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Wetland plant communities of the Tsitsikamma Plateau in relation to fire history, plantation management and physical factors ☆

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Abstract

The remnant palustrine wetland plant communities of the highly transformed Tsitsikamma Plateau are almost entirely located as linear features within commercial pine plantations. Being highly flammable fynbos wetlands, these features pose a serious hazard to plantations. Consequently, foresters require management guidelines that will reduce fire hazard to plantations but also maintain the biodiversity of wetlands. Here we report on the floristic community structure of wetlands located in plantations on the Tsitsikamma Plateau, and attempt to explain this structure in terms of geographic location, fire history and plantation management. We identified five palustrine wetland communities whose structure was primarily determined by location along a west–east gradient and fire history. Maintaining wetland plant biodiversity, especially populations of the rare *Leucadendron conicum*, will require a fire return interval in the order of 10 years; fire season is unlikely to have a significant effect. However, implementing this burning regime is likely to pose important challenges to the forestry sector. The forestry industry should internalise these risks and associated costs as a consequence of persisting with an industry not suited to a fire-prone environment.

Keywords: Community analysis; Eastern CFR; Fire management; NMDS; Palustrine wetlands

1. Introduction

From a landscape perspective wetlands are becoming exceedingly rare and wetland losses both internationally and nationally are estimated at over 50%, with agriculture and forestry accounting for most of this loss (Cronk and Fennessy, 2001; Joosten, 2009; Kotze et al., 1995; Maltby, 2009). Afforestation alters species and ecosystem diversity, alters the fire regime, reduces water yield and increases nutrient run-off after fertilisation (Joosten, 2009; Van Wilgen et al., 1994). Throughout South Africa plantation forestry has encroached onto natural ecosystems, and in turn the occurrence of wildfires has threatened the plantation forestry industry (Kraaij et al., 2011; Van Wilgen, 2009). Presently the Tsitsikamma Plateau is extensively afforested with pine plantations which have widely replaced the fire-prone fynbos vegetation (Geldenhuys, 1994; Kraaij et al., 2011) and within these stands occur the wetlands of our study — irreplaceable in the unique perennially moist environment of the Tsitsikamma (Vromans et al., 2010). Although wetlands in South Africa are delineated and protected from afforestation as stipulated by the National Water Act (No. 36 of 1998), the National Wetland Classification System (NWCS) and commonly the Forestry Stewardship Council (FSC) certification (Forestry Industry Environmental Committee, 2002; SANBI, 2009), the wetlands in our study are considered to increase fire risk. These wetlands are linear features oriented north to south within plantations and considered by foresters to behave as fire funnels by channelling wind along these corridors. When mature, post-fire, the Tsitsikamma wetlands support a high biomass which can support high-intensity fires, especially when these coincide with extreme weather conditions such as fierce hot, dry, north–

☆ Nomenclature: Goldblatt and Manning (2000).

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northwest bergwinds (Van Wilgen et al., 2007). Weather conditions, rapid post-fire fuel accumulation rates and principally a non-seasonal natural fire regime in the eastern Cape Floristic Region (CFR), support intense fires across a wide range of vegetation ages (Cary et al., 2009; Geldenhuys, 1994; Kraaij et al., in press-a–b; Southey, 2009; Van Wilgen, 2009; Van Wilgen et al., 2010). In addition, high fuel loads limit access and make fire fighting extremely difficult. This poses a severe risk to the commercial forestry sector and since 1998, four uncontrolled fires have devastated vast areas of plantation in the Tsitsikamma, with resultant financial loss. However, apart from an alien eradication programme, wetland management within plantations in the Tsitsikamma is non-existent and foresters require guidelines for wetland management that will reduce the fire hazard, while maintaining biodiversity and functioning.

Here we focus on the composition and management of the palustrine wetlands (freshwater wetlands dominated by emergent vegetation) on the Tsitsikamma Plateau. Palustrine wetlands are the dominant wetland type on the plateau and are those not directly associated with flowing or permanent water, but rather with soils high in organic matter, which may be saturated for extended periods without the presence of surface water (Kotze et al., 1994; Masundire and Mackay, 2002; Mergili and Privett, 2008). These wetlands fall within the eastern division of the CFR and support fire-prone fynbos vegetation. In South Africa, there are special cases, where the morphological signs of wetness are not readily detectable in the soil profile (Department of Water Affairs and Forestry, 2005). One of these special cases involves the sandy soil profiles of coastal aquifer systems such as the Coastal Aquifer System of the Southern Cape (e.g. Tsitsikamma). Therefore, as elsewhere, the dominant delineator of palustrine wetlands on the Tsitsikamma Plateau is certain plant species that are indicative of soil wetness (Cronk and Fennessy, 2001; DWAF, 2005; Schafer, 2002; Tiner, 1991) and in the CFR these include *Berzelia intermedia* (D. Dietr.) Schltdl., *Carpha glomerata* (Thunb.) Nees, *Cliffortia ferruginea* L.f. and *Wachendorfia thyrisiflora* Burm. (Kirkman, 2007; Mergili and Privett, 2008; Schafer, 2002; Werger et al., 1972). However, there has been very little research specifically on the community structure of Cape wetland vegetation. Here we contribute to filling this gap by undertaking a floristic survey of the palustrine wetlands of the Tsitsikamma Plateau. We also attempt to explain this structure in terms of geographic location, the height of the adjacent plantation and fire history, in order to provide guidelines for managing these wetlands in a plantation forestry context.

1.1. Study area

The study area was located on the Tsitsikamma Plateau in the eastern part of the CFR, roughly 30 km east of Plettenberg Bay and 30 km west of Humansdorp. The plateau comprises an approximately 7 km wide coastal platform bounded in the south by steep cliffs abutting the Indian Ocean and in the north by the Tsitsikamma Mountains, an arm of the Cape Folded Belt (Grey et al., 1987; Rebelo et al., 2006). Altitude ranges between 150 and 260 m. Most of the plateau is underlain by the Peninsula Formation quarzitic sandstones of the Table Mountain Group (Geldenhuys, 1994; Strydom and Schafer, 1997). Soils are infertile, poorly drained, duplex forms (sand overlying clay at 0.5–1.0 m depth) — the largest coherent area of such soils in South Africa (Louw, 1991; Strydom and Schafer, 1997).

The mean annual temperature at Storms River Bos – a station in the centre of the Tsitsikamma Plateau – is 15.4 °C (Grey et al., 1987); temperatures exceed 35 °C in summer and drop below 5 °C in winter. Rainfall data for this study were obtained from the Lottering and Witelsbos weather stations. Rainfall is fairly constant throughout the year and mean annual rainfall (1970–2008) for the Lottering and Witelsbos Plantation was 1019.8 mm and 1093.7 mm respectively. The study period coincided with a severe drought in the area, and the annual rainfall for 2009 at Lottering was 563 mm and at Witelsbos was 711 mm; the lowest ever recorded.

The predominant vegetation is Tsitsikamma Sandstone Fynbos, a tall (up to 5 m) proteoid shrubland (*Protea mundii* Klotzsch, *Protea neriifolia* R.Br., *Protea coronata* Lam., *Leucadendron eucalyptifolium* H. Buek ex Meisn.) with a dense understorey of ericoid shrubs and restioids (Rebelo et al., 2006). Patches of Southern Afrotemperate Forest occupy fire-protected bergwind shadows associated with heavier soils of the Gydo Formation (Geldenhuys, 1994). About 90% of the fynbos on the plateau has been transformed by plantation forestry and dairy pastures (Hugo, pers. obs.).

2. Methods

2.1. Data collection

As study regions we identified two plantations managed by the forestry company Mountain to Ocean (MTO): the Lottering Plantation, as the main study area owing to its varied fire history, and the Kromriver Plantation, 50 km east of Lottering. All wetlands generally had a north to south orientation running parallel to one another from the mountains towards the ocean.

We sampled 21 sites (in 17 wetlands) at the Lottering Plantation and three sites (in three wetlands) at the Kromriver Plantation between July 2009 and January 2010. We attempted as far as possible to sample a wide range of fire histories, hereafter referred to as fire treatments. At Lottering, we distinguished between seven different fire treatments based on number of fires in the past 25 years (this was the period for which we could get accurate records) and post-fire vegetation age: (i) no burn (one treatment) — sites that had not burnt in more than 25 years; (ii) one burn (four treatments) — sites which had burnt once in the last 25 years but in different periods and therefore represent different post-fire vegetation ages (August 1998, August 1999, July 2000 or October/November 2005); (iii) two burns (two treatments) — sites which had burnt twice in the last 25 years, the first in different periods (August 1998 and August 1999) and the second in the same period (October/November 2005), and thus had four year old vegetation at the time of sampling. The three sites at Kromriver all experienced a single burn in the last 25 years (October/November 2005) and had four year old vegetation. From these data, we derived two fire-related variables: post-fire vegetation age and number of fires in the