To the Graduate Council:

I am submitting herewith a thesis written by Brian T. Hemel entitled "Prescribed Burning in Tennessee: Importance and Barriers, Goals, and Information Needs of Private, State, and Federal Managers." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

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Prescribed Burning in Tennessee:

Importance and Barriers, Goals, and Information Needs of Private, State, and Federal Managers

A Thesis Presented

for the

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Abstract

Early in the 20th century, intense and severe wildfires were frequent due to abundant fuels generated by logging and the presence of anthropogenic ignition sources in close proximity to these fuels. As timber was depleted, this period of lumbering ceased and the realization that vast tracts of cutover land had to be reforested and protected led to the inception of fire suppression organizations and techniques. The fire exclusion that occurred over much of the 20th century due to organized fire suppression efforts has led to two sets of problems: the buildup of fuels and the decline of fire-adapted species and fire-dependent ecosystems.

Managers interested in maintaining fire-adapted species and fire-dependent ecosystems are interested in restoring fire through prescribed burning (Vose 1994). Despite widespread interest and the clear ecological and economic benefits of prescribed burning, information on the effects of implementing this practice in appropriate forest types and other wildlands in Tennessee is incomplete. Precisely how common the use of prescribed burning is across the state has not been established. Barriers to prescribed fire implementation are likely to vary across private and federal management organizations, goals of prescribed burning, forest types, and local regions.

Objectives of this research included: 1) Determining the current level of use of prescribed fire by forest types, local regions, and management agencies and individuals, 2) Determining specific fire research and technology transfer needs and the barriers to implementation of prescribed fire across forest types, local regions, and management

agencies and individuals, and 3) Comparing effects of two fire regimes on Table Mountain Pine (*Pinus pungens*) in East Tennessee.

A survey was developed to address the first two objectives and was programmed in SPSS Data Entry format. The survey was e-mailed to approximately 350 Natural Resource Managers across the state of Tennessee. A modified Dillman Total Design Method (TDM) (Dillman 2000) was applied to the survey administration, whereby managers received an initial e-mail introducing the project and telling them when it would arrive. Next, managers were sent an e-mail message with a cover letter along with the web-site to answer the questionnaire. Reminder e-mail messages were sent to residents that had not responded within one and a half weeks of the initial mailing. Cross Tabulations and MANOVAs were run in SPSS.

For the third objective, two *P. pungens* stands of differing age structure and disturbance history at Horsehitch Gap on the Cherokee National Forest in Greene County, Tennessee were analyzed using dendrochronology and stand reconstruction techniques. The stands studied at Horsehitch Gap represented two regeneration cohorts resulting from two stand replacing fires in 1941 and 1981. The 1941 stand has experienced disturbances from low intensity ground fires and the Southern pine beetle (*Dendroctonus frontalis*). The 1981 stand is in the stem exclusion stage and is experiencing waves of density dependent mortality.

Survey results suggested the Tennessee Wildlife Resources Agency definitely uses prescribed burning the most in their management for wildlife and recreation. Private consultants use prescribed burning the least, but a majority of them would like to use prescribed burning on the land they manage. These two groups could be combined with federal/state agencies or with private firms. Different emphasis on economic returns were the main factors distinguishing these two groups. The private agencies are likely more concerned with having a sellable product in the future. The state/federal agencies have greater manpower to conduct these burns and are less likely to need the forest products to generate income.

Results for Table Mountain pine at Horsehitch Gap indicate that both stands of Table Mountain pine are in danger of being replaced by other species. This is particularly evident in the 1941 stand, where *P. pungens* individuals in the intermediate size classes are absent.

In conclusion, prescribed burning is an effective, economic, and ecological management tool. Managers spend less than 6.5 percent of their time on prescribed burning on forested land in Tennessee. According to managers, additional research on prescribed burning is needed in both hardwood and mixed pine/hardwood stands, and the correct seasons to burn in these ecosystems.

Based on measurements in the 1941 and 1981 stands, a stand replacing fire regime favored the regeneration of Table Mountain pine at Horsehitch Gap. Measurements obtained at Horsehitch Gap support the hypothesis forwarded previously by other researchers that a lack of stand replacing fire is likely to result in losses of many *P. pungens* stands from the landscape. Further, Southern Pine Beetle outbreaks have the effect of hastening conversion of *P. pungens* stands to other forest types. Further investigation of appropriate burning practices in hardwood stands will facilitate increased use of prescribed burning in Tennessee forests. For example, research on relationships between intensities of fire and season of burning in hardwoods will allow managers to determine when to burn in ecosystems without damaging crop trees. Additional research in areas such as smoke management will also facilitate increased use of prescribed burning for habitat improvement and other goals. Therefore, with managers, landowners, researchers and the general public working together, information on this management practice can be useful for everyone.

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Chapter 1: Background and Literature Review

History of 20th Century Fire in Southeast

Early in the 20th Century, intense and severe wildfires were frequent due to abundant fuels generated by logging and the presence of anthropogenic ignition sources in close proximity to these fuels. During this period, steam locomotives were used to transport timber to mills across the southeastern United States, and sparks from these locomotives ignited many wildfires. Large amounts of timber were systematically removed from forests to maintain the productivity of band saw mills, which resulted in a significant amount of logging slash left on the ground. These factors resulted in a new fire regime in the southeast as wildfires became very common.

As timber was depleted, this period of lumbering ceased and the realization that vast tracts of cutover land had to be reforested and protected led to the inception of fire suppression organizations and techniques. The United States Forest Service was opposed to the use of fire in forests during the 1920s (Pyne 1982). Even light burning was prohibited on all national forests, creating a fire regime that was very different from the pre-settlement and early European settlement periods (Van Lear and Waldrop 1989). The Forest Service used the Civilian Conservation Corps (CCC) to suppress fires in the national parks and national forests. Their main job, besides firefighting, included the construction of roads, firebreaks, and lookouts in the war against fire (Cohen 1996). Since 1944, the Smokey Bear campaign has been very successful in teaching the public to be careful with fire and that it has no role in the maintenance of America's forests (Brose et al. 2001). For the past 70 years, fire exclusion has completely altered fire regimes in most ecosystems (Buckner 2000).

Effects of Fire Exclusion

The fire exclusion that occurred over much of the 20th century due to organized fire suppression efforts has led to two sets of problems: the buildup of fuels and the decline of fire-adapted species and fire-dependent ecosystems. Without fire, "understory brush and hardwoods became more dense and both live and dead vegetation accumulated, increasing the risk of large and damaging wildfires" (Long 1998). Harmon (1982) concluded that fire suppression since the 1930s in the Great Smoky Mountains National Park would result in a major change in forest composition on north and south facing slopes, resulting in a loss of fire-dependent ecosystems.

Since fires, both natural and anthropogenic, were present in the southeast, they have created a unique forest cover with trees evolving with and adapting to fire, like Table Mountain pine (*Pinus pungens*) with cones that do not open until exposed to high heat (Komerak 1974, Van Lear and Waldrop 1989). Fire can be selective and favors fire-adapted species while simultaneously hindering less fire tolerant species. Natural regeneration of southern pine has diminished due to the accumulation of duff, which results in a lack of bare mineral soil seedbeds needed for seed germination. Competition between pine seedlings and hardwoods has also increased due to increased survival of hardwood sprouts in these stands. Research has shown that many oak species establish an extensive root system that will produce more vigorous sprouts after fire than the less fire-tolerant red maple and yellow-poplar saplings, which will eventually die after several fires (Thor and Nichols 1974).

Use of Prescribed fire by Natural Resource Managers

Goals

Fuel reduction

The most common objective of prescribed burning is fuel reduction. Managers are interested in reducing fuel loads and the risk of catastrophic wildfire through prescribed burning. Applied correctly, repeated prescribed burning will decrease rates of spread and intensities of wildfires or subsequent prescribed fires in any ecosystem (van Wagtendonk 1996). Since fuel loads are reduced by prescribed fire, crown fire occurrence is reduced (Smith et al. 1997). The accumulation of litter and needle drape in pine stands can become dangerous, creating vertical ladder fuels that fire can climb. The recent southern pine beetle outbreak has resulted in stands of standing dead trees with large amounts of dead litter on the ground. Literature is lacking on fuel reduction in hardwood and mixed pine/hardwood ecosystems (Van Lear and Waldrop 1989). This makes management decisions difficult because some hardwood species will curl up and collect water after rain events while others will dry up allowing fire to spread (Stanturf et al. 2002).

Managing for Fire-adapted Species

Managers interested in maintaining fire-adapted species and fire-dependent ecosystems are interested in restoring fire through prescribed burning (Vose 1994). Since natural and anthropogenic fires have been present for millennia in the Southeast, they have created a unique forest cover with plant species evolving with and adapted to fire, like Table Mountain pine (*Pinus pungens*) (Komerak 1974, Van Lear and Waldrop 1989). Some of the extensive natural yellow pine stands found in the southern Appalachians would not have developed without the canopy openings created by fire (Barden and Woods 1976). In hardwood stands, managers are trying to reduce the number of shade-tolerant species (e.g. red maple *Acer rubrum*) and fast-growing competitors (e.g. tulip poplar *Liriodendron tulipifera*) to favor the regeneration of economically and ecologically valuable oak species (Van Lear 2000). Research on the Highland Rim in Tennessee has revealed an increase in the number of oak seedlings from controlled burning compared to control plots (Thor and Nichols 1974).

Prescribed burning is an effective silvicultural tool for meeting wildlife goals ranging from increasing the abundance of game species to the conservation of endangered species. Prescribed fires are used to increase mast availability and return species composition to early-successional plant species assemblages necessary for certain wildlife species (Buckner and Landers 1979). Prescribed fire can be used to create ideal bird habitat conditions in herbaceous or shrub dominated communities for bird species that require open habitat. For example, the taxonomic family Emberizidae (sparrows) requires open habitats to survive (Brownlie and Engstrom 2001). Frequent low intensity burns maintain grasses which are needed for nesting. Red-cockaded woodpeckers

(*Picoides borealis*) nest in pine ecosystems with open understories. By burning on 3-to 5-year rotations, managers are able to produce suitable habitat for colony and forage sites for this endangered species (Stamps et al. 1983). Recent research on black bear (*Ursus americanus*) has been focused on how habitat can be enhanced. Prescribed burning can enhance fruit production in berry-producing plants and create dens in the base of trees used for hibernation purposes (Hamilton 1981). Overall, fire is a very useful multipurpose natural resource tool for both forestry and wildlife management.

Techniques

Prescribed burning, as a management tool, uses regulated or controlled fire to reduce and/or remove ground and surface fuels from the forest. This technique, when practiced effectively, can be used simultaneously for timber management, wildlife management, and reducing fire hazards (Smith 1986). Fuel breaks, areas that have a reduced amount of fuel, are often constructed within landscapes in order to help reduce the spread of wildland fire. Fuel breaks can be a temporary fix until more permanent fuel management can be implemented. In forested areas, shaded fuel breaks are constructed through manual or mechanical means, and in different overstory and understory prescriptions (Agee et al. 2000). Roads and streams are also used as fuel breaks.

Three main firing techniques are used in prescribed burning, depending on characteristics of the area that will be burned.

- Head fire: "Head fires burn with the wind or upslope. They are of relatively high intensity and move through fuels at a relatively high rate of speed. Head fires are often ignited in strips (called strip head fires) to speed the burning process and to provide the desired intensity. Fire intensity increases as the rear of a previously ignited strip merges with the advancing front of a subsequent strip," (Van Lear and Waldrop 1989 who cited from Brown and Davis 1973).

- Backing fire: "Backing fires back into the wind or burn down slope. They burn with lower flame heights or lower intensity and move through the stand at slower speeds than head fires. Backing fires, because of their lower intensity and slower speeds, are more easily controlled." (Van Lear and Waldrop 1989).

- Flanking fire: "Flanking fires are set moving parallel and into the wind. They are generally used to supplement other burning techniques. For example, flanking fires can be used to speed the process of burning with backing fires. Flanking fires are set perpendicular to backfires. Where flanking fires merge, fire intensity increases," (Van Lear and Waldrop 1989).

Prescribed burning is usually the cheapest method for fuel reduction and favors fire-adapted species. However, barriers to its usage may present problems for federal, state and private natural resource managers. For example, prescribed fire is very hazardous in pine stands killed by the southern pine beetle (*Dendroctonus frontalis*). Further, more research is needed in hardwood stands to determine the correct intensity and frequency to burn in order to avoid decreasing timber quality.

Mechanical fuel reduction methods used as a silvicultural tool are known to lower rates of spread and intensities until fuels can re-accumulate (van Wagtendonk 1996). Reducing rates of spread and decreasing intensities require reducing the size and compactness of live and dead vegetation. Three common mechanical practices include uprooting large woody plants, chopping smaller plants, and plowing grasses and other herbaceous growth in order to destroy the root systems of vegetation, thereby decreasing the chance of re-growth (Smith et al. 1997). A caution with mechanical methods is the fact that machines can alter the mineral soil structure and could possibly reduce the productivity of the site (Gent et al. 1984). Literature supports the idea that soil compaction occurs as a result of harvest operations, but does not emphasize how crucial a problem compaction can be (Greacen 1980).

Chemical herbicide treatments are used to reduce the height, cover, and/or loading of highly flammable (rhododendron/mountain laurel) shrub layers but the degree of reduction and longevity of hazardous fuel after treatment is not well defined (Brose and Wade 2002b). Chemical research is limited with respect to fuel reduction. The small amount of literature on chemical reduction methods deals mostly with pines; for example, slash pine (*Pinus elliottii*) stands treated with herbicide reduced fuel over time (Brose and Wade 2002b). The treatments that are used in pines can eliminate almost all vegetation from most kinds of sites with little hardwood species selectivity (Smith et al. 1997).

Prescribed burning, mechanical, and chemical fuel reduction treatments all have advantages and disadvantages. Based on the types of fuels present, one method or a combination of these methods may be most effective. For example, Romancier (1971) found that rhododendron was best controlled by using a prescribed fire/herbicide combination. Basal spraying or mist blowers were very effective in killing sprouts surviving prescribed burning (Romancier 1971).

Despite widespread interest and the clear ecological and economic benefits of prescribed burning, knowledge is incomplete in implementing this practice in appropriate forest types and other wildlands in Tennessee. Precisely how common the use of prescribed burning is across the state has not been established. There are three categories of forests and other wildlands in Tennessee: those that are currently being managed with prescribed fire; those that are not currently managed with prescribed fire, but could; and those in which fire is ecologically inappropriate. The category of forests and wildlands in which prescribed fire is appropriate, but is not being implemented is of substantial importance due to the potential risk of catastrophic fire and the loss of fire-adapted species integral to maintaining these ecosystems.

The overall use of prescribed fire in Tennessee needs to be assessed in order to judge the magnitude of the risk of catastrophic fire across the state, and also the risk of losing fire-adapted species and fire-dependent ecosystem types. Identifying important barriers to employing prescribed fire in appropriate forest and wildland types is needed to determine what actual prescribed fire research needs remain, as well as needs for increased transfer of existing technology.

Economic Incentives

Many economic incentives are available for natural resource managers to implement prescribed fire in their silvicultural practices. "Silviculture is applied ecology, tempered by economics and social concerns to achieve management objectives" (Van Lear 2000). Mechanical and hand thinning treatments for releasing crop trees have been effective in pine ecosystems, but very costly. Similar results can be obtained through low-intensity prescribed fire at a fraction (5 to 15 percent) of the cost of mechanical thinning (Lloyd and Waldrop 1999). As a silvicultural treatment, the impact of prescribed burning on soil is less than most mechanical silvicultural methods. Large machinery will compact the soil and decrease porosity and aeration, affecting root growth (Gent et al. 1984). Prescribed burning can be performed at lower cost than chemical or mechanical methods for fuel reduction as well as site preparation.

Chapter 2: Prescribed Burning in Tennessee

Use of Prescribed Fire in Tennessee

Tennessee is unique in having a variety of different forest ecosystems across the state comprising its 14.4 million acres of forested land (Schweitzer 1999). These forests are managed by private industry and firms, and federal and state agencies. Due to the diverse geologic history of the state, several different forest systems can be found, ranging from bottomland hardwoods in the Mississippi Alluvial Valley to southern pine ecosystems in the Cherokee National Forest. Therefore, natural resource managers need a good working knowledge of forest ecology, "the structure, composition, and function of forests" (Barnes et al. 1998) in order to apply silvicultural prescriptions, "the application of knowledge…in the treatment of a forest" (Smith et al. 1997). Natural Resource Managers have a variety of silvicultural prescriptions and tools they can use to accomplish their management objectives, including prescribed fire.

Potential Barriers and Information Needs

A variety of barriers may prevent the implementation of prescribed fire in systems where it is appropriate. Different treatments have their time and place in management. Two factors that influence the use of prescribed burning by managers include public opinion and costs (Cleaves and Haines 1996). Risk is a common concern for managers in implementing prescribed fire. Managers are concerned with the wildland/urban interface, liability, smoke hazards, and unintended effects of prescribed fire. Depending on where residents live, either wildland or urban areas, support and knowledge of prescribed fire will vary significantly (Butry et al. 2002). Liability is a major concern for individuals and agencies that can be sued for damages created from problems associated with prescribed burning. Smoke is an important health issue and can be very hazardous along roads, resulting in many accidents and fatalities (Achtemeier 1998). Finally, with all precautions taken, prescribed burns can get out of control with an unexpected weather change, resulting in unintended damage to adjacent areas. Along with outbreaks of catastrophic fire, these problems have stimulated much of the fire research across the country.

Barriers to prescribed burning by individuals and agencies can be either internal or external. For example, societal pressures generated by citizens can eliminate a manager's ability to use prescribed burning as a management tool (Cleaves and Haines 1996). These people are usually influential in their region, but are uneducated on the role of fire in the development and functioning of ecosystems. Private consulting firms and consultants often are not able to prescribe burn due to a lack of manpower, liability, and the costs involved. Burning permits in some states need to be acquired less than one day in advance (Butry et al. 2002) and weather can be a determining factor. Sudden wind changes can cause a prescribed burn to be cancelled. Institutional and private policies, protocol, tradition and mission will determine whether or not a manager is able to implement prescribed burning as a management tool.

The lack of information on prescribed burning methods for certain forest types is a barrier that needs to be addressed. In pine stands, prescribed fire is not only used to decrease the amount of hazardous fuels, but also to prepare stands for regeneration, to control hardwood regeneration, and to dispose of logging slash (Rudis and Skinner 1990). Also, prescribed fire is used to thin natural regeneration in pine stands that would produce too many seedlings and create a fire risk (Lloyd and Waldrop 1999). The use of fire in pine stands has been researched intensively in the Southeast, and research on prescribed fire in hardwoods has increased due to wildlife and economic benefits derived from prescribed burning. In mixed pine-hardwood stands, studies have revealed that a high intensity prescribed fire benefits both pine and hardwood regeneration (Vose et al. 1993). Opening a mixed stand allows suppressed hardwoods to enter the midstory and creates patches of bare mineral soil for germination of pine seed. Fire will also reduce unwanted hardwoods allowing for advanced regeneration of desirable species such as oak (Vose 1994, Keyser et al. 1996). Research on the implementation of prescribed fire in hardwoods has been limited because foresters have long recognized that wildfire during the growing season is a major cause of butt rot in hardwoods. Therefore, little information is available concerning the relationship between prescribed fires of lower intensity and stem damage (Van Lear 1990). Research is needed in hardwoods to determine the precise frequency, season, and intensity needed to obtain desired objectives.

Fire has been studied within various forest types in terms of species of interest, but information is lacking for entire ecosystems. For example, effects of fire in mixed white-pine/hardwood stands on basic ecosystem attributes is uncertain (Vose 1994).

Scientists may or may not be conducting research that natural resource managers need in the field to better manage for timber and/or wildlife. Also, some questions have already been addressed through research, but the answers to these questions have not reached managers due to inadequate technology transfer and communication methods.

Barriers to prescribed fire implementation are likely to vary across private and federal management organizations, goals of prescribed burning, forest types, and local regions. One recent survey in the South on pine type ecosystems (Haines et al. 2001), indicated that both federal and private managers are hesitant to burn because of air quality and smoke regulations and the risk of liability. Additional barriers that limit prescribed burning include public opinion, local residential development, shortage of personnel, and a narrow time frame in which prescribed burning is possible (Haines et al. 2001).

Managers also have obstacles to using prescribed fire that influence management plans and preparation. If a natural resource manager's objective is to achieve desirable habitat for an endangered species, such as the red-cockaded woodpecker, they have to meet agency policy directives and protocols to work in this unique area. A timber manager needs to ensure that he/she is not going to degrade the quality of timber when using fire and keep the stand sustainable for future harvests. More research directed to answering these questions is needed to determine if fire is the best solution for fuel management or site preparation in various ecosystems. Currently, the Joint Fire Science Program is funding investigations of several different fuel reduction techniques in ecosystems across the United States. Prescribed burning in conifer stands has been studied and practiced for many years, but fuel loads are a common concern and prohibit managers from using this technique.

Wildland/urban interface and rural settings also have their own barriers to prescribed burning. More individuals live in the wildland/urban setting than in rural areas, so there is greater public concern resulting in an increased amount of social pressure against prescribed burning. Also, smoke mixed with fog is very dangerous to motorists and homeowners. Researchers are not able to predict precisely how smoke will travel on the ground, which could cause harm to those in the vicinity with respiratory problems. Barriers in rural settings include the risk of fire damaging landowner property. Published information on these barriers is lacking, and could be improved upon.

Importance for fire-adapted species

Table Mountain pine (*Pinus pungens* Lamb.) has historically been maintained in the southern Appalachians by recurrent fires of both natural and anthropogenic origin. Historic natural events and cultural practices aided in maintaining this fire-dependent species on south-southwest facing slopes throughout the southern Appalachians (Delcourt and Delcourt 1997). A majority of Table Mountain pine stands in the southeastern region originated from landscape-scale, stand replacing fires of the early twentieth century (Welch and Waldrop 2001). However, after a century of fire suppression, Table Mountain pine's dominance in areas of historically recurrent fires is diminishing (Sanders 1992, Welch and Waldrop 2001). Table Mountain pine is now listed as one of the 31 rare communities in the southern Appalachians (SAMAB 1996).

Due to both natural and anthropogenic fires being present in the southeast, the forests have developed a unique forest cover which includes tree species that have evolved with and adapted to fire. For example, Table Mountain pine exhibits cone serotiny in which the seed bearing cones do not open until exposed to high heat (Komerak 1974, Van Lear and Waldrop 1989). Table Mountain pine is an endemic species to the Appalachians Mountains and ranges from Pennsylvania to North Georgia (Waldrop and Brose 1999). It functions as a secondary pioneer species after disturbances and can live long into an established stand (Zobel 1969).

Table Mountain pine is important and one of the rarest components of the Southern Appalachians (Sanders 1992, Waldrop and Brose 1999, Brose et al. 2002). The anthropogenic alteration of the fire regime of mid-elevational communities is driving this species toward extirpation in these communities and possibly extinction if little is done. Research has shown that fire suppression can be considered one of the greatest threats to this species (Sanders 1992, Waldrop 1999, Waldrop and Brose 1999, Welch et al. 2000, Welch and Waldrop 2001, Brose et al. 2002). However, successional replacement of Table Mountain pine is even being documented in systems where fire is still a persistent disturbance (Armbrister 2002), yet has been largely overlooked in both research and management. In addition, disturbance-mediated accelerated succession (Abrams and Scott 1989) in Table Mountain pine stands, due to the current Southern pine beetle (*Dendroctonus frontalis* Zimmerman) outbreak, is posing a new threat.

Project Objectives

This research project had three major objectives. The first objective was to determine the current level of use of prescribed fire and barriers to the use of prescribed fire by forest types, local regions, and management agencies and individuals.

The second objective was to determine if specific fire research and technology transfer needs that create barriers to implementation of prescribed fire exist across forest types, local regions, and management agencies and individuals. Objectives 1 and 2 were completed using a survey of natural resource managers over the internet.

The final objective was to compare effects of two fire regimes on a fire adapted species, Table Mountain pine (*Pinus pungens*), in East Tennessee. A stand dynamics field project was undertaken to determine the structure and dynamics of a stand of Table Mountain pine in the Cherokee National Forest.

Chapter 3: Methods

Survey Methodology

Natural resource managers across the state were contacted by e-mail and a SPSS (SPSS Inc. Chicago, Illinois) internet questionnaire was used to collect data. Natural resource professionals who manage land were asked a series of questions pertaining to prescribed fire. If prescribed fire was used, the questionnaire directed the manager to questions on the reasons why they use prescribed fire and the future of prescribed fire in their management activities. If the manager did not use prescribed fire, the questions were directed to barriers that may inhibit their use of prescribed fire.

Natural resource managers were divided into three categories based on whether they were federal, state, or private/personal employees working in Tennessee.

This study has a three-part methodology, 1) the survey instrument, 2) the survey population, and 3) the survey execution and analysis.

Survey Instrument

The objectives of this study required responses from natural resource managers across the state of Tennessee. The internet survey method was used in the interest of time and cost. The personal interview method could have been more effective (Dillman 1978), but was not used due to time and travel constraints. Also, sending the survey via e-mail eliminated the cost of both postage and long-distance toll charges.

The survey was developed by the researcher and faculty advisors (Dr. David Buckley, Dr. Wayne Clatterbuck, Dr. Mark Fly, and Dr. Donald Hodges). The survey questions were stated as simply and clearly as possible so that anyone reading the questions would understand them the same way (Dillman 2000). Once the questionnaire was completed, it was reviewed by experts who are familiar with prescribed burning as a management tool for natural resources. A pretest of the questionnaire was conducted with forestry professionals from the East Tennessee Chapter of the Society of American Foresters to determine any inconsistencies with the survey in order for everyone to interpret the questions the same way. Once the inconsistencies were resolved, the survey was incorporated into the SPSS Data Entry format with the assistance of Cary Springer from the University of Tennessee Statistics Department. A modified Dillman Total Design Method (TDM) (Dillman 2000) was applied to the administration of the survey to increase response rates, whereby managers received an initial e-mail introducing the project and telling them when it would arrive (Appendix 1A). Managers were then sent an e-mail with a cover letter along with the web-site to answer the questionnaire (Appendix 1B). A reminder e-mail message was sent to residents that had not responded within one and a half weeks of the initial mailing (Appendix 1C). If the manager did not respond to the reminder e-mail, a final e-mail was sent asking again for their help in this research (Appendix 1D).

The survey directed the respondent to enter his or her e-mail address, allowing determination of whether a participant successfully completed the survey so that a reminder e-mail was not sent. The e-mail address database was kept separately from the data. Once the surveys were completed the addresses only were kept if the respondent requested to enter a drawing or for the results to be e-mailed to them.

Study Population

The study population included 351 natural resource managers across Tennessee including: private industry; self-employed consulting foresters; foresters employed by consulting firms; and personnel from Tennessee Division of Forestry, Tennessee Division of Environment & Conservation, Tennessee Wildlife Resources Agency, Tennessee Valley Authority, United States Department of Agriculture, United States Forest Service, United States National Park Service, and United States Fish & Wildlife Service. These organizations and firms utilize a wide variety of management practices across the state in all ecosystems in which fire could be used to achieve desired goals. Requirements for managers to participate in the survey included managing or assisting in management decisions on forested land in Tennessee

Survey Execution and Analysis

The SPSS survey was completed and distributed to the study population in mid-August 2003. The study population was created through internet searches, Tennessee Society of American Foresters directory, and the Tennessee Wildlife Society directory. The survey was reviewed/fine-tuned by my committee members and submitted to the University of Tennessee Institutional Review Board (IRB) for approval to survey human subjects (See Appendix 1E). The pre-survey e-mail message was sent in early August to prospective participants to introduce the survey, stimulate interest, and tell them when the survey would be available. The survey website was made accessible on 15 August 2003 and remained available until 1 November 2003. Leaving the website open until 1 November 2003 provided time to contact those who did not respond to allow ample time for managers to complete the survey given their travel and work schedules.

After closing, the survey data was analyzed by running Chi-square tests and Multivariate Analysis of Variance (MANOVA). The Pearson's Chi-square tests showed correlations between the different variables based on an alpha of 0.05. These numbers are based on a minimum residual value of (RV) +/- 2. The adjusted residual gives the difference between the observed and expected value. The MANOVA tests compared the mean Likert scale responses (1=Not at all Important, 5= Extremely Important) of several populations based on job description, employer, and region and on selected variables (responses to barriers that prevent managers from prescribed burning and responses to where science-based information on prescribed burning is needed) based on an alpha of 0.05. Tukey's Honestly Significant Difference (HSD) test was then run with alpha = 0.05 to investigate differences between pairs of means.

Fieldwork Methodology

Study Site

The study area was located on a south to southwest facing slope adjacent to Horsehitch Gap, located in Greene County, Tennessee, within the Nolichucky District of the Cherokee National Forest (36° 2′ 15″ Lat., 82° 46′ 30″ Long.). Horsehitch Gap

(HHG) is located between Short Mountain and Greene Mountain in the Unaka Mountain range of the southern Appalachians. The area surrounding HHG ranges from 634 m to 835 m in elevation and the climate at HHG is characterized as Hot Continental (Bailey 1995). Mean annual temperature is 14°C (57°F) with July being the warmest month at 24°C (76°F) (USDC 1989, Sanders 1992). Mean annual precipitation is 107.3 cm (42.25 inches). July is the wettest month, averaging 11.76 cm (4.63) inches and October is the driest month averaging 6.48 cm (2.55 inches). The soils on this site are of the Ramsey series (loamy, siliceous, subactive, mesic Lithic Dystrudepts) consisting of stony loams that are strongly acidic, poorly developed, and low in fertility (Edwards et al. 1958).

Horsehitch Gap Disturbance History

The current assemblages at HHG are a result of two major fire events. First, a stand replacing fire in 1941 consumed around 3000 acres, creating a mix of *P. pungens* and *P. rigida* Mill. (pitch pine) with a minor component of *P. echinata* Mill. (shortleaf pine) and *Pinus virginiana* Mill. (Virginia pine). *P. pungens* dominated the stand and generally comprised 80% of the stems (Sanders 1992). In 1981, a second stand replacing fire consumed approximately 2000 acres of the stand that originated after the 1941 fire, and was colonized by a new cohort of mostly *P. pungens* with a small component of *P. rigida*. As the 1981 fire became less intense, the remaining acreage from the 1941 stand burned as a surface fire through the understory (Sanders 1992, Brown 2002). Given that the stand burned at different intensities within separate locales, two cohorts, and therefore two discrete stands, were created: an even-aged 1981 cohort and the relic 1941 cohort.

In 2000 *Dendroctonus frontalis* (southern pine beetle) killed virtually the entire 1941 cohort and many mature pines in adjacent stands. However, approximately 10 acres in the southeast corner of the 1941 stand remain. Within the residual 10 acres, many of the larger diameter individuals succumbed to the *D. frontalis* outbreak leaving only scattered small diameter *P. pungens* (the only remaining individuals from the original 1941 cohort). The last minor disturbance was in 2001 when a small wildfire burned thorough part of the area killing approximately 5 acres of the 1981 cohort (Brown 2002). In 2002-03 approximately 60 percent of the area covered by the original 1941 *P. pungens* stand was still dominated by *P. pungens* with only approximately 10 acres of the 1941 stand remaining in *P. pungens*..

Methodology

In the fall of 2002, data were collected to characterize the 10-acre 1941 relic stand and a 20-acre subset of the 1981 stand. Two transects were located within each of the two stands. Five plots were located at 2.5 chain intervals along each transect through the interior of each of the two distinct stands resulting in a total of 10 plots per stand, 20 plots overall. Data were used for quantifying vegetation and dendroecological characteristics. Due to stand differences, separate sampling protocols were designed for each stand.

1941 stand

All vegetation was surveyed using fixed-area plots. To characterize the overstory component, species, diameter at breast height (dbh), crown class and stem condition (live or dead) were recorded for all stems greater than four (4) inches dbh occurring in 0.02 acre circular plots. Classifications of crowns into four classes were based on the amount of light received for each crown (Smith et al. 1996). For the midstory component, species and diameter were recorded for all stems greater than 4.5 feet in height and less than four (4) inches dbh occurring in the same 0.02 acre plots. Understory vegetation was characterized by recording a count of each species within four designated height classes (less than or equal to 1 ft., greater than 1ft. - less than 2ft., greater than 2 ft. - less than 3 ft. and greater than 3 ft. – less than 4 .5 ft.) occurring in 0.01 acre subplots nested within the overstory plots. For each tree species, relative importance values were calculated by acquiring the average of the relative frequency, relative dominance (basal area) and the relative density for that species (Cottam and Curtis 1956).

1981 stand

All vegetation was surveyed using fixed-area plots. Species and height class (less than 5 ft., greater than 5 ft. – less than 10 ft., greater than 10 ft. – less than 15 ft., greater than 15 ft. – less than 20 ft., and greater than 20 ft.) were recorded for all stems occurring in 0.01 acre plots. Each plot was divided into four (4) equal quadrants and one (1) quadrant was selected at random for recording species, and dbh.

At each plot (1941 & 1981) approximately four representative stems from all age and diameter classes were chosen for coring (Abrams and Copenheaver 1999). All stems were cored at ground level using Haglof increment borers and cores were used for age determination. All cores (n=96) were air-dried and each core surface prepared using standard dendrochronological techniques (Fritts and Swetnam 1989, Wimmer and Vetter 1999) that allowed intra-annual ring detail to be easily discernable. When the pith was not captured in the coring process standard pith estimators were used during age determinations (Applequist 1958). Age determinations for all cores were made using a standard dissecting microscope.

Chapter 4: Results

Results of Survey

Survey Population Demographics

Of the original 351 natural resource managers (NRM) contacted to take the survey, 241 were included in the final population because the survey was not relevant to some individuals. For example, one individual listed as a natural resource manager living in Tennessee manages land in Kentucky. Another individual was not able to complete the survey due to agency protocol. Of the remaining 241, 165 NRMs completed the survey for a response rate of 68.4 percent. Respondents managed an average of 74,468 ranging from 0 to 74,468 acres, and had worked in natural resources 14 years on average. Managers represented the 5 regions across the state based on the counties where they manage land. For this project, the state was classified into five regions: West, West Central, Central, Plateau and East (Figure 1, Table 1). At least 12.4% of the respondents were located in each region, with the East region representing the highest percent at 33.1 (Figure 2). The amount of job responsibility involving prescribed burning across the state (6.4%) varied within each region (Table 2 and 3). A majority (51%) of the NRMs surveyed were foresters (Figure 3) followed by biologists (16%), ecologists (10%), wildlife biologists (8%), and refuge managers (5%), The remaining 15 percent included fire managers, rangers, and others (Figure 3). The respondents were distributed across the full range of employers with the Tennessee Division of Forestry (TDF) (19.5%)

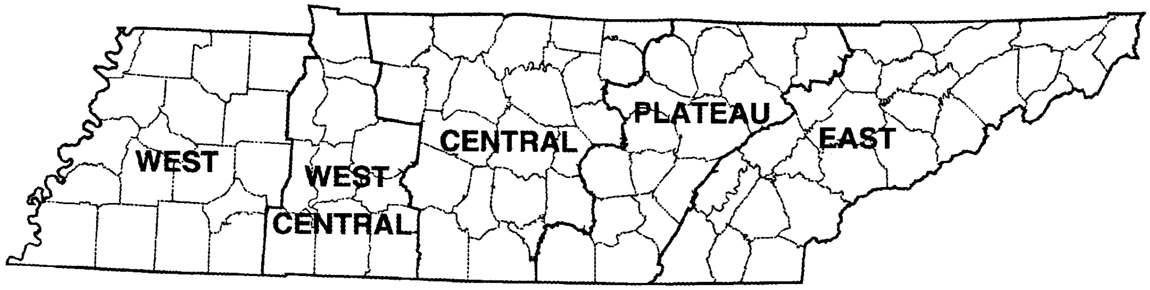

Figure 1: Tennessee state map split into separate regions (Schweitzer 1999).

Table 1: Counties associated with Tennessee Regions (Schweitzer 1999).

West	West Central	Central	Plateau	East
Carrol	Benton	Bedford	Bledsoe	Anderson
Chester	Decatur	Cannon	Campbell	Blount
Crockett	Hardin	Cheatham	Cumberland	Bradley
Dyer	Hickman	Clay	Fentress	Carter
Fayette	Houston	Coffee	Franklin	Claiborne
Gibson	Humphreys	Davidson	Grundy	Cocke
Hardeman	Lawrence	De Kalb	Marion	Grainger
Haywood	Lewis	Dickson	Morgan	Greene
Henderson	Perry	Giles	Overton	Hamblen
Henry	Stewart	Jackson	Pickett	Hamilton
Lake	Wayne	Lincoln	Putnam	Hancock
Lauderdale		Macon	Scott	Hawkins
Madison		Marshall	Sequatchie	Jefferson
McNairy		Maury	Van Buren	Johnson
Obion		Montgomery	Warren	Knox
Shelby		Moore	White	Loudon
Tipton		Robertson		McMinn
Weakley		Rutherford		Meigs
		Smith		Monroe
		Sumner		Polk
		Trousdale		Rhea
		Williamson		Roane
		Wilson		Sevier
				Sullivan
				Unicoi
				Union
				Washington

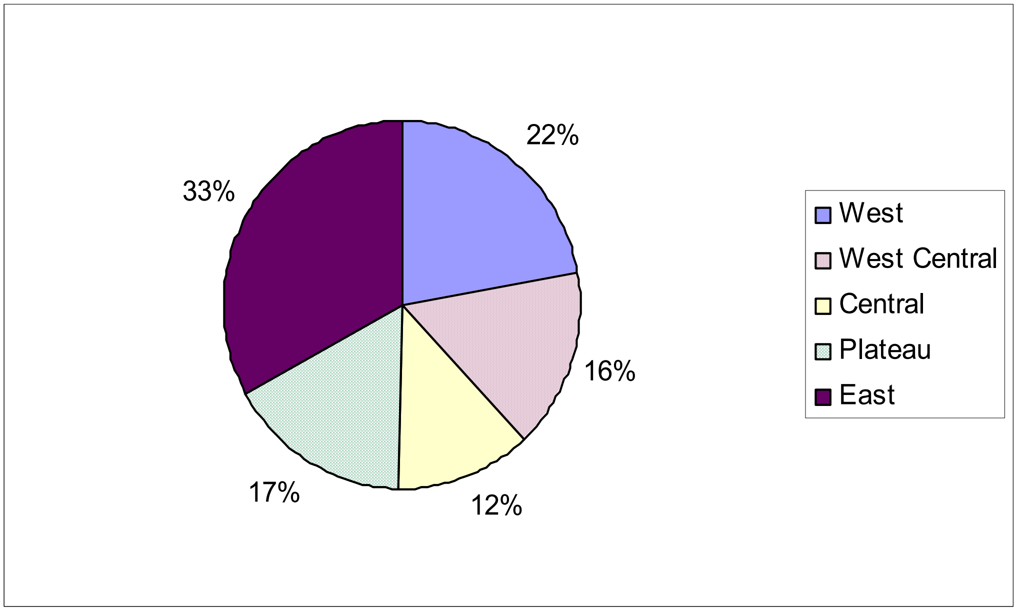

Figure 2: Percentage of Tennessee natural resource managers who responded to the survey by management region. Counties within regions are found in Table 1.

Table 2: Total Tennessee forested acres managed by those surveyed and the percentage of job responsibility involving prescribed burning. Overlap may occur in acres managed due to district foresters managing the same land as private managers.

Acres Managed	Percent of Job Involving Burning
9,495,710	6.4

Table 3: Number of acres managed, based on survey responses of managers that use or recommend prescribed burning, and the percentage of job responsibility involving prescribed burning in each region. Overlap may occur in acres managed due to district foresters managing the same land as private managers.

Region	Acres Managed	Percent of Job Involving Burning
West	1,196,200	9.96
West Central	437,950	25
Central	100,000	2.9
Plateau	671,600	.02
East	4,862,775	12.5

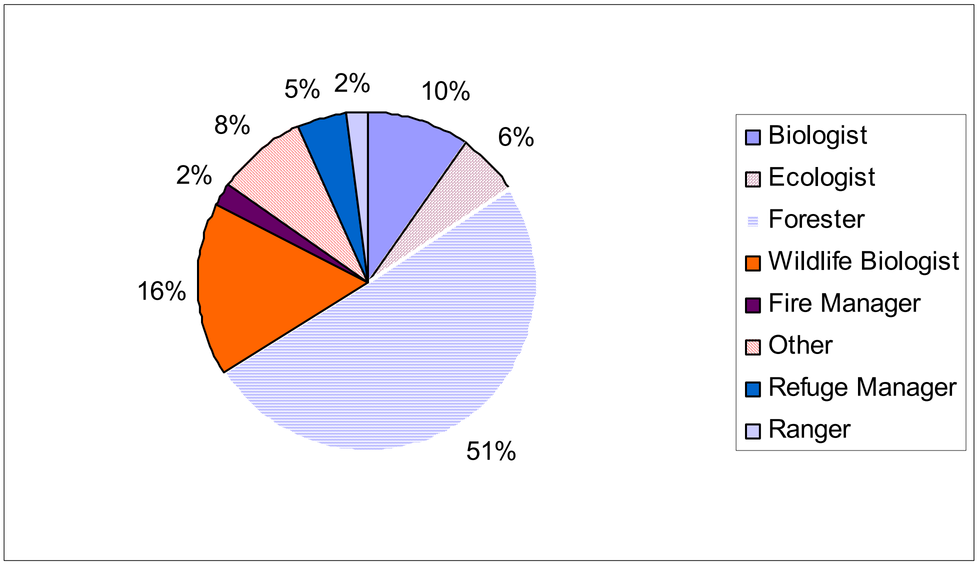

Figure 3: Percentage of Tennessee natural resource managers who responded to the survey by job description.

representing the highest percent of respondents with 32 managers surveyed (Table 4). Of the managers that completed the survey, a little over half (55.2%) of them assist private landowners. More than 98 percent of the managers had earned a B.S. (58.2%), M.S. (36.4%), or Ph.D. (3.6%) with a majority (92%) of terminal degrees in the natural resource field (Table 5).

Cross Tabulation Results: Level of prescribed fire use by forest types, local regions, and management agencies and individuals

Due to an error in the construction of the survey, data analysis was not possible when considering data responses by forest type. The survey question, "What forest type(s) do you work in? (*Check all that apply*)" was asked of all respondents. This question was asked before the question of whether they recommended or used prescribed

Table 4: Percentage of Tennessee natural resource managers who responded to the survey by employer.

	Frequency	Percent
Consulting Firm	11	6.7
Private Industry	17	10.4
Self-Employed Consultant	16	9.8
Tennessee Division of Forestry	32	19.5
United States Forest Service	11	6.7
National Park Service	10	6.1
United States Fish and Wildlife Service	15	9.1
Tennessee Valley Authority	9	5.5
Tennessee Wildlife Resources Agency	20	12.2
Other	6	3.7
The Nature Conservancy	3	1.8
United States Department of Agriculture	5	3.0
United States Army Corps of Engineers	9	5.5
Total	164	100.0

Table 5: Percentage of Tennessee natural resource managers who responded to the survey by highest degree completed

	Frequency	Percent
Some College	1	.6
Bachelors Degree	96	58.2
Masters Degree	60	36.4
Ph.D Degree	6	3.6
Other	2	1.2
Total	165	100.0

burning, and should have been followed by a question asking what forest types they burn in. Therefore, for those that do use or recommend prescribed burning, forest types managed with prescribed fire could not be accurately determined.

Cross tabulations were run based on the natural resource manager's (NRM) employer and whether or not they used or recommend prescribed burning as a management tool. First, frequencies on the number of different employer categories were run using SPSS. Three employer categories were removed based on their low frequencies: Other, The Nature Conservancy, and the United States Department of Agriculture. Pearson's Chi Square test revealed significantly ($p=0.001$) fewer managers from consulting firms used prescribed burning (36.4%) than did not use prescribed burning (63.6%). Significantly ($p=0.001$) more managers from the Tennessee Wildlife Resources Agency (TWRA) used prescribed burning (100%) than did not use prescribed burning (0%). Over all employers, significantly ($p=0.001$) more managers used or recommended prescribed burning than those who did not. Overall 82 percent of the managers, used or recommended prescribed burning, and 18% did not (Table 6). Other employers that showed a high percentage of using or recommending prescribed burning were self-employed consultants (93.8%) and the United States Forest Service (90%) but these percentages were not statistically significant (Table 6).

Cross tabulations were also evaluated based on employer and responses of NRMs concerning whether prescribed burning will increase, decrease, or stay the same on the land they manage in Tennessee. Significantly more (58.8%) managers ($p=0.001$) from private industry believe prescribed burning will decrease on the land they manage in the next ten years (Table 7). Significantly ($p=0.001$) more managers from United States Fish

Table 6: Association between employer and whether or not prescribed burning is practiced. Percentages in bold represent individual significance p<0.05 deviations. Significant employers will have an adjusted residual of +/- 2.

Employer		Do you use or recommend prescribed burning?		Total
		Yes	No	
Consulting Firm	Count	4	7	11
	Response Percentage	**36.4%**	**63.6%**	100%
	Adjusted Residual	**-4.1**	**4.1**	
Private Industry	Count	12	5	17
	Response Percentage	70.6%	29.4%	100%
	Adjusted Residual	-1.3	1.3	
Self-Employed Consultant	Count	15	1	16
	Response Percentage	93.8%	6.3%	100%
	Adjusted Residual	1.3	-1.3	
Tennessee-Division of Forestry	Count	28	4	32
	Response Percentage	87.5%	12.5%	100%
	Adjusted Residual	.9	-.9	
United States Forest Service	Count	10	1	11
	Response Percentage	90.9%	9.1%	100%
	Adjusted Residual	.8	-.8	
National Park Service	Count	6	4	10
	Response Percentage?	60.0%	40.0%	100%
	Adjusted Residual	-1.9	1.9	
USF&WS	Count	13	2	15
	Response Percentage	86.7%	13.3%	100%
	Adjusted Residual	.5	-.5	
Tennessee Valley Authority	Count	7	2	9
	Response Percentage	77.8%	22.2%	100%
	Adjusted Residual	-.3	.3	
TWRA	Count	**20**	**0**	20
	Response Percentage	**100.0%**	**.0%**	100%
	Adjusted Residual	**2.3**	**-2.3**	
USACE	Count	8	1	9
	Response Percentage	88.9%	11.1%	100%
	Adjusted Residual	.6	-.6	
Total	Count	**123**	**27**	150
	Response Percentage	**82.0%**	**18.0%**	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	28.054(a)	9	0.001

Table 7: Association between employer and whether or not the use of prescribed burning on the land you manage in Tennessee will decrease, stay the same, or increase in the next ten years. Percentages in bold represent individual significance p<0.05 deviations. Significant employers will have an adjusted residual of +/- 2.

Employer		In the next ten years, the use of prescribed burning in the land you are managing in Tennessee will:			Total
		Decrease	Same	Increase	
Consulting Firm	Count	2	5	4	11
	Response Percentage	18.2%	45.5%	36.4%	100%
	Adjusted Residual	-.3	.7	-.4	
Private Industry	Count	**10**	**6**	**1**	17
	Response Percentage	**58.8%**	**35.3%**	**5.9%**	100%
	Adjusted Residual	**3.9**	**.0**	**-3.2**	
Self-Employed Consultant	Count	5	7	3	15
	Response Percentage	33.3%	46.7%	20.0%	100%
	Adjusted Residual	1.1	1.0	-1.9	
TDF	Count	8	10	14	32
	Response Percentage	25.0%	31.3%	43.8%	100%
	Adjusted Residual	.4	-.6	.2	
USFS	Count	1	3	6	10
	Response Percentage	10.0%	30.0%	60.0%	100%
	Adjusted Residual	-1.0	-.4	1.2	
NPS	Count	0	3	7	10
	Response Percentage	.0%	30.0%	70.0%	100%
	Adjusted Residual	-1.8	-.4	1.8	
USF&WS	Count	**0**	**7**	**7**	14
	Response Percentage	**.0%**	**50.0%**	**50.0%**	100%
	Adjusted Residual	**-2.1**	**1.2**	**.6**	
TVA	Count	3	3	2	8
	Response Percentage	37.5%	37.5%	25.0%	100%
	Adjusted Residual	1.1	.1	-1.0	
TWRA	Count	**1**	**3**	**15**	19
	Response Percentage	**5.3%**	**15.8%**	**78.9%**	100%
	Adjusted Residual	**-1.9**	**-1.9**	**3.5**	
USACE	Count	2	4	2	8
	Response Percentage	25.0%	50.0%	25.0%	100%
	Adjusted Residual	.2	.9	-1.0	
Total	Count	**32**	**51**	**61**	144
	Response Percentage	**22.2%**	**35.4%**	**42.4%**	100%

Chi-Square Tests

	Value	df	p-value
Pearson Chi-Square	42.267(a)	18	0.001

and Wildlife Service believe that prescribed burning will increase on the land they manage in the next ten years (50%) (Table 7). Pearson's Chi Square test showed that significantly ($p=0.001$) more managers from TWRA indicate prescribed burning will increase on the land they manage in the next ten years (78.9%). Over all employers, significantly ($p=.0001$) more managers think the use of prescribed burning on the land they manage will increase (42.4%) over the next ten years than those who thought it would decrease (22.2%) or stay the same (35.4%) (Table 7). Finally, cross tabulations were run based on employer and if managers wanted prescribed burning to be implemented. Results were not significant based on Pearson's Chi Square ($p=0.251$), but 79.8 percent of managers wanted to see more prescribed burning implemented on the land they manage. Results from the survey indicate that 63.6 percent of private consultants did not use or recommend prescribed burning, but 72.7 percent of them would like to use prescribed burning on the land that they manage in Tennessee (Table 8).

Cross tabulations were run based on the NRM's job description and whether or not they used or recommend prescribed burning as a management tool. Frequencies on the number of different employer categories were created. Two categories were removed based on low frequencies: Other and Ranger. Pearson's Chi Square test showed that there were no significant differences in percentages of those that did or did not use or recommend prescribed burning based on job description ($p=0.881$). Over all job descriptions, 84 percent of managers indicated that they use or recommend prescribed burning (Table 9). Cross tabulations were also run based on job description and the response of NRMs as to whether prescribed burning over the next ten years will increase,

Table 8: Association between employer and whether prescribed burning on the land you manage in Tennessee will increase or decrease. No significant differences were found at p=0.05.

Employer		More burning being conducted Yes	No	Total
Consulting Firm	Count	8	3	11
	Response Percentage	72.7%	27.3%	100%
	Adjusted Residual	-.5	.5	
Private Industry	Count	11	6	17
	Response Percentage	64.7%	35.3%	100%
	Adjusted Residual	-1.5	1.5	
Self-Employed Consultant	Count	12	4	16
	Response Percentage	75%	25.0%	100%
	Adjusted Residual	-.4	.4	
TDF	Count	24	7	31
	Response Percentage	77.4%	22.6%	100%
	Adjusted Residual	-.2	.2	
USFS	Count	6	3	9
	Response Percentage	66.7%	33.3%	100%
	Adjusted Residual	-.9	.9	
National Park Service	Count	7	3	10
	Response Percentage	70%	30.0%	100%
	Adjusted Residual	-.7	.7	
USF&WS	Count	10	3	13
	Response Percentage	76.9%	23.1%	100%
	Adjusted Residual	-.2	.2	
Tennessee Valley Authority	Count	8	0	8
	Response Percentage	100%	.0%	100%
	Adjusted Residual	1.5	-1.5	
TWRA	Count	19	0	19
	Response Percentage	100%	.0%	100%
	Adjusted Residual	2.4	-2.4	
USACE	Count	7	1	8
	Response Percentage	87.5%	12.5%	100%
	Adjusted Residual	.6	-.6	
Total	Count	112	30	142
	Response Percentage	78.9%	21.1%	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	11.377(a)	9	0.251

Table 9: Association between job description and whether or not prescribed burning is practiced. No significant differences were found at p=0.05

Job Description		Do you use or recommend prescribed burning? Yes	No	Total
Biologist	Count	13	3	16
	Response Percentage	81.3%	18.8%	100%
	Adjusted Residual	-.3	.3	
Ecologist	Count	8	2	10
	Response Percentage	80.0%	20.0%	100%
	Adjusted Residual	-.4	.4	
Forester	Count	70	13	83
	Response Percentage	84.3%	15.7%	100%
	Adjusted Residual	.1	-.1	
Wildlife Biologist	Count	24	3	27
	Response Percentage	88.9%	11.1%	100%
	Adjusted Residual	.8	-.8	
Refuge Manager	Count	6	2	8
	Response Percentage	75.0%	25.0%	100%
	Adjusted Residual	-.7	.7	
Total	Count	121	23	144
	Response Percentage	84.0%	16.0%	100%

Chi-Square Tests

	Value	df	p-value
Pearson Chi-Square	1.180(a)	4	0.881

decrease, or stay the same. Pearson's Chi Square test showed that there were no significant differences (p=0.337). Trends are similar for responses by both job description and employer based on the question if prescribed fire will increase, decrease, or stay the same over the next ten years, slightly favoring an increase (42.9%) in burning (Table 10). Finally, cross tabulations were run by employer on the question of whether you would like to see more prescribed burning on the land you manage. Findings were not significant with Pearson's Chi Square (p=0.181), but a majority of the biologists (93%) would like to increase prescribed burning on their land (Table 11).

Cross tabulations were run based on the NRM's region and whether or not they used or recommend prescribed burning as a management tool. There were no significant differences in percentages of those that did or did not use or recommend prescribed burning based on region (p=0.663). Over all job regions, 81% of managers indicated that they use or recommend prescribed burning (Table 12). There were also no significant differences (p=0.163) between regions in the response NRMs as to whether prescribed burning over the next ten years will increase, decrease, or stay the same. However, the Plateau region had the greatest response (63.2%) that prescribed burning on the land they manage will increase (Table 13). Finally, cross tabulations were run on region and the question of whether you would like to see more prescribed burning on your land. Findings were not significant with Pearson's Chi Square (p=0.739) (Table 14).

Table 10: Association between job description and whether or not the use of prescribed burning on the land you manage in Tennessee over the next ten years will decrease, stay the same, or increase. No significant differences were found at p=0.05.

		In the next ten years, the use of prescribed burning in the land you are managing in Tennessee will:			Total
Job Description		Decrease	Same	Increase	
Biologist	Count	1	7	8	16
	Response Percentage	6.3%	43.8%	50.0%	100%
	Adjusted Residual	-1.6	.7	.6	
Ecologist	Count	1	3	6	10
	Response Percentage	10.0%	30.0%	60.0%	100%
	Adjusted Residual	-.9	-.4	1.1	
Forester	Count	24	29	29	82
	Response Percentage	29.3%	35.4%	35.4%	100%
	Adjusted Residual	2.7	-.1	-2.1	
Wildlife Biologist	Count	3	8	13	24
	Response Percentage	12.5%	33.3%	54.2%	100%
	Adjusted Residual	-1.2	-.3	1.2	
Refuge Manager	Count	1	3	4	8
	Response Percentage	12.5%	37.5%	50.0%	100%
	Adjusted Residual	-.6	.1	.4	
Total	Count	30	50	60	140
	Response Percentage	21.4%	35.7%	42.9%	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	9.062(a)	8	0.337

Table 11: Association between job identification and whether prescribed burning on the land you manage in Tennessee will increase or decrease. No significant differences were found at p=0.05.

Job Description		Would you like to see more prescribed burning being conducted on the land you manage? Yes	No	Total
Biologist	Count	14	1	15
	Response Percentage	93.3%	6.7%	100%
	Adjusted Residual	1.5	-1.5	
Ecologist	Count	6	4	10
	Response Percentage	60.0%	40.0%	100%
	Adjusted Residual	-1.4	1.4	
Forester	Count	62	19	81
	Response Percentage	76.5%	23.5%	100%
	Adjusted Residual	-.5	.5	
Wildlife Biologist	Count	20	3	23
	Response Percentage	87.0%	13.0%	100%
	Adjusted Residual	1.1	-1.1	
Refuge Manager	Count	5	3	8
	Response Percentage	62.5%	37.5%	100%
	Adjusted Residual	-1.1	1.1	
Total	Count	107	30	137
	Response Percentage	78.1%	21.9%	100%

Chi-Square Tests

	Value	df	p-value
Pearson Chi-Square	6.259(a)	4	0.181

Table 12: Association between region and whether or not prescribed burning is practiced. No significant differences were found at p=0.05.

Region		Do you use or recommend prescribed burning? Yes	No	Total
West	Count	24	3	27
	Percentage	88.9%	11.1%	100%
West Central	Count	14	5	19
	Percentage	73.7%	26.3%	100%
Central	Count	11	4	15
	Percentage	73.3%	26.7%	100%
Plateau	Count	16	4	20
	Percentage	80.0%	20.0%	100%
East	Count	33	7	40
	Percentage	82.5%	17.5%	100%
Total	Count	98	23	121
	Percentage	81.0%	19.0%	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	2.396(a)	4	0.663

Table 13: Association between region and whether or not the use of prescribed burning in Tennessee, on the land you manage will decrease, stay the same, or increase over the next ten years. No significant differences were found at p=0.05.

Region		In the next ten years, the use of prescribed burning in the land you are managing in Tennessee will: Decrease	Stay the Same	Increase	Total
West	Count	6	9	12	27
	Percentage	22.2%	33.3%	44.4%	100%
West Central	Count	1	10	8	19
	Percentage	5.3%	52.6%	42.1%	100%
Central	Count	5	6	3	14
	Percentage	35.7%	42.9%	21.4%	100%
Plateau	Count	1	6	12	19
	Percentage	5.3%	31.6%	63.2%	100%
East	Count	10	13	17	40
	Percentage	25.0%	32.5%	42.5%	100%
Total	Count	23	44	52	119
	Percentage	19.3%	37.0%	43.7%	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	11.734(a)	8	0.163

Table 14: Association between region identification and whether prescribed burning on the land you manage in Tennessee will increase or decrease. No significant differences were found at p=0.05.

Region		Would you like to see more prescribed burning being conducted on the land you manage? Yes	No	Total
West	Count	21	6	27
	Percentage	77.8%	22.2%	100%
West Central	Count	15	4	19
	Percentage	78.9%	21.1%	100%
Central	Count	10	4	14
	Percentage	71.4%	28.6%	100%
Plateau	Count	18	2	20
	Percentage	90.0%	10.0%	100%
East	Count	30	8	38
	Percentage	78.9%	21.1%	100%
Total	Count	94	24	118
	Percentage	79.7%	20.3%	100%

Chi-Square Tests

	Value	Df	p-value
Pearson Chi-Square	1.982(a)	4	0.739

Managers who use Prescribed Burning

Managers were split in two categories: those who use prescribed burning and those who do not use or recommend prescribed burning. For those managers who use prescribed burning, a majority (90.7%) of them use it for work (Appendix 2). Of the total number of managers, 68.5 percent burn for wildlife habitat improvement and 64.2 percent use fire for competition control. Finally, of those that did burn, a majority (69.85%) would burn more, whereas a few (27.3%) would burn less (Appendix 2).

A frequency table was created based on the number of managers who used or recommended prescribed burning based on their employer. To avoid low statistical power, only agencies with at least ten respondents were used to calculate the statistics. A Multivariate Analysis of Variance (MANOVA) of Likert scale values (1 = not at all important to 5 = extremely important) was run for those managers that prescribed burned and the questions dealing with barriers that may have prevented them from using prescribed burning in the past. Results of the MANOVA were significant at (F (20, 206) =2.229, p=0.012). Managers employed by TWRA responded that cost of prescribed burning was significantly (p=0.012) less important than managers employed by private industry (Table 15). Managers employed by United States Fish and Wildlife Service

Table 15: Cost as a barrier to prescribed burning by employer.

Who is your employer?	N	Mean
TWRA	19	2.05 (A)
Tennessee-Division of Forestry	26	2.50 (AB)
US Fish & Wildlife Service	11	2.64 (AB)
United States Forest Service	10	2.80 (AB)
Self-Employed Consultant	11	3.00 (AB)
Private Industry	11	3.55 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05.
Values based on Likert scale values from 1=not at all important to 5=extremely important

Table 16: Reduced future economic returns as a barrier to prescribed burning by employer.

Who is your employer?	N	Mean
United States Fish and Wildlife Service	11	1.73 (A)
Tennessee Wildlife Resources Agency	19	1.84 (AB)
Tennessee-Division of Forestry	26	2.27 (AB)
United States Forest Service	10	2.30 (AB)
Private Industry	11	3.09 (B)
Self-Employed Consultant	11	3.09 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

(USF&WS) responded that reduced future economic returns were significantly ($p=0.011$) less important than managers employed by private industry and self-employed consultants (Table 16).

A MANOVA was conducted for those who prescribed burned or recommended prescribed burning based on job description. (The same variables were left out for job description as previously mentioned for the cross tabulation section). Results of the MANOVA were significant at $F(30, 220.816)=1.892$, $p=0.005$. The only barrier that was close to being significant was societal factors at $p= 0.064$. Ecologists (3.714) and wildlife biologists (3.250) seem to think this is an important constraint (Table 17). Finally, a MANOVA was run for those that prescribed burned or recommended prescribed burning based on region. Results of the MANOVA were not significant ($F(40,252.120) =1.176$, $p=0.229$) and no differences were found across the different regions.

Table 17: Societal factors as a barrier preventing managers from burning based on job description. Differences were marginally insignificant (p=0.064).

Dependent Variable	Job Description	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Societal Factors	Biologist	2.300	.356	1.592	3.008
	Ecologist	3.714	.425	2.868	4.560
	Forester	2.964	.152	2.662	3.266
	Wildlife Biologist	3.250	.281	2.690	3.810

Values based on Likert scale values from 1 = not at all important to 5 = extremely important

No MANOVA's were run for those managers that did not prescribe burn due to the low number of respondents in this category. Likert scale response show that risk damage is the most important barrier (4.06). Also, the mean response of (2.67) indicates that a lack of research on specific forest type is not a relatively important barrier (Table 18).

Need for More Science-based Research

In the next ten years, a majority (42.3%) of managers believe that the use of prescribed burning in their management activities will increase. The remaining managers predict that prescribed burning will either decrease (21.8%) or stay the same (35.9%) (Appendix 2). The majority of managers (77.1%) indicated prescribed burning research is needed in hardwood stands and mixed pine/hardwood stands (74.3%) (Appendix 2). Only 36.7% of managers feel that more prescribed burning research was needed in pine stands (Appendix 2).

MANOVA's were conducted for all managers concerning what science-based research is needed. First, a MANOVA was run for all managers based on their job

Table 18: Mean Likert scale responses by managers that do not use or recommend prescribed burning by barrier.

Barriers	Mean
Damage Risk	4.06
Lack of Research on Specific Forest Type	2.67
Societal Factors	3.24
Manpower	3.18
Cost to your Agency or Firm	2.63
Institutional or Private, Policies, Protocol, or Mission	2.80
Cost to Landowner	2.75
Time/Weather Constraints	3.47

Values based on Likert scale values from 1 = not at all important to 5 = extremely important

description and Likert scale responses on whether more science-based information was needed in particular categories. Job descriptions with the appropriate statistical power included foresters, biologists, and wildlife biologists. Managers who are classified as wildlife biologists responded that appropriate season to achieve goals with prescribed burning was significantly (p=0.002) more important (4.08) and needs more research compared to foresters (3.07) (Table 19.1). Managers who are classified as wildlife biologists responded that wildlife habitat management with prescribed burning was significantly (p=0.001) more important (4.13) and needs more research compared to foresters (3.19) (Table 19.2). Managers who are classified as wildlife biologists responded that smoke management with prescribed burning was significantly (p=0.039) more important (3.93) and needs more research compared to biologists (3.13) (Table 19.3). Managers who are classified as wildlife biologists responded that management of wildlife habitat using prescribed burning was significantly (p=0.010) more important (3.92) and needs more research compared to foresters (3.01) (Table 19.4). This is in line with the majority of wildlife biologists (81.8%) who burn for fire-adapted animal species.

Table 19: The following results are information needs that were significantly important after running MANOVA's. MANOVAs were run on where science-based research is lacking (multiple dependent variables) with managers split by job description (independent variables). The following science-based research needs are ANOVAs for each information need.

Table 19.1: Appropriate Season to Achieve Goals

Job Description	N	Means
Forester	81	3.07 (A)
Biologist	16	3.31 (AB)
Wildlife Biologist	24	4.08 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

Table 19.2: Wildlife Habitat

Job Description	N	Mean
Forester	81	3.19 (A)
Biologist	16	3.75 (AB)
Wildlife Biologist	24	4.13 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

Table 19.3: Smoke Management

Job Description	N	Mean
Biologist	16	3.31 (A)
Forester	81	3.48 (AB)
Wildlife Biologist	24	4.17 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

Table 19.4: Potential Damage to Crop Trees

Job Description	N	Mean
Biologist	16	3.13 (A)
Forester	81	3.30 (AB)
Wildlife Biologist	24	3.96 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

Table 19.5: Risk of Escape

Job Description	N	Mean
Forester	81	3.01 (A)
Biologist	16	3.56 (AB)
Wildlife Biologist	24	3.92 (B)

Any two means followed by the same letter are not significantly different at Alpha = .05. Values based on Likert scale values from 1 = not at all important to 5 = extremely important

Also, a MANOVA was run for all managers based on their employer and the Likert scale on whether more science-based information was needed for particular categories. Even with adjusting for higher power results, the MANOVA results were not significant ($F\ (81,538.897) = 1.152$, $p=0.186$). Finally, a MANOVA was run for all managers based on their region managed and the Likert scale on whether more science-based information was needed. Results of the MANOVA were not significant ($F\ (36,282.797)=0.120$, $p=0.301$).

Results of Field work

The dendrochronological analysis data indicated an important recruitment period of Table Mountain pine (TMP) (*Pinus pungens*) at Horsehitch Gap after the 1941 stand replacing fire from 1942-1945 (Figure 4). The data also show two other recruitment episodes: one between 1947 -1949, and another following the 1981 fire. An important occurrence following the 1981 surface fire is that hardwoods (blackjack oak (*Q. marilandica*) and blackgum (*N. sylvatica*)) started to enter the stand (Figure 4). Data for the 1981 stand indicate a similar recruitment pattern with TMP. This species enters the stand within the first 3 years after the stand replacing fire in 1981 (Figure 5).

From 2000-2003 since, southern pine beetle (SPB) (*D. frontalis)* outbreaks have caused significant mortality in the dominant and co-dominant crown classes. SPB outbreaks have removed 48% of the overstory TMP component, all within the largest diameter class of TMP (Table 20). In the 1941 stand there are far fewer stems per acre compared to the 1981 stand at approximately the same height class (Table 21).

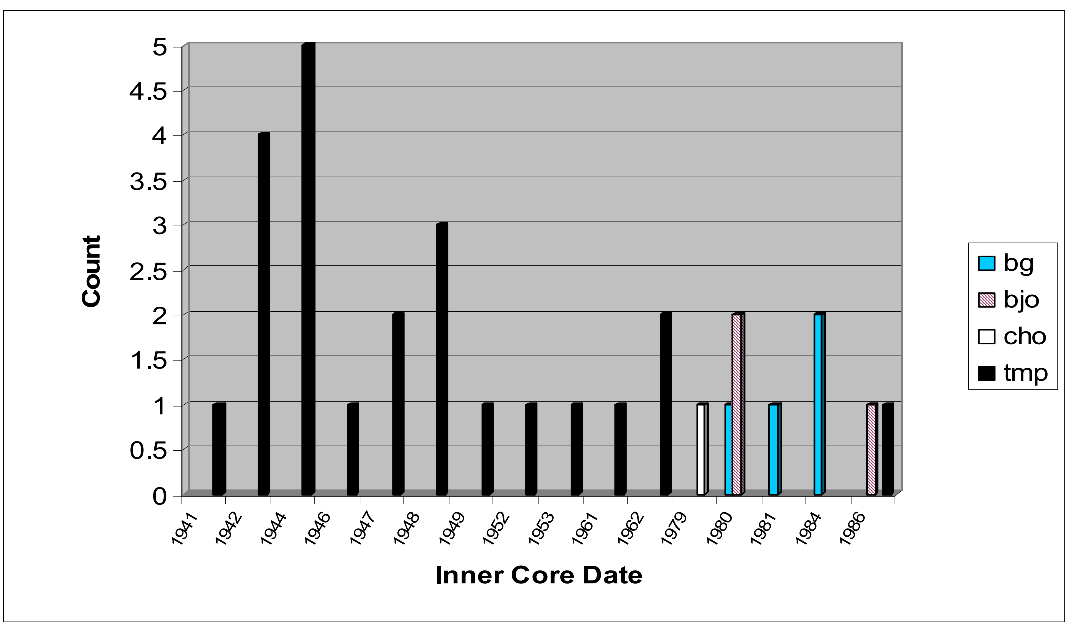

Figure 4: Recruitment results for 1941 Table Mountain pine stand in Cherokee National Forest--dendrochronology results. bg = Blackgum; bjo = blackjack oak; cho = chestnut oak; and tmp = Table Mountain pine.

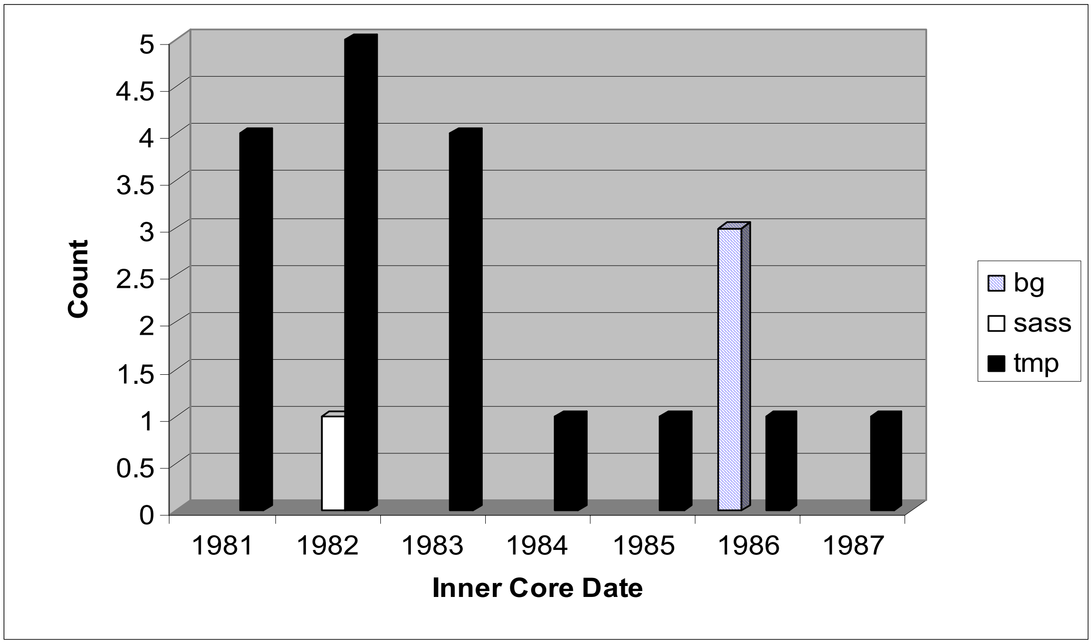

Figure 5: Recruitment results for 1981 Table Mountain pine stand in Cherokee National Forest--dendrochronology results. bg = Blackgum; sass = sassafras; and tmp = Table Mountain pine.

Table 20: 1941 Stand: Table Mountain pine stems/acre at Horsehitch Gap, Greene County, Tennessee in 2002.

Ht.Class	Total Stems/Ac
X < 1 ft	340
1 < x < 2 ft	220
2. < x < 3 ft	100
3 < x < 4.5 ft	0
4.5 ft < x < .3 ft DBH	170
≥ .3 feet DBH (Live)	240
≥ .3 feet DBH (Total)	740
Total (Live, all size classes combined)	1070
Total (Live and Dead, all size classes combined)	1570

Table 21: Comparison of Table Mountain pine stems/acre in the 1981 Stand measured in 1992 and 2002 at Horsehitch Gap, Cherokee National Forest Greene County, Tennessee

1992		2002	
Ht. Class	Stems/Ac	Ht. Class	Stems/Ac
< 1.6 ft	167	< 1.6 ft	0
1.6-3.19 ft	667	1.6-3.19 ft	20
3.2-6.2 ft	3833		
6.21- 9.5 ft	5000	4.92- 9.5 ft	2140
> 9.51 ft	1333	9.51- 13.3 ft	4080
		13.31- 19.6 ft	2200
		> 19.61 ft	0
Total	11000		8440

The total stems/acre is considerably less (88% less) than the stems/acre in the 1981 stand (Table 20, 21).

Comparing the stems/acre data in each height class collected by Sanders (1992) with data collected in 2002, the 1981 stand has been progressing through the stem exclusion stage over the past ten years of development (Table 21). The 1992 data resulted in 167 stems/acre in the < 1.6 ft height class, while no stems were recorded in the < 1.6 ft. height class during 2002 data collection. In 1992, 5000 stems/acre were recorded in the 6.21- 9.5 ft height class, whereas in 2002 only 2140 stems/acre were found in the 4.92- 9.5 ft height class.

The 2002 data indicate that a total of 6280 stems/acre were recorded as greater than 9.51 ft and in 1992 only 1333 stems/acre were recorded in the same height class. There has been a 23% mortality rate over the last ten years (Table 21). Comparing the two stands, the 1941 stand has only a 170 TMP stems/acre in the midstory but the 1981 stand has over 8000 stems/acre (Table 20 and 21).

Chapter 5: Discussion

Survey Population Demographics

The high (68.4%) response rate to this survey is likely the result of Dillman's (2000) Modified Total Design Method. The 5 contact messages sent to individuals were very effective. The first contact introduced the survey to managers to gain their interest and encouraged them to pass it along to those that may not have been on my original list. This first contact also allowed managers to which this survey did not pertain to indicate their names should be removed from future mailings. These additional contacts increased the number of responses for two reasons. First, many of the managers surveyed work in the field and work away from their desks for days or weeks. The additional responses allowed them time to complete the survey at their convenience upon returning to their office. The second benefit to this method includes the possibility of e-mail failure. During the months (August-November 2003) when this survey was administered, the University of Tennessee was hit with several viruses which locked up systems and caused servers to reject e-mails coming from the institution. Therefore, by using additional contacts, I was able to survey those first response e-mails that were rejected by other servers. Also, fire is a topic that interests many natural resource managers and caused them to reply or initiate the survey.

On average, managers who responded to this survey managed a large amount of land and have several years of experience. This amount of responsibility provides incentive for managers to stay current on developments and changes in management practices over time (Appendix 2).

Cross Tabulation: Level of use of prescribed fire by forest types, local regions, and management agencies and individuals

The strong negative association between employees of consulting firms and using and recommending prescribed burning is likely due to the costs and liability associated with prescribed burning. Employees of consulting firm's responses show they do not burn as often as other employers surveyed. These firms work for landowners to meet their goals and objectives. These firms are often responsible for timber harvest and most timber harvested in Tennessee is hardwood timber. Currently, managers may be hesitant to prescribe burn in hardwood forests for fear of decreasing the timber value of the stand (Van Lear and Waldrop 1989). TWRA employees indicated a significant positive response to the use of prescribed fire. The mission of this agency is to:

> "… preserve, conserve, protect, and enhance the fish and wildlife of the state and their habitats for the use, benefit, and enjoyment of citizens of Tennessee and its visitors" (TWRA).

The use of prescribed burning is not surprising due to the wildlife benefits for game and non-game species (Brownlie and Engstrom 2001). As more research develops on ecological benefits, more prescriptions would probably be used by this agency. On the other hand, compared to other employees, members of private industry thought that prescribed burning would not increase. This is probably do to the manpower requirements and liability associated with prescribed burning.

Why Managers use Prescribed Burning

Prescribed burning has numerous ecological benefits in addition to reducing fuel loads. Prescribed burning is also a valuable tool for decreasing pest outbreaks, supporting seed germination of shade intolerant species, and creating wildlife habitat (DellaSala and Frost 2001). The results suggest that managers using prescribed burning across the state are mainly using burning for wildlife habitat improvement and for competition control. Burning is used to create pine openings necessary for red-cockaded woodpeckers and early successional habitat for grassland birds (Stamps et al. 1983). Prescribed burning will also favor desirable oak species as opposed to red maple.

MANOVA: Managers who use Prescribed Burning

Barriers preventing private industry and consulting firms from prescribed burning were likely related to economic objectives. When managing a stand, these managers need to look long term to make sure their business is both economically productive and sustainable for future job security. There are several costs associated with prescribed burning which include planning, conducting, and contracting each burn. With these costs, potential losses can occur including the mortality or injury of healthy trees and the threat that the fire can escape the burn perimeter (Cleaves and Haines 1996). Therefore, prescribed burning may not be the most attractive prescription. The average number of acres managed by private industry is over 136,000 acres, which requires a large number of employees to carry out prescribed burning (Appendix 2). Compared with private industry and consulting firms, government and state agencies have a greater ability to gather the manpower required for prescribed burning, and there is less emphasis on long term economic returns.

Societal factors clearly play a role, based on wildlife biologists, in preventing managers from using prescribed burning. Although prescribed fire is used to accomplish specific ecological objectives it has failed to get the support of the general public (Van Lear 2000). Events leading up to societal scrutiny include human health and traffic hazards from air pollutants, and escaped wildfires (Cleaves and Haines 1996, Winter et al. 2002). One reason for managers not to burn is the risk of damage. Therefore, states have prescribed burning regulations and permits (Cleaves and Haines 1996). In the continuing development of the Northeast Decision Support System (NED) (Rauscher et al. 2001), computer programmers are creating software for managers and landowners that accounts for these variables to predict a stand's fire risk and means for reducing that risk. The use of fuel breaks are being evaluated in order to prevent escaped fires. Each ecosystem is different, however, and the size, treatment, and maintenance required to have an effective fuel break has not been determined for all ecosystem types (Agee et al. 2000).

Science-based Research Needs

Even though prescribed fire has been studied for the past 70 years, there are still aspects that need to be studied as knowledge of ecosystems advances. The managers surveyed in this study support Van Lear's (2000) statement that fire research is needed in hardwood and mixed pine/hardwood stands. Prescribed burning in hardwood stands is limited because managers fear reductions in stem quality of crop trees (Van Lear and Waldrop 1989). Due to the past 70 years of fire suppression in the east, less desirable species, such as red maple (*Acer rubrum*), are recruiting in the overstory (Buckner 2000). One researcher suggests that, "Without future fires, the regeneration of pine/hardwood community will probably become transient," (Elliot et al. 1999). Elliot et al. (1999) have also shown that prescribed fire can increase the number of oak (*Quercus* spp.) and hickory (*Carya* spp.) seedlings which could be effective in returning mid-slope communities back to oak dominated stands in the southern Appalachians. Losing oak-hickory forests has both economic and ecological significance (Loftis 1990). Oak wood has high economic value and the loss of this community would negatively impact wildlife species, due to the importance of oak as a source of food and den trees (Huntley and McGee 1980, Franklin et al. 2003).

Wildlife Biologists surveyed also agree that additional research is necessary for multiple areas. These individuals are most concerned with wildlife habitat. By burning at the right time of year, these managers will be able maximize soft mast in the understory for wildlife (Hamilton 1981).

Current research funded by the Joint Fire Science Program is investigating several treatments for reducing the amount of fuel in different ecosystems across the United States, and their ecological impacts. For example, when fuels are reduced, either mechanically or by burning, the nutrient makeup of the stand is changed (Hough 1981). Effects of fuel reduction need to be fully understood by evaluating different treatments and a combination of treatments. The strengths of one treatment may offset the weaknesses of another (Brose and Wade 2002a).

Importance of Fire to Table Mountain Pine

Certain tree species dominate geographic areas due to competitive advantages resulting from frequent disturbances (Oliver and Larson 1990). The data show that both the 1941 and 1981 stand replacing fires resulted in a new stand of TMP. The data also show the 1981 surface fire in the 1941 stand was not effective in clearing the ground and promoting TMP germination. Instead, the low intensity fire opened up the stand enough for shade-intermediate (Barnes et al. 1998) species to start advancing into the midstory. Under this regime, along with the southern pine beetle outbreak, the stand will soon become dominated by hardwoods. The southern pine beetle is only affecting mature pines in the overstory, so it is also possible the stand will change into a mixed pine/hardwood system.

The data also suggest that the 1981 stand is in the stem exclusion stage of its development and no new TMP individuals are occupying the smaller size classes. TMP in this 1981 stand is very dense and strong intraspecific competition is likely resulting in a great deal of stress. The stressed trees are likely more vulnerable to southern pine beetle, which could decimate the stand. Another problem is that a stand replacement fire could get into this stand and kill all the viable seed (Waldrop and Brose 1999).

The results of this study support hypotheses of Waldrop and Brose (1999) that a stand replacing fire is necessary to maintain Table Mountain pines, and suggest that the futures, of both the 1981 and 1941 stands are uncertain, especially the 1941 stand that had only a surface fire.

Chapter 6: Conclusion

The Tennessee Wildlife Resources Agency definitely uses prescribed burning the most in their management for wildlife and related recreation. In contrast, private consultants use prescribed burning the least. A majority of private consultants, however, would like to use prescribed burning on the land they manage. These two groups could be combined and separated between federal/state agencies or private firms. Emphasis on economic returns may be the main factor distinguishing these two groups. Private Industry and Consultants are more concerned with having a sellable product for the future, and liability from injury and damage. On the other hand, the state/federal agencies have the manpower to conduct prescribed burning and are less likely to focus on the forest products to generate income.

On average, 4.4 million acres are prescribed burned each year in the South and prescribed burning has become a well accepted professional forestry practice (Cleaves and Haines 1996). Prescribed burning in Tennessee will probably follow the prediction of TWRA managers, namely that it will increase as more information is gained on the correct frequency, intensity, and season to burn. According to managers, the most important prescribed fire research needs are burning in both hardwood and mixed pine-hardwood stands and the correct seasons to burn in these ecosystems.

Before research is carried out, we need to first determine where fire-adapted species and ecosystems are located across the state and determine what fire regime is needed to ensure stand health. For example, succession is normal and is a “natural” process, but without future fire and with the occurrence of future *D. frontalis* outbreaks, areas such as Horsehitch Gap and perhaps the Appalachians as a whole may lose *P. pungens*. Although lumber of *P. pungens* is of poor quality (Hardin et al. 2001), the loss of this species would be significant. Since, *P. pungens* has adapted to fire, it may serve as an indicator species. Losing *P. pungens* may be a sign of future losses of other fire-adapted species in the Appalachians. Collaborative research between federal, state, and private agencies on this problem is needed.

Societal factors dealing with the pros and cons of burning need to be addressed. Managers and consultants across the state need to take an unbiased approach in teaching landowners about prescribed burning, especially if fire-adapted species are located on his/her land. The research that is being done is important to this educational effort and needs to be assessed and transferred to managers. The United States Forest Service is supporting a collaborative effort between schools and researchers across the Southeast creating the Encyclopedia of Southern Fire Science, synthesizing and integrating the past 50+ years of research on fire and prescribed burning in southern forests. The University of Tennessee is developing a Collaborative Web Based Learning Center to enhance natural resource information via the web particularly for private landowners. By creating lessons on natural resource topics and uploading them to the web, the public will be able to access these modules and integrate them into their management. Also, the modules will serve as teaching tools that state and federal agents can use when working with the general public (Jackson et al. 2004). The fire component of NED, a computer-based forest management decision support tool, will help managers and landowners determine fire risk (Rauscher et al. 2001). This software is based on a hierarchy that will create a fire risk for the land users manage based on several variables (e.g. aspect, slope, cover type) and give the manager/landowner suggestions on how to decrease that risk.

A collaborative effort between land managers and biologists has resulted in another way that managers in Florida are prioritizing areas in need of burning. These two groups are using conservation criteria and management objectives to determine importance values for landscapes. They are then able to incorporate these classified landscapes into GIS and determine which lands should be scheduled for prescribed burning. This software will allow landscape settings to change as they evolve over time (Hiers et al. 2003).

Finally, prescribed burning is an effective management tool (Lanham et al. 2000). Additional research in areas such as appropriate burning practices in hardwood stands will facilitate increased use of prescribed burning in Tennessee forests. For example, research on relationships between intensities of fire and season of burning in hardwoods will allow managers to determine when to burn in ecosystems without damaging crop trees. Additional research in other areas, such as smoke management, will also facilitate increased use of prescribed burning for habitat improvement and other goals. With managers,, landowners, researchers, and the general public working together, information on this management practice can be useful for everyone.

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Appendices

Appendix 1 IRB Form

FORM A

IRB #__________

Certification for Exemption from IRB Review for Research Involving Human Subjects

---

A. PRINCIPAL INVESTIGATOR(s) and/or CO-PI(s): Brian T. Hemel and David S. Buckley

B. DEPARTMENT: Forestry, Wildlife, and Fisheries

C. COMPLETE MAILING ADDRESS AND PHONE NUMBER OF PI(s) and CO-PI(s):
274 Ellington Plant Sciences Building
Knoxville, Tennessee 37996-4563
865-974-0857 or 865-974-7978

D. TITLE OF PROJECT: Tennessee Natural Resource Manager Prescribed Burning Survey

E. EXTERNAL FUNDING AGENCY AND ID NUMBER (if applicable): United States Forest Service

F. GRANT SUBMISSION DEADLINE (if applicable):N.A.

G. STARTING DATE: Upon IRB approval

H. ESTIMATED COMPLETION DATE (Include all aspects of research and final write-up.): December, 2003

I. RESEARCH PROJECT:

1. Objective(s) of Project (Use additional page, if needed.):

   The objectives of this research project are threefold: first, determine the current level of use of prescribed fire by forest types, local regions, and management agencies and individuals; second, determine specific fire research and technology transfer needs by establishing what barriers to implementation of prescribed fire exist across forest types, local regions, and management agencies and individuals; and third, estimate the future for risk and potential loss of fire-adapted species and fire-dependent ecosystems in Tennessee. The information we obtain from the survey will be used for thesis research and feedback to managers and researchers as a part of the overall evaluation on prescribed burning use in Tennessee.

2. Subjects

Individual subjects were selected if they worked as a state, federal, or private Natural Resource Managers in Tennessee, eighteen years of age and older.

3. Methods or Procedures:

The survey attached was developed to address each of the objectives listed above and programmed into a computer based survey in SPSS Data Entry format. The survey will be e-mailed to approximately 350 Natural Resource Managers across the state of Tennessee. A modified Dillman Total Design Method (TDM) (Dillman 2000) will be applied to the survey administration, whereby managers will receive an initial e-mail introducing the project and telling them when it will arrive (See Appendix 1). Next, managers will be sent an e-mail message with a cover letter along with the web-site to answer the questionnaire (See Appendix 2). Typical e-mail responses will be gained within three days from the time the survey is received. A reminder e-mail message will be sent to residents that have not responded within one and a half weeks of the initial mailing (See Appendix

3). If the manager does not respond after the reminder e-mail message, a final e-mail message will be sent asking again for their help in this research (See Appendix 4).

Each survey will ask the participant to enter his or her e-mail address. If a participant has successfully completed the survey, their name and e-mail address will be taken off the reminder list and the responses will no longer be associated with a name. All identifying information associated with the responses will be destroyed. The name and e-mail address database (which will no longer be linked to the response data) will only be kept if the respondent requests to enter a t-shirt drawing or requests a copy of the completed results. The response to this survey is expected to be around 30%, which is average for e-mailed surveys. Using the TDM method should increase the response rate that would normally occur.

Participation in this survey has minimal risk and is not considered to be any different from tasks encountered in ordinary life. The survey does not deal with sensitive subjects and does not discriminate on race, sex, or religion. The contents of this survey will not place the respondents at any risk for criminal liability and will not be harmful to the respondent's character or employment standing. Access to e-mail addresses file will be limited to Brian Hemel (Room 204 Ellington Plant Sciences Building), Master's student, and Cary Springer, Statistician (237 Stokely Management Center). All returned data will be kept in each respective offices computer guarded by passwords. Finally, the e-mail lists will be destroyed/ deleted once respondents who asked for results are e-mailed the results of this survey.

4. CATEGORY(s) FOR EXEMPT RESEARCH PER 45 CFR 46 (see reverse side for categories): _2____________

J. CERTIFICATION: The research described herein is in compliance with 45 CFR 46.101(b) and presents subjects with no more than minimal risk as defined by applicable regulations.

Principal Investigator____
Name Signature Date

Student Advisor____
Name Signature Date

Dept. Review
Comm.Chair____
Name Signature Date

APPROVED:
Dept.
Head____
Name Signature Date

COPY OF THIS COMPLETED FORM MUST BE SENT TO COMPLIANCE OFFICE IMMEDIATELY UPON COMPLETION.

Rev. 01/97

Appendix A of IRB: Pre-Letter

July x, 2003

Dear Natural Resource Manager,

A few days from now you will receive an e-mail request to fill out a brief questionnaire for an important research project being conducted by the University of Tennessee concerning natural resource managers and their use or non-use of prescribed burning in the state of Tennessee.

I am writing in advance because many people like to know ahead of time that they will be contacted. The study is an important one that will help managers and researchers in Tennessee understand the current level of use or non-use of prescribed fire and identify important prescribed fire research questions that need to be studied by forest type, local region, and management agencies and individuals.

Thank you for your time and consideration. It's only with the generous help of people like you that our research can be successful.

Sincerely,

Brian Hemel
Graduate Research Assistant
University of Tennessee
Department of Forestry, Wildlife & Fisheries
274 Ellington Plant Science building
Knoxville, Tennessee 37996-4563
bhemel@utk.edu
865-974-0857

Appendix B of IRB: Cover Letter and Survey

Dear Natural Resource Manager:

The Forestry, Wildlife, & Fisheries Department at the University of Tennessee is conducting an evaluation of the use or non-use of prescribed burning by Natural Resource Managers across Tennessee. I am asking you to fill out this survey because we want to know about your experiences working in the field as a natural resource manager in the state of Tennessee.

To ensure that the evaluation is comprehensive and includes the input and perspectives of essential persons like you, we ask that you complete the entire survey attached to this e-mail. Clicking on the Internet link provided leads you to the survey. Upon completion, the survey will be sent directly to the evaluation center.

The information we obtain from the survey will be used for thesis research and for feedback to managers and researchers as a part of the overall evaluation on prescribed burning use or non-use in Tennessee. Your responses are confidential. Once we have received your response, all identifying information associated with your responses will be deleted/ destroyed. Your e-mail address (no longer associated with your responses) will be used to take your name off the reminder list and entered for a drawing for a free t-shirt. Only summarized data will be used in combined form and present results.

Please complete the survey within 10 days. Thank you for your cooperation and the valuable information you will provide with completion of this survey. We would greatly appreciate your participation. Please do not hesitate to contact me if you have any questions at (865) 974-0857) or (bhemel@utk.edu).

The survey will take approximately 10-15 minutes. Please click on this link to begin the survey. http://surveys.utk.edu/prescribeburn/index.htm

Sincerely,

Brian Hemel
Graduate Research Assistant
University of Tennessee
274 Ellington Plant Science Building
Knoxville, TN 37996-4563
bhemel@utk.edu
865-974-0857

Appendix C

Please fill in the blank, mark the correct number, or check the appropriate circle for each question. All surveys are confidential and data collected from this study will only be used in combined form to analyze results. Your participation is voluntary. You may refuse to answer any questions, and you may withdraw from the study at any time. Thanks again for your assistance

1. Please type your e-mail address for a chance to win a free t-shirt, and to remove your e-mail address from the list for follow-up reminders ________________.

2. What job description best describes you (Please check only one)?

   O Biologist
   O Ecologist
   O Fire Manager
   O Private Landowner
   O Silviculturalist
   O Wildlife Biologist
   O Other____
   ____

3. Do you assist non-industrial private forest landowners in land management?

   O Yes
   O No

4. How many forest acres do you manage in Tennessee (Total acres for personal use, others, and work)? ________acres

5. What forest type(s) do you work in? (*Check all that apply*)

   O Upland Hardwood
   O Bottomland Hardwood
   O Conifer
   O Mixed Hardwood-conifer
   O Other ____
   ____

6. Do you have any prescribed burning training?

   O Yes
   O No

If you answered **no** go to question **8,** if you answered **yes** go to question **7**.

7. What formal prescribed burn training do you have? (*Check all that apply*)

O Industrial
O College
O Federal
O State
O Other (please explain): ____

8. How many years experience do you have with implementing prescribed burning?
_____ years

9. Have factors limited you from obtaining any prescribed burning training and information? (*Check all that apply*)

O None
O Budgets
O Lack of Available Resources
O Time constraints
O Other :____
____

10. Do you use or recommend Prescribed Burning?

O Yes
O No

If you answered **no** go to question **12**, if you answered **yes** go to question **11**.

11. Please mark **yes** or **no** if you use or recommend prescribed burning for the following areas.

work	O Yes	O No
personal use	O Yes	O No
other landowners	O Yes	O No

If you answered **"Yes"** to any item in question **11** go to question **15.** If you answered **"No"** to all responses in question **11,** please answer questions **12, 13**, and **14** then go to question **20**.

12. Would you like to use prescribed burning in your management activities?

O Yes
O No

13. Below is a list of possible barriers that may **prevent** you from using prescribed burning. For each barrier, please circle the appropriate number that rates how important the barrier is in **preventing** you from using and/or recommending prescribed burning.

Barrier	Not at All Important	Somewhat Important	Important	Very Important	Extremely Important	Do not Know
Damage risk	1	2	3	4	5	6
Lack of research on specific forest type	1	2	3	4	5	6
Societal factors	1	2	3	4	5	6
Manpower	1	2	3	4	5	6
Cost to your Agency or Firm	1	2	3	4	5	6
Institutional or private policies, protocol, or mission	1	2	3	4	5	6
Cost to landowner	1	2	3	4	5	6
Time/ weather constraints	1	2	3	4	5	6

14. Are there any other barriers that prevent you from using prescribed burning?
____
____

GO TO QUESTION 20.

15. What percentage of your job responsibility involves prescribed burning?
_______%

16. What is your primary reason(s) for using or recommending prescribed burning? (*Check all that apply*)

O Competition Control
O Fuel Load Reduction
O Logging Slash Disposal
O Restoration of Fire-dependent ecosystems to a desired condition
O Wildlife Habitat Improvement
O Maintaining Fire-Dependent Plant Species
O Maintaining Fire-Dependent Animal Species
O Other____
____

17. Based on the amount of burning you do, would you like to prescribe burn:

O Less.
O the Same.
O More.
O Not at all.

18. Below is a list of possible barriers that may **prevent** you from using prescribed burning. For each barrier, please circle the appropriate number that rates how important the barrier is in **preventing** you from completing the amount of prescribed burning you would like to do.

Barrier	**Not at All Important**	**Somewhat Important**	**Importan t**	**Very Important**	**Extremely Important**	**Do not Know**
Damage risk	1	2	3	4	5	6
Lack of research on specific forest type	1	2	3	4	5	6
Societal factors	1	2	3	4	5	6
Manpower	1	2	3	4	5	6
Cost of prescribed burning	1	2	3	4	5	6
Institutional or private policies, protocol, or mission	1	2	3	4	5	6
Future economic returns	1	2	3	4	5	6
Future growth of stand	1	2	3	4	5	6
Stand condition	1	2	3	4	5	6
Wildlife habitat	1	2	3	4	5	6

19. Are there any other barriers that would prevent you from the amount of prescribed burning you would like to do?

____

____

20. In your opinion, in the next 10 years, the use of prescribed burning in the land you are managing in Tennessee is most likely to:

O Increase
O Stay the same
O Decrease

21. In your opinion, check **yes** or **no** if additional prescribed burning information is needed for each of the forest types below:

	Yes	No
Hardwood Stands	O	O
Pine Stands	O	O
Mixed Pine/Hardwood Stands	O	O

22. Would you like to see more prescribed burning being conducted on the land you manage?

O Yes
O No

23. Please circle the appropriate number indicating if more science-based research information on prescribed burning is needed in the following areas.

Prescribed Burning Areas	Not Needed	Little Needed	Needed	More Needed	Greatly Needed	Do Not Know
Appropriate frequency to achieve goals	1	2	3	4	5	6
Appropriate intensity to achieve goals	1	2	3	4	5	6
Appropriate season to achieve goals	1	2	3	4	5	6
Fuel reduction	1	2	3	4	5	6
Management of non-timber resources	1	2	3	4	5	6
Potential damage to crop trees	1	2	3	4	5	6
risk of escape	1	2	3	4	5	6
Smoke management	1	2	3	4	5	6
Wildlife habitat	1	2	3	4	5	6

24. Please indicate other science-based research information on prescribed burning that is needed and not previously mentioned.

____

____

25. Who is your employer?

O Consulting Firm
O Private Industry
O Self-Employed Consultant
O Tennessee-Division of Forestry
O Tennessee Department of Environment and Conservation
O U.S. Forest Service
O National Park Service
O U.S. Fish and Wildlife Service
O Tennessee Valley Authority
O Tennessee Wildlife Resource Agency
O Other____

26. How many year(s) experience do you have as a professional Natural Resource Manager? _____ year(s)

27. What Tennessee county(ies) do you manage forested land in?

O All Counties
O Anderson
O Bedford
O Benton
O Bledsoe
O Blount
O Bradely
O Campbell
O Cannon
O Carroll
O Carter
O Cheatham
O Chester
O Claiborne
O Clay
O Cocke
O Coffee
O Crockett
O Cumberland
O Davidson
O Decatur
O DeKalb
O Dickson
O Dyer
O Fayette
O Fentress
O Franklin
O Gibson
O Giles
O Grainger
O Greene
O Grundy
O Hamblin
O Hamilton
O Hancock
O Hardeman
O Hardin
O Hawkins
O Haywood
O Henderson
O Henry
O Hickman
O Houston
O Humphreys
O Jackson
O James
O Jefferson
O Johnson
O Knox
O Lake
O Lauderdale
O Lawrence
O Lewis
O Lincoln
O Loudon
O Macon
O Madison
O Marion
O Marshall
O Maury
O McMinn
O McNairy
O Meigs
O Monroe
O Montgomery
O Moore
O Morgan
O Obion
O Overton
O Perry
O Pickett
O Polk
O Putnam
O Rhea
O Roane
O Robertson
O Rutherford
O Scott
O Sequatchie
O Sevier
O Shelby
O Smith
O Stewart
O Sullivan
O Sumner
O Tipton
O Trousdale
O Unicoi
O Union
O Van Buren
O Warren
O Washington
O Wayne
O Weakley
O White
O Williamson
O Wilson

28. Please indicate the highest level of education you have completed.

O High School
O Some College
O Technical School
O Bachelors Degree
O Masters Degree
O Ph.D. Degree
O Other____

29. Is your college degree(s) in Natural Resources?

O No College Degree
O Yes
O No

30. Please write below any other comments you have about prescribed burning and/or the need for research and information on the effects and use of prescribed fire.

____

____

31. Would you like the results of this survey e-mailed to you?

O Yes
O No

Appendix D of IRB: First Replacement Letter

August X, 2003

Dear Natural Resource Manager,

About 10 days ago I sent an Internet questionnaire to you that asked about your use or non-use of prescribed burning. To the best of our knowledge, we have not received your responses in the questionnaire.

The comments of people that have already responded include a wide variety of reasons of why they use or do not use prescribed burning in their management practices in Tennessee. Many have described barriers in implementation, worries, or future research needs about prescribed burning. We think the results will be very useful to private, state, and federal managers as well as researchers across Tennessee.

If you are not a current natural resource manager working in Tennessee, and you feel that we have made a mistake including you in this study, please reply to this e-mail with a note indicating so. This would be very helpful.

If for any other reason you prefer not to answer it, please let us know by replying to this e-mail and asking to be removed from the list.

I understand that your time is valuable and I hope you will take a few minutes to complete the questionnaire. It should take 10-15 minutes to complete. Thank you for your time.

The questionnaire can be obtained by clicking on this link.
http://surveys.utk.edu/prescribeburn/index.htm

Sincerely,

Brian Hemel
Graduate Research Assistant
University of Tennessee
Department of Forestry, Wildlife & Fisheries
274 Ellington Plant Science building
Knoxville, Tennessee 37996-4563
bhemel@utk.edu
865-974-0857

Appendix E of IRB: Final Contact Letter

August X, 2003

Dear Natural Resource Manager,

During the last couple of weeks we have sent you several e-mails about an important research study we are conducting for the University of Tennessee.

Its purpose will describe barriers in implementation, worries, or future research needs about prescribed burning in Tennessee for Natural Resource Managers.

The study is drawing to a close, and this is the last contact that will be made with the sample of Natural Resource Managers we have collected across Tennessee. Hearing from everyone in this statewide sample helps assure that the survey results are as accurate as possible.

We also want to assure you that your response to this study is voluntary, and if you prefer not to respond that's fine. If you are not a current Natural Resource Manager working in Tennessee, and you feel that we have made a mistake including you in this study, please reply to this e-mail with a note indicating so. This would be very helpful.

Finally, we appreciate your willingness to consider our request as we conclude this effort to better understand barriers and research needs dealing with prescribed burning in Tennessee. Thank you very much.

The questionnaire can be obtained by clicking on this link.
http://surveys.utk.edu/prescribeburn/index.htm

Sincerely,

Brian Hemel
Graduate Research Assistant
University of Tennessee
Department of Forestry, Wildlife & Fisheries
274 Ellington Plant Science building
Knoxville, Tennessee 37996-4563
bhemel@utk.edu
865-974-0857

Appendix 2 Managers Mean Survey Responses

Refer to survey in Appendix 1 to see which questions follow and jump one another.

1. Please type your e-mail address for a chance to win a free t-shirt, and to remove your e-mail address from the list for follow-up reminders _______________.

2. What job description best describes you (Please check only one)?

   9.7 % Biologist
   6.1 % Ecologist
   2.4 % Fire Manager
   0 % Private Landowner
   50.3 % Forester
   16.4 % Wildlife Biologist
   4.8 % Refuge Manager
   1.8 % Park Ranger
   8.5 % Other

3. Do you assist non-industrial private forest landowners in land management?

   55.2 % Yes
   43.0 % No
   1.8 % Did Not Answer

4. How many forest acres do you manage in Tennessee (Total acres for personal use, others, and work)? Total number of acres managed 9,495,710 acres
   Average number of acres managed per manager 88,744 acres

Average Acres managed by:

Job Description		Region		Employer	
Biologist	14,146	West	58,267	Consulting Firm	46,147
Ecologist	136,170	West Central	49,277	Private Industry	112,393
Fire Manager	358,000	Central	20,006	Self-Employed Consultant	7,491
Forester	94,310	Plateau	50,496	TDF	111,170
Wildlife Biologist	32,426	East	153,979	USFS	385,425
Refuge Manager	20,391			NPS	42,011
Other	11,656			USF&WS	15,527
Park Ranger	3,725			TVA	26,334
				TWRA	42,433
				Other	10,700
				TNC	300
				USACE	9,009

5. What forest type(s) do you work in? (*Check all that apply*)

   85.5 % Upland Hardwood
   58.2 % Bottomland Hardwood
   55.2 % Conifer
   65.5 % Mixed Hardwood-conifer
   7.3 % Other

6. Do you have any prescribed burning training?

   63.6 % Yes
   35.8 % No
   0.6 % Did not Answer

7. What formal prescribed burn training do you have? (*Check all that apply*)

   9.1 % Industrial
   37.0 % College
   27.9 % Federal
   32.7 % State
   0.04 % Other

8. How many years experience do you have with implementing prescribed burning?
   Mean response = 14.4 years

9. Have factors limited you from obtaining any prescribed burning training and information? (*Check all that apply*)

   37.6 % None
   30.3 % Budgets
   18.8 % Lack of Available Resources
   35.8 % Time constraints
   13.3 % Other

10. Do you use or recommend Prescribed Burning?

   81.2 % Yes
   18.8 % No

11. Please mark **yes** or **no** if you use or recommend prescribed burning for the following areas.

work	90.7 % Yes	9.3 % No
personal use	56.1 % Yes	43.9 % No
other landowners	75.8 % Yes	24.2 % No

12. Would you like to use prescribed burning in your management activities? (Percentages based on those that do not use or recommend prescribed burning.)

51.4 % Yes
48.6 % No

13. Below is a list of possible barriers that may **prevent** you from using prescribed burning. For each barrier, please circle the appropriate number that rates how important the barrier is in **preventing** you from using and/or recommending prescribed burning.
(Mean Likert scale responses based on those that do not use or recommend prescribed burning.)

Barrier	**Mean**
Damage Risk	4.06
Lack of Research on Specific Forest Type	2.67
Societal Factors	3.24
Manpower	3.18
Cost to your Agency or Firm	2.63
Institutional or Private, Policies, Protocol, or Mission	2.80
Cost to Landowner	2.75
Time/Weather Constraints	3.47

14. Are there any other barriers that prevent you from using prescribed burning?

15. What percentage of your job responsibility involves prescribed burning?
Mean response = 6.4%

16. What is your primary reason(s) for using or recommending prescribed burning? (*Check all that apply*)

64.2 % Competition Control
41.8 % Fuel Load Reduction
29.7 % Logging Slash Disposal
32.7 % Restoration of Fire-dependent ecosystems to a desired condition
68.5 % Wildlife Habitat Improvement
33.9 % Maintaining Fire-Dependent Plant Species
18.2 % Maintaining Fire-Dependent Animal Species
7.3 % Other

17. Based on the amount of burning you do, would you like to prescribe burn: (Percentages based on those that do use or recommend prescribed burning.)

0.7 % Less.
27.3 % the Same.
69.8 % More.
2.2 % Not at all.

18. Below is a list of possible barriers that may **prevent** you from using prescribed burning. For each barrier, please circle the appropriate number that rates how important the barrier is in **preventing** you from completing the amount of prescribed burning you would like to do.
(Mean responses based on those that use or recommend prescribed burning.)

Barriers	Mean
Damage Risk	3.81
Lack of Research on Specific Forest Type	2.19
Societal Factors	2.93
Manpower	3.85
Cost of Prescribed Burning	2.74
Institutional or Private Policies, Protocol, or Mission	3.06
Future Economic Returns	2.31
Stand Condition	2.93
Wildlife Habitat	3.07
Future Growth of Stand	3.04

19. Are there any other barriers that would prevent you from the amount of prescribed burning you would like to do?

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20. In your opinion, in the next 10 years, the use of prescribed burning in the land you are managing in Tennessee is most likely to:

    40.0 % Increase
    20.6 % Stay the same
    33.9 % Decrease
    5.5 % Did not Answer

21. In your opinion, check **yes** or **no** if additional prescribed burning information is needed for each of the forest types below:

	Yes	No
Hardwood Stands	77.1 %	22.9 %
Pine Stands	36.7 %	63.3 %
Mixed Pine/Hardwood Stands	74.3 %	25.7 %

22. Would you like to see more prescribed burning being conducted on the land you manage?

    77.8 % Yes
    22.2 % No

23. Please circle the appropriate number indicating if more science-based research information on prescribed burning is needed in the following areas.

Scienced-Based research	Mean
Based on the amount of prescribed burning you do, would you like to prescribe burn:	1.35
Damage Risk	3.81
Lack of Research on Specific Forest Type	2.19
Societal Factors	2.93
Manpower	3.85
Cost of Prescribed Burning	2.74
Institutional or Private Policies, Protocol, or Mission	3.06
Future Economic Returns	2.31
Stand Condition	2.93
Wildlife Habitat	3.07
Future Growth of Stand	3.04

24. Please indicate other science-based research information on prescribed burning that is needed and not previously mentioned.

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25. Who is your employer?

6.7 % Consulting Firm
10.4 % Private Industry
9.8 % Self-Employed Consultant
19.5 % Tennessee-Division of Forestry
6.7 % U.S. Forest Service
6.1 % National Park Service
9.1 % U.S. Fish and Wildlife Service
5.5 % Tennessee Valley Authority
12.2 % Tennessee Wildlife Resource Agency
3.6 % Other
1.8% The Nature Conservancy
3.0% United States Department of Agriculture
5.5 % United States Army Corps of Engineers

26. How many year(s) experience do you have as a professional Natural Resource Manager? 14.4 year(s)

27. What Tennessee county(ies) do you manage forested land in? (count)

9	All Counties	15	Decatur	19	Henry	8	Maury	11	Sequatchie
17	Anderson	4	DeKalb	9	Hickman	19	McMinn	6	Sevier
4	Bedford	12	Dickson	14	Houston	9	McNairy	10	Shelby
16	Benton	9	Dyer	20	Humphreys	14	Meigs	6	Smith
10	Bledsoe	10	Fayette	7	Jackson	21	Monroe	19	Stewart
14	Blount	11	Fentress	0	James	7	Montgomery	11	Sullivan
11	Bradely	6	Franklin	5	Jefferson	4	Moore	5	Sumner
13	Campbell	7	Gibson	8	Johnson	15	Morgan	12	Tipton
5	Cannon	5	Giles	9	Knox	13	Obion	6	Trousdale
15	Carroll	11	Grainger	9	Lake	7	Overton	7	Unicoi
8	Carter	9	Greene	11	Lauderdale	11	Perry	5	Union
11	Cheatham	13	Grundy	8	Lawrence	7	Pickett	10	Van Buren
7	Chester	5	Hamblin	7	Lewis	19	Polk	8	Warren
10	Claiborne	16	Hamilton	4	Lincoln	6	Putnam	6	Washington
7	Clay	4	Hancock	13	Loudon	13	Rhea	8	Wayne
11	Cocke	8	Hardeman	5	Macon	21	Roane	11	Weakley
6	Coffee	16	Hardin	6	Madison	4	Robertson	7	White
5	Crockett	6	Hawkins	11	Marion	7	Rutherford	6	Williamson
13	Cumberland	11	Haywood	2	Marshall	15	Scott	7	Wilson
10	Davidson	11	Henderson						

28. Please indicate the highest level of education you have completed.

0 % High School
0.6 % Some College
58.2 % Bachelors Degree
36.4 % Masters Degree
3.6 % Ph.D. Degree
1.2% Other

29. Is your college degree(s) in Natural Resources?

0.6 % No College Degree
92.0 % Yes
7.4 % No

30. Please write below any other comments you have about prescribed burning and/or the need for research and information on the effects and use of prescribed fire.

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31. Would you like the results of this survey e-mailed to you?

77.1 % Yes
22.9 % No

Vita

Brian Thomas Hemel was born in New Orleans, Louisiana on July 23, 1979. He was raised in Orleans Parrish and graduated from Jesuit High School in 1997. Brian then attended Brevard College, Brevard, North Carolina where he earned the Bachelor of Arts degree in Ecology and Integrated Studies. Brian attended Graduate School at the University of Tennessee where he earned a Master of Science Degree in Forestry with a minor in Statistics in 2004.

Brian is going to work at Chiricahua National Monument in Arizona where he will work as a wildland firefighter for the National Park Service.