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# Fire occurrence and fire mitigation strategies in a grassland reforestation area in the Philippines

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ABSTRACT

While fire has been identified as a major factor negatively affecting success of reforestation projects in the Philippines, no study so far has been conducted on the types and extent of fire mitigation strategies being implemented by upland farmers. This study presents an analysis of the occurrence of grassland fire, the factors influencing it, and the fire mitigation strategies employed by small farm-holders in four adjacent upland communities in Carranglan, Nueva Ecija, Philippines. With a total of 779 fire incidents recorded from 2002–2014 covering an estimated overall total of 19,500 ha, grassland areas in Carranglan warrants urgent rehabilitation. The number of fire occurrence in Carranglan were found to have significant positive relationship with temperature, compound topographic index (CTI) and aspect ($P < 0.05$). In response, upland farmers implement several fire mitigation strategies that are either vegetational and structural in nature. The most common practices include regular grass cutting and the establishment of fire lines. Using simple linear regression, the number of fire mitigation strategies implemented by upland farmers is very highly associated to the years of residence in the area, number of children in the household, age of respondents, educational level, livelihood, and farm lot ownership ($P < 0.01$). The limited number of fire-mitigating strategies implemented by the upland farmers may have contributed to the frequent occurrence of grassland fires in Carranglan. Strategies that would significantly increase farmers' awareness of and capability in implementing various fire-mitigating strategies must be incorporated in a fire hazards management program to ensure success of reforestation projects, which is a key approach in rehabilitating the upland ecosystems.



## 1. Introduction

Reforestation is a major activity among developing countries as a direct response to the rapid decline of tropical forests (FAO, Food and Agriculture Organization of the United Nations, 2013; Le et al., 2014). At the minimum, it involves planting of trees on cleared land to establish tree cover (de Jong, 2010) that in the long-run is expected to provide vital ecosystem services (Sayer et al., 2004). Depending on the identified cause of forest degradation, reforestation projects are being designed and implemented using a wide array of approaches, types of technologies and resources, level of stakeholder participation, and implementing actors. Over the past decades, success of reforestation projects vary across different countries depending on a combination of technical, socioeconomic and environmental factors (Chokkalingam et al. 2005; Le et al., 2014).

Grassland ecosystems formed as a result of deforestation and degradation of forestlands particularly require immediate reforestation activities (FAO, Food and Agriculture Organization of the United Nations, 2013). Zanne and Chapman (2001) observe that forest regrowth is often slow in cleared and abandoned tropical forests. In the Philippines, grasslands are classified under two distinct types: (1) *Imperata cylindrica*-dominated areas, which generally represent degraded, acidic, low organic matter, and dry soil areas susceptible to erosion; and (2) *Saccharum spontaneum*-dominated areas that occur in areas where there is adequate moisture (Concepcion and Samar, 1995; Magcale-Macandog and Galinada, 1998). For years, reforestation programs in the Philippines have focused on *Imperata*-dominated landscapes that are prone to environmental hazards such as wildfires, landslides, among others. The spread of *Imperata* is associated with a decline in soil fertility contributing to reducing crop productivity (Van Noordwijk et al., 1996). The rehabilitation of *Imperata* grasslands will require a much better understanding of their area, distribution, and characteristics (Garrity et al., 1996).

Over the past four decades, however, reforestation in the Philippines has gained limited success (Chokkalingam et al., 2005; Rebugio et al., 2007; Israel and Israel and Lintag, 2013). In terms of the institutional aspect, many reforestation projects face similar challenges. These include low acceptability among the local people, non-involvement of key stakeholders in reforestation planning, untimely release of funds, improper mode of reforestation implementation, regular occurrence of

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fire, poor site quality, and poor site-species matching (Rebugio et al., 2007; Florece, 2010). Analysis on where, when, and why fires occur could enable more effective and forward-looking damage reduction strategies to significantly mitigate fire risks especially in reforestation areas (Prestemon et al., 2001).

Fire has been part of the ecological processes of grasslands (Collins, 1992; Fuhlendorf and Smiens, 1999). The probability of fire occurence is greatest in areas with high biomass accumulation (Fuhlendorf and Engle, 2004). The role of fire in grasslands and savannahs is well recognized and can either be beneficial or detrimental depending on its use. Grasslands have been found to maintain biodiversity if burnt every 1–3 years in Australian savannahs (Setterfield, 2002); reduce fuel load in California and other areas in the western United States (Faulkner et al., 1989); manage invasive species (DiTomaso et al., 1999); and eliminate old foliage and encourage regrowth of grasses for the benefit of browsing livestock. In rural Philippines, fire appears to be socially condoned because it is a cultural norm in preparing swidden farms. Using fire in land preparation has been documented to be the leading cause of fire escaping to adjoining reforestation projects (Florece, 2010). As fire could negatively affect the biophysical components of the ecosystem, reforestation managers and decision makers opt to adopt a fire exclusion policy. Goldammer and Penafiel (1990) expressed that forest managers and fire control officers are still running behind the wildfire problem as they are inadequately prepared. Balancing ecosystem management, human rural development, and fire risk remains a major concern to natural resource agencies (Dombeck et al., 2004; Sturtevant et al., 2009). Thus, a better approach toward integrated fire management that would allow reaping the benefit from fire but excluding the negative impacts of uncontrolled fire, is still wanting.

While fire has been identified as a major factor negatively affecting success of reforestation projects in the Philippines (Chokkalingam et al., 2005; Rebugio et al., 2007; Israel and Lintag, 2013), no study so far has been conducted on the types and extent of fire mitigation strategies being implemented by upland farmers who are also engaged in reforestation projects. To accelerate success of reforestation projects, an analysis of the factors that affect fire occurrence and the use of fire mitigation strategies among upland farmers is imperative. Schemes and programs that could heighten implementation of fire mitigation strategies could then be crafted accordingly. This study provides an analysis of grassland fire occurrence, factors influencing it, and fire mitigation strategies of upland farmers in a large grassland area in Carranglan, Nueva Ecija, Philippines—an area that for years has been subject to several reforestation programs. Specifically, this paper aims to identify the types of fire mitigation strategies among the upland farmers and determine the factors affecting the number of fire mitigation strategies employed by upland farmers.

## 2. Materials and methods

### 2.1. Study site

The Philippines provides a classic example of deforestation common to many developing countries. The Food and Agriculture Organization of the United Nations (FAO) (2013) explains that the cycle of tropical deforestation typically begins with excessive logging that results in logged-over forests being converted for agricultural uses. Unproductive farmlands are subsequently abandoned after being subjected to intensive anthropogenic activities, soil degradation, recurring disturbances (especially fires), and isolation from intact forests, among other reasons. Being one of the 17 mega-diverse countries (Mittermeir, 1997), the loss of vital forest ecosystems in the Philippines resulted in the decline of a wide array of ecosystem services (Rebugio et al., 2007; Lasco, 2008). In response, a number of reforestation efforts particularly on open grasslands and denuded lands were implemented across the country (Harrison et al., 2004; Sayer et al., 2004; Chokkalingam et al., 2005).

Among the recipients of massive reforestation projects is the municipality of Carranglan in Nueva Ecija (15°59′42″ N, 121°1′40″ E), which is the focus of this study. It is an agriculture-based town with a total land area of 70,531 hectares (ha) (Fig. 1). It is the northernmost municipality of the province of Nueva Ecija in the island of Luzon. The landscape is characterized by rugged mountainous terrain that ranges from nearly level, undulating, to hilly slopes as it approaches the Caraballo and Cordillera mountain ranges in the north and the Sierra Madre mountain range in the east. The major land uses in Carranglan are grassland, alienable and disposable land, forest plantation, and forestland vegetated predominantly by secondary growth forests (Peras et al., 2009). There are two soil types in Carranglan: Annam sandy clay loam and Umingan sand (PhilGIS, Philippine GIS Data Clearinghouse, 2013). Recommended crops for the Annam soil type include upland rice, lowland rice, coconut, corn, plantation crops, root crops, vegetables, and perennial trees whereas the Umingan soil series is suitable for corn, vegetables, lowland rice, coconut, sugarcane, and perennial trees (Carating et al., 2014). The municipality has Type I climate with a pronounced wet season from May to November and dry during the rest of the year. The observed normal annual precipitation rate is 1854.9 millimeters (mm) (PAGASA-DOST, Philippine Atmospheric, Geophysical and Astronomical Services Administration-Department of Science and Technology, 2014).

Land in Carranglan is under the administrative jurisdiction of several government agencies as it hosts the watershed that supplies water to the hydroelectric power plant in Pantabangan, Nueva Ecija. The presence of several government agencies represents varying and oftentimes competing interests with regard to resource use and conservation efforts. So far, large tracts of grasslands currently abound in Carranglan despite the attempts and investments to rehabilitate the watershed. While grassland fires may have positive ecological benefits (e.g., improving the pasture areas of some farmers through the regrowth of grass species like *Themeda triandra* and *Imperata cyclindrica* for the production of thatch), most grassland fires affect regenerating tree species that in six to eight years would have improved the carbon stock and the biophysical and microclimate of the site for the entry of other plant species. Generally, policies on the use of fire in regulating biomass in upland areas in the Philippines exist but are not widely practiced.

### 2.2. Overview of reforestation projects in grassland areas in Carranglan, Nueva Ecija

For a long time, a number of reforestation projects have been implemented as a key strategy to rehabilitate the grassland areas of Carranglan, Nueva Ecija (Table 1). The overall intention of these reforestation projects is to facilitate succession of these grassland areas to shrubland or a forest stand. These projects were mostly initiated by the Department of Environment and Natural Resources (DENR) of the Philippines (e.g., Program on Forest Ecosystem Management [PROFEM] and the Philippine–Japan Reforestation Project) in the 1970s. Other government agencies such as the National Irrigation Authority and the National Power Corporation that have stakes in Carranglan also engage in reforestation programs. A recent reforestation project that also covers Carranglan, is the National Greening Program (NGP), a multi-government agency effort aimed at planting about 1.5 billion trees covering 1.5 million ha in the Philippines for a period of six years (2011–2016).

The reforestation projects in Carranglan were particularly targeted to rehabilitate its grassland areas. In terms of area coverage, many of these projects covered all of the villages in the municipality of Carranglan. The total area covered ranged from 30–54,090 ha. In terms of components, these projects included reforestation, afforestation, plantation establishment, replanting, forest protection, agroforestry establishment, and community and institutional strengthening. The DENR in collaboration with a number of foreign and local partners initiated and implemented these projects. In the 1970s to 1980s, most of the