

# Systems dynamics model for Indonesia's terrestrial national parks

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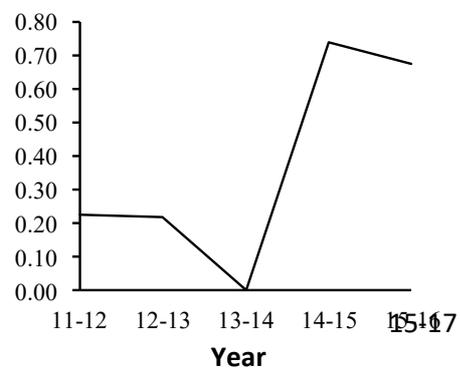
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## ABSTRACT

Protected areas (PAs) around the world have main goals conserving wildlife and habitats. However, PAs in Indonesia is still equal to non-PAs such as industrial forest in their ability to conserve the forests (Gaveau *et al.*, 2012). PAs ability to stop forest loss and wildlife extinction is highly related to PAs management effectiveness (Bruner *et al.*, 2001). Other important factors are the interaction of PAs and their surrounding areas. Siregar *et al.* (2018) showed that complex non-linear conditions affected forest cover in West Kalimantan, Indonesia in which included PAs. We believe the same conditions apply in other islands of Indonesia.

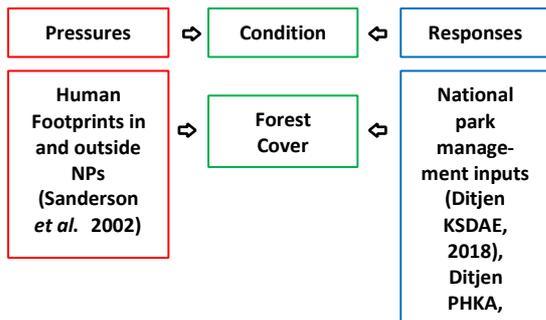
Among many of its PAs, Indonesia currently has 54 national parks (NPs), consisting of 47 terrestrial NPs and 7 marine NPs. In Indonesia, NPs have the best management institution compare to other PAs statuses. Because of that, this study is only concerned with NPs, especially the 43 terrestrial NPs established up to and including 2012. In 2014, there were changes in Indonesia's PAs management. Previous to 2014, PAs were managed under the Directorate General of Forest Protection and Nature Conservation (Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam – PHKA), Ministry of Forestry, and then changed under the Directorate General of Natural Resource and Ecosystems Conservation (Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem – KSDAE), Ministry of Environment and Forestry. The major differences between the 2 managements are, law enforcement power is within the directorate general PHKA itself, while KSDAE now has to work with different directorate general within the Ministry of environment and forestry for law enforcement. These changes were meant for better protection and conservation efforts.

## Percentage of forest cover loss



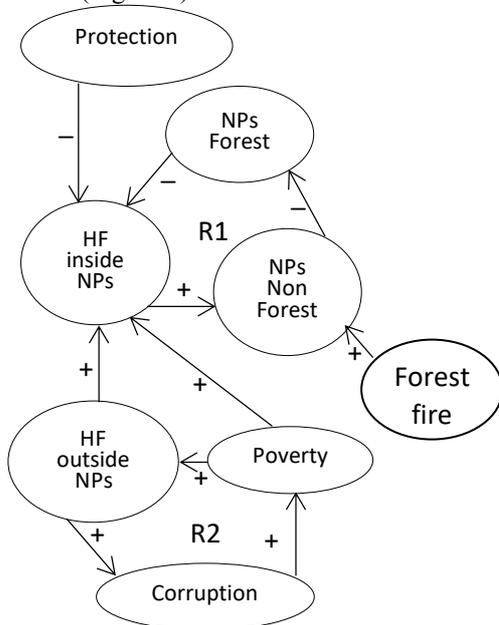
**Figure 1.** Percentage of total forest cover loss in 43 terrestrial national parks in Indonesia from 2011 to 2017.

Total percentage of forest cover loss were noticeably increased between 2014 and 2015 just after the above management changes (Figure 1). However, the changes were more likely influenced by forest fire occurred in 2015. Government data showed that total forest fires in 2015 were hundreds of thousands of ha compared to thousands of ha in other years (2011-2017). Hence, this study aims to analyze the direct and indirect impacts of the complex influencing factors using system dynamics modeling. The model will also predict the NPs forests cover future conditions. The model is first built using pressures-condition-responses framework (Figure 2) modified from Geldmann (2013), in which the impacts of human footprints scores within and 10-km outside the PAs (pressures) and management inputs of NPs (responses) to NPs forest cover (condition) were first statistically analyzed using multiple regression and principal component analyses in R to determine the most influential ones.



**Figure 2.** The pressures-condition-responses framework used in the study analysis.

Influencing variables defined from the linear statistics analyses plus additional common problems such as poverty and corruption were then used to build causal loop diagram of the system dynamics model (Figure 3).



**Figure 3.** Causal loop diagram of the system dynamics model for Indonesia's terrestrial national parks (HF: Human Footprint, NPs: National Parks, R: Reinforcing relation, +: positive relation, -: negative relation).

This study will be the first combining linear and system dynamics analyses to define influencing factors of forest loss in Indonesia. This study will also be the first looking at the influenced of PAs internal management inputs as well as external pressures from human activities onto the conditions of forest inside protected areas, especially national parks.

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