Ecological, political and social challenges of prescribed fire restoration in east Texas pineywoods ecosystems: a case study

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Summary

The effectiveness of prescribed fire restoration of forested sites in three state parks in east Texas, USA was studied. Two sites consisted of mixed shortleaf (*Pinus echinata* Mill.) or loblolly pine (*Pinus taeda* L.) and broadleaf overstoreys. The third site was a longleaf pine (*Pinus palustris* Mill.)/little bluestem (*Schizachyrium scoparium* (Michx.) Nash.) stand. Mid- and understoreys at all sites consisted of a variety of shrubs and herbaceous vegetation. Prolonged drought resulting in county burn bans prohibited burning until immediately after rain events. Results indicated no effect from the burns in the overstorey, seedling, shrub or herbaceous layers at any park. At two sites, there was a significant increase in the percentage of dead standing saplings in the burn plots from pre- to post-burn. The only significant decreases in fuels were in the weight and depth of combined O_i and O_e horizons (litter). Compliance with burn bans greatly reduced the restorative powers of the burns. Park visitors' attitudes concerning fire were also examined, indicating a need for education concerning differences between wildfire and prescribed fire, and benefits of prescribed fire.

Introduction

Fire has an influence in such ecosystem processes as recycling of nutrients, regulating plant succession and wildlife habitat, maintaining biological diversity, reducing biomass, and controlling insect and disease populations. Forests in many parts of the world have suffered unprecedented health problems due to exclusion of fire over the past 100 years (Pyne *et al.*, 1996; Nordlind and Östlund, 2003). Exclusion has contributed to increased stand densities (Kaufmann *et al.*, 2003), damage from insects and disease, and increased crown fire potential (Mutch, 1994). In recent

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years, severe wildfires in forests have accelerated the rate of forest mortality, threatened people, property and natural resources, and emitted large amounts of particulate matter (Mutch, 1994). These fire suppression effects have resulted in an increased need for forest fire restoration on a global basis.

In addition, the United States public largely misunderstands the role of fire in wildland areas (Williams, 1995; Dowd, 1996). This misunderstanding has even been fostered by management policies, such as the USDA Forest Service 10 o'clock fire regulation of 1936, which proclaimed that every fire would be extinguished by 10.00 hours the day following its discovery. This policy strengthened the opinion that all fire should be extinguished (Williams, 1995).

'Bambi mythology', belief of an 'evil' nature of fire, has also affected public perception of forest management for almost 60 years (Dowd, 1996). The 'Bambi' film has even been called the most important historical document in fire management policy (Williams, 1995). Following Bambi, Smokey Bear was generally accepted as the voice of fire prevention. Smokey's original message 'Only you can prevent forest fires' was one of unilateral abhorrence. Not until April 2001 was Smokey's message changed to 'Only you can prevent wildfires', allowing room for prescribed burning (Salisbury Post, 2001).

In the environmental arena, it is important that the public understands management procedures and policies (Hendee *et al.*, 1974). By the same token, understanding visitors' attitudes and beliefs concerning prescribed burning allows land managers to enhance desirable and minimize negative aesthetic effects. Communicating management goals, and explaining long-term effects of practices, such as prescribed burning, that are aesthetically offensive in early stages will influence approval levels. When park visitors understand long-term effects, they are more likely to soften opposition to otherwise offensive forest practices (Bliss *et al.*, 1997).

The objectives of the project were two-fold. The first was to determine short-term ecological effects of prescribed burning on vegetation and fuel loading in selected east Texas state parks. The second was to discover park visitors' attitudes and beliefs concerning wildfires and the use of prescribed fire as a management tool in the parks. 'Wildfire' is defined here as any unwanted fire. 'Prescribed fire' is one that meets predetermined criteria concerning location, season, weather and fuel conditions designed to further forest restoration objectives. The three parks surveyed in this study were all part of the East Texas Pineywoods Region of Texas Parks and Wildlife Department's (TPWD) Parks and Historic Sites. Specific objectives of this paper are to discuss difficulties involved in prescribed fire restoration. In this case, political and social issues affected the restorative powers of prescribed fire on vegetation and fuel loading. Thus, we have presented results of the fires' impacts on vegetation and fuel loading to illustrate the relationships between ecological, political and social elements.

The primary objectives of each burn were to establish or re-introduce the use of prescribed fire to further conservation of the parks' natural resources, and to reduce risk of wildfire by reducing fuel loads. Secondary objectives included reducing heavy fuel loadings of 1-h, 10-h and 100-h fuels; killing or weakening understorey shrubs, while encouraging herbaceous species; increasing species diversity and richness; and encouraging longleaf pine seedlings at Village Creek State Park (Robinson and Blair, 1997; Sparks, 1999a, b).

Study sites

Mission Tejas State Historical Park (MTSHP) consists of 148.5 ha in Houston County, Texas. Tyler State Park (TSP) is a 399-ha park located in Smith County, Texas. Rainfall in these parks averages 105–110 cm per year. January's low temperature averages 0°C, and July's high averages 35°C. Steep terrain abounds in both parks, with elevations ranging from 51 to 175 m (Texas Parks and Wildlife Department, 2000a, b). Mixed pine/hardwood forests consisting of loblolly pine (*Pinus taeda* L.)/oak (*Quercus* spp.) and shortleaf pine (*Pinus echinata* Mill.)/oak stands dominated burn units, with pines accounting for at least 20 per cent of the stems (Sparks, 1999a). Typical hardwood species included various oaks, sweetgum (*Liquidambar styraciflua* L.), hickories (*Carya* spp.), white ash (*Fraxinus americana* L.) and American holly (*Ilex opaca* Ait.). Common understorey species included yaupon (*Ilex*

vomitoria Ait.), flowering dogwood (*Cornus florida* L.), pawpaw (*Asimina triloba* (L.) Dunal), American beautyberry (*Callicarpa americana* L.), longleaf uniola (*Chasmanthium laxum* var. *sessiliflorum* (L.) Yates), panicums (*Panicum* spp.) and various sedges (Robinson and Blair, 1997). Historically, the fire return interval (FRI) at both sites was 4–6 years. It is presently >20 years (Jurney, 2000).

Village Creek State Park (VCSP) in Tyler County, Texas is heavily forested and consists of 406 ha. The burn unit was a relatively flat, low-lying area within the Village Creek floodplain with a mean elevation of 7 m. July's average high temperature is 34°C, while January's average low is 3°C (Texas Parks and Wildlife Department, 2000c). Vegetation in the burn unit consisted of longleaf pine (*Pinus palustris* Mill.)/little bluestem (*Schizachyrium scoparium* (Michx.) Nash.), which was being overtaken by various hardwoods in the absence of fire. In the Village Creek area, historic FRI was 1–3 years. It is now >20 years (Jurney, 2000).

Methods

Methods for establishing plots and sampling vegetation and fuel loads were as defined in the *National Park Service Western Region Fire Monitoring Handbook* (Western Region Prescribed and Natural Fire Monitoring Task Force, 1992). Eight plots were located in each park. Five burn plots were randomly located within a stand scheduled for burning that year. Three control plots were randomly located within a stand that closely resembled the burn unit in vegetative and fuel loading characteristics. The entire 20 × 50 m plot was used for sampling overstorey trees with d.b.h. >15 cm. Saplings with d.b.h. ≥2.5 cm and ≤15 cm were sampled in one 10 × 25 m quarter. Seedlings with d.b.h. < 2.5 cm were monitored in a 5 × 10 m section.

The point line-intercept method as defined in the *National Park Service Western Region Fire Monitoring Handbook* (Western Region Prescribed and Natural Fire Monitoring Task Force, 1992) was used for sampling shrub and herbaceous layers along one outside 50 m transect. To obtain shrub density, the transect was widened to a 0.5 m belt. To measure herbaceous density, a stem count was conducted within a 1 m^2 frame placed on the plot side of both outer 50-m transects every 10 m, beginning at the 9-m mark. The total area sampled using this method was 10 m^2. Dead and detached woody fuels and depth of O_a (duff) and O_i and O_e soil horizons combined (litter) were monitored along four fuel inventory transects (Brown *et al.*, 1982) extending 15.24 m in random directions from the centre-line at the 10-, 20-, 30- and 40-m marks.

All pre-burn sampling was completed in June and July 1999. Post-burn sampling took place during the same months of 2000. Due to prolonged drought, county burn bans prohibited burning in the parks until immediately after a rain episode. Burns were conducted between 28 February and 20 March 2000, when bans were temporarily lifted. Because of the necessity to wait until a rain event, fuels were wet and resulting burns were of low intensity. The firing method used at each park was strip head-fires. Flame lengths averaged 0.3–0.6 m at VCSP, and 0.6–1.2 m at MTSHP and TSP. Tiles with heat-sensitive paint recorded ground-level temperatures at plot centres, ranging from no apparent effect to 93°C at VCSP, 93°C to 538°C at MTSHP, and 93°C to 204°C at TSP.

A park visitor survey was developed and implemented using Likert scale statements to determine attitudes and beliefs concerning wild and prescribed fire in the parks' forests (Likert, 1932). Because terms such as 'attitudes' and 'beliefs' are not easily defined, the researchers' intent here was not to focus on such definitions, rather to supplement TPWD's prescribed burning programme with useful information on state park visitors' education and interpretive programming needs.

Survey respondents were asked to circle 'strongly agree', 'agree', 'undecided', 'disagree' or 'strongly disagree' for each Likert statement. Demographics questions concerning age, gender, education, income, etc. were also asked. A pre-survey was conducted during autumn 1999 and revisions were made to the questionaire. Surveys were administered in the parks after prescribed burns had been conducted in the spring and summer of 2000. Five hundred questionaires were delivered to each park with administration instructions for park staff. Staff members were instructed to ask all adults checking into the park to complete and return the survey. The survey was

self-administered and could be folded, taped and mailed to researchers with postage paid.

There are several limitations to the survey results. Due to limited information concerning park visitors, no attempt to identify or contact non-respondents could be made. With several people staffing front desks it is not certain if all surveys were distributed. Results of the surveys are only representative of Texas state park visitors who are comfortable completing a self-administered written survey.

ANOVA and paired *t*-tests were performed to test for significant differences in pre- and post-burn fuel loads and vegetation in SPSS Base 10.0 (SPSS Inc., 1999). Morisita's index of similarities was conducted on pre- and post-burn seedling, shrub and herbaceous community composition (Morisita, 1959). Chi-square, Cramer's *V*, and Spearman's rho were performed in SPSS Base 10.0 on the public opinion survey to determine significant relationships among Likert responses, and relationships between responses and demographics of respondents.

Results and discussion

Effects of burns on vegetation and fuels

For all parks combined, litter weight decreased significantly, 0.98 Mg ha^{-1} ($P < 0.001$), in the burn plots (Table 1). There was also a significant decrease in litter depth in the burn plots ($P = 0.042$), while there was a significant increase in control plots ($P < 0.001$). The actual difference in depth between post-burn burn and control plots was 0.99 cm. The fires had a statistically significant effect on 1-h fuels ($P < 0.017$); however, the actual pre- to post-burn difference was only 0.05 Mg ha^{-1} (Table 2). This is not considered ecologically significant. The fires had no discernible effect on 10-, 100- or 1000-h fuels. It appears the burns did not fully reach management objectives defined in the burn plans to reduce fuel loading.

t-Tests indicated no effect from the burns on the overstorey of any park. With the exception of the herbaceous community at VCSP, Morisita's Similarity Index showed high (from 0.61 to 1.20) similarity in composition of seedling, shrub and herbaceous species at all parks between 1999 and 2000. This indicated no effect from the prescribed burns in these communities.

At VCSP, the effect of prolonged drought was evident in the herbaceous community. All comparisons in Morisita's Similarity Index received a low rating (0.00–0.42). This was due to the total lack of herbaceous vegetation in many of the sample frames, particularly in control plots, in 2000. At TSP and VCSP, paired *t*-tests indicated significant increases from 1999 to 2000 in the percentage of dead standing saplings in burn plots

Table 1: Mean measurements in 1999 and 2000 and paired t-test results for O_i and O_e combined (litter) and O_a (duff) horizons in Mission Tejas, Tyler and Village Creek State Parks in Texas, USA combined (from Rideout and Oswald, 2002)

Plot type	Measurement	O_i and O_e weight (Mg ha^{-1})	Oi and Oe depth (cm)	Oa depth (cm)
Burn*	1999	2.99	1.35	1.43
(n = 60,	2000	2.02	1.20	1.35
d.f. = 59)	Mean difference	0.98	0.15	0.08
	SD	1.41	0.54	0.55
	t	5.182	2.074	1.084
	Significance	<0.001	0.042	0.283
Control	1999	3.72	1.49	1.57
(n = 36,	2000	3.48	2.20	1.60
d.f. = 35)	Mean difference	0.24	−0.71	−0.03
	SD	1.66	0.64	0.74
	t	0.850	−6.641	−0.234
	Significance	0.401	<0.001	0.817

* n = 56 for O_i and O_e weight in the burn plots, d.f. = 55 for O_i and O_e weight in the burn plots.

Table 2: Mean fuel loads and paired t-test results for fuels in 1999 (pre-burn) and 2000 (post-burn) in Mission Tejas, Tyler and Village Creek State Parks in Texas, USA combined (from Rideout and Oswald, 2002)

Plot type	Measurement	1-h	10-h	100-h	1000-h	Total
Burn	1999 fuel load (Mg ha^{-1})	0.29	1.78	1.81	1.63	5.53
(n = 60,	2000 fuel load (Mg ha^{-1})	0.24	1.58	2.49	2.42	6.68
d.f. = 59)	Mean difference	0.05	0.19	−0.68	−0.79	−1.15
	SD	0.15	2.17	3.73	4.88	5.52
	t	2.453	0.687	−1.406	−1.254	−1.608
	Significance	0.017	0.495	0.165	0.215	0.113
Control	1999 fuel load (Mg ha^{-1})	0.31	2.25	1.74	2.55	6.84
(n = 36,	2000 fuel load (Mg ha^{-1})	0.24	1.01	2.04	6.20	9.50
d.f. = 35)	Mean difference	0.07	1.23	−0.30	−3.64	−2.50
	SD	0.28	1.60	3.30	9.58	10.04
	t	1.518	4.610	−0.553	−2.282	−1.584
	Significance	0.138	<0.001	0.584	0.029	0.122

(t = 3.003952, P = 0.003; t = 2.2860, P = 0.023, respectively). They increased from 7.9 to 18.5 per cent at TSP and from 12.6 to 19.6 per cent at VCSP. Because control plots indicated the opposite trend, the increase in the burn plots was evidently due to burning. Saplings were already suffering drought stress and additional stress of the burn contributed to the mortality of weaker individuals. Further t-tests indicated no significant differences in d.b.h. or height class from 1999 to 2000, indicating that combined stresses affected saplings of all diameters and heights evenly. There was no change in the sapling community at MTSHP.

Overall, the burns partially met the objective of reducing underbrush by causing a significant increase in dead saplings at two sites. These appear to be the only significant changes in vegetation. The objectives of increasing herbaceous species, increasing richness and diversity, and encouraging longleaf seedlings were not met probably because sites were already stressed by drought and the intensity of the burns was too low to modify site conditions.

Visitor survey results

Of 1500 surveys delivered to the parks, only 48 visitors participated in the survey. Respondents were almost all Caucasian. This characteristic is not specific to east Texas state parks, rather it is common at outdoor wildland recreation sites across the United States (Washburne, 1978; Wallace and Witter, 1990; Rideout and Legg, 2000). Slightly more females (56 per cent) than males responded. The mean age of respondents was 46. All respondents had graduated from high school. Twelve respondents had attended college, 19 had bachelors degrees, nine had masters degrees and two held a Ph.D., MD or law degree. Mean combined gross household income was $73 400, while $60 000 was both the median and the mode.

Likert scale statements showed both support and disapproval of wild and prescribed fires in the parks (Table 3). Responses to selected statements are discussed here.

Responses to 'Wildfires should be prevented in state parks' were spread across the continuum. While 69 per cent were in agreement with the statement, 27 per cent disagreed. Spearman's test revealed that visitors who were likely to agree that wildfires should be prevented in state parks were likely to disagree that fire is necessary for the health of certain forests (cc = −0.389, P = 0.007). They were also likely to agree that prescribed burning creates harmful smoke (cc = −0.317, P = 0.030). These correlations indicated general negative attitudes toward any type of fire in the parks among those respondents.

The practice of prescribed burning was given generous support, with 81 per cent agreeing with the statement 'Prescribed burning can be a useful management tool'. Respondents who agreed with this statement were also likely to agree that fire is necessary for the health of certain forests (cc = 0.554, P < 0.001), and that prescribed burning can reduce the likelihood of wildfires (cc = 0.617,

Table 3: Percentages of Likert scale responses combined from visitors in spring 2000 to Mission Tejas, Tyler, and Village Creek State Parks in Texas, USA

Likert statement	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	*n*
Wildfires should be prevented in state parks	52	17	4	23	4	48
Prescribed burning can be a useful management tool	44	38	10	2	6	48
Prescribed burning and wildfire have the same impact on forests	25	31	25	10	8	48
Prescribed burning reduces the likelihood of destructive wildfires	38	38	21	2	2	48
Fire is necessary for the health of certain forests	51	27	13	6	2	47
Prescribed burning can create wildlife habitat	29	38	21	4	4	48
The benefits of prescribed burning outweigh the risks	29	40	21	8	2	48
Prescribed burning creates harmful smoke	11	27	32	27	2	47
Wildlife is harmed by prescribed burning	4	23	31	35	6	48
Prescribed burning should not be used as a management tool in state parks	4	10	19	31	35	48

$P < 0.001$), and create wildlife habitat (cc = 0.477, $P = 0.001$). They also believed its benefits outweigh its risks (cc = 0.637, $P < 0.001$), and it should be used in state parks (cc = 0.683, $P < 0.001$). These correlations indicated support for prescribed burning and aggressive management of state park forests.

Over 56 per cent of respondents were in agreement with the statement that 'Prescribed burning and wildfire have the same impact on forests', while 25 per cent were undecided. There was a significance between respondents who agreed with that statement and the statement 'Prescribed burning should not be used as a management tool in state parks' (cc = 0.317, $P = 0.028$).

Seventy-five per cent agreed or strongly agreed that 'Prescribed burning reduces the likelihood of destructive wildfires', while almost 21 per cent were undecided. This statement was positively correlated to those indicating prescribed burning can be a useful management tool (cc = 0.617, $P < 0.001$), fire is necessary for health of certain forests (cc = 0.697, $P < 0.001$), prescribed burning can create wildlife habitat (cc = 0.552, $P < 0.001$), and its benefits outweigh its risks (cc = 0.595, $P < 0.001$). These correlations, and that pertaining to the use of prescribed burning as a management tool in state parks (cc = 0.486, $P < 0.001$), were also indicative of support for aggressive management and prescribed burning in the forests.

The statement 'Fire is necessary for the health of certain forests' received a surprising amount of support considering responses received by other statements. Seventy-eight per cent agreed or strongly agreed. There was a significant negative correlation between this statement and 'Wildfires should be prevented in state parks' (cc = –0.389, $P = 0.007$). In other words, respondents who agreed that fire is necessary for forest health, tended to disagree that wildfires should be prevented in state parks.

Almost 70 per cent of respondents were in agreement with 'The benefits of prescribed burning outweigh the risks', while only 10 per cent disagreed. All of the statements that were significantly correlated with this statement indicated values in support of aggressive management of forests and wildlife. They demonstrated support for the use of prescribed burning as a management tool for reducing risk of wildfire (cc = 0.595, $P < 0.001$), improving forest health

(cc = 0.535, $P < 0.001$) and enhancing wildlife habitat (cc = 0.396, $P = 0.006$).

The statement 'Prescribed burning creates harmful smoke' resulted in the highest portion of 'undecided' responses and the most even spread of responses across the continuum. Almost 32 per cent were undecided. Just under 40 per cent were in agreement, while roughly 30 per cent disagreed. The lack of agreement is understandable. While prescribed burning does emit smoke, and all smoke is potentially harmful, it reduces the risk of wildfire, which could create even greater smoke.

There was a significant relationship between this statement and 'Prescribed burning should not be used as a management tool in state parks' (cc = 0.376, $P = 0.009$) and 'Wildfires should be prevented in state parks' (cc = −0.317, $P = 0.030$). This creates a conflict, as adhering to all of these values would require preventing wildfire without the use of prescribed fire, while prescribed fire is one of the most effective tools for reducing the risk of wildfires and their harmful smoke.

Also, as income increased, respondents were more likely to agree that 'Prescribed burning creates harmful smoke' ($r_s = -0.342$, $P = 0.036$). There was also a significant relationship between this statement and gender ($\chi^2 = 10.858$, $P = 0.028$; $V = 0.481$, $P = 0.028$). Males tended to express an opinion either way, 43 per cent disagreed, while 48 per cent agreed; however, 50 per cent of females were 'undecided'.

The statement 'Wildlife is harmed by prescribed burning' also produced a high portion of 'undecided' responses and a wide spread of responses across the continuum. Thirty-one per cent were undecided. This reflected the difficulty in definitively stating that wildlife is or is not harmed by prescribed burning. In reality, for many species a few individuals may perish, while the fate of the population as a whole is improved (Hobbs and Spowart, 1984; Gabrey and Afton, 2000). The statement correlated positively with 'Prescribed burning should not be used as a management tool in state parks' (cc = 0.378, $P = 0.008$) and 'The benefits of prescribed burning outweigh the risks' (cc = 0.334, $P = 0.020$). Because negative statements were scored in reverse, this indicated that respondents who believed wildlife is harmed by prescribed burning did not believe that its benefits outweigh the risks, or that it should be used in state parks.

Management implications

A primary goal of each of these burns was to establish or re-introduce prescribed burning in these parks. That objective was met. However, this short-term project has determined that future burns must be more intense to meet the fuel loading and vegetation goals defined in the burn plans.

The burns studied here did not reduce fuel loads sufficiently to allow for safe growing-season burns. Dormant season burns should continue and be conducted every 2 years until fuel loads have been reduced sufficiently to initiate growing-season burns. This will require at least two more cool season burns of greater intensity than those presently studied. Conducting growing season burns every 3 years should establish a vegetation restoration phase. After establishing a diverse herbaceous layer and open understorey, a maintenance phase of burning every 5–8 years during the growing season, depending on desired vegetation, can begin.

Many ecologists believe native species respond best to a fire regime that mimics the frequency and season of pre-settlement fires (Robbins and Myers, 1992; Brennan and Hermann, 1994). Prescribed burning should not be undertaken when weather conditions, such as extreme drought or flooding, will negate the desired ecological effect. It is too expensive, inefficient and dangerous to remove employees from their normal duties, and use expensive equipment to accomplish so little ecologically. However, TPWD personnel must be willing to take risks based on the best available knowledge. Increasingly, scientific information points to the necessity of fire in maintaining sustainable, healthy forests in the south-eastern United States (Pyne *et al.*, 1996). Being too cautious could be just as detrimental to the forest as an escaped prescribed fire. The risks of damage from wildfire, disease, insects and overcrowding are increased when prescribed fire is delayed another year in hopes of better burning conditions.

In Texas, judges are responsible for issuing county burn bans. Ideally, a relationship should be fostered between TPWD and county judges. In

this instance, had TPWD not been confined by bans, more effective burns could have been conducted when fuels were drier. The failure to reach several objectives was a direct result of waiting to burn until after a rain event had occurred.

Several responses in the visitors survey indicated a general level of support for prescribed burning as a management tool. However, other responses indicated there is a need for more education and interpretive programming for state park visitors concerning wild and prescribed fire effects in the parks. Fire professionals must also educate and work in close cooperation with local policy makers. As demonstrated here, the absence of this political cooperation can have a detrimental impact on the efficacy of prescribed fire restoration.

Long-term interdisciplinary research projects that include human dimensions are necessary to quantify the ecological effects, and economic and social trade-offs of prescribed burning. Only through long-term research may it be determined which historic fire functions can be emulated with prescribed burning, which are irreplaceable, and the implications for management. Prescribed burning must be more than environmentally necessary to be sustainable. It must also be socially and economically acceptable as it depends on public support.

Acknowledgements

The authors wish to thank Texas Parks and Wildlife Department, particularly Jeff Sparks, Natural Resources Co-ordinator; student workers Stephanie Price, Kelly Scott and Terry Hanzak; and Drs Kenneth W. Farrish and Ray L. Darville from Stephen F. Austin State University. The authors also appreciate the constructive comments of two anonymous reviewers.

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