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Impact of forest fire on diversity, stand structure and regeneration of woody species in a tropical deciduous forest of Western Ghats

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Abstract

Fire is an essential process in many ecosystems to maintain species composition, biodiversity and structure. It also causes considerable damage to ecosystem and considered to be a potential hazard with physical, biological, ecological and environmental consequences. The majority of fires occurring in India are in tropical dry deciduous forests, which account for >40% of all forests in India.

This study was aimed to understand that how a single fire incidence affects species diversity, stand density and regeneration of trees. We studied impact of single fire on 2 year old burn (B2), 5 year old burn (B5) and 15 year old burn (B15). Results showed that number of species decreased in B2 (20) & B5 (20) but recovered to the level of control (24) in B15 (25). Shannon &Weiner and Simpson (1-D) indices were less than control in all burn classes. Though the tree density and basal area showed an increasing trend from B2 to B15 but it could not reach to the level of control (367±43.59 ha^{-1}& 36.81 m^2 ha^{-1}). However, the number of seedlings showed a positive correlation with burn classes (B2-B15) and was higher than control (2300±556.78 ha^{-1}).In the case of sapling density, it decreased in B2 (73±11.55 ha^{-1}) but increased in B5 (113±5.77 ha^{-1}) & B15 (137±23.10 ha^{-1}) and was higher than control (83±20.82 ha^{-1}). Results suggest that fire incidences, irrespective of time of occurrence, negatively impacted species diversity, stem density and basal area, but improved the seedling and sapling density in all burn classes.

Keywords: Dry deciduous forest, Forest fire, species diversity, regeneration, Western Ghats.

Introduction

➢Fire occurs naturally in most ecosystems around the world due to lightning, but many of the fires frequently observed, especially in the tropical belt, are of human origin (Kennedy 1992).

➢ Fire is considered as a friend as well as a foe for natural ecosystem depends on origin, frequency, history and damage caused by it. It is helpful in maintaining diversity and stability of ecosystems (Bond and Keeley 2005; Verma and Jayakumar 2012

➢The majority of fires occur in India are in tropical dry deciduous forests, which account for >40% of all forest in India (Hiremath and Sundaram 2005; Krishna and Reddy 2012).

➢In Western Ghats, fire return interval was reduced from 10 years (1909-1921) to 3.3 year (1989-2002) due to land-cover transformations in the surrounding landscape and forest fragmentation (Kodandapani et al. 2004).

➢Forest fires affect forest regeneration directly by killing stem tissues of seedlings and saplings, heating the soil sufficiently to kill seeds and roots near the soil surface (Kennard et al., 2002) and also indirectly influence regeneration patterns by killing reproductive trees with thin bark (Balch et al. 2013; Pinard et al. 1999).

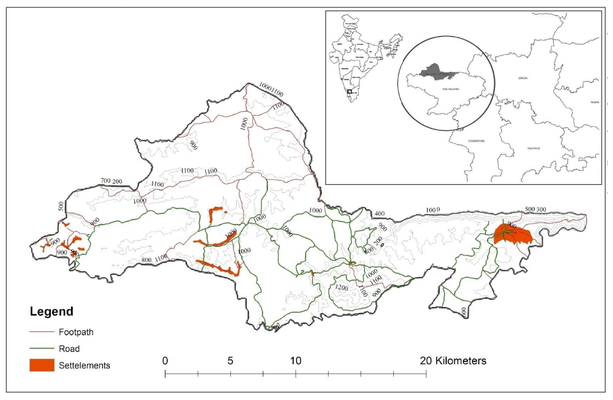
➢Current study is aimed to understand the impact of a single fire event on species diversity, stand structure and regeneration of woody species in a tropical deciduous forest of Western Ghats.

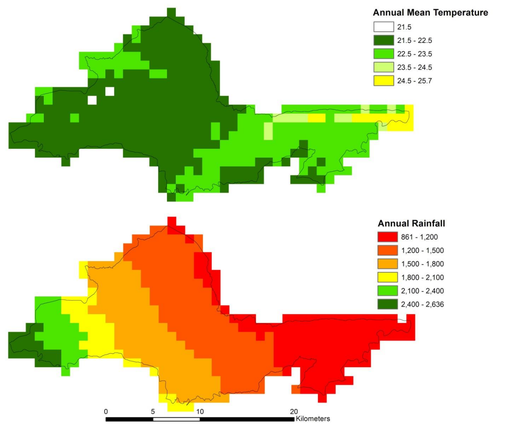
Materials and Methods

Study Area

➢The study was conducted in Mudumalai Tiger Reserve (MTR), which is located in the state of Tamilnadu and is a part of the Nilgiri Biosphere Reserve. It lies between 11^0 32' & 11^0 43' N and 76^0 22' & 76^0 45' E.

➢The vegetation types found in MTR are classified into southern tropical dry thorn forest, southern tropical dry deciduous forest, southern tropical moist deciduous forest, southern tropical semi-evergreen forest, moist bamboo brakes and riparian forest (Champion and Seth 1968).





Study Design and Data Collection

➢Fire maps for the year 1999, 2000 and 2013 were prepared by using images of Landsat 5 Thematic Mapper Landsat 7 ETM and Landsat 8 OLI-TIRS and remaining were collected from Tamilnadu forest department.

➢Three areas B2 (Burned 2 year ago) B5 (Burned 5 year ago) and B15 (Burned 15 year ago) were identified from the composite fire map which burned only once between 1999-2013 and compared with B0 (Unburned).

➢Three 0.1 hectare square plots were prepared in each strata and all woody stems ≥ 1cm gbh inside the plots were enumerated. For seedlings, four 5 x 5 meter subplots were laid.

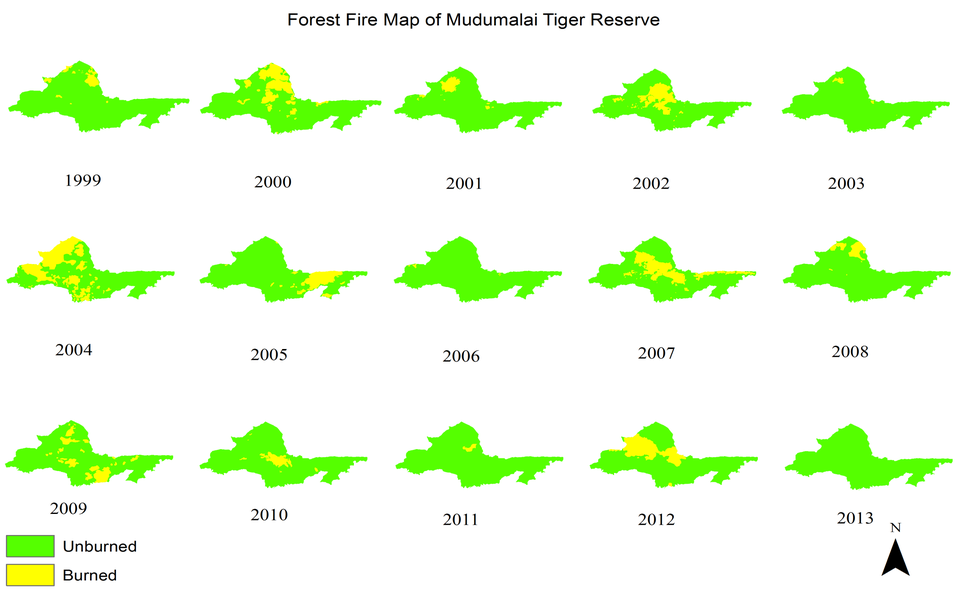
➢Measurements such as collar girth (CG), girth at breast height (GBH) and height (H) were recorded for all the woody plants for both living and dead. For seedlings only number was counted. Seedling was defined as height less than 50 cm and collar girth less than 1 cm whereas sapling was defined as height 50 – 150 cm and collar girth 1 to ≤10 cm. Trees were defined as >10 cm GBH.

Data Analysis

➢Diversity of all living stems was estimated by using the Shannon–Wiener index (*H'*) and Simpson's dominance index (1-D).

➢Regression analysis was performed to examine the relationship of stem density and basal area for the trees gbh>1 cm and total number of species regenerating with burn year.

➢For each growth forms (seedling, sapling and tree) stem density was calculated and subjected to one-way ANOVA to examine significant differences in these variables among burn years.



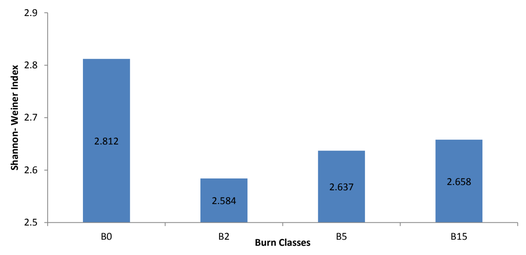
Results

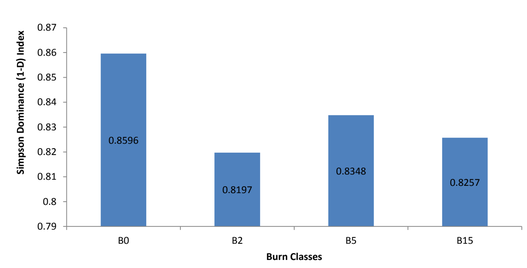
Species Diversity

➢We found a total 40 tree species in our plots. B2 and B5 were represented by 20 species each and 25 species in B15 and 24 in control.

➢Forest fire showed negative impact on species diversity and dominance. Shannon- Weiner index was highest for the unburned plots (2.812) and lowest for the B2 (2.584).

➢Diversity started increasing with time but could not reach to the level of unburned plot in 15 year. Dominance also increased after fire event.

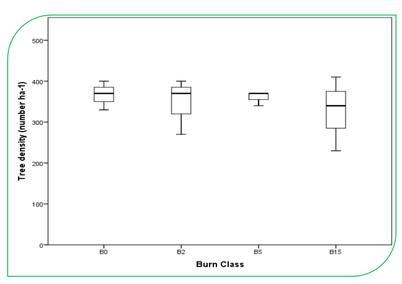


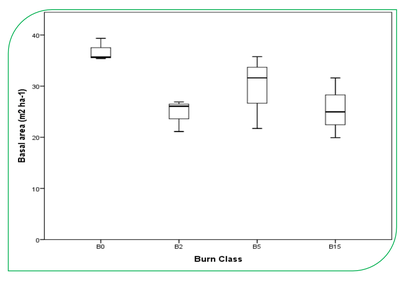


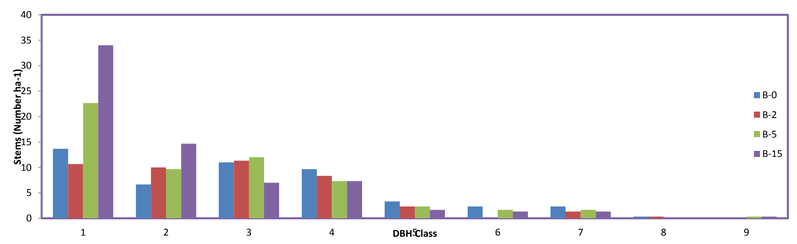
Stand Structure

➢Results showed that single fire event did not affect tree density ($F_{3,8}$=0.259, p=0.853) and basal area ($F_{3,8}$=3.654, p=0.63) significantly.

➢Stem diameter distribution in the smaller stem size (1-10, 10-20cm DBH) showed significant difference between control (B0) and burned plots (B2, B5 and B15).

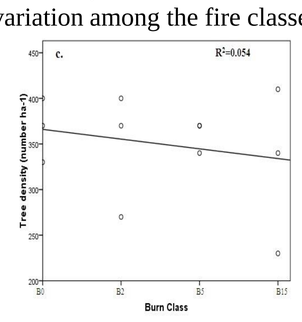


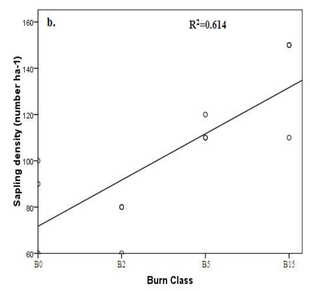


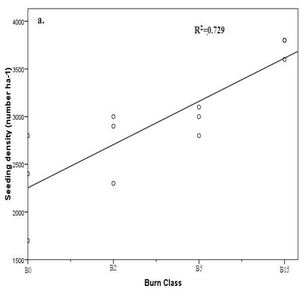


Regeneration

➢Significant differences in the mean stem density of seedlings ($F_{3,8}$= 8.834; p = 0.006) and saplings ($F_{3,8}$ = 8.824; p = 0.006) were observed among fire classes. Tree population($F_{3,8}$=0.259, p=0.853) did not show substantial variation among the fire classes.







Discussion

➢Results showed that even a single fire event can affect diversity and regeneration of trees very significantly. Species diversity decreased and dominance increased immediately after fire due to stem mortality in lower size class.

➢ After 5 years of burn, diversity starts increasing but it takes longer time than 15 years to reach the level of control.

➢Single fire event did not show any significant impact on density of trees (>10cm GBH) and basal area. Which also suggest that mortality caused by fire would be in the lower size classes.

➢Density of seeding and sapling was significantly higher in burned plots and increasing with time. It suggested that single fire event could be good for the regeneration of trees.

Conclusions

It is concluded from this study that even a single fire event has varying degree of impact on tree species of dry deciduous forest. All fire classes (B2, B5, B15) have shown less diversity than control. Most of the impacts of fire were on smaller trees or tree in smaller stem size. Any kind of fire regime will have some impact on vegetation either beneficial or detrimental but decline in tree diversity in all fire classes suggests that fire is a matter of serious concern. Further research on fire should continue to test various ecological effects of fire, in particular, the testing of prediction based model on population dynamics.

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