Economics and Prescribed Fire Law in the United States

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Prescribed burning is increasingly recognized as a useful but risky land management and conservation tool. Common law relating to prescribed fire is generally predicated on negligence rules. However, virtually all states also have statutory law specifying liability rules or criminal penalties for prescribed burning, and the laws in many states have been changing substantially in recent years. We develop an economic model of the incentive and welfare effects of prescribed burning, where both the burner and potential victims of escaped fires can reduce expected damage with precautionary effort. The model provides implications regarding the comparative advantages of strict liability versus negligence rules. We then examine the characteristics and geographic distribution of prescribed fire liability law in the United States in the context of the model. Specifically, we discuss possible economic underpinnings of the recent emergence of statutes in southeastern states that are more supportive of prescribed fire use, despite its associated risks.

The use of prescribed fire faced strong resistance from policy makers and natural resource managers throughout much of the 20th century (Pyne; Biswell), but is increasingly recognized as a useful tool for promoting rangeland productivity, biodiversity, and for reducing wildfire risk and severity (Bernardo, Engle, and McCollum; Svejcar; Briggs and Knapp; Zimmerman; Babbitt; Pattison). Nonetheless, prescribed burning is an inherently risky resource management tool. A fire set by the U.S. National Park Service near Los Alamos, New Mexico, in May 2000

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resulted in approximately $24.5 million in control costs, damage, and rehabilitation costs (Interagency Burned Area Emergency Rehabilitation Team). Litigation resulting from an escaped fire can be costly. For example, the plaintiff in a case (Lowe vs. Jones et al., Case No. CJ 95-345) tried in Osage County, Oklahoma, (unsuccessfully) argued for $9.3 million in damages in a 200-acre wildfire that the plaintiff claimed resulted from a prescribed burn on adjacent property (no structures were burned, only grassland). Legal and other fees for the defense approached $0.5 million.

Prescribed fire is the subject of increasing legislative attention and regulation in many states (Haines and Cleaves). For example, in the last decade many southeastern states have enacted legislation that explicitly recognizes careful application of prescribed fire as a public good, and simultaneously clarifies liability rules and codifies more stringent specific regulations over its use. The state of Washington now prohibits burning to clear grass-seed fields except under special circumstances (Washington Administrative Code 173-430-045), and in California, the Connelly--Areias--Chandler Rice Straw Burning Reduction Act of 1991 prohibits burning rice straw except to control disease.

In the absence of statutory law, the Common Law relating to prescribed fire is generally based upon negligence: To be found liable for damage to a neighbor's property, the burner must be found to have exerted insufficient precaution to reduce the likelihood of damage to neighboring property (American Law Reports). Today, virtually all states have codified civil or criminal statutory law for prescribed burning, but the structure of these laws varies substantially across states. Four states impose strict liability on prescribed burners, making them liable for the damage caused by an escaped prescribed fire regardless of the precautions they take to control the fire. Most states with prescribed fire statutes impose negligence rules of some form on the burner, but again, these vary substantially across states.

The intent of this paper is to provide a useful conceptual framework for further development and refinement of prescribed burning liability law. Different liability rules provide different incentives for both prescribed burners and potential victims of escaped fire or smoke. We adapt a model from the law and economics literature to examine the incentive effects of a number of common liability rules, and discuss their relative efficiency under various technological, demographic, and informational environments. We then discuss the distribution and structure of current liability law in the United States in the context of the theory in order to illustrate the model's capacity to explain the broad outline of existing law and to illustrate its application to policy design.

A Model of Liability for Prescribed Burning

Consider two neighboring risk-neutral property owners, one who intentionally applies a prescribed burn to his land, and the other whose property would suffer damage if the fire managed to escape onto his land (adapted from Brown). Suppose the probability of an escaped fire depends on precaution effort by the burner, and the extent of damage—given that a fire escapes—depends on the mitigation and preparation efforts taken by the victim.

A number of simplifying assumptions are maintained throughout the subsequent analysis. First, we assume a wealth-maximization objective and risk neutrality for both the burner and the victim. In this setting, both parties would be
equally well off with or without actuarially fair insurance, so we abstract from
insurance issues. Second, we do not address complications associated with			
potential bankruptcy and its impact on incentives for care, so the burner is implicitly
assumed to be capable of fully compensating the victim for damage if a fire
escapes. Third, we assume that if damage occurs to a neighbor, the burner will face
certain litigation. Fourth, we assume that no damage will occur to the burner’s
property if the fire gets out of control.

We will first consider the efficient (wealth-maximizing) levels of precaution,
and then examine the effectiveness of various liability rules for inducing this
allocation. The total net value of a prescribed burn, \( \Pi \), is the value of the benefits
from the burn minus the expected value of damage and any costs of care incurred
by the burner and victim:

\[
\Pi = R - D(V)P(B) - W^b V - W^b B.
\]

where

\[
\begin{align*}
R > 0 & \quad \text{the value of the burn to the burner,} \\
D(V) & \quad \text{damage to the victim if fire escapes,} \\
P(B) \in (0, 1) & \quad \text{probability of damage to the victim,} \\
V & \quad \text{the level of care invested by the victim,} \\
B & \quad \text{The level of care invested by the burner,} \\
W^b, W^v & \quad \text{cost of a unit of care for the victim and burner, respectively.}
\end{align*}
\]

\( V \) might include fire-proofing buildings and clearing combustible materials
from around buildings, as well as evacuation efforts in case of fire or smoke. \( B \)
might include the use of inputs, such as making firebreaks and assuring water
availability for any errant sparks. Waiting for low temperature and reasonable
wind conditions is an important factor that can be considered a costly input as
well. The statistical expectation of damage is the product of potential damage to
the victim \( D(V) \) and the probability of damage: \( E[D(V, B)] = D(V)P(B) \).

The first-order condition for maximization implicitly defines the economically efficient
level of care for each party:

\[
\begin{align*}
(2a) & \quad -D(V)P'(B) - W^b \leq 0 \\
(2b) & \quad -D'(V)P(B) - W^v \leq 0.
\end{align*}
\]

The first-order conditions for the burner and victim are illustrated in figure 1. The
first term in the equation (2a), \( -D(V)P'(B) \), is the marginal expected value of care
(VMP) by the burner in terms of reductions in expected damage. Two VMP curves
are shown in the left panel of figure 1: one corresponding to no victim mitigation
effort and high damage \( (-D(0)P'(B)) \), and one corresponding to efficient victim
mitigation \( (-D(V^*)P'(B)) \).

The first term in the equation (2b), \( -D'(V)P(B) \), is the expected value of the
marginal product of care (VMP) by the victim in terms of reductions in expected
damage. The right panel of figure 1 shows two VMP curves: one (1) sufficiently
high relative to the marginal cost of care ($W^c$) to result in a positive optimal level of victim care (represented by $V^*$ in figure 1), and a low VMP (2), which results in a corner solution with the optimal level of care by the victim being zero (a corner solution for burner precaution is also feasible). The relative productivities of the burner and the victim play a critical role in the comparative efficiency of different liability rules.

The model presented above provides a framework for understanding the incentive effects of different liability rules. Strict liability will be considered first, followed by an analysis of negligence rules. The subsequent analysis is founded on the assumption that the burner and victim do not interact or bargain privately over precautionary effort prior to a prescribed fire; a common assumption in models of ex post liability. Therefore, the Coase Theorem and its implications regarding the possible irrelevance of initial property rights do not apply.

**Strict Liability**

A strict liability rule requires the burner to compensate the victim for damage regardless of the amount of precaution the burner takes when starting and managing the fire. The expected cost to the burner subject to a strict liability rule is therefore $W^b B + D(V) P(B)$. Given perfect compensation, the victim suffers no damage and would have no incentive to invest in reducing the probability of damage, so $D(V) = D(0) = D^\text{max}$. Thus, the first first-order condition (2b) would only be satisfied if the victim has little influence over damage to his own property, if the probability of damage is very low, or the costs of damage abatement are high ($D'(V) P \leq W^c$). In other words, a strict liability rule is efficient if and only if the victim cannot economically reduce potential damage. The following implication follows:

**Implication 1.** Strict burner liability leads to efficient precaution when the victim does not have cost-effective means of reducing expected damage.

By “cost-effective,” we mean here that the efficient allocation of $V$ and $B$ as defined by (2a) and (2b) is not zero. Implication 1 suggests that when prescribed fire is easy to control or is used very seldom in the vicinity, it makes less economic sense for potential victims to expend effort to prepare for it, and therefore efficiency losses from assigning liability to the burner are low. Exceedingly costly or ineffective fire-proofing technologies available to the victim have the same result.
Figure 2. Cost and revenue functions for the burner under a negligence rule

$\bar{B}$

$W^B$  $D(V)P(B)$

Care by burner (B)

Negligence

Now consider a negligence rule, where the burner is not liable for damage if $B$ is greater than or equal to some standard $\bar{B}$. If the burner satisfies the negligence rule ($B \geq \bar{B}$), he will only accrue his input costs, $W^B \bar{B}$. If the burner does not satisfy the rule, his costs will be $W^B B + D(V)P(B)$. This cost function is represented by the thick line in figure 2, which is discontinuous at $\bar{B}$. In the figure, $\bar{B}$ is set to minimize the total expected cost of the prescribed burn (given $V$), which is the economically efficient negligence standard.

The burner will expend just enough effort to satisfy the negligence standard as long as the negligence standard is not too high. The burner chooses $B = \bar{B}$, and the liability will fall on the victim. We are assuming complete information, so the victim will know that the burner will exert just enough care to satisfy the liability rule. Thus, the burner’s net benefit function is

$$\Pi^n = R - W^B \bar{B}. $$

The expected cost to the victim will include the full expected damage of the burn, $-D(V)P(\bar{B})$, which induces the victim to exert the optimal level of care (defined by equation 2b), given that $\bar{B} = \bar{B}^*$.\(^5\)

**Implication 2:** When both burner and victim can affect expected damage, a strict liability rule cannot elicit efficient effort by both parties, but a negligence standard can.

To Burn or Not to Burn

The results above relate to the allocation of effort given that the burner sets a prescribed fire. The decision whether or not to burn is also affected by the liability rule. The burner will decide to burn if the private net gains of doing so given equilibrium effort levels are positive.

Under strict liability, the burner’s expected net benefit function is given by equation (1), and the burner will internalize all expected damage due to both
rule alone does not. Practically speaking, it may lead to limits on when a prescribed burn may be performed. The net expected benefits (including expected damage from escape) may be negative at the end of summer, but positive in the spring when weather and fuels allow more controllable burning.

The second approach to address the incentive to start too many fires is to support the negligence rule with ex ante regulation: Require burners to acquire a permit before burning. Presumably, this permit would be issued only if the expected social net benefits of the burn are positive. Acquisition of these permits may also be contingent on proof of some level of preparation, and may be used as explicit elements of a negligence standard if litigation ensues, thereby facilitating pretrial settlement and minimizing court costs. Kolstad, Ulen, and Johnson and Cooter and Ulen show that given the existence of a negligence rule and assumptions about the distribution of trial outcomes, ex ante regulation will promote efficiency if the injurer would otherwise expend too little precautionary effort. They also show that when regulation is used in conjunction with a negligence rule for liability, the minimum ex ante regulatory requirement should be set below the socially optimal level of precaution. This extension of the formal model suggests the following implication.

Implication 5. Input-based negligence standards can be complemented by negligence rules based on the net value of the fire, or ex ante regulation.

Information, Transaction Costs, and Liability Rules

The costs of gathering information and the effects of inconsistent or inaccurate standards play a role in the relative effectiveness of a strict liability rule versus a negligence rule, because enforcement of the two rules requires different information (Cooter).

Perfectly specified negligence standards lead to efficient effort for any prescribed fire, but misspecified negligence standards will result in inefficient precaution by both parties. Consider figure 2 again. Because the burner minimizes personal expected costs at exactly \( \hat{B} \) (unless \( \hat{B} \) is set extremely high), the burner’s behavior will be highly responsive to a consistently misspecified negligence rule. On the other hand, if the legal standard is vague and applied inconsistently by the courts, a negligence rule is likely to induce either too much or too little precautionary effort on the part of the burner even if the standard is on average applied correctly (Kolstad, Ulen, and Johnson; Shavell 1984; Cooter and Ulen). Both imprecise and inaccurate negligence rules reduce the benefits of negligence standards relative to strict liability, and both imprecision and inaccuracy follow from imperfect information about the cost and damage functions in a given case of prescribed burning.

Thus, there is a trade-off when it comes to the specificity of negligence standards between the efficiency losses resulting from a precise negligence rule that misses the mark, and the legal costs and efficiency costs that follow from an ambiguous standard. Cooter suggests that courts are poorly suited to effectively deal with these types of informational deficiencies, and that negligence rules therefore tend to be more effective when widely accepted standards have developed from past disputes that the courts can apply. In other words, negligence rules are more effective when \( P(B) \) is well understood.
If a negligence rule is imposed, information deficiencies also will shape the structure of a negligence rule. Maine’s prescribed fire law states, “Whoever kindles or uses a fire on his own land shall do so at a suitable time and in a careful and prudent manner and is liable in a civil action to any person injured by his failure to comply with this provision” (12 M.R.S.§9324 (1999)). This rule relegates the definition of “careful and prudent” to the courts. It may be associated with substantial a priori uncertainty as to the actual standard that will be imposed by the court. On the other hand, it allows a court to adjust to event-specific variation in the productivity and costs of precaution on a case-by-case basis. When the efficient precaution level is relatively invariant across events, a clear statutory standard may reduce litigation costs at little cost in terms of case-specific mis-specification. This characterization of statutory ambiguity relates closely to the problem of incomplete contracts (for further discussion on this topic, see Hart). The following implication is suggested by the foregoing discussion.

Implication 6. Negligence standards may be precisely specified on efficiency grounds when precaution productivity and costs are relatively invariant across events.

Discussion

Statutory law related to prescribed burning is currently in a state of flux. In the following section, we examine current statutory law in the context of our model. We begin with a discussion of variation in laws across space and time, and then look more closely at specific statutory negligence rules and the economic logic behind these rules. The discussion is motivated by two goals: to provide an economic basis to explain the distribution and structure of current statutory law in broad terms, and to support our model as a prescriptive policy tool.

Table 1 includes selected categories of fire liability laws and a list of the states whose statutes include them. The first three categories are prescribed fire liability rules in order of decreasing stringency from the burner’s perspective: (1) strict liability, (2) negligent unless proven otherwise, and (3) not negligent unless proven negligent. The latter two are different in that in (2) the burden of proof is on the burner (defendant), and in (3) the burden of proof is on the victim (plaintiff).

Four states currently impose strict liability on prescribed burners—Connecticut, North Dakota, New Hampshire, and Oklahoma. If a fire escapes, the burner is liable for damage regardless of precautionary effort. Twenty-two states have some form of negligence rule in their statutory code. Five of these states place the burden of proof on burners in that escaped fire is prima facie evidence of negligence; the burner must show due care to escape liability for the damage. Sixteen states place the burden on the plaintiff to prove negligence on the part of the burner in order to receive damages. Oregon falls in both of these categories, allowing plaintiffs to collect double damages if the burner is proven negligent or single damages if there is no proof of negligence and no proof of due care. Eleven states treat uncontrolled fire as a nuisance, requiring landowners to pay for the cost of fire suppression by public agencies.

A number of state statutes support penalties or liability for fires escaping from one’s own land even if the fire is not intentionally set (table 1). For example, Michigan law states that anyone who willfully allows a fire to pass from his
Table 1. State liability law for prescribed fire and spread of wildfire

<table>
<thead>
<tr>
<th>Liability or property rule</th>
<th>State a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burner strictly liability</td>
<td>CT, ND, NH, OK</td>
</tr>
<tr>
<td>Burner presumed negligent if fire escapes</td>
<td>AK, GA, MD, OR, UT</td>
</tr>
<tr>
<td>Burner liable for damage if proven negligent</td>
<td>AL, AR, CA, DE, FL, LA, MS, ME, MI, NC, NJ, OR, TX, VA, WA, WI</td>
</tr>
<tr>
<td>Notification requirements ([N] = neighbors, [A] = agency)</td>
<td>AR[N,A], CO[A], LA[N], NY[N], NC[N], TN[N], UT[A]</td>
</tr>
<tr>
<td>Permits or bans supported by statute</td>
<td>AL, AZ, CA, CO, CT, FL, GA, ID, IA, ME, MA, MN, MS, NE, NV, NH, NJ, NY, OR, RI, SD, UT, WV, VT, WA</td>
</tr>
<tr>
<td>Criminal penalties for leaving fire unattended or failure to extinguish and negligent escape</td>
<td>AL, AK, CA, MI, NJ, NM, NV, NC, OK, OR, SC, SD, TN, UT, WI, WY</td>
</tr>
<tr>
<td>No statutes addressing prescribed fire</td>
<td>HI, IN, KS, MO, MT</td>
</tr>
<tr>
<td>Liable for negligently allowing uncontrolled spread of wildfire</td>
<td>AK, DE, MI, OH, OR, PA, SD, TN, TX, UT, VT, WA, WV</td>
</tr>
<tr>
<td>Uncontrolled fire is a nuisance: can be billed for public fire suppression costs</td>
<td>CO, GA, ID, MS, NH, ME, MD, OK, OR, WA, WI</td>
</tr>
<tr>
<td>Regulations restricting excessive vegetative fuel loads</td>
<td>MN, MT, NM, WA</td>
</tr>
</tbody>
</table>

*a Citations for supporting statutes are available from the authors. Compiled in 2001.

property to another’s property is guilty of a felony. Furthermore, some states impose liability or penalties for excessive fuel loads on their land. For example, Montana statutes focus extensively on requirements for mitigating fire hazards during timber harvest activities. Wisconsin (and other states) require railroad companies to mitigate fire hazards along railways to reduce the probability of fire from locomotive sparks.

**Strict Liability versus Negligence Rules**

Our model implies that strict liability is likely to induce efficient mitigation effort and frequent prescribed fire use if burners have most or all control over the likelihood of damage due to prescribed fire, and when it is not cost effective for potential victims to reduce potential property damage from fires (implication 1). Table 1 shows that 21 states explicitly impose negligence rules and only 4 impose strict liability on burners. This distribution of liability rules is consistent with a recognition by policymakers that potential victims generally have some control over the extent of damage that might be sustained as a result of prescribed burning, despite the risk of external costs in the form of damage from escaped fire (implication 2).

Two specific elements common to a number of negligence standards also support this conclusion. First, many states require that burners inform their neighbors about their intent to burn (table 1). Arkansas statutes, for example, have a two-part negligence standard: (a) The burner must notify all adjacent landowners of
the intention to burn, and (b) the burner must use all due caution to prevent the fire from escaping the property. The first element is very specific, and (at least in principle) easily verifiable. The second element leaves the definition of “due caution” for the court to define on a case-by-case basis. The point is that if neighbors have no means to mitigate potential damage, there would be no apparent motivation for the notification requirement.

Second, two states (Connecticut and Illinois) have a contributory negligence element to their statute. This means that if victims do not expend reasonable effort to mitigate potential damage to their own property, the prescribed burner from whose land the fire originated will not be held liable. This contributory negligence rule also recognizes a role for potential victims for damage mitigation. The model suggests that strict liability provides little incentive for potential victims to exercise damage mitigation effort. Given that potential victims of escaped fire have an ability to mitigate damage, these specific requirements of notification and contributory negligence are consistent with the finding that most states with prescribed fire statutes rely on negligence rules rather than strict liability.

Recall that four states impose strict liability on the burner. Oklahoma’s law is currently under review, with pressure to change to a negligence rule. Connecticut, North Dakota, and Oklahoma statutes are quite old. Oklahoma’s liability law was enacted in 1890 (prior to statehood) and last revised in 1931. North Dakota’s was enacted in 1877 (last revised in 1943), and Connecticut’s was enacted in 1884 (last revised in 1959). New Hampshire’s law for prescribed burning, on the other hand, was enacted in 1995. A related law imposing strict liability on railroad companies for damage by sparks from locomotives, enacted in 1951, may have been a basis for the later statute for prescribed burning.

**Negligence Rules**

Negligence rules vary substantially across states and time. Statutory rules relating to prescribed fire often contain an ambiguous statement requiring “due care,” as well as more specific rules that are necessary (but not sufficient) to satisfy due care.

One common specific rule, the requirement to notify neighbors, has already been discussed. The economic logic behind this rule is as follows. If landowners expect to be notified of their neighbor’s intentions of prescribed burning, they need only be on alert for escape from prescribed fire when such a fire is planned (and reported). This undoubtedly lowers their overall mitigation costs, because time-sensitive mitigation of potential damage (clearing dry vegetation near a house that might contribute to the extent of damage, for example) may then be performed only when the potential for an escaped prescribed fire exists, and need not be applied at other times. Furthermore, the cost to a burner of notifying adjacent landowners is likely to be relatively low. As a result, notification of neighbors will reduce the overall expected costs of a prescribed burn.

It would also be possible for a notification requirement to extend beyond just adjacent landowners. However, notifying nearby landowners is not costless, and the potential gains from prior notification are likely to be lower because landowners further away will most likely have more time to react to the news of an escaped
fire. Also, the probability of a fire crossing an adjacent landholding and burning property further away are lower, so the expected costs to distant landowners are lower. Thus, the expected net benefits from a notification requirement for distant landholdings is not as compelling. Indeed, no landowner notification requirements extend to nonadjacent landowners.

In some cases, a burner must notify a related regulatory agency prior to burning in order to escape potential criminal penalties or civil liability. For example, Colorado statutes state that a person who starts a fire is not liable for the expenses of extinguishing an escaped fire if he notifies the sheriff of the time and place of the controlled burn. To the extent that prior notification reduces the cost or increases the effectiveness of public fire-fighting effort, this negligence requirement does so at only a small cost to the burner (a telephone call, perhaps).

Another common specific requirement is that burners must remain with the fire until it is completely extinguished ("dead out"). The cost to a landowner (or the landowner’s agent) for remaining an additional hour or day on a burn site is likely to be relatively low compared with the expected costs of the resurgence of an unattended smoldering fire. The crucial point leading to such a requirement is that without such a negligence standard, the costs of a burner leaving a site prematurely would likely be borne at least to some extent by a neighboring landowner rather than the burner.

Specific negligence rules for cost-effective inputs such as notification and on-site presence are consistent with implication 6, because it is unlikely that the costs of such precautions will outweigh their expected benefits (i.e., reductions in expected damage). Statutory specification of these rules will provide a higher degree of certainty about negligence requirements, thereby more effectively inducing proper precautionary incentives and reducing transaction costs of court proceedings.

The productivity and costs of many precautionary inputs, however, depend on the specific circumstances of a case. Attempts to impose ex ante statutory requirements for input levels may lead to improperly specified negligence rules for many cases, and therefore should, on efficiency grounds, be left for a case-by-case analysis. Indeed, all statutory negligence standards for prescribed fire allow the courts the leeway to define "due care" (implication 6). Common elements considered by the courts in setting due care standards include starting fires during excessive dryness and foreseeable winds, failing to build adequate firebreaks around the burn area, burning too close to neighboring property or buildings, and lacking sufficient accessible water (American Law Reports). The appropriate use of each of these inputs is relatively case dependent. Specification of statutory limits to be used in all cases would likely induce inappropriate precautionary levels in many cases. Specifying a complex set of statutory requirements based on a broad set of possible states of nature would arguably be more difficult (costly) than addressing these issues on a case-by-case basis.

An important characteristic of court negligence findings is that courts usually distinguish between foreseeable factors and abnormal or unforeseeable factors contributing to the spread of fire, such as abnormal changes in wind patterns (speed and direction). Our model suggests that the probability of the fire spreading to neighboring lands should be considered when establishing negligence. This probability is in turn based, in part, on expectations about exogenous factors,
such as wind. When deciding whether a burner started a fire negligently, courts generally base their decisions on the information available to burners at the time the fire was started. A burner may be found negligent if prevailing winds were unsatisfactory when the fire was lit, but generally would not be found negligent for the spread of fire resulting from an abnormal and unforeseen change in the wind patterns that occurred after the fire was set (American Law Reports).

Permits and Regulatory Requirements

Regulatory restrictions and permits are property rules providing landowners with the right to burn only if they satisfy a set of requirements delineated by statute and regulatory agencies. Otherwise, the burner may be subject to criminal penalties (we ignore issues of criminal intent to focus on law relating specifically to productive burning). These are different from liability rules, where burners have the right to perform prescribed burns but must bear the liability associated with the burn. As is the case with many environmental issues, ex ante regulation and ex post liability are often used simultaneously to address prescribed fire externalities.

Property rules for prescribed burning are imposed for burning without a permit or contrary to permit stipulations, and for leaving a fire unattended or for negligent escape and failure to extinguish. Most states maintain a permit system for prescribed burning under some circumstances. In some states, satisfaction of permit requirements is necessary to avoid potential fines and other criminal penalties. To acquire a permit, the landowner may have to show sufficient knowledge, preparation, and notification of neighbors or public fire-fighting entities. Colorado’s statute, for example, requires that permit issuance be contingent on the proximity of the planned burn to buildings, the potential contribution of the fire to air pollution, climatic conditions, and other related factors. These requirements, when used in conjunction with a negligence rule, are consistent with implication 5. Pre-fire acquisition of a permit is necessary to be eligible for public fire-suppression support in some states, and the acquisition of a permit is an element of a negligence rule in some states as well.

Certified Burn Managers

New statutes in Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, and Texas specifically promote the use of certified prescribed burn managers by limiting landowner liability if certified burn managers are present, or requiring them to be present as a condition of permit issuance. If the certification process can be considered a process of human capital investment for reducing the likelihood of a fire, then a certified burn manager requirement is much like a technology requirement.

The extent to which a technology requirement is effective depends in part on the certification process itself. The benefits from certification accrue from increased effectiveness in reducing the probability of escaped fire (and possibly more proficient use of other inputs), while the costs are associated with education and testing as a requirement for certification. The relevant policy question then
becomes: Should a certified burn manager be required as a component of a liability rule, and if so, what should the certification requirements be? Answering these questions effectively sets an element of a negligence standard, $B$.  

**Excessive Fuel Loads**

Montana, Minnesota, New Mexico, and Washington statutory law require landowners to reduce excessive fuel loads to reduce the possibility of wildfires. A 1999 revision of Florida’s statute gives the Florida Department of Agriculture and Consumer Services primary authority to perform prescribed burning as a wildfire management tool on both public and private land. An Oregon statute requires landowners who find a wildfire on their land to attempt to abate the fire. These laws can be viewed as attempts to account for potential externalities associated with the risk of fire spreading across landholdings.

The problematic element of prescribed fire from a legal and economic perspective is that its use may impose costs on others that are not automatically internalized by the burner. If excessive fuel loads on one individual’s land increase the probability or severity of a wildfire that may then move onto the land of others, then excessive fuel loads also may impose external costs. Thus, criminal and civil liability for allowing the accumulation of excessive fuel loads makes economic sense for the same fundamental reasons that regulation of prescribed fire is appropriate. For an interesting illustration of the potential costs of this type of legal requirement for land managers in California, see Bakken.

**A New Generation of Prescribed Fire Statutes**

A new generation of prescribed fire statutes has been developed in the southeastern states beginning with Florida in 1990 (Brenner and Wade; Haines and Cleaves). The Florida statute goes to great length to recognize prescribed burning as a useful land management tool. The legislation explicitly recognizes ecological benefits, and benefits from reducing the likelihood and severity of wildfires. It explicitly recognizes prescribed burning as a property right, subject to a relatively detailed set of precautionary requirements. Finally, it specifies that if landowners satisfy the statutory and regulatory requirements set by the regulating agency, a finding of gross negligence (reckless disregard) is required for burner liability. If landowners do not satisfy the specific set of standards and requirements, a finding of gross negligence may not be required (Eshee). In the model, a gross negligence requirement essentially lowers $B$ to a very low point for potential precautionary inputs that are not explicitly required by either the statute or the regulatory agency. This combination of a large set of specific requirements supported by negligence combined with unstated precautionary requirements supported by gross negligence leads to a relatively clear set of guidelines for prescribed fire activity.

Georgia, Louisiana, Mississippi, and North Carolina also explicitly recognize prescribed burning as a beneficial property right. In the context of our model, the explicit recognition of the value of prescribed burning acts to emphasize the possibility that $R'$ in figure 2 is high, arguably increasing the likelihood that the Learned Hand rule is found by the courts to be satisfied. The requirement of
gross negligence arguably lowers $\bar{B}$ relative to not requiring gross negligence. These statutes are therefore consistent with an apparent attempt to reduce the likelihood of prescribed burner liability.

If land and demographic characteristics of southern states result in relatively large benefits from prescribed fire, our model predicts more widespread use of negligence rules in these states (implication 4). One conjecture regarding the relative support of prescribed burning in these new statutes is that these statutes are a response to an apparent growing recognition of the role of prescribed fire as a wildfire management tool (this relates to the preceding section).

To the extent that reduction of fuel loads resulting from controlled burning reduces the likelihood and severity of wildfires, prescribed burners may contribute positive externalities by reducing their potential fuel contributions for wildfires moving across numerous landholdings in a region. If this conjecture is correct, we would expect this type of statutory response in areas where prescribed burning can reduce the total social costs of fire generally (i.e., the net cost of prescribed fires plus the costs of wildfires and their control). Although a formal analysis of the geographic and demographic distribution of negligence rules across states is beyond the scope of this paper, table 1 shows that southern states have had a greater tendency to introduce negligence standards and explicit support of prescribed burning than northern states.

**Conclusion**

Prescribed fire is a land management tool with long historical roots in North America, Australia, and elsewhere, and a resurgence in interest from natural scientists, public land managers, and legislators has led to substantial changes in the statutory law of many states in recent years. This paper examines the economics of liability for prescribed fire, and is motivated by two goals: to provide a model to explain the structure and variation of existing liability law relating to prescribed fire, and to provide a conceptual framework for improving existing policy at a time when prescribed burning policy is in a state of flux.

The risk of fire escaping to neighboring landholdings always accompanies the use of prescribed fire, and burners therefore may not bear all of the potential costs of their prescribed burning decisions. Criminal and civil liability rules specified by legislation and enforced by the courts act to internalize these costs. The relative effectiveness of liability rules depends in large part on the relative ability of burners and other landowners to mitigate the probability and extent of damage, as well as the transaction costs associated with implementing a given liability rule.

We develop a model for comparing the relative economic efficiency of liability rules, provide a summary of current statutory law relating to prescribed fire in the United States, and discuss our findings in the context of the model. Only four states with statutory liability rules specific to prescribed burning impose strict liability on burners. The rest impose a negligence rule of some form. All negligence rules rely on an ambiguous requirement of due care that is left to be defined more specifically by the courts, and many states include specific negligence standards as well. A number of state codes include similar laws requiring landowners to attempt to extinguish wildfires on their land, and require landowners to limit the accumulation of excessive fuel loads such as dead plant material.
Many recent changes in statutory law relating to prescribed fire provide substantial support for prescribed fire as a land management tool despite the risks associated with its use. Factors supporting these changes may include increasing evidence that prescribed fire can be a cost effective means of controlling wildfires, promoting plant biodiversity, and increasing pasture and timber productivity. Nonetheless, application of prescribed fire becomes more costly and risky with increasing urbanization and accompanying land and land tenure fragmentation. Indeed, increasing general support in some respects has been coupled with more specific formal restrictions and constraints in other respects.

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Endnotes

1 Data on the use of prescribed fire on private lands are elusive, but the use of fire is increasing on federal lands. The federal government now formally recognizes the use of prescribed fire as an integral element of wildfire management (U.S. Department of Agriculture), and the number of national forests using prescribed fire increased 76% between 1985 and 1994 (Haines, Martinez, and Cleaves), and prescribed fire was applied to approximately 1.1 million acres of public land in 2000 (National Interagency Fire Center).

2 This specific form of expected damage assumes that potential damage and the probability of escape are independent of each other. Other forms of expected damage are possible, but this form is used for ease of exposition.

3 Necessary curvature conditions to ensure a maximum are $D'(V) < 0, P'(B) < 0, D''(V) > 0, D(0) > 0$. If risk aversion were to be assumed, optimal victim mitigation $V$ would be lower for any level of $B$ relative to the risk-neutral case, but the optimal level of $B$ for any $V$ could be higher or lower. We do not consider risk preferences further because it complicates the mathematics substantially, it is not crucial for the purposes of this paper, and the existing literature also generally is based on the assumption of risk neutrality.

4 Note that if no legal requirements are placed on the burner, the result in effect is a strict liability rule imposed on the victim: the victim bears the damage regardless of precaution efforts by either party.

5 If a negligence standard is set too high, it may become a de facto strict liability rule. Suppose $B$ is set so high that $W^0 B$ is larger than $W^0 B + D(0) P(B)$, where $D(0)$ is the level of potential damage given $V = 0$, and $B$ is the burner’s optimal $B$ given $V = 0$. In this case, the burner is better off accepting liability and minimizing total expected costs. This case is not shown in the figure, but it would be the minimum point along the total cost curve corresponding to $D(0) P(B) + W^0 B$, which would lie above the total cost curve shown in the figure for all $B$ because $D(0)$ is the maximum potential damage.

6 We base our examination of existing law on the supposition that regulatory and legal institutions that raise efficiency are more likely to be adopted and maintained than those that lead to relatively lower efficiency even when considering interest group behavior (Becker).

7 We report only current statutes. Strict liability statutes may have been enacted and revoked that we do not include here. For example, Kansas statutory law imposed strict liability from 1868 until 1972. We do not have comprehensive data on historical statutes.

8 Generally, prescribed fire insurance markets are either very shallow or nonexistent. Another argument in favor of certification requirements discussed briefly by Haines and Cleaves is that certification may provide information useful for potential insurers about burner qualification and prescribed fire risk, and may provide a basis for the development of prescribed fire insurance markets. It remains to be seen whether insurance markets develop in such settings, but this is a potentially fruitful area for future research.

References