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The Impacts of Forest Landscape Changes on Ecosystem Provisioning Services in the North Central Mountainous Areas, Vietnam

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Introduction

Natural forest landscape change causes serious effects to ecosystem provisioning services in A Luoi district, Thua Thien Hue province. The natural forest area spatially declined over time, which showed the decrease of ecosystem services provisioning possibility. Land cover and land use comparison with forest quality evaluation and forest quality in terms of structural parameters confirmed the decline of natural forest area and its quality correlated significantly to land use change in the study area.

Study Site

The study area is located between the north and the central Truong Son Mountain Range. It is ecologically situated in the north central area of Vietnam (Fig 1). The study area located between 107°E to 107°30´E and 16°N to 16°30´N in the western part of Thua Thien Hue province with typical complex topographic terrain, the elevation ranged 156 to 1162m a.s.l and total annual rainfall of more than 3300 mm, mean temperature is 22.5°C, the highest temperature is 26.1°C and lowest temperature is 18.5°C. The area is dominated with moist evergreen forests.

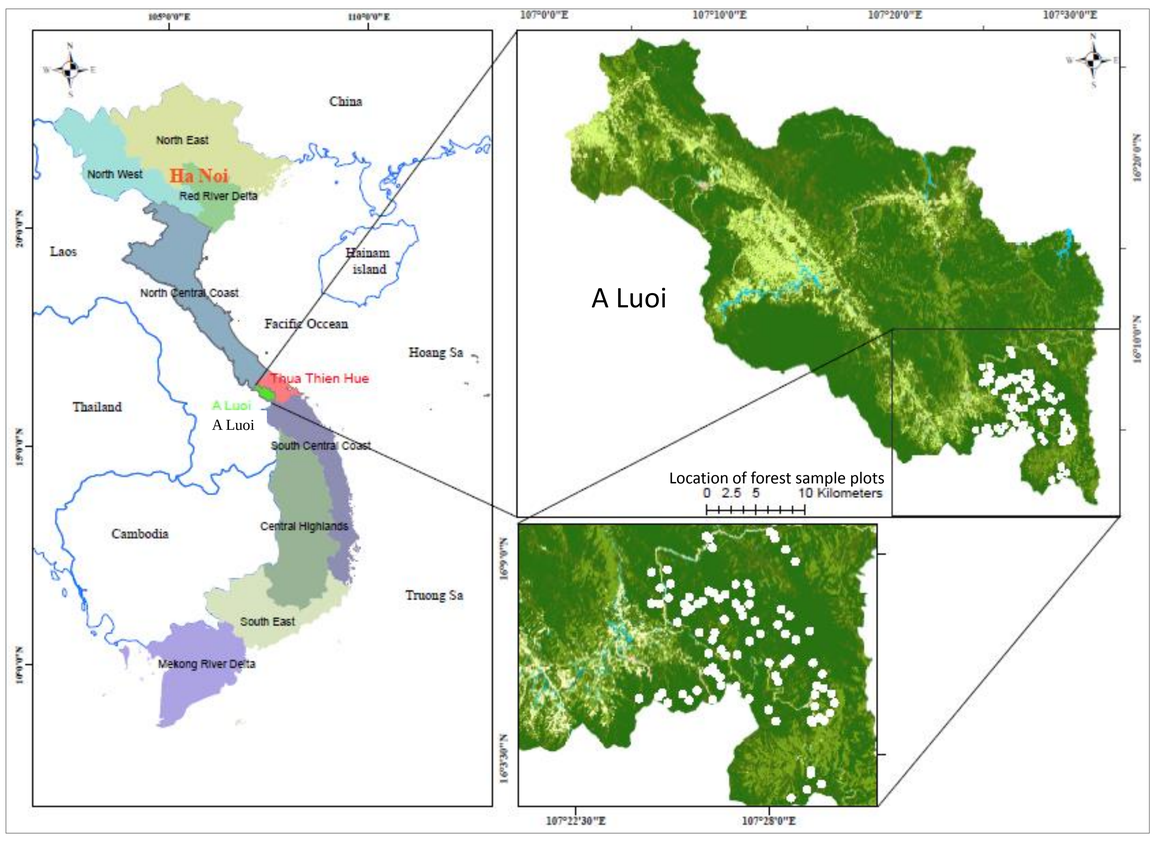
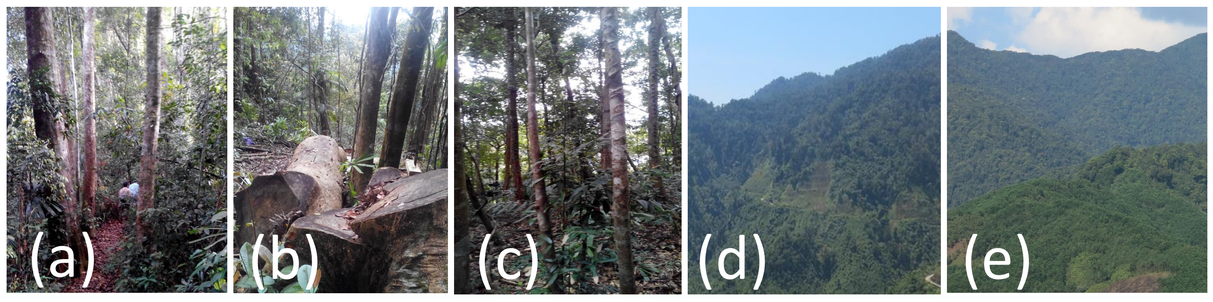


Fig. 1. Location of the study area

Methods

Forest inventory was randomly sampled on forests which were classified into three types: Undisturbed (UF), Disturbed (DF) and Low Disturbed(LD). All trees with DBH ≥ 10cm were measured. Forest inventoried data analyzed (Table 1) and (Equation a). The Landsat5 (TM, 1989) and Landsat8 (OLI, 2016) were used to extract NDVI to compare the vegetation index change over time series (Fig 2). Supervised classification of land cover on two time series 1989 and 2016. All land cover classification and NDVI values calculation were done in ArcGIS. T- test analysis was done to test the significant difference between NDVI values and forest parameters of different forest types by using Statistica 13.3. Supervised land cover of 1989 and 2016 was done to compare the land cover areas in the study area.



Photos showed the natural forest landscape change in the study area

Results

Table 1: Forest Inventory data and NDVI values per forest type

Forest status	Plot area (m^2)	No. Plots	Mean stem density (ha^{-1})	Mean BA (m^2 ha^{-1})	Mean volume (m^3 ha^{-1})	Mean DBH (cm)	Mean NDVI 1989	Mean NDVI 2016
UF	1000	26	$526^{6.3a}$	$39^{0.8a}$	$432^{11.8a}$	$26.3^{2.6a}$	$0.43^{0.09ab}$	$0.44^{0.06a}$
LF	1000	32	$487^{10.2ab}$	$24.7^{0.3b}$	$250^{3.3b}$	$22.7^{2.2b}$	$0.44^{0.07b}$	$0.43^{0.06a}$
DF	1000	32	$378^{13.1c}$	$13.8^{0.4c}$	$129^{4.1c}$	$20.0^{2.5c}$	$0.48^{0.07a}$	$0.43^{0.07a}$

(*The same lowercase letters showed no significant difference at p<0.05)*

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The parameters of three forest types showed significant difference with p<0.05. The UF had highest number of stem density, Basal area, volume ha^{-1} including DBH followed by LF. DF has the smallest values of those stand parameters. The NDVI values of UF increased very little from 1989 to 2016 but that decreased in LF, especially decreased more in DF (Table 1). The mean DBH, BA, volume, stem density ha^{-1} and NDVI of 1989 and 2016 of three different forest types were presented in Fig 2 where the NDVI of LF and DF in 1989 was significant difference (p<0.05). The SOC contents in Table 2 showed the SOC, N and pH values of soil quality at different land use types in the study area. Land use change between 1989 and 2016 were presented in Fig 3,

Table 3. Forest quality change in different forest types was expressed by equations 2; 3; 4 for further modelling. Equation a: $V = 0.0002326 \times \mathrm{DBH}^{2.3457}$

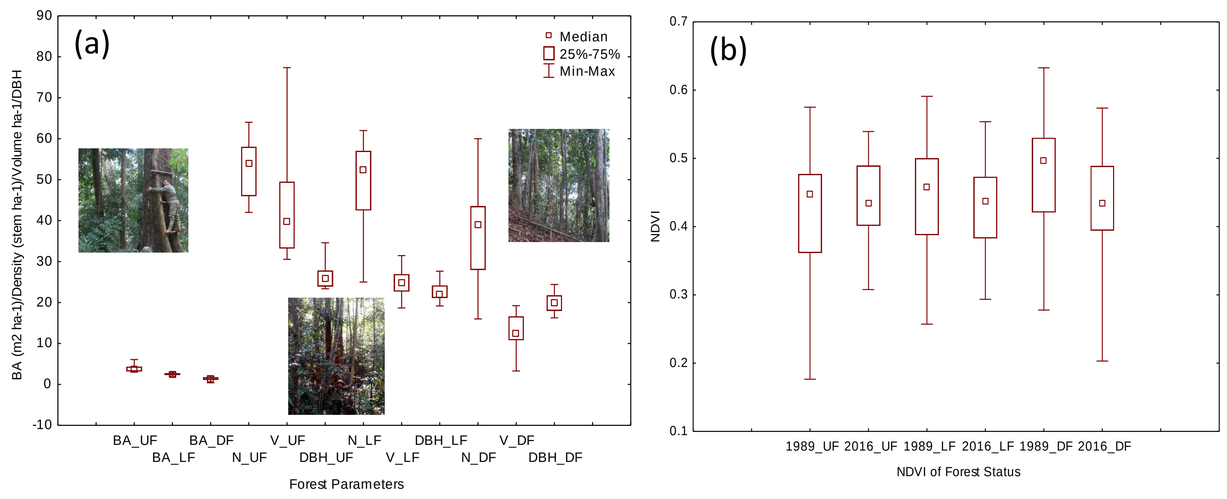

Fig 2. (a) mean of basal area, of forest status, (b) mean of NDVI values of different forest status in 1989 and 2016

Table 2: Mean values of SOC, N and pH at 0-30cm depth in the study area

Land use type	No	SOC	N	pH
GL	31	1.10 ± 0.40^{aA}	0.107 ± 0.030^{aA}	4.05 ± 0.19^{aA}
NF	50	1.18 ± 0.36^{aA}	0.090 ± 0.029^{bA}	4.05 ± 0.16^{aA}
PF	31	1.43 ± 0.44^{bA}	0.115 ± 0.030^{aA}	4.05 ± 0.17^{aA}
AL	43	1.50 ± 0.44^{bA}	0.104 ± 0.025^{aA}	4.24 ± 0.18^{bA}

(No: Number of samples; within columns, values followed by the same lowercase letter (a, b) are not significantly different (p<0.05) between land use types; within rows, values followed by the same capital letter (A, B) are not significantly different (p<0.05) between soil depths).

Table 3: Land cover change in 1989 and 2016

Land use types	Area 1989 (ha)	Area 2016 (ha)	Difference (ha)
GL	10.501	8.491	2.010
NF	56.914	35.288	21.626
PF	49.140	57.926	(8.786)
AL	5.815	20.716	(14.901)

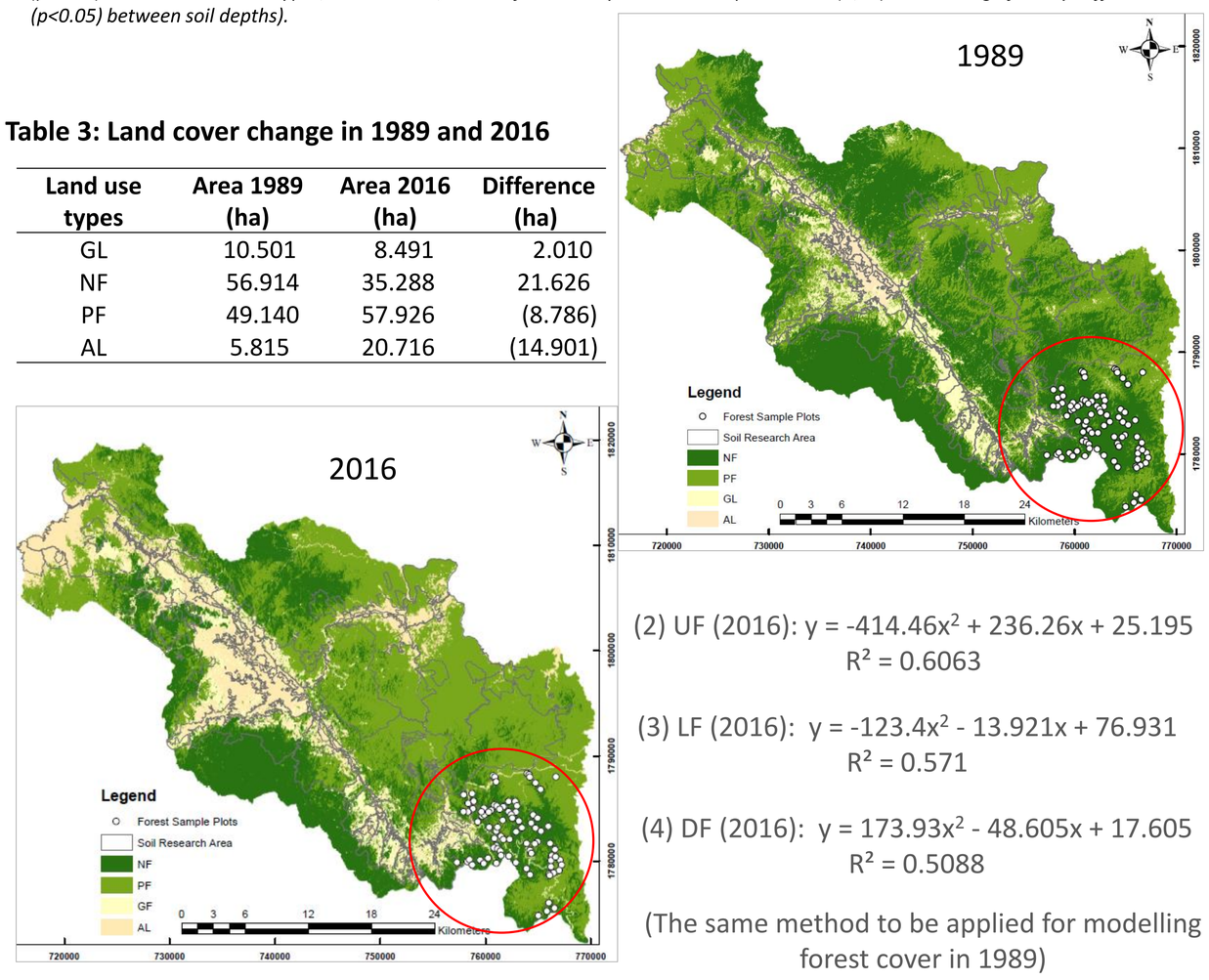

Fig. 3. Land cover classification 1989 and 2016

(2) UF (2016): $y = -414.46x^2 + 236.26x + 25.195$
$R^2 = 0.6063$

(3) LF (2016): $y = -123.4x^2 - 13.921x + 76.931$
$R^2 = 0.571$

(4) DF (2016): $y = 173.93x^2 - 48.605x + 17.605$
$R^2 = 0.5088$

(The same method to be applied for modelling forest cover in 1989)

Conclusions

The forest landscape changes impacts to the ecosystem services provisioning in the study area. It may lead to the food security, wood, fresh water, fiber, fuel decrease of ecosystem provisioning.

Causes of forest landscape changes mostly derive from anthropogenic sources which relates to the management perspectives of natural forest landscape in the study area.

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