COMBUSTIBILITY OF SELECTED DOMESTIC VEGETATION SUBJECTED TO DESICCATION[1]

by

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ABSTRACT: Combustibility is the rate at which material burns, using the definition of Anderson (1970). Although there are data on some wildland species, data are almost non-existent for domestic vegetation. Furthermore, there are no standard methods for measurement of combustibility.

This study explores methods which could be standardized for combustibility testing of vegetation and presents data for Tam junipers (Juniperus sabina var. tamariscifolia). Vegetation was ignited under original living moisture content and after desiccation of the shrubs between 1 and 10 days. Three samples of live foliage were taken for each plant to estimate moisture content just before ignition; moisture content varied between 31.7 - 105.2%. Ignition was by a natural gas wand which is the standard method in testing the combustibility of roofs. Wind was held close to 13 kph (8 mph). Mass loss and oxygen consumption were measured throughout the burning period for 10 shrubs. Maximum heat released surpassed 2 Megawatts within 1 minute of ignition in some shrubs.

KEYWORDS: combustibility, junipers, urban/wildland interface.

INTRODUCTION

The Stanislaus Complex Fire of 1987, the Cambell and Santa Barbara Paint fires of 1990, the Oakland Hills fire of 1991, the Old Gulch, Cleveland, and the Fountain fires of 1992, and finally, the fires of 1993 in Southern California are examples of urban/wildland interface fires moving into California's Mediterranean ecosystem. Burning as little as a few thousand acres to well over hundreds of thousands of acres, these types of fires have caused considerable damage and will continue to do so in the state of California. Fueled by an effective campaign of fire suppression for the last 100 years and an unprecedented expansion of urban growth into California's wildlands, the risk of major urban/wildland interface fires has reached levels never before seen.

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The questions of how and why these fires occur are raised every year as this type of fire rages throughout a part of California. Studies currently being completed at U.C. Berkeley (Gordon, 1994) are attempting to answer these and other questions about urban/wildland interface fires by identifying significant factors which control the behavior of the fire and its corresponding damage. Preliminary results of a study being completed on the Oakland Hills fire (Gordon, 1994) where 2305 structures were destroyed (Table 1) provide insight into the nature of conflagrations of this magnitude and how damage from them may be reduced.

Table 1. Structures destroyed, damaged or threatened in Oakland Hills fire of 1991.

Structures Destroyed	2305
Structures Receiving Major Damage	56
Structures Receiving Minor Damage	75
Structures Receiving Minimal Damage	103
Structures Threatened but Undamaged	437

Of the factors studied in the Oakland Hills fire there appear to be three major themes significant to the mitigation of this fire. The first major factor is the defense of the structure by either fire fighters or civilians. This has major implications for public policy and raises serious policy issues regarding the rights of property owners to protect their property versus the legality of forced evacuation by public safety agencies.

Other factors such as landscaping and structural modifications also played an important role in structure survivability during the Oakland HIlls fire (Gordon, 1994). Of factors associated with structures, the presence of ornamental vegetation was the second highest cause of structure loss in the Oakland Hills fire. Studies have been performed which investigate and model the combustibility of Eucalyptus litter (Jones and Raj, 1988; Jones and Rahmati, 1990; Jones, 1990; Jones, 1990) but the combustibility of domestic vegetation commonly used in landscaping has not been investigated. Probably one of the most hazardous elements in the urban/wildland interface is the introduction of non-native vegetation to the landscape. General guidelines of possible vegetation which should be used in areas with high fire danger have been developed but scientific study of the actual combustibility of the vegetation has not been done. Often homeowners neglect proper maintenance of ornamental vegetation and over time this can provide a rich fuel source primed for ignition.

Junipers and other hedges growing next to a house provide an excellent vector for transmitting fire from the wildlands to a structure by providing dead, dry material beneath a green exterior. Many homes destroyed by the Oakland Hills fire were landscaped with over mature junipers which provided a rich fuel bed of tinder dry litter beneath a canopy of foliage rich with volatile oils. While California state law requires wildland vegetation to be cleared at least 30 feet from the roof of a structure with rain gutters and roof valleys clean of leaves and twigs, the maintenance of ornamental vegetation often goes unchecked. When this factor is combined with other significant factors such as the presence of subfloor and eve vents and if these vents are screened, the probability of structure survivorship is drastically reduced.

The actual combustion of wood is a complex process and can be described in four stages: (1) heating and drying, (2) solid-particle pyrolysis, (3) gas phase pyrolysis and oxidation, and (4) char oxidation (Tillman et. al., 1981). Flammability of domestic and wildland vegetation is also important in understanding the dynamics of urban/wildland interface fires (Martin et. al., 1994).

In this study the combustibility of mature horizontal junipers was investigated. Combustion characteristics measured include heat released during flaming combustion and mass loss rate. Development of standard methods which can be used to determine the combustibility of domestic vegetation are also presented.

METHODS

Eleven mature Tam junipers (Juniperus sabina var. tamariscifolia) were harvested and allowed to dry between 0 and 10 days. Tam junipers are a low growing domestic species frequently planted in the western United States. Harvesting was done by cutting the trunk of the shrub at ground level. Shrubs were allowed to air dry after harvesting. Three samples of fine foliage and stems were collected off each plant immediately before ignition to determine moisture content on a dry weight basis. Vegetation samples were oven dried at 70 C for 48 hours to determine oven dried weight.

Whole junipers were placed on a burning table and ignited for 15 seconds using a natural gas wand 60 cm long. Flame length during ignition was approximately 30 cm. Average plant diameter and height were 1.5m and .4m, respectably. Wind was created using a portable fan and was maintained at approximately 13 kph (8 mph) throughout the test.

Heat produced during combustion was measured using an oxygen depletion technique (Huggett, 1980). The oxygen depletion sensors were installed in the exhaust hood of the laboratory and interfaced to a microcomputer for data acquisition. Mass loss of the junipers during combustion was measured using a load cell placed under the burning table. The load cell was also interfaced to the microcomputer and was sampled every 10 seconds during the test.

RESULTS

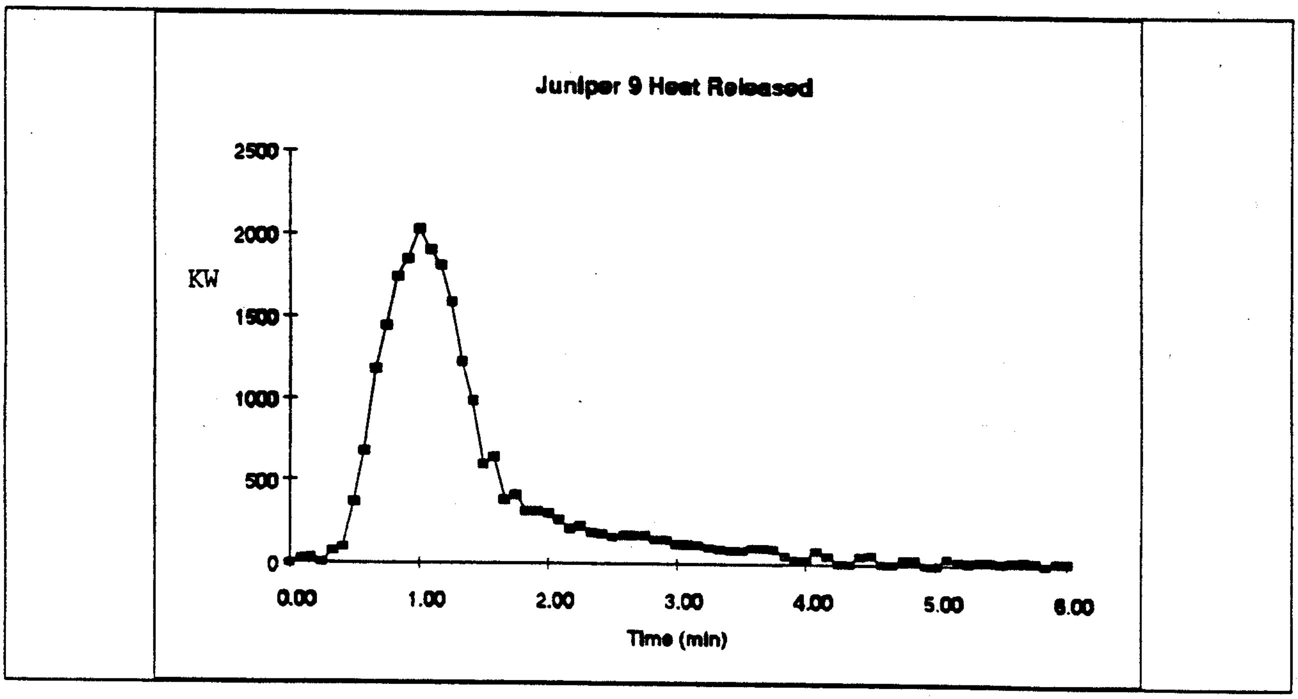
Juniper moisture content varied between 31.74-105.2% (Table 2). One juniper which was harvested the evening before ignition and had a moisture content of 105.2% would not ignite. This particular juniper was stored overnight in a sealed truck bed and the fine dead fuel was at the fiber saturation point. The juniper probably did not ignite because the entire shrub was at a high moisture content. Maximum heat released during flaming combustion varied between 165 KW - 2130 KW (Table 2). Mass loss rate during flaming combustion varied between 10 - 145 g/second (Table 2).

Table 2. Summary of test results.

Juniper Number	Moisture Content Mean (%)	Moisture Content Standard Error (%)	Maximum Heat (KW)	Mass Loss Rate (g/sec)
1	69.68	.92	897	86.4
2	77.08	.75	1158	90.9
3	70.93	.86	646	59.1
4	50.21	1.65	1826	145.4
5	57.57	.60	648	50.1
6	66.74	.52	684	59.1
7	60.77	.86	831	70.9
8	92.8	2.90	159	10.1
9	31.74	.33	2130	159.1
10	72.17	.61	913	90.9

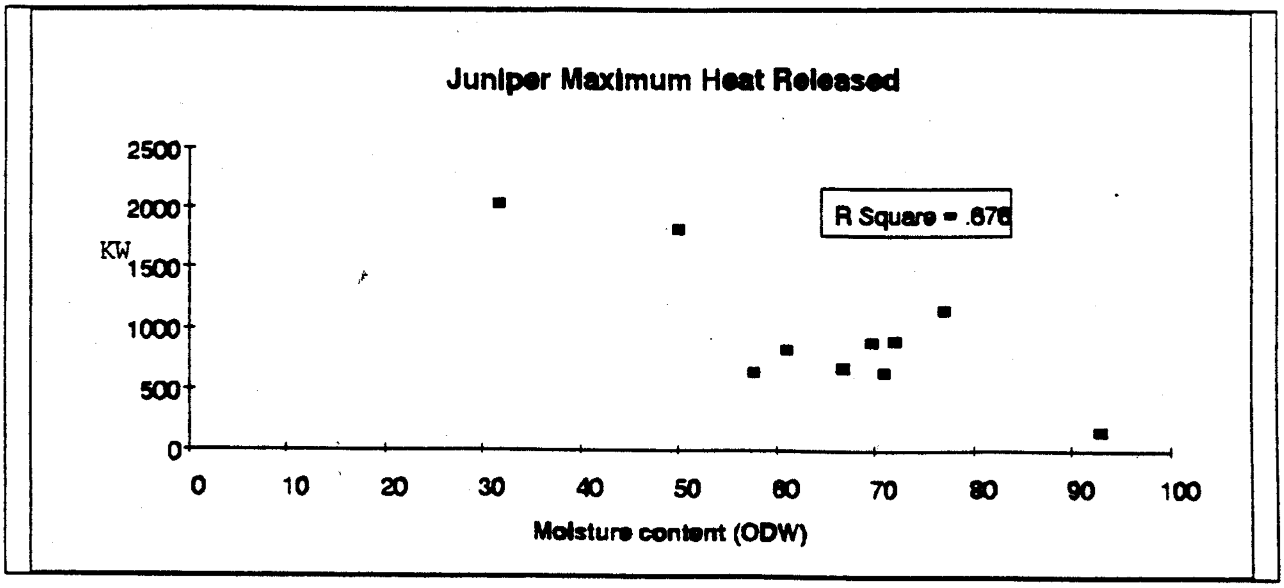
Maximum heat released for shrub number 9 approached 2.1 MW within one minute of ignition (Figure 1). This shrub produced flame lengths of approximately 3 meters but the maximum height was obscured by the exhaust hood in the laboratory.

Figure 1. Heat released from juniper #9.



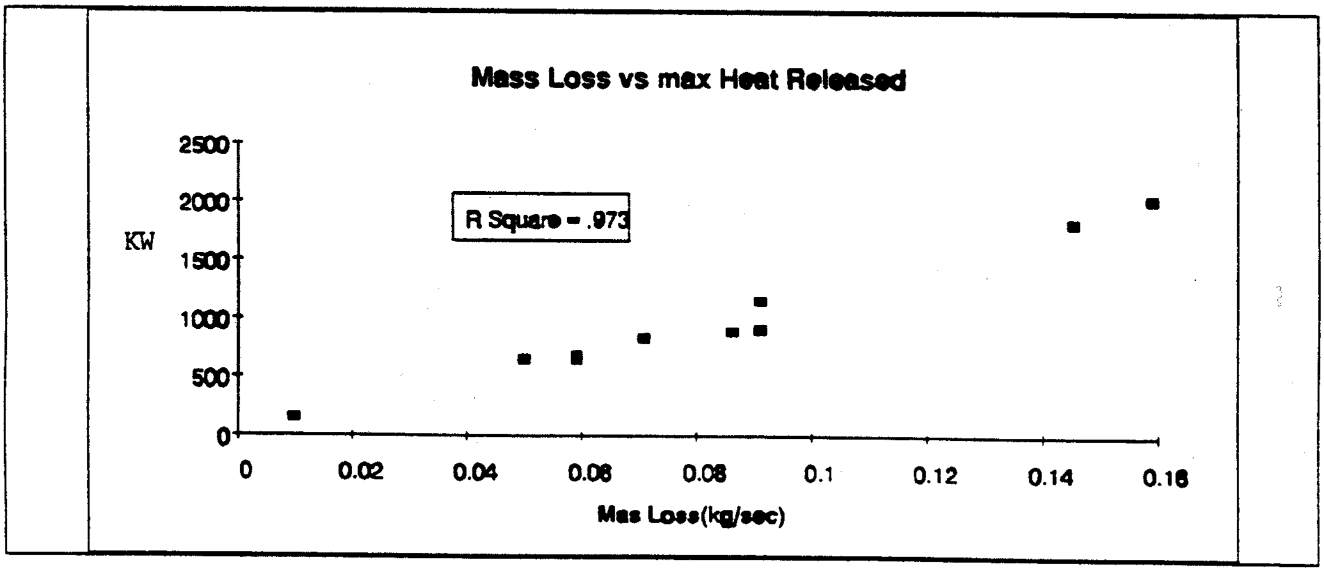
Juniper moisture content was significantly correlated (R Square = .676, n = 10) to maximum heat released during flaming combustion (Figure 2).

Figure 2. Correlation of moisture content to maximum heat released during flaming combustion.



Juniper mass loss rate during flaming combustion was significantly correlated (R Square = .973, n = 10) to maximum heat released (Figure 3).

Figure #3. Correlation of juniper mass loss rate during flaming combustion to maximum heat released.



CONCLUSION

The potential for large, destructive fires in the urban/wildland interface is as high as it has ever been in the history of the state. Influenced by an effective policy of fire suppression for the last 100 years and an unprecedented expansion of urban growth into California's wildlands, these types of fires are becoming an annual event.

Management of domestic and wildland fuels, along with building structures which have an increased probability of surviving such fires is the only way to reduce the destruction from these events. The management of vegetative fuels must be central to any program which has an objective to decrease the risk of urban/wildland interface fires. Fuel production is a dynamic process and therefore must be intensively managed to reduce risk. The use of prescribed fire along with livestock grazing and mechanical treatments can be combined to produce an effective fuel management program.

Domestic vegetation located in the urban/wildland interface provides an effective vector for transmitting fire from wildlands to structures. The heat released from the combustion of mature Tam junipers could be sufficient to ignite many structures found in California's wildlands. Homeowners must take responsibly for managing their own domestic vegetation to reduce fire risk.

Understanding how the moisture content of living domestic vegetation changes is response to different atmospheric conditions and watering regimes is needed to determine how the vegetative fuels will react to field conditions such as strong, warm easterly winds (Gutierrez et. al., 1994). Information from this study can be used to predict how juniper moisture content will respond to different environmental conditions which will in turn effect juniper combustibility.

The ignitability of Tam junipers in response to different amounts of desiccation and to different sizes of embers can be used to predict if domestic vegetation will provide a vector for fire to enter a structure (Schroeder et. al., 1994). Ignitability is also important because spotting is a major mechanism of fire spread in fires of the urban/wildland interface do to the high number of embers produced from vegetation and untreated shake roofs.

Private land owners along with public agencies must manage the vegetative fuels found on their properties. In many cases fire also provides ecological benefits to the flora and fauna found in California. Fire suppression activities will continue to be needed in California but unless a comprehensive program of fuel management is included, large destructive and potentially deadly urban/wildland interface fires will continue to occur.

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