

## Tigers, Rhinos, and Fire Management in India

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**Abstract.** Fire management capabilities in India are limited both in suppression of wildfires and use of prescribed fire. Fire has long been a modifier of the grassland habitat upon which the Bengal (Asian) tiger (*Panthera tigris tigris* Linnaeus, 1758:14) and the Indian one-horned rhinoceros (*Rhinoceros unicornis* Linnaeus, 1758:56) depend, directly or indirectly. Both the Bengal tiger and one-horned rhinoceros are "red listed" as threatened and endangered species. The Bengal tiger depends upon healthy grasslands to support the ungulate species that are its primary prey. The Indian rhino is dependent upon grasslands for forage and cover. Grasslands that are not burned become impenetrable, even by rhinos.

Research in the grasslands of Chitwan National Park, Nepal, showed season of burning altered production-biomass, the time of appearance of young succulent shoots, and the length of the grazing season of various grass species. Applied research is needed to determine size, intensity, and frequency of prescribed fires for management of grassland habitat for Bengal tigers and one-horned rhinoceros. The creation of a strong fire management program, which includes the use of prescribed fire, will provide India with additional options for the management of its rich forest and grasslands resources.

**Keywords:** India; Bengal tiger; Rhinoceros; One-horned rhinoceros; Fire management; Grasslands; *Panthera tigris*; Asian tiger.

### Introduction

India's rich biodiversity includes some of Earth's most magnificent and largest terrestrial mammals. Among the species of Indian fauna on the "red list" of threatened and endangered species (International Union for Conservation of Nature and Natural Resources 1974) are the Bengal tiger (*Panthera tigris tigris* Linnaeus, 1758:14) and the one-horned rhinoceros (*Rhinoceros unicornis* Linnaeus, 1758:56). The habitat for both Bengal tigers and one-horned rhinoceros includes specific vegetation types, especially grasslands. Tigers depend on grasslands to provide prey, which include several species of ungulates.

Rhinos depend on grasslands to provide forage and cover. Successful management of grasslands, therefore, is a key to the development and maintenance of viable populations of Bengal tigers and one-horned rhinoceros. Implicit in the management of grasslands is the role of fire in these community types. Here we present the current fire management situation in India as backdrop to the use of prescribed fire in habitat management for tigers and one-horned rhinos; the status of tiger and rhinoceros management in one or two reserves in India or Nepal; the response of Nepalese grasslands to prescribed fire; and the role of fire in the future management of habitat for tigers and rhinoceros.

### Fire Management in India

Fire has long been used in India's forests and grasslands. Native villagers set fires to light the way ahead for walking, remove tigers from forested areas near villages, clear land for slash-and-burn (*jhum*) agriculture, bare the ground for collection of *mahua* flowers, keep woodlands and prairies in grass, assist hunters in locating game, and open sites that might otherwise hide cobras (Pyne 1994).

When the British came to India, European — particularly German — forestry came with them. In the European tradition, forests were to be rationalized and fires to be suppressed. Ignored was the fact that fire had co-existed with India's forests and grasslands for millennia.

In India, "... fire is traditionally perceived either as an act of God about which one is helpless or a natural phenomenon harmless to the forest. There is no focus on fire in economic or ecological terms, and the curriculae of foresters training at all levels are rather inadequate in fire science and technology. There is no clear fire strategy. Only now is an awareness of strategic planning for fire management beginning to engage the attention of planners, and the awareness of fire effects ... is severely limited" (Mutch et al. 1995a).

### Fire Statistics

It has been said that historically, in India "... every forest that would burn was burned almost every year" (Shebbeare 1928). The current number of fires and the area affected by fire in India are not known with any certainty. Recent fire statistics, collected by the Central government (federal) from the State governments (Mutch et al. 1995a), show a minimal number of fires in the states that reported (Table 1). As is seen, many States reported no fires. This is inconsistent with the nature of much of India's forested area which is fire-prone, dry-deciduous, thorn, or pine forest (Table 2) (Mutch et al. 1995a).

Table 1. Number of forest fires for three fire seasons from states that reported.

State	1991-92	1992-93	1993-94
Andhra Pradesh	None	None	None
Arunachal Pradesh	1	2	2
Assam	None	None	None
Bihar	7	15	10
Gujarat	507	633	654
Haryana	None	None	None
Karnataka	106	16	None
Kerala	211	90	112
Maharashtra	1456	1428	None
Manipur	2	4	6
Mizoram	None	None	None
Punjab	15	31	107
Tamil Nadu	101	93	90
Tripura	None	None	None
Andamans	None	None	None

A very recent example of the inconsistencies in the reported fire statistics is the discrepancy between reports from two agencies on the same 1995 Himalayan fires in Uttar Pradesh: the forest administration reported about 19,000 ha of its own forests and 80,000 ha of other forests were affected; whereas, satellite imagery interpreted by the Forest Survey of India put the total at 536,000 ha — almost five and a half times the area reported by the forest administration. Some of the difference could be due to different interpretations of what is fire "affected," but the large difference indicates the lack of a uniform reporting standard.

Table 2. Forest area by type.

Forest Type	ha x 10 <sup>6</sup>
Moist deciduous	23.6
Dry deciduous	29.1
Thorn forest	5.2
Pine forest	3.7
TOTAL	61.6

### Current Fire Management Capability

Fire management in India is supported in federal policy by the National Forest Policy (1988) which lays down a strategy for protection of the forests including protection from fire and allows for the use of prescribed fire. A United Nations (UN) Development Programme project from 1984 to 1990 in "Modern Forest Fire Control" (Food and Agriculture Organization (FAO) of the UN 1991) began the process of installing fire suppression in two Indian states. Some of the technology brought in at that time, however, was not appropriate for India because fuel, financial support after 1990, and replacement parts for imported equipment were not available.

Fire management in India is receiving new attention under the 1995 UN Technical Cooperation Program, "Training in Forest Fire Management Planning" (FAO of the UN 1995). Under the aegis of this program, a training course in forest fire management planning was developed and presented to three groups of Indian Forest Service Officers. As an outcome of this program, the Ministry of Environment and Forests of the Government of India requested a proposal from the FAO for fire management in all of India. The proposal that was developed (Mutch et al. 1995b) recommends the creation of a Forest Fire Research and Training Institute for India. The Institute will be responsible for the development of appropriate fire management for India utilizing technology that is relevant to the local situation and India's vast labor pool. Technology appropriate for India will include, among other things, very basic equipment as indicated by the Deputy Director of Jim Corbett National Park, who shared that in 1995 they were able to provide, for the first time, equipment — shoes, water bottles, and whistles — to their "fire watchers" (personal communication<sup>1</sup>).

### Bengal Tigers

Tiger habitat and fire management are intertwined because, "The only apparent requisites of tigers for survival are some form of plant cover, water supply, and sufficient prey" (Schaller 1967). Fire management is important because the habitat upon which tiger-prey depend can be fire dependent in itself.

Tigers were placed on the red list in 1969 because of their critically low numbers. As late as the 1940s, eight subspecies of tigers roamed Asia. Now five subspecies remain and three are extinct. The Bengal tiger is the only tiger in India and has the greatest number of individuals of any remaining subspecies. Bengal tiger numbers dwindled from an estimated 40,000 in the early 1800s to

<sup>1</sup>Rajiv Bhartari, Deputy Director, Corbett Tiger Reserve, Ramnagar, District nainital, Uttar Pradesh, India.

an all time low in the 1960s. In the 1972 census, 1,800 Bengal tigers were counted. With the development of tiger reserves by Project Tiger (Forum for Forest Furtherance 1994) in India in the 1970s, the number of tiger reserves has increased to 20. The population of tigers has slowly increased reaching about 4,000 by the late 1980s (Figure 1). The 1993 census showed a new decline to about 3,700 due to a "... sudden spurt in tiger poaching for its bone smuggling..." (Forum for Forestry Furtherance 1994).

Bengal tigers are territorial, prey-based animals. The main prey of the Bengal tiger consists of large mammals including several ungulates: cheetal (*Axis axis*), hog-deer (*Axis porcinus*), sambar (*Cervus unicolor*), bharasingha (*Cervus duvauceli*), and barking-deer or kakar (*Muntiacus muntjak*) (Mazák 1981, Sunquist and Sunquist 1988). Other smaller animals are eaten when there is a lack of other prey (Mazák 1981). The ungulates upon which tigers chiefly depend for their prey are, in turn, dependent upon grasslands for their survival. Tiger research in Chitwan National Park has shown tigers spend most of their hunting time in riverine forest and grassland habitats because four times as many ungulates are found there than are found in sal (*Shorea robusta*) forest (Sunquist and Sunquist 1988). Smith (1984) found prey density was a good predictor of the way tigers used an area: tigers used areas with a high prey density year around while areas with a low prey density were used only temporarily or traveled through. Moreover, vegetation density was also a good predictor of the way tigers used an area and seemed to be closely tied to prey density (Smith 1984).

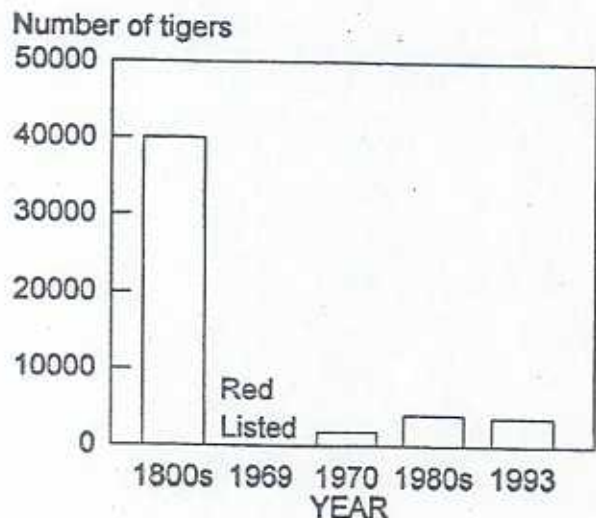


Figure 1. Population of *Panthera tigris tigris* in India.

### One-horned Rhinoceros

The Indian one-horned rhinoceros depends primarily upon grasslands for forage. Management of these grasslands for rhinoceros often entails the use of fire.

Currently, only two disjunct populations with more than 250 rhinos per population exist — one in Kaziranga National Park, Assam, India, and the other in Chitwan National Park, Nepal (Sunquist and Sunquist 1988). The rhinoceros population in India dwindled in 1908 to 12 animals in the area that is now Kaziranga National Park. From those 12 animals, the rhinoceros herd has grown to more than 750 (Figure 2), enough so rhinos can be exported to other reserves.

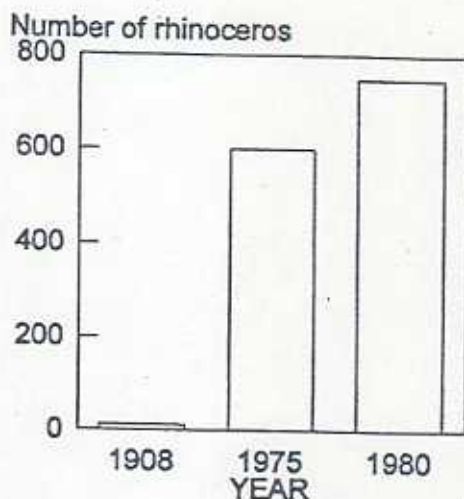


Figure 2. Population of *Rhinoceros unicornis* in Kaziranga National Park, Assam, India.

In Chitwan National Park, Nepal, the one-horned rhino population was well protected prior to 1950 in hunting reserves that belonged to the ruling family. In the 1950s, a program for resettlement of villagers led to the destruction of large areas of rhino habitat and poaching was rife (Laurie et al. 1983) producing a continuing decrease in rhino numbers (Figure 3). In the 1960s, stricter protection of both habitat and animals was enforced, and Chitwan National Park was established in 1973 leading to a slow recovery in rhinoceros numbers.

The total world population of one-horned rhinos in the 1980s was estimated at 1,500 of which 1,200 were living in these two reserves, Kaziranga and Chitwan National Parks, underscoring the importance of careful habitat management.

Rhinos are found in riverine grasslands where grasses reach 8 m tall and in swampy areas bordered by riverine

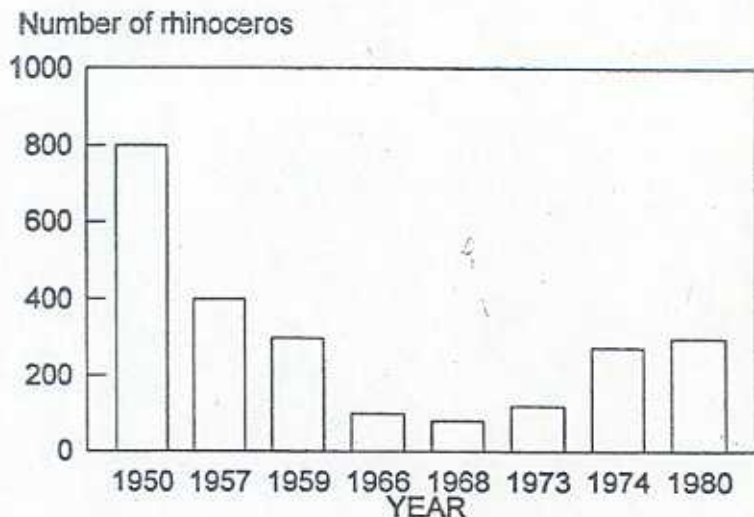


Figure 3. Population of *Rhinoceros unicornis* in Chitwan National Park, Nepal.

woodlands (Laurie et al. 1983). Laurie (1975) noted rhinos feed mainly on *Saccharum spontaneum* and *Imperata cylindrica* and the charred stalks and new shoots of up to 29 species of grasses and bushes around wallows and along river beds. With these areas decreasing in size due to human pressures and most rhinos confined to reserves, habitat management for the one-horned rhino becomes increasingly critical. "Thus, for effective preservation of rhinos . . . it is essential that they should be protected from . . . the destruction of their habitat" (Mishra and Mishra 1982).

#### Fire in Habitat Management for Tigers and Rhinos

Fire has been present on Earth for the last 350 to 400 million years, and grasslands have been present in the rhino and tiger areas of the Asian subcontinent for the last 20 million years (Badgely 1984, Mathur 1984, Gaur 1987). Burning by humans has been considered a primary factor in the formation of south Asian plant communities for perhaps the last 5,000 years (Wharton 1968).

Tropical grasses are notoriously poor in nutrient quality during mature stages (Van Soest 1982) and are poor forage for herbivores like tiger-prey or rhinoceros. However, fresh regrowth initiated after fire is high in protein and is an important forage for herbivores during the dry season when forage quality is lowest (Daubenmire 1968, Christensen 1977). If large ungulate populations are limited by nutrient or resource availability (Klein 1970, McNaughton 1983), understanding and managing fire to manipulate forage quantity and quality will be important for managing ungulates.

About 80 percent of the grasslands in Chitwan National Park burn each year between late January to May from fires ignited by the villagers to assist in the harvest of grasses for fodder and thatching (Lehmkühl 1989). The

fires, ignited in the grasslands, often move into the adjacent forests where a surface fire burns the forest floor material. These fires are unmanaged — the conditions under which the fires occur are not regulated — and the intensity and frequency vary from year to year and area to area.

#### Response of Riverine Grasslands to Fire

Lehmkühl (1989) examined the effects of early (January) and late (April) growing season burning on grassland production in Chitwan National Park. The effect of burning season on production varied among grass types. Early burning of ungrazed *Imperata cylindrica*, a relatively short, 1-m, grass, produced 20% more biomass than late burning, and biomass production in the burned areas was more than double the production in the unburned areas. More biomass was removed by the grazing of wild ungulates from the late-burn units than from the early-burn units because the vegetation in areas surrounding the late-burn units was at a later stage of development and less palatable. Grazing lasted longer in the late-burn areas because the new shoots remained relatively more palatable than surrounding areas; as new shoots were grazed down, more new and highly palatable shoots were produced perpetuating the cycle.

Production of *Narenga porphyrocoma*, a tall grass often >6 m high, was highest on the early-burn plots, intermediate on unburned plots, and lowest on late-burn plots. Very little grazing was detected in this grass type regardless of burning regime. It is, however, an important species for use in house construction by the villagers who live adjacent to the National park.

*Saccharum spontaneum*, another tall floodplain grass, showed still another pattern; production on early-burned and unburned units was similar, whereas production on late-burned units was about one-fifth their value. This

grassland type is perhaps the most important for grazers. Low production in all types from late burning primarily resulted from destruction of advanced regrowth initiated during January at the start of the growing season.

Lehmkuhl (1989) recommended staggered burning of grasslands in small patches to provide fresh, high-quality forage for a longer time during the dry season than presently occurs with a single burn. A staggered, patch burn pattern would produce a mosaic where some areas would have new shoots for fodder; some areas would have older material for cover; and other areas would be at stages in between. Similar suggestions have been made by Laurie (1978) and Dinerstein (1979) to increase carrying capacity for large mammalian herbivores in Nepalese reserves, and by Roy (1986) who described a successful patch burning program in Manas Wildlife Sanctuary in Assam, India. Rodgers (1986) provides a good review of this and other fire management practices for wildlife habitat management in south Asia.

In addition to creating a patch mosaic, staggered burning may foster the formation of pasture-like grazing lawns by concentrating grazing pressure on limited areas (McNaughton 1984). Grazing lawns would produce high-quality forage year-round and increase herbivore carrying capacity. They might decrease crop depredation by attracting wild herbivores away from agriculture. Patch size would be critical for success; a patch too large would be hard for herbivores to crop fast enough to keep the grass short, and a patch too small might be overgrazed and not provide adequate benefits to warrant management.

Fire suppression may have less-obvious detrimental effects on rhino and tiger habitat. Community analysis and model simulations by Lehmkuhl (1989, 1994) revealed complete suppression of fire would affect grassland succession to riverine forest. Riverine forest, which occurs in a landscape mosaic with grassland and is one of the most productive and valuable habitats for rhinos and ungulate tiger prey, may increase or decrease with fire suppression. Conventional thinking says that riverine forest would increase with fire suppression; but, Lehmkuhl's observations suggest riverine forest could decrease instead.

Patch burning would also increase cover for other wildlife that are negatively impacted by widespread burning. Oliver (1980) concluded that widespread burning was one of the factors contributing to the decline of the endangered pygmy hog (*Sus salvanius*) (likely extinct in Chitwan) and hispid hare (*Caprolagus hispidus*). Roy (1986) claims that his patch burning program has been instrumental in increasing the population of pygmy hog in the Manas Reserve and in managing high quality habitat for other species. Patch burning also would provide essential spring nesting habitat for grassland birds in unburned sites now missing with widespread, uncontrolled fire (Rodgers 1986).

## Discussion

The utilization of prescribed fire in Indian and Nepalese grasslands for habitat management for the Bengal tiger and the one-horned rhinoceros, or both, follows a long history of using fire for various purposes by local villagers. Before British rule, the use of fire was common, and although the British and their German forester associates believed fire to be a menace and introduced that philosophy into Indian forestry education, villagers did not necessarily change their practices. Since at least the eighteenth century, grasslands have been burned regularly to provide grazing for thousands of cattle and buffalo in the dry season (Sunquist and Sunquist 1988). Fire was still prevalent after many years of British rule. The British botanist, Sir Joseph Hooker, described how, during his descent from the Himalayas in the early 1850s, he saw the plains of Bengal immersed in smoke, the product of fires "raging in the Terai forest" (1855a). He described the grasslands as "supporting a prodigious undergrowth of gigantic tall grasses that reached to our heads though we were mounted on elephants. These gigantic grasses seem to be destroyed by fire with remarkable facility at one season of the year and it is well that this is the case, for whether as a retainer of the miasma or a shelter for wild beasts. . . these grass jungles are a serious obstacle to civilization" (1855b).

An astute Anglo forester, writing under the pen name "An Aged Junior," (1890), observed that fire had not been random and ravenous but had been applied to particular sites at particular seasons for particular purposes by particular peoples. Those selective burns had ordered the landscape. Thanks to fire, fresh browse appeared at the proper place at the proper time; deer migrated to those sites; tiger followed the deer; and hunters knew where to find rogue tigers.

Nonetheless, the suppression of fires was obtained in some areas, usually by villagers beating out the flames especially when their villages were threatened. Burns et al. (1925) noted how "an unforeseen result of the policy of non-interference with the vegetation" was the accumulation of dead straw that defiantly withstood "rotting" and eventually had to be burned, an act which quickly yielded a variety of useful results (Pyne 1994). The Director of Kaziranga National Park which is a rhino reserve in Assam, India, commented that the only bad fire is the fire that doesn't happen<sup>2</sup>. The tall-grass habitat of the rhino becomes impenetrable, even to rhinos, within three years of the last fire. Kaziranga National Park is attempting to put the entire rhino reserve on a three-year burn cycle.

<sup>2</sup> S.K. Sen, Director, Kaziranga National Park, Bokakhat, Golaghat, Assam, India.

Research by Lehmkuhl indicates utilization of prescribed fire in the grassland habitat of rhinos and Bengal tigers can increase the amount of biomass produced, alter the time of peak production, and increase the time grass is available for forage. Increasing the amount of a particular grass at a time when other grasses are less palatable and less nutritious, and extending the grazing season for palatable grasses are helpful and beneficial tools in the management of habitat for threatened and endangered species dependent upon these grasslands. These results suggest it may be feasible to increase the density of large grazers and their predators in these grasslands. In Ranthambhore National Park the population density of Bengal tigers is much greater than in other areas, possibly due to the herd-forming characteristic of the sambar in that area (Sunquist and Sunquist 1988).

The planned and monitored integration of fire into grassland and forest management may aid in the perpetuation of healthy, vigorous grasslands and forests and of their threatened and endangered fauna.

#### Research needed

Managers of the grassland reserves for tigers and rhinos need to know how to best maintain and enhance these areas for the benefit of the threatened and endangered species. Information needed includes the response of the grasslands to prescribed fire, especially staggered patch fires: When to burn? How large a patch to burn? What intensity to burn? How often to burn? Additionally, the response of grasslands to fire suppression needs to be determined: Does fire suppression increase or decrease the rate of succession from grassland to riverine woodland? How does fire suppression affect tiger and rhino populations? All of these questions need to be answered in the context of the response of the threatened and endangered species.

#### Conclusions

The Indian subcontinent has a rich and diverse flora and fauna. The appropriate use of prescribed fire to enhance and preserve these natural systems will benefit all the population of India from the villagers to the city residents. The population of the world at large will also benefit from the maintenance of biological diversity and gene pools plus the opportunity to see these majestic animals in their natural environments. Prescribed fire has been shown to enhance grassland biomass production, alter the time of appearance of succulent and nutritious shoots, and extend the grazing season — results which have potential benefits for the management of grasslands for Bengal tigers and Indian one-horned rhinoceros. An active fire management system, which includes prescribed fire, is

needed for grassland and forest management. This fire management system, institutionalized at the state level with strategic inputs from the Central government in the form of training, research, and awareness-building, will enhance the survival potential of these splendid animals — the Bengal tiger and the Indian one-horned rhinoceros.

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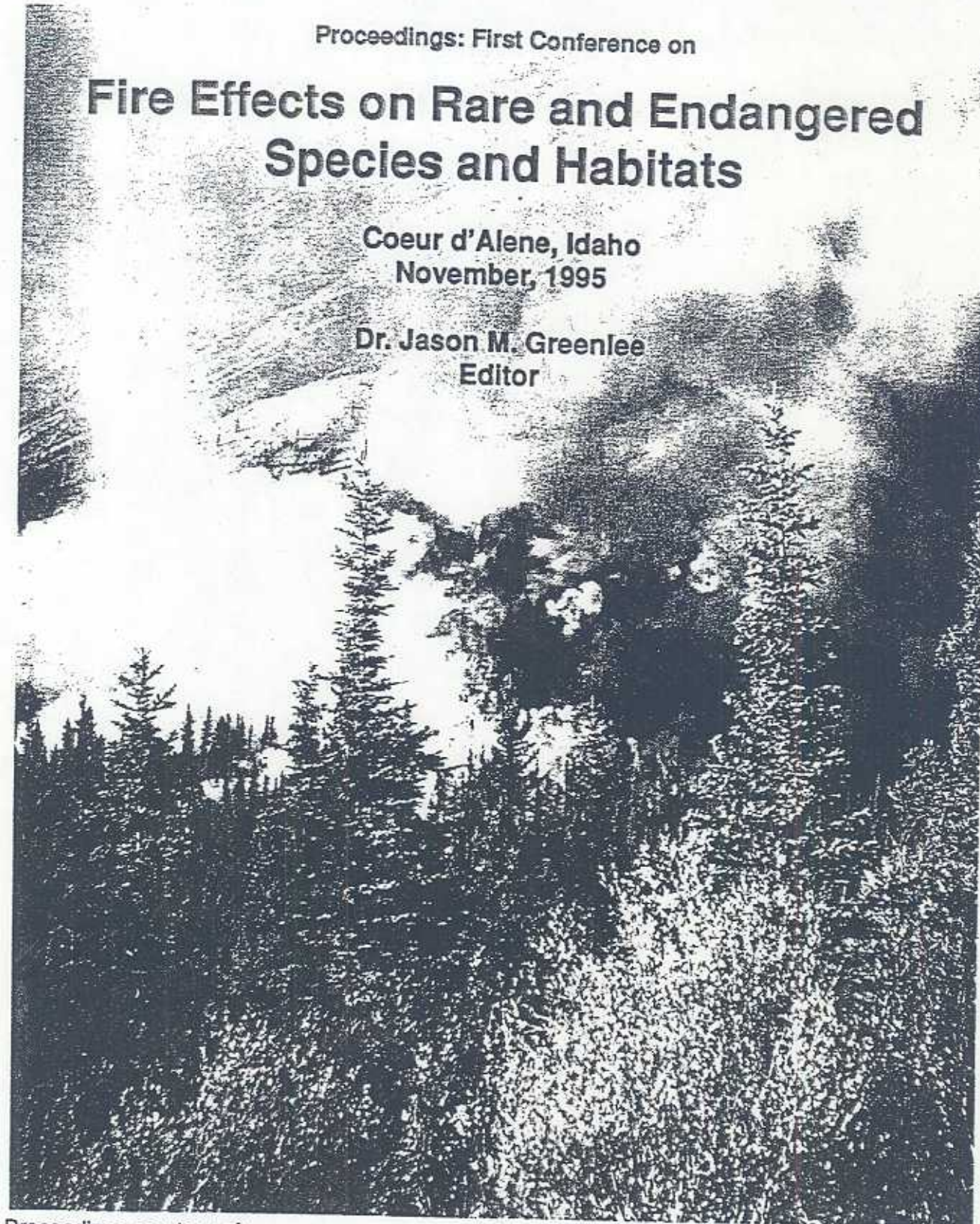
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