers are also used to reduce fuels, generally on large blocks rather than small lots. A roller chopper is large and cylindrical with blades welded across the flat surface. The weight of the implement crushes vegetation and debris, and breaks up root systems, greatly reducing the standing fuel load. As noted before, using an axe or machete to reduce fuels is also considered a mechanical treatment, but both tools are associated with a high risk of injury for landowners. A major drawback to any of these methods is that most vegetation resprouts quickly, and often more prolifically than before the treatment. Thus, fuel loads are restored within a few years and frequent retreatment is necessary.

Figure 5. A tractor fitted with a front mount rotary mower used to conduct mechanical fuel reduction treatments. (Photo by A. Long)

Brose and Wade (2001) determined that thinning is a viable way to reduce fuels. In a study conducted in Florida, they observed a reduction in one-hour fuel loads from 33.47 Mg/ha to 9.79 Mg/ha following a thinning treatment. Five years after the treatment, fuel loading of one-hour fuels remained lower (19.17 Mg/ha) than pre- treatment levels (33.47 Mg/ha). Similar results were achieved with respect to ten-hour fuels, however, live woody material which had been crushed by the logging equipment was found to be more resilient. Live woody material was reduced from 12.9 Mg/ha pre-treatment to 4.08 Mg/ha post-treatment. Five years later the site had regained almost 75% of its original live woody material (9.07 Mg/ha). These results suggest that a thinning treatment would remain effective for a maximum of five years after which sprouting vegetation returns fuel loads to pre-treatment levels. Though mowing methods of fuel reduction are gaining popularity, research is needed to assist landowners in assessing the longevity of these treatments.

The costs of mechanical treatments can be prohibitive. The equipment itself can cost tens of thousands of dollars. Private consultants and contractors offer the most affordable means to small landowners. The average cost of site treatments went up between 2000 and 2002 from $136.03 to $166.50 per acre. These treatments were conducted for forestry, and prices could vary when applied to small private landowners (Dubois et al. 2003). Private contractors using Positrac machines often charge $100 per lot. These machines operate at a rate of about one acre per hour. The Florida Division of Forestry (2000) charges between $60 and $100 per hour using similar machines. The cost of these treatments can be very high, but they are effective methods to reduce hazardous fuels for small landowners for several years. Reducing the fuel loads and heights may also facilitate the future use of prescribed burning.

Livestock

Another fuel management alternative for landowners utilizes livestock to reduce ground-level fuels. This method involves fencing off the areas that need treatment and allowing livestock to forage. Davidson (2002) reported that homeowners living adjacent to sheep grazing treatment sites in Nevada were overwhelmingly supportive of that method and preferred it to other mitigation techniques.

Davidson placed 350 sheep into an area approximately 2.5 miles long and 150-200 feet wide. The long, narrow area was designed to create a fuel break between a wildland-urban interface residential development and an adjacent wildland area. The sheep were contained using an electric fence. After the first growing season, standing fuels were reduced in amounts ranging from 765 pounds per acre to 2,622 pounds per acre. The reduction is attributed to the sheep consuming and trampling much of the fuel. Two growing seasons after the treatment, the standing fuel load was reduced to half of that found on an adjacent untreated area (Davidson 2002).

In California, goats have been used for similar treatments. Angora, Spanish, Boer, Pygmy and Alpine goats are combined in a herd due to their individual preferences regarding native vegetation or fuels (Morales and Oyarzun 2002). In the grazing system in California, landowners pay farms to graze their goats on private lands. The goats are tended by a shepherd, who is responsible for moving the goats along at a pace necessary to achieve the desired objectives. Goats can consume plants down to bare ground if needed (Morales and Oyarzun 2002). Another advantage that livestock have over other methods is that slope is less of a limiting factor, although this is not a problem in much of the Southeast. Cattle grazing will also reduce hazardous fuels. For hundreds of years, ranchers have grazed cattle on the natural vegetation in southern ecosystems. Grazing can help offset the costs associated with maintaining a herd by reducing the amount of feed the ranchers need to purchase. Although there is little scientific evidence to support the effectiveness of cattle grazing, it is thought to be a useful way to reduce hazardous fuels (Tyree and Kunkle 1995).

There are many costs associated with grazing for fuel reduction. Morales and Oyarzun (2002) discuss the notion of "leasing" a herd of goats or sheep in detail. Although a total cost is not mentioned, they report that the cost will vary depending on the location and the amount of vegetation. The individual who owns the herd incurs all costs associated with tending the animals. No information exists in literature on similar lease agreements for cattle. Although land is often leased for cattle grazing, fuel reduction is seldom the primary objective. Standard arrangements are for the landowner to receive a fee from the cattle owner.

When a landowner decides to purchase and tend to a herd of animals, numerous additional costs will be incurred. Water is a necessity and can be a primary expense. Cattle consume about 12-15 gallons of water per day. If a water source is not available on-site, a well must be built (Tyree and Kunkle 1995). The construction of a containment fence can be another substantial expense, if no fencing is present. Health maintenance of the herd includes additional costs associated with vaccinations, parasite control, supplemental feeding, and working facilities. Finally, the price of the cattle themselves can be high. Cattle can be purchased at auctions where calves can cost from $200 to $500 each. Each individual in a cattle herd requires a minimum ¾ to 2 acres of forage (Tyree and Kunkle 1995). Some of the purchase cost is recovered if/when the animals are eventually sold.

Grazing animals are effective tools for managing undesirable vegetation, but the disadvantages associated with their use should also be considered. Erosion and compaction can be negative impacts caused by grazing animals (Morales and Oyarzun 2002). The initial expense of starting a herd of grazing animals can be high. Maintenance of the herd requires a trained individual, and contracting such a person can lead to additional costs for the landowner. Fewer risks are associated with leasing the animals from a reputable farm than growing and maintaining a herd. The best option for interface landowners will probably be to lease their land to a livestock owner.

Conclusion

The growing number of residents who live in the wildland-urban interface should be aware of the fire risks to which they are exposed. These interface areas pose specific problems with respect to wildfire and hazardous fuel management. Prescribed burning, probably the most cost effective of the treatments, is becoming a less common tool in interface areas, due to the risk that it poses to encroaching development. Several alternative methods can be safely and effectively used. Herbicide treatment can be an effective method of reducing live fuels. Although the effect is not immediate, herbicide treatments provide lasting protection from wildfires. Mechanical treatments, though expensive, provide immediate reduction of standing fuel loads. These treatments generally need to be reapplied more often than herbicides. Additional research is needed to determine exactly how effective the treatments are and the length of their usefulness. Grazing livestock on areas with hazardous fuel loads is also a viable option. The general public often views this method as the best option. Successful applications of goat and sheep grazing have been documented in the West. Farms may lease their animals to private landholders for grazing or may lease land from landowners. This method can be expensive if initiated by an individual landowner.

As property owners realize the need for fuel management, they should be made aware of efficient and lasting methods that will help accomplish their goals. Each situation has unique characteristics, and a plan should be developed individually. This plan should take into account the owner's objectives, the fuel loads, and surrounding developments (roads, airports), and match them with the fuel management technique that best suits their needs. The reduction of hazardous fuels is a necessary hazard mitigation activity for landowners at the interface, and the alternative methods described in this paper and in the new extension publication (Appendix 4) will provide landowners with information to help them decide on the best method to reduce the risk that wildfires pose to their properties.

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Appendix 1

Commonly used forestry herbicides and their active ingredients.

Product	Active Ingredient
Accord	Glyphosate
Arsenal	Imazapyr
Atrazine 4L	Atrazine
Chopper	Imazapyr
Escort	Metsulfuron methyl
Garlon 3A	Triclopyr
Garlon 4	Triclopyr
Oust	Sulfometuron
Pronone 10G	Hexazinone
Velpar L	Hexazinone

(McNabb 1996)

Appendix 2

General Herbicide Prescriptions for Florida.

Herbicide Prescription for Herbaceous Weeds (Grasses and Forbs)

Herbicide	Formulation	Timing
Accord + Arsenal	4 qt + 8 oz/A	Summer
Garlon + Arsenal	2 qt + 8 oz/A	Summer
Oust	4 oz/A in 15 gals water	Spring
Oust + Velpar L	2-3 oz + 1-3 pts/A 15 gals water	Spring
Oust + Atrazine	2-4 oz + 2-4 qts/A	Spring
Oust + Accord	2 oz + 1 pt/A	April-May
Arsenal + Oust	4-6 oz + 2 oz/A	Spring
Arsenal	6-10 oz/A	Spring/Summer
Escort + Arsenal	2 oz + 8 oz/A	Summer

(Long 1998)

Herbicide Prescription for Evergreen Shrubs (Gallberry, Waxmyrtle)

Garlon 4 + Arsenal	1-2 qt + 8-16 oz/A	Fall
Accord + Arsenal	2-5 qt + 8 oz/A	Fall

(Long 1998)

Herbicide Prescription for Saw Palmetto

Garlon + Accord	1-1.5 qts + 1.5 qts/A
Garlon + Chopper	1 pt + 40-48 oz/A

(Long 1998)

APPENDIX 3

A STUDY TO COMPARE THE EFFECTIVENESS, COST, AND LONGEVITY OF VARIOUS VEGETATION MANAGEMENT TECHNIQUES

ABSTRACT

As the population of the United States continues to grow, the need for people to live at or near the interface is inevitable. Due to the influx of people in these areas, conventional fuel management techniques, such as prescribed fire, have become less practical. In order to protect structures, property, and resources in these interface areas, new, more acceptable methods of fuel management need to be investigated and developed. This study compares the effectiveness and cost of three different methods of reducing fuel in interface areas. Five, four acre blocks in Alachua County, Florida were surveyed for percent cover, density and height of gallberry (*Ilex glabra*), saw palmetto (*Serenoa repens*), and wiregrass (*Aristida beyrichiana*). These blocks were then divided into four, one-acre study areas and the following treatments were randomly applied to three of them, leaving one block as a control: prescribed burning, mowing, or treatment with herbicide. The sites will be sampled twice per year for three years for percent cover, density and height of the three target species. The cost of each treatment will be determined and compared with the effectiveness over time of each treatment. The results of this study will establish a basic comparison of cost effectiveness that will enable property owners at the interface to make appropriate decisions about fuel reduction methods, thereby reducing risk in the event of a wildfire.

Problem

Fire at the wildland-urban interface has quickly become an issue that must be dealt with on many fronts. As homes are constructed in areas that were previously uninhabited, conventional methods of fuel reduction have become dangerous and unacceptable. Alternative methods of vegetation management that can be applied by owners of small tracts in a cost effective manner need to be developed in order to reduce the risk of wildland fire damaging or destroying property. By equipping owners of small parcels with information regarding fuel management techniques, they will be able to make informed decisions about fuel mitigation on their land. Educating these landowners to Firewise practices and presenting ideas for management of surrounding fuels will prove to lessen the risk of catastrophic fires in interface communities. This will result in fewer human and property casualties related to wildland fire.

Objectives

The specific objectives of this study are:

(1) To compare the ecological effectiveness of three different fuel management treatments - burning, mowing, and herbicide, with a no-treatment control

(2) To compare the cost effectiveness of the three fuel management methods.

Research Plan

Study Area

Five study blocks, four acres in size, have been selected on Austin Cary Memorial Forest, northeast of Gainesville, Florida. Each of the five blocks are in thinned pine plantations with similar soils and understory vegetation. The primary understory vegetation consists of gallberry, saw palmetto, and wiregrass. These stands are located in Compartments 3, 9 and 20.

Study Design

Each of the four-acre blocks was divided into one-acre study areas. In each one-acre study area, saw palmetto, gallberry, and wiregrass were sampled using sixteen, square meter plots, for percent cover, density, and height. After the initial survey (Appendices 3.1, 3.3), a randomly selected treatment was applied to each of the three study areas (Appendices 3.1, 3.4), leaving the forth to serve as a control. Each of the five study areas serve as a replication. The treatments are as follows: (1) the first area was burned using a backfire method (Appendix 3.2), (2) the second area was entirely mowed using a farm tractor equipped with a Brown tree cutter, (3) and the third area had herbicide (3 quarts of Garlon 4, 1 quart of Chopper, and 1 quart of surfactant to the acre) applied by a contractor. Each of the areas will be resurveyed twice per year for the duration of the study.

Appendix 3.1. Sample/Treatment Dates

Block Number	Initial Sample Date	Treatment Applied	Treatment Date
1.1	5/6/02	Mechanical	1/30/03
1.2	5/6/02	Herbicide	8/19/02
1.3	5/6/02	Burn	10/18/02
1.4	5/6/02	Control	NA
2.1	5/6/02	Mechanical	2/3/03
2.2	5/6/02	Burn	10/18/02
2.3	5/7/02	Control	NA
2.4	5/7/02	Herbicide	8/19/02
3.1	5/7/02	Burn	9/30/02
3.2	5/7/02	Control	NA
3.3	5/7/02	Mechanical	2/4/03
3.4	5/7/02	Herbicide	8/20/02
4.1	5/9/02	Herbicide	8/20/02
4.2	5/9/02	Control	NA
4.3	5/9/02	Mechanical	2/4/03
4.4	5/9/02	Burn	9/9/02
5.1	5/9/02	Herbicide	8/19/02
5.2	5/10/02	Burn	2/25/03
5.3	5/10/02	Control	NA

5.4	5/10/02	Mechanical	2/5/03

Appendix 3.2. Weather for Prescribed Burn Treatments

Date	Block #	Build	Spread	Dry Bulb Temp.	Min. Temp.	Max. Temp.	Relative Humidity	Wind Direction	Wind Speed	State of Weather (*)	Season	Herb Stage (**)	Drought Index
9-Sep-02	4.4	18	9	88	74	88	59%	NE	9	2	Summer	3	150
30-Sep-02	3.1	10	5	90	73	90	54%	variable	7/gust 17	2	Fall	3	235
18-Oct-02	1.3, 2.2	27	11	71	52	71	39%	N	11	0	Fall	3	351
25-Feb-03	5.2	38	16	73	52	73	56%	ESE	4	0	Winter	1	46

*** State of Weather**

0 Clear (less than 1/10th of sky cloud covered)
2 Broken clouds (6/10th to 9/10th cloud covered)

**** Herb Stage**

1 cured
2 intermediate
3 green

APPENDIX 4 – EXTENSION PUBLICATION DRAFT

Fire in the Wildland-Urban Interface: Fuel Mitigation Techniques for Private Landowners

UNIVERSITY OF FLORIDA

Cooperative Extension Service
Institute of Food and Agricultural Sciences

DRAFT

Fire in the Wildland-Urban Interface: Fuel Mitigation Techniques for Private Landowners

J. Douglas Doran

INTRODUCTION

Wildfires in the South are occurring more frequently and causing more damage than the natural fires of the past. One reason for the increase in damage is the dramatic population increase in natural areas. Many of these areas, under the natural cycle of fire occurrence, burned every one to three years. These frequent fires, often ignited by lightning, regularly reduced the woodland fuels so that fire intensity was low instead of erratic. However, the number of homes now in these wildland-urban interface (WUI) areas has made it necessary to aggressively suppress fires in order to protect citizens and their property. This suppression has allowed forest fuels to grow substantially, greatly increasing the risk of a catastrophic wildfire and therefore, human casualty and property damage to those living at the interface.

At the national level, hundreds of homes in these WUI areas are destroyed by wildfires each year. Those who live in these natural areas can take several precautions that will reduce their risk of damage in the event of a fire. Fuel reduction, also known as mitigation, is one such activity. Owners of small properties are often faced with difficult decisions concerning fuel management. This publication will identify and discuss practical methods of fuel reduction that are available to the owners of small parcels.

In order to understand the concept of fuel mitigation, it is important to understand the composition of forest fuels. Fuels, in a wildland situation, are defined as plant materials that can ignite and support a fire (Bond and van Wilgen 1996). They originate from an abundance of sources but are primarily living and dead material from grasses, vines, shrubs, and trees. The long growing season experienced by many of the southern states promotes the accumulation of substantial amounts of fuel within five to six years (Wade and Lunsford 1989).

Homeowners can reduce risk to their property by manipulating the fuels that are available to promote the advance of a fire. By breaking up the continuity of forest vegetation, fire spread is disrupted, and fire behavior is less intense, decreasing the risk of property loss. There are four primary fuel mitigation methods that are available to property owners in the wildland-urban interface:

prescribed fire, herbicide treatments, mechanical treatments, and grazing.

Prescribed Fire

Prescribed fire is the controlled application of fire over a predetermined area to achieve a specific set of objectives (Florida Division of Forestry 2000). In interface situations, the most common objective of prescribed fires is the reduction of hazardous fuels. Given that objective, prescriptions vary based on season of burning, existing fuel loads, and current weather conditions. There are many elements to consider when preparing for a prescribed burn. Firelines must be created to disrupt fuel continuity around the boundaries of the proposed burn area. These lines include waterways, roads or powerlines, or may be bare soil created by tractors. Some southern states require that managers contact and obtain a permit from local forestry agencies in order to legally perform a prescribed fire. Permits may or may not be available depending on current weather conditions. Burning without a permit may result in a citation and/or a fine. Burn plans are also required in many southern states. Burn plans should include: fire weather, expected conditions, desired conditions, fuel type and loading, and the basic plans to carry out the burn. Contingency plans are often included in the event that a fire may escape the desired boundary. Many other elements such as proximity to nearest water source and fire services should also be considered.

A prescribed, backing fire designed for fuel reduction in Waldo, Florida.

Prescribed fires must be repeated in order to maintain safe fuel loads. As previously discussed, the weather in the Southeast promotes the rapid regrowth of vegetative fuels after a prescribed burn. Sackett (1975) determined that a three-year burn interval is optimum for minimizing wildfire potential and damage. McNabb (2001) suggests that cool season, backing fires can be conducted every two to five years.

In 2002, the overall cost for prescribed burning in the South decreased 19% over the previous two years (from $17.70 in 2000 to $14.41 per acre in 2002). The cost of three different burning treatments ranged from $13.25 to $18.07 per acre (Dubois et al. 2003). The range of costs reflects differences in objectives, fuel loads, burn unit size, and other variables. Costs will probably be higher on small acreages and near residential areas. Private companies or consultants plan and execute prescribed burns for a fee. Private landowners can also get assistance from state agencies to carry out prescribed burns. Often, the state assistance is free if the objective of the burn is wildfire hazard reduction. For example, in areas where private vendors cannot provide the service, the Florida Division of Forestry will assist landowners burning up to 250 acres per year. They will contract burn for $10.00 per acre for the first 50 acres or less and $6.00 per acre for additional acreage. In addition, they will construct fire lines at a rate of $60 per hour (Florida Division of Forestry 2000).

Herbicide Treatments

The use of herbicides to reduce hazardous fuels is another alternative available to private landowners living at the wildland-urban interface. Herbicides are chemicals that have been developed to control or kill specific groups of plant species. Plants such as gallberry and saw palmetto, that are considered to be fire hazards in the South and rapidly resprout after prescribed burns, can be controlled or eliminated by using herbicides.

A single herbicide treatment can provide a long term reduction of hazardous fuels and changes in species composition, but the effect on fuels is not immediate. After the herbicide is applied, the fuels remain in place. Although the plants are dead, they still remain available to a fire for several years. After one year, leaves and fine twigs decompose and the structure of the fuels is altered. This alteration continues for the next 2-5 years as larger dead stems decompose and new vegetation begins to grow. The effects of a properly applied herbicide treatment could last as many as eight to ten years before reapplication is needed. This is one of the major advantages of herbicides compared to burning or mechanical treatments - a longer period of fuel reduction.

A modified farm tractor applying herbicide on a research plot near Gainesville, Florida.

The cost of herbicide treatments is dependent on the management objectives and the specific nature of the application. In the period between 2000 and 2002, average treatment costs across the South increased from $68.12 per acre to $70.18 per acre (Dubois et al. 2003). However, these figures were reported for forestry applications. Smaller landowners may expect to pay more per acre due to the small size of the area treated and associated costs of moving equipment. Treatments applied for a recent study on five acres near Gainesville, Florida cost $86.50 per acre. These treatments were conducted in conjunction with a larger application which helped offset the price. The highest bid for the same application was over $100 per acre. One reason for the high cost of herbicide treatments is the cost of the herbicide itself. Products range in cost from $55 per gallon to near $450 per gallon. Private individuals should be aware that a special permit is required to purchase some forest herbicides (eg. Tordon/picloram). All herbicide labels should be read and studied before their use. It is illegal to use herbicides in a manner that is not consistent with the label.

A number of methods are available for applying herbicides. Each method is directly related to the size and species composition of the area where the application is to take place. On large parcels of land, tractors rigged with spray equipment and aerial applications (helicopter and airplane) are common. There are a number of methods that are available for owners of smaller properties. A variety of hand and backpack sprayers are available that are sufficient for applying herbicides. These sprayers typically hold from one to three gallons of herbicide. Using a hand pump, air is forced into the container. When the wand is directed toward the target plant, a handle is pulled, releasing the herbicide. New sprayers can cost from $35 to over $200. Hypo-hatchets are also used effectively for the removal of unwanted trees. These tools allow users to specifically treat individual targets. A small container is connected to a hatchet by tubing. The herbicide in the container moves through the tubing as the user swings the hatchet into the woody stem. During this process, the herbicide is introduced through holes in the axe head, placing the herbicide directly into the cambium layer of the target species. These tools range in cost from $30 to $100. All terrain vehicles can be fitted with sprayers, allowing the user to move quickly and easily through the target area. Wand and boom attachments are available for these systems allowing for the careful selection of target species or covering the entire area over which a boom passes. ATV's range in cost from about $2,000 to $6,000 and the spray systems can cost over $500.

Mechanical Treatments

Mechanical treatments are becoming one of the most popular methods for fuel reduction. Mechanical treatment utilizes a piece of equipment to reduce fuel heights and size. Examples of commonly used equipment include an axe, tree cutting machines, chippers, a tractor pulling a roller chopper, or mowers. The selective removal of individual trees to reduce overall tree density is called thinning and can be considered a mechanical treatment of hazardous fuels.

Most of the equipment used in mechanical fuel reduction is expensive; therefore, purchasing the equipment is not a viable option for most landowners. Large tractors are needed to pull and/or push many of the currently available implements. An array of mowers and choppers exist that masticate or crush fuels reducing them to ground level. As noted before, using an axe or machete to reduce fuels is also considered a mechanical treatment. A major drawback to any of these methods is that most vegetation resprouts quickly, and often more prolifically than before the treatment. Thus, fuel loads are restored within a few years and frequent retreatment is necessary.

Though mowing methods of fuel reduction are gaining popularity, research is needed to assist landowners in assessing the longevity of these treatments.

A Hydro-Axe mower used for the mechanical treatment of forest fuels.

The costs of mechanical treatments are often higher than either of the previously described methods. The equipment itself can cost tens of thousands of dollars. Private consultants and contractors offer the most affordable means to small landowners. The average cost of site treatments went up between 2000 and 2002 from $136.03 to

$166.50 per acre. These treatments were conducted for forestry, and prices could vary when applied to small private landowners (Dubois et al. 2003). Private contractors using Positrac machines often charge $100 per lot. These machines operate at a rate of about one acre per hour. The Florida Division of Forestry (2002) charges between $60 and $100 per hour using similar machines. The cost of these treatments can be very high, but they are effective methods to reduce hazardous fuels for small landowners for several years.

Livestock

Another fuel management alternative for landowners utilizes livestock to reduce ground-level fuels. This method involves fencing off the areas that need treatment and allowing livestock to forage. Davidson (2002) reported that homeowners living adjacent to sheep grazing treatment sites in Nevada were overwhelmingly supportive of that method and preferred it to other mitigation techniques.

Davidson placed 350 sheep into an area approximately 2.5 miles long and 150-200 feet wide. The long, narrow area was designed to create a fuel break between a wildland-urban interface residential development and an adjacent wildland area. The sheep were contained using an electric fence. After the first growing season, standing fuels were reduced in amounts ranging from 765 pounds per acre to 2,622 pounds per acre. The reduction is attributed to the sheep consuming and trampling much of the fuel. Two growing seasons after the treatment, the standing fuel load was reduced to half of that found on an adjacent untreated area (Davidson 2002).

In California, goats have been used for similar treatments. Angora, Spanish, Boer, Pygmy and Alpine goats are combined in a herd due to their individual preferences regarding native vegetation or fuels (Morales and Oyarzun 2002). In the grazing system in California, landowners pay farms to graze their goats on private lands. The goats are tended by a shepherd, who is responsible for moving the goats along at a pace necessary to achieve the desired objectives. Goats can consume plants down to bare ground if needed (Morales and Oyarzun 2002). Another advantage that livestock have over other methods is that slope is less of a limiting factor, although this is not a problem in much of the Southeast. Cattle grazing will also reduce hazardous fuels. For hundreds of years, ranchers have grazed cattle on the natural vegetation in southern ecosystems. Grazing can help offset the costs associated with maintaining a herd by reducing the amount of feed the ranchers need to purchase. Although there is little scientific evidence to support the effectiveness of cattle grazing for fuel reduction, it is thought to be a useful way to reduce hazardous fuels (Tyree and Kunkle 1995).

There are many costs associated with grazing for fuel reduction. Morales and Oyarzun (2002) discuss the notion of “leasing” a herd of goats or sheep in detail.

Although a total cost is not mentioned, they report that the cost will vary depending on the location and the amount of vegetation. The individual who owns the herd incurs all costs associated with tending the animals. No information exists in literature on similar lease agreements for cattle. Although land is often leased for cattle grazing, fuel reduction is seldom the primary objective.

When a landowner decides to purchase and tend to a herd of animals, numerous additional costs will be incurred. Water is a necessity and can be a primary expense. Cattle consume about 12-15 gallons of water per day. If a water source is not available on-site, a well must be built (Tyree and Kunkle 1995). The construction of a containment fence can be another substantial expense, if no fencing is present. Health maintenance of the herd includes additional costs associated with vaccinations, parasite control, supplemental feeding, and working facilities. Finally, the price of the cattle themselves can be high. Cattle can be purchased at auctions

These pictures, taken on April 15, 2003, demonstrate the effectiveness of three fuel mitigation treatments.

**Top left - control, no treatment applied*
**Top right – mechanically mowed (1/30/03)*
**Bottom left – herbicide treatment (8/19/02)*
**Bottom right – prescribed fire (10/18/02)*

where calves can cost up to $500 each depending on market value. Each individual in a cattle herd requires a minimum ¾ to 2 acres of forage (Tyree and Kunkle 1995). Some of the purchase cost is recovered if/when the animals are eventually sold.

Selecting the best treatment

Many property owners struggle to determine the best treatment for their particular situation. It can be a confusing process as many of the techniques will be sufficient for the same treatment area.

Prescribed fire is the most affordable treatment. It is most effective when used in areas with five years or less of fuel build-up. When the fuels exceed five years of accumulation, fire behavior becomes very intense and unpredictable. As smoke management can be a major problem, the proximity of neighboring homes, roads, hospitals, and airports can discourage the use of prescribed fire. In situations where these are a concern, another method should be used. If prescribed fire is selected as the treatment, then it should be repeated every three years or as often as the fuels will allow.

Herbicide treatments are another possibility. Though fairly expensive, herbicide treatments last longer than the other treatments. Depending on the size of the treatment area and the availability of equipment, herbicides can be applied by the landowner. When the treatment is to be applied on small areas (1/2 to 5 acres), backpack sprayers can be used. On larger properties (up to ten acres), an ATV rigged with a boom sprayer would be efficient. When the treatment needs to be applied on property over 20 acres in size a commercial spray rig may be the best option. Take care to select the proper herbicide and to use it in accordance with its label. Also, be aware of environmentally sensitive areas such as waterways and ditches; follow best management practices in all applications.

Mechanical treatments, while expensive, are often the first treatment used when fuels are heavy and tall. Mechanical treatments, whether masticating or crushing, reduce fuels to a level that allows for the use of prescribed fire or herbicide treatments in the future. Mowing or crushing treatments are sufficient for up to three years. Once the initial rough is reduced, mowing with common farm tractors, prescribed fire, and herbicide treatments can all be used to maintain low fuel levels. On properties less than five acres in size, small machines are needed. Small, commercial mowing and masticating equipment are expensive and it is usually necessary to hire a contractor to complete this work. When properties exceed five acres in size, roller choppers and larger masticating equipment is most efficient. Again, the cost of such equipment limits the property owner's ability to carry out these treatments alone. However, once the initial rough is reduced then a common farm tractor and mower can be used by the owner to maintain the area.

Using livestock to reduce fuels can be an effective method on small and large parcels. The size of the treatment area dictates the number of animals needed to adequately apply the treatment. Initial costs include the livestock itself, and things like fencing, wells or another watering facility, and care of the animals. Animals can be leased, leaving the responsibility of the animals care to the owner. Larger tracts may be leased to a livestock owner and can generate income for the property owners. There is little formal research specific to the Southeast to suggest effectiveness and costs of the treatment.

For all four treatment options, per acre costs may be reduced when several landowners arrange for the same treatments at one time.

Conclusion

The growing number of residents who live in the wildland-urban interface should be aware of the fire risks to which they are exposed. These interface areas pose specific problems with respect to wildfire and hazardous fuel management. Prescribed burning, probably the most cost effective of the treatments, is becoming a less common tool in interface areas, due to the risk that it poses to encroaching development.

Several alternative methods can be safely and effectively used. Although herbicide effects are not immediate, treatments provide more lasting protection from wildfires than mechanical or prescribed burning options. Mechanical treatments, though expensive, provide immediate reduction of standing fuel loads. These treatments generally need to be reapplied more often than herbicides. Additional research is needed to determine exactly how effective the treatments are and the length of their usefulness. Grazing livestock on areas with hazardous fuel loads is also a viable option. Success with goat and sheep grazing have been documented in the west. Farms may lease their animals to private landholders for grazing or may lease land from landowners. This method can be expensive if initiated by an individual landowner.

As property owners realize the need for fuel management, they need to understand te relative logistics, effects and costs of different fuel treatments. Each situation has unique characteristics, and a plan should be developed individually. This plan should take into account the owner's objectives, the fuel composition and loads, and surrounding developments (roads, airports), and match them with the fuel management technique that best suits their needs. The reduction of vegetative fuels is a necessary hazard mitigation activity for landowners at the interface, and the alternative methods described in this paper offer an effective means for landowners to reduce the risk that wildfires pose to their properties

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APPENDIX 5 - EXTENSION PUBLICATION DRAFT

Fire in the Wildland-Urban Interface: Selecting and Maintaining Fire-Safe Plants

UNIVERSITY OF FLORIDA
Cooperative Extension Service
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Fire in the Wildland-Urban Interface: Selecting and maintaining fire-safe plants

J. Douglas Doran, Cotton K. Randall, and Alan J. Long

INTRODUCTION

One of the major issues in the southern wildland-urban interface is the loss of homes to wildland fire. While fire control agencies play an important role in reducing fire hazards and protecting homes, individual landowners must also assume some responsibility. Creating an area of **defensible space** is the most important action that homeowners can take to protect their house and property from wildfires. Defensible space is defined as an area of modified vegetation between natural areas (e.g., woodlands) and homes that allows firefighters to protect the home or, in absence of firefighters, allows the home to better survive on its own. Recommendations for defensible space call for an area extending at least 30 feet outward from a house to be modified and maintained.

The proper selection and maintenance of fire-safe plants is critical when creating defensible space. However, most homeowners consider more than just fire safety when deciding how to landscape their yard, such as aesthetics, wildlife habitat, or energy conservation. These objectives or values can be incorporated into the landscape design without sacrificing fire safety. To do so, homeowners must understand how individual plants and groups of plants contribute to the flammability of their landscape and, consequently, to the risk of fire damaging their homes.

Multiple factors influence the flammability of a landscape. The types of plants or species that are present can be important. Plant species vary in their degree of flammability due to differences in the chemical composition and the arrangement and shape of their leaves. However, most plants that are stressed by dry conditions will burn if exposed to enough heat, regardless of species. One of the most important factors determining how wildfires move when they approach homes is the vertical and horizontal arrangement of plants across the landscaped zone. This extension fact sheet outlines three sets of plant characteristics that influence plant flammability: plant parts (primarily leaves), individual plants, and groups of plants.

WHICH PLANT PARTS ‘FUEL’ THE FIRE?
Plants are the primary fuels during wildland fires, and both living and dead plant material will burn. When researchers compare the flammability of different plant species, they often focus on leaves, because they are usually the first part of shrubs and trees to ignite. Grass, leaves, and small branches are lightweight fuels that ignite easily and burn rapidly. These lightweight fuels, or ‘fine’ fuels, affect the rate of spread of an advancing fire and carry the fire to heavier fuels, such as larger branches and stems, or even houses. However, leaves from different plant species ignite and burn at different rates and intensities depending on chemical and structural characteristics. The most important characteristics of light fuels that influence their flammability are:

- The amount of water contained in a leaf, or its **moisture content**. The moisture content of leaves varies significantly depending on local conditions, such as air humidity and soil moisture, but differences also exist between plant species growing under the same conditions. Plants that have thick, succulent leaves, such as cacti, aloe, and jade plants, often maintain a high leaf moisture content during extended dry periods and thus have a low flammability. Before plant parts can ignite, any moisture located near the surface must be expelled or vaporized. Therefore, dry leaves ignite much faster than moist leaves. Dead leaves are drier and more flammable than living leaves.

- The size and shape of leaves. Small, needle-like leaves, such as pine needles, are generally more flammable than broad leaves, such as maple or hickory leaves. Leaf thickness is also important because thick leaves have more plant tissue (and often more water) relative to the area of exposed surface than thin leaves. Due to these physical properties, most thin leaves are heated and subsequently ignite faster than thick leaves when exposed to fire. When dead leaves drop from a tree, their shape can affect whether they get caught in understory shrubs or collect on the ground. For example, the fact that pine needles are attached at the base increases their likelihood of getting caught on small branches; as they fall, different needles from the same cluster can easily get lodged around a branch. If dead leaves are allowed to buildup on other plants, the fire hazard of those plants and their surrounding landscape can increase (Figure 1).

- The presence of oils, resins (e.g., tree sap), waxes, or other chemicals in leaves or branches. These chemicals, when present, can increase the flammability of a plant. Plants with high content of oils or other chemicals in their leaves should be avoided around homes in high fire hazard areas. Most leaves that contain significant amounts of these chemicals will emit an odor when they are crushed.

Figure 1. Dead needles, falling from taller pine trees, can buildup on branches of smaller trees and shrubs, like the wax myrtle in this picture. The dry, dead needles dramatically increase the flammability of the shrub and vegetation around it.

FLAMMABILITY AT THE INDIVIDUAL PLANT SCALE

The overall flammability of a plant is dependent on the relative flammability of its individual leaves and branches, as well as the entire plant's structure (i.e., how its leaves and branches are arranged). Before discussing differences in plant structure between species, general differences between broad types of vegetation will be introduced. Wildfires require continuous sources of fuel to spread; therefore, the vertical and horizontal distribution of plant material is very important.

Grasses, shrubs, and trees have different structural characteristics influencing ignition and fire spread during wildfires.

- Grasses ignite rapidly and burn fast due to their thin leaves and position at ground level. They also dry out quicker than shrubs and trees during extended periods of dry weather, which is when most wildfires occur.
- Shrubs have the majority of leaves less than six feet from the ground and, therefore, are susceptible to ignition from fires spreading at ground level. The abundance of leaves on shrubs contributes to their overall flammability.
- Trees usually have branches that start several feet up from the ground, which may be above the flames of a ground-level fire.

Shrub and tree species differ in their flammability based on several key characteristics.

- Branching patterns are important because they influence the distribution and amount of leaves on a shrub or tree. In general, as the amount of leaves or needles increases relative to the total plant weight, a plant's flammability increases. Plants with open and loose branching and sparse leaves generally have a low flammability.

- Deciduous vs. evergreen. Shrubs and trees that lose their leaves in the fall are referred to as **deciduous**, and those that retain living leaves throughout the year are called **evergreen**. In the southern United States, some common deciduous species include hickories, red and white oaks, and maples; evergreen species include cedars, pines, and hemlocks. Deciduous shrubs and trees are usually less flammable than evergreens for several reasons. The moisture content of living deciduous leaves tends to be higher than in evergreen leaves. In addition, deciduous shrubs or trees do not ignite or burn well during winter because they have no leaves to burn.

- The retention of dead material on plants can significantly increase their flammability due to the low moisture content of dead fuels. This includes dead leaves and branches (Figure 2). As forest trees grow taller, their lower branches die in many species. However, the lower branches may remain attached for long periods and contribute to the flammability of the entire tree. Some trees, called self-pruners, lose their lower, dead branches on their own as they grow. Self-pruning can lower a plant's flammability by creating greater vertical separation between the ground and the part of the tree containing leaves (tree crown) (Figure 3). Manual removal of branches up to 10 feet from the ground will reduce the fire hazard of mature trees that do not self-prune.

Figure 2. The dead or dying material on this cabbage palm increases its overall flammability and creates a fire hazard when in close proximity to a house. By removing the dead fronds, the hazard can be reduced.

(a) (b)

Figure 3. Many southern pines, such as longleaf pine (a), are good self-pruners and their lower trunks are often devoid of any branches. Sand pines, which do not self-prune, often have living branches close to the ground (b), which make them more prone to burn when exposed to surface fires.

PLANT ARRANGEMENT WITHIN THE LANDSCAPED AREA (AND BEYOND)

The arrangement of plants within the landscaped area around homes can significantly influence the vulnerability of those homes to approaching wildfires. Plant arrangement is important because the leaves and small branches of plants are the primary fuels that carry the flames of wildfires and their arrangement across the landscape directly influences fire spread. The key characteristics of plant arrangement that influence landscape fire risk include the following.

- Vertical and horizontal separation. Shrubs and small trees of intermediate height can act as ladders carrying the flames from the ground to the tree crowns; such plants are called **ladder fuels** (Figure 4). A fire-safe landscape has vertical and horizontal separation between all major fuel sources within the area of defensible space. To maintain vertical separation, all ladder fuels should be cleared from this area, and the lower branches on trees should be pruned up at least10 feet from the ground. Horizontally, groups of plants or landscape beds should be separated by nonflammable areas, such as decorative gravel, stepping stone pathways, or a well-maintained lawn. Note: Dry, dead grass can carry a fire, as can most organic mulches.

- Selecting "the right plant for the right place" is important in landscaping and can significantly affect the fire hazard of a landscape. Factors to consider when selecting plants are light, water, and soil requirements (http://hort.ufl.edu/fyn/right-plant-right-place.htm). Consult with your county extension agent or local nursery to determine the best plants for your yard. Shrubs or trees that are not well suited for the local environment may have health problems in the future, and consequently, a higher flammability. For example, unhealthy plants may exhibit a higher percentage of dead material, such as dead or dying braches, and a lower overall moisture content, both of which significantly increase plant flammability.

Figure 4. Ladder fuels are medium-sized shrubs or trees that connect fuels at the forest floor to tree crowns.

ROUTINE MAINTENANCE IS ESSENTIAL!

Once the plants are selected and the landscape design is created, routine maintenance is required to preserve fire-resistant properties. Routine maintenance includes timely pruning, irrigation, and the removal of dead leaves, branches, and annual herbaceous plants that have gone to seed and have dry stems. Irrigation is important to maintaining healthy plants; homeowners who live in regions that experience periodic drought should avoid drought-sensitive plants in their landscaping. Dead plant materials removed during routine maintenance can be used as mulch outside of the area of defensible space to keep nutrients on-site. By selecting plants that are slow growing, homeowners can reduce the frequency of required maintenance practices.

SUMMARY

The most important characteristics of fire-safe plants are:

- High moisture content. The moisture content of leaves and branches is the single most important factor influencing flammability (plants that do not naturally maintain high moisture content during drought conditions can be watered to decrease their flammability).
- Broad and thick leaves. Thin leaves or needles tend to dry out quickly and ignite easily.
- Low chemical content. The presence of sap or other chemicals in the leaves and branches can increase flammability.
- Open and loose branching patterns.

- Non-evergreen leaves. Deciduous plants are generally less flammable than evergreens.
- Low amounts of dead materials. The accumulation of dead leaves and branches on plants can increase flammability.

To maintain a fire-safe landscape, the following routine maintenance practices must be conducted within the area of defensible space:

- Prune shrubs and trees periodically to reduce fuel volume and maintain healthier plants; pruning should also maintain vertical separation between shrubs and trees to prevent development of ladder fuels.
- Remove dead leaves and branches from standing vegetation and from the ground.
- Remove annual plants once they start to dry out and die.
- Water plants adequately to maintain healthy plants and prevent drought stress.

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