Agriculture, Ecosystems and Environment 262 (2018) 1–10

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Impact of oil palm development on the integrity of riparian vegetation of a tropical coastal landscape

Marcus Sheaves[a,b,*], Ross Johnston[a,b], Kelsey Miller[a,b], Paul N. Nelson[a,b]

[a] College of Science and Engineering, James Cook University, Townsville, Queensland, Australia
[b] TropWATER – Centre for Tropical Water & Aquatic Ecosystem Research, James Cook University, Townsville, Queensland, Australia

ARTICLE INFO

Keywords:
Oil palm
Papua New Guinea
Ecosystem function
Riparian buffer zones
Ecological assessment

ABSTRACT

Palm oil production provides economic benefits in developing countries but its development can drastically alter landscapes. We investigated an oil palm-dominated landscape in New Britain, Papua New Guinea, and developed a simple remote sensing approach, supported by site visits and video surveys, to assess the condition and the extent of recent change in riparian zones. Riparian buffer zones were extensively modified. Riparian disturbance occurred in both corporate plantations and smallholder blocks. Older areas of oil palm were planted before riparian buffer zone protocols were established, but there has been continuing recent loss and disturbance of natural riparian vegetation, despite increasing awareness of the importance of riparian buffer zones. Explanations for this are complex. For smallholders, a rapidly growing population is increasing the need for income-generating oil palm planting and household gardens, leading to utilisation of riparian zones for oil palm, gardens or villages. Improved management of riparian zones, combined with effective monitoring, is essential to maintain or improve ecological functioning and biodiversity of aquatic ecosystems and the associated benefits for local communities. In conclusion, the simple remote sensing approach developed here, supported by ground truthing and video surveys, provides a robust and effective means of assessing riparian condition in a complex and changing landscape. The techniques could be used to assess the effectiveness of future initiatives to improve aquatic ecosystem condition in similar agriculture-dominated regions.

1. Introduction

Palm oil production contributes substantially to developing economies and livelihoods but also entails adverse ecological impacts (Fitzherbert et al., 2008; Turner et al., 2011; Sayer et al., 2012; Nelson et al. (in press)). Consequently, the palm oil industry needs to engage with the issues and develop substantive solutions to perform its vital economic and livelihood supporting roles without imperilling long-term sustainability. Expansion of the palm oil industry often involves conversion of diverse near-natural or managed ecosystems to monoculture and as a result, often threatens biodiversity and ecosystem functioning Sayer et al., 2012; (Foster et al., 2011; Gray and Lewis, 2014; Norhayati et al., 2014). In turn, impacts of the large-scale loss of natural systems can ramify to degrade the functioning of adjacent and downstream ecosystems (Gibbs et al., 2010; Foster et al., 2011). Many species are poorly equipped to exist under human-modified conditions (Edwards et al., 2010), consequently, the conversion of near-natural and partially near-natural habitats to plantation agriculture can result in the loss of the most vulnerable species (Faruk et al., 2013) and decreased abundances of many more, often including species of high conservation value (Persey et al., 2011). In addition to the direct effects of land use conversion on ecosystems, increased population pressure and human activities associated with the change also exert significant pressure on local environments and resources (Nelson et al., 2010; Cramb and Curry, 2012; Koczberski et al., 2012; Sayer et al., 2012).

The loss or degradation of riparian vegetation through agriculture expansion has negative consequences for aquatic ecosystem functioning. For example, changing agricultural practices in Amazonia have drastically changed the properties of riparian forests, reducing their capacity to regulate water quality erosion and temperature (Macedo et al., 2013). However, there is limited but expanding knowledge about aquatic ecosystems and their riparian borders in oil palm-dominated landscapes. Natural riparian buffers have been shown to contain species-rich assemblages of trees with higher aboveground biomass than oil palm (Singh et al., 2015). At the same time, riparian zones can harbour high densities of pest species (Naiman and Décamps, 1997), so have the potential to promote increased pest activity in adjacent oil palm, although it has been demonstrated that this is not the case for

* Corresponding author at: College of Science and Engineering, James Cook University, Townsville, Queensland, Australia.
E-mail address: marcus.sheaves@jcu.edu.au (M. Sheaves).

https://doi.org/10.1016/j.agee.2018.04.011
Received 12 October 2017; Received in revised form 10 April 2018; Accepted 12 April 2018

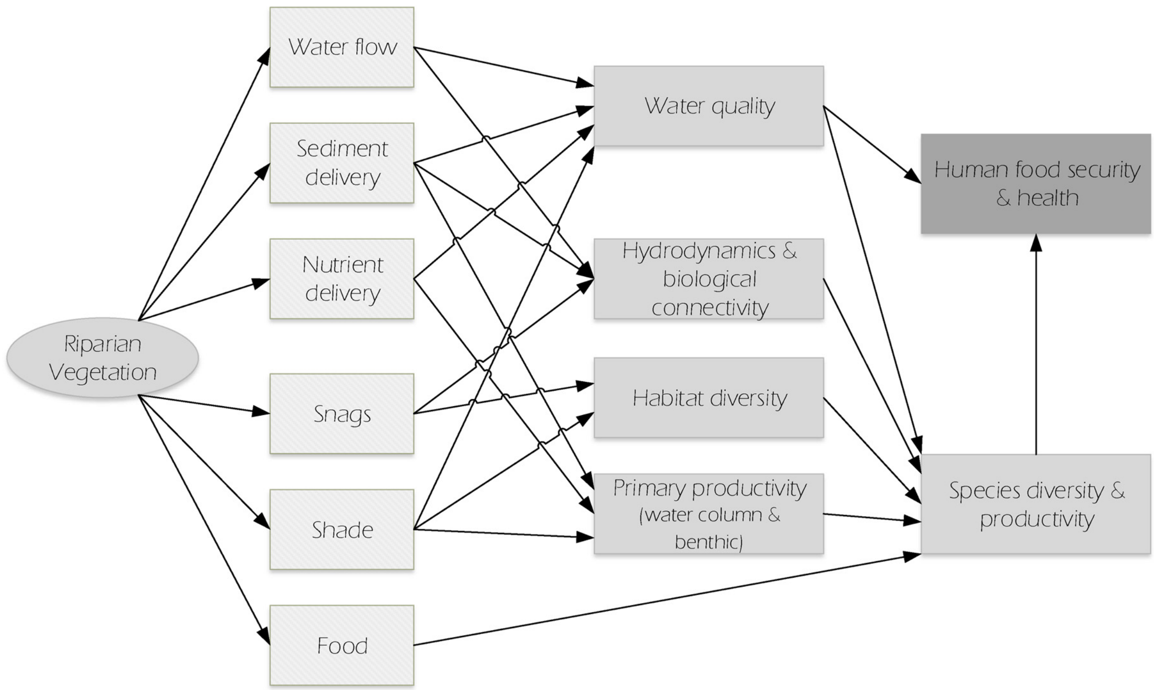

Fig. 1. A summary of the ways in which riparian vegetation influences aquatic ecosystem characteristics, food security and human health. The first set of light filled boxes are impact factors and the second set of darker grey boxes signify aquatic ecosystem characteristics. Biological connectivity is the ability of organisms to move through landscapes to fulfill their necessary life functions.

defoliating insects in Borneo (Gray and Lewis, 2014). Conversion of forest and peatland to oil palm damages stream systems (Anderson, 2008; Luke et al., 2017a), and streams draining oil palm plantations have been shown to have elevated temperature and total suspended solids concentrations (Carlson et al., 2014, 2015; Luke et al., 2017a), although such effects are likely to be very site and situation specific (Chew and Goh, 2015).

There are clearly many gaps in our knowledge about aquatic ecosystems and riparian forests in oil palm landscapes (Foster et al., 2011; Norhayati et al., 2014). These need to be addressed, not just because of the biodiversity values of streams and their riparian buffers, but because local communities are highly dependent on stream resources (Butler et al., 2014) (Fig. 1). In countries like Papua New Guinea (PNG), most of the population relies on streams for drinking, cooking and bathing, as well as a source of fish for protein (Koczberski et al., 2012; Wood et al., 2013). Ensuring the long-term sustainability of aquatic resources is an urgent necessity (Koczberski et al., 2006), with the maintenance of existing riparian vegetation and rehabilitation of lost vegetation priority issues for ensuring improved aquatic ecosystem function and water quality to support human health and food security (Ward et al., 2008), and ecotourism development (Barnett et al., 2016; Sheaves et al., 2016).

In light of the value of streams in oil palm landscapes, and the rapid expansion of oil palm plantations, there is a critical need to ensure the integrity of vegetated riparian zones. A key first step is the establishment of baselines (Kauffman et al., 1997) and effective assessment and monitoring of riparian condition. However, the problem is not simple in developing countries, where large areas need to be surveyed but on-ground conditions, logistics and resources limit the application of detailed techniques requiring high-level remote sensing and detailed on-ground botanical studies. Consequently, simple robust methods for assessing current riparian condition and change over time are urgently required. To address this need we (a) developed a simple remote sensing approach, supported by ground truthing and video surveys, and (b) used the approach to assess the condition and the extent of recent change of riparian zones in oil palm growing areas of West New Britain Province (WNB), PNG.

2. Methods

2.1. Site description

The Kimbe area in West New Britain Province (WNB), PNG (Fig. 2), provides a diversity of stream types (i.e. estuarine and freshwater main river channels and off-channel tributaries) and geomorphological and riparian settings across the full range of oil palm plantation states, from long-term plantations (since 1967) to newly planted areas, and including both company and smallholder plantations. Consequently, the area provides a cross-section of the issues surrounding palm oil production, from population pressures on environments to expansion into new growing areas, as well as the environmental and social issues associated with expansion.

Study sites spanned over 800 km^2 of the coastal plains and adjacent foothills of the Whiteman Range, from Haella in the west to Kapiura in the east, with the Kimbe Bay catchment at the centre (Fig. 2). Historically, lowland rainforest covered most of the coastal plain, and slopes were forested with montane rainforest. However, this region has been extensively logged and cleared since the 1950s, and logging operations persist today in upland sections of many streams. The coastal plain (over 500 km^2 in the study area) is now extensively planted with oil palm (Fig. 1)(Nelson et al., 2010; Webb et al., 2011). Oil palm cultivation began in the study area in the 1960s, with oil palm replacing previous plantation crops (Nelson et al., 2010). The palm oil mills and corporate plantations in the study area are owned by New Britain Palm Oil Ltd (NBPOL). More recent plantings (mainly occurring in the last 15 years) extend onto the foothills of the adjacent ranges. Soils in the study region are predominately comprised of recent volcanic ash (Allen and Bourke, 2009). The area is volcanically active and there are landslips visible on many slopes. There is a clear seasonal pattern in rainfall with monthly totals exceeding 500 mm common from December to April and annual rainfall of around 3–4 m (Allen and Bourke, 2009).

Study sites included rainforest streams upstream from oil palm