# Influence of land use systems on soil resources in northern Thailand

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## Abstract
In order to investigate the link between different land use types on seasonal changes of soil properties and soil degradation, a field trial was carried out in northern Thailand, Mae Hong Son province, Pang Ma Pha district, covering five land use types namely secondary forest (SF), mixed orchard (MO), maize field (MF), upland rice field (RF) and fallow land (FL).
The measured data under different types of land use were the amount of soil translocation rate using modified Gerlach troughs. Furthermore, soil properties such as bulk density (BD), aggregate stability (SAT), infiltration rate (IR), soil texture (sand-silt-clay), total stored soil water (TSW), soil reaction (pH), extractable phosphorus and potassium (Ext.P and Ext.K), and organic matter (OM) contents were determined under each land use type.
The effects of different land use types on pH values were not different and OM values under different land use systems tended to be low. MF-B and MF-A gave the highest Ext.P and Ext.K, when compared to the other land use types. Furthermore, the highest and the lowest values of BD values were found in RF-A and SF while MF-A and FL had the highest values of IR and SAT, respectively.
Different types of land use had an essential influence on the soil translocation rate. The measurement of soil translocation showed that the lowest rate of translocation was found under SF as well as under MO or FL, while RF and MF tended to give the highest and the second high translocation rate compared to the other types of land use.

## Key Words
Conventional agriculture, soil translocation, total stored soil water

## Introduction
The study area is located in the mountainous Mae Hong Son province in northwestern Thailand. The traditional agriculture system in this area was based on crop rotation including fallow periods more than five years. During the last decades, land use was intensified and the fallow periods were reduced or abolished due to population growth and land pressure (Schuler 2008), causing severe soil erosion accompanied by soil losses varying from 5 – 297 t/ha/y (Vlassak *et al*. 1992, Panomtaranichagul 2005) under rainfall ranging from 1,132 – 1,723 mm/y. These soil losses are continually leading to critical deterioration in soil properties, like decreased soil quality, soil productivity and agro-ecological quality (Panomtaranichagul 2005). The purposes of this paper are (i) to present field results during 2007 – 2009, which compared the effects of land use systems on the seasonal changes of soil properties and soil water storage, and (ii) to investigate the variation of soil translocation under different types of land use.

## Methods
The investigation was conducted around the villages Bor Krai and Luk Kao Lam, Pang Ma Pha district, Mae Hong Son province, Northern Thailand, at 19° 33' N and 98° 12'E, at 600 – 1100 m above sea level. The petrography consists mostly of limestone and claystone (Schuler 2008). The most common reference soil groups in the study area are Alisols (IUSS Working Group WRB 2006). Climatic measurements for the years 2004, 2005 and 2007 showed that the mean annual precipitation ranges from 1,200 to 1,550 mm, falling mainly in June to October, with a mean annual temperature of 22°C. Five types of land use were studied in eight small catchments, (i) secondary forest (SF), (ii) mixed orchard (MO), (iii) maize field in three different sites (MF-A, MF-B and MF-C, respectively), (iv) upland rice field in two locations (RF-A and RF-B, respectively), and (v) fallow (FL). MO, MF-A, RF-A and FL are on soils from clay stone, while soils from

limestone are supporting SF, MF-A, MF-C and RF-B. Measurements of soil translocation and soil properties were recorded from 2007 to 2009. The measurements were done in SF, MO, MF-A, RF-A and FL only in 2007. In 2008 and 2009, the measurements were obtained in all studied sites.

Investigation of soil translocation (soil loss and soil deposition) was measured using modified Gerlach troughs (GT) made of local bamboo. Gerlach troughs were installed in a W-formation on each field. Their quantity depended on the size of each small catchment. The soil translocation of different slope sections was determined by comparing the input of a higher GT row with the output at a lower GT row. The quantities of samples (soil sediment) taken from the upper GT row are subtracted by those from the lower GT row; then divided by the area between the two rows. In the study, soil translocation per slope segment was calculated in t/ha.

Soil sampling (composite and undisturbed soil samples) and field measurements of soil properties (physical, hydrological and chemical) at 0–200 mm, like bulk density (BD), stable aggregates based on total soil mass (SAT), steady infiltration rates (IR), soil reaction (pH), extractable P (Watanabe and Olsen 1958), extractable K (Jackson 1958; Black 1965) and organic matter (Black 1965). Moreover, total stored soil water within 1 m soil depth was taken 200 mm soil depth increments and calculated as equivalent depth of water (mm).

## Results

### Soil chemical properties

The average values during rainy season of soil chemical properties within 200 mm soil depth, under different land use systems showed similar trends. Values of pH were not significantly different among all land use types, FL and MO tended to give the highest and the lowest pH values, with the range from 5 – 7 (Fig 1a). OM of limestone soil tended to have higher values than in claystone soil. The mean OM values of all sites were low throughout the study period (Fig 1b). The highest and the lowest values were in MF-C (6.36 g/100 g) and RF-A (2.68 g/100 g), compared to the other land use types.

In general, seasonal changes of extractable P values increased during the study period. Meanwhile, the values of extractable K decreased dramatically from 2007 to 2009 (Fig 1c, d). MF-B and MF-A gave the highest values of extractable P (72 mg/kg) and extractable K (377 mg/kg), on the other hand, the lowest extractable P (25mg/kg) and extractable K (160 mg/kg) values were measured in SF and MO respectively.
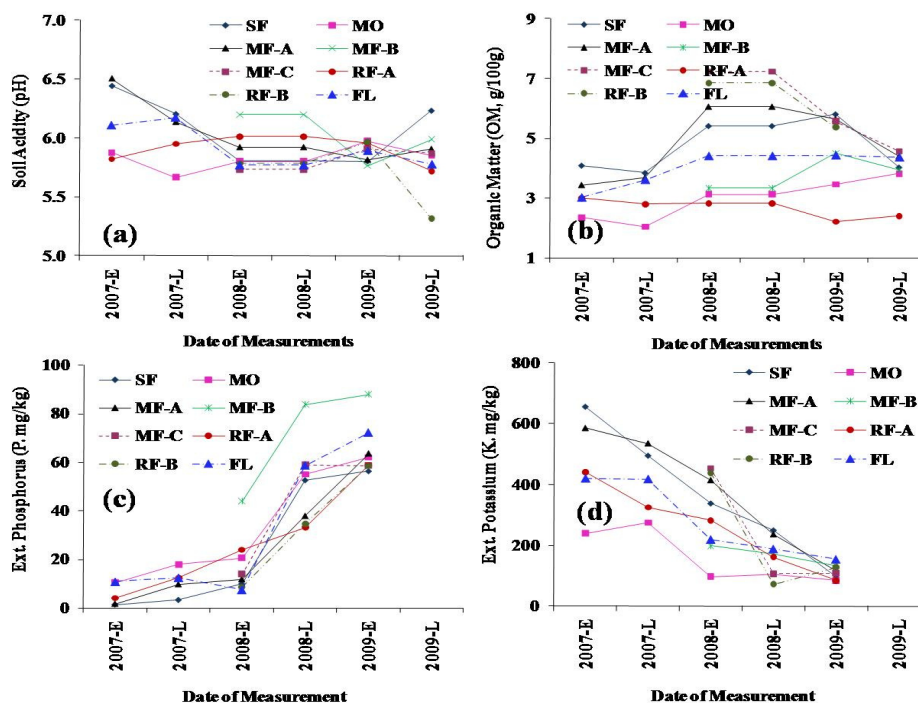


**Figure 1. Average values of soil chemical properties within 200 mm soil depth, (E) = early rainy season, (L) = late rainy season, (a) soil acidity (b) organic matter (c) ext. phosphorus and (d) ext. potassium under different land use types during 18 June 2007 to 30 December 2009.**

### Soil physical and hydrological properties

The results showed similar changes for all soil physical and hydrological properties under the different types of land use. In general, soils from claystone (MO, MF-B, RF-A and FL) tended to give higher values of BD than soil from limestone (SF, MF-A, MF-C and RF-B) (Fig 2a). BD tended to decrease from early of rainy

season to mid of rainy season, then slightly increased to late of rainy season, while SF and RF-A showed the lowest BD (0.88 Mg/m$^3$) and the highest BD (1.32 Mg/m$^3$) values respectively. MF-A tended to have the highest IR values (88.01 cm/hr), while FL had the highest SAT (49.2%) values (Fig 2b). The average IR and SAT values were not correspondent to each other because different land use systems showed different soil structure, which govern sub- surface soil pore continuity and IR but not SAT of the surface soil.

The seasonal variations of total stored water within 1 m soil depth (TSW) under different land use types showed similar trends (Fig 2c). TSW was significantly affected by land use system. In comparison to soils from limestone, soils from claystone led to lower TSW values. SF tended to have the highest amount of TSW during 18/6/2007 - 25/5/2008, while, during 25/5/2008 – 30/10/2009, the highest values of TSW were found in MF-C and RF-B due to the highest clay content including higher IR, SAT and lower values of BD. However, during the dry season (8/9/2007 – 25/5/2008 and 17/12/2008 – 25/4/2009), SF, MO and FL had the highest values of TSW.
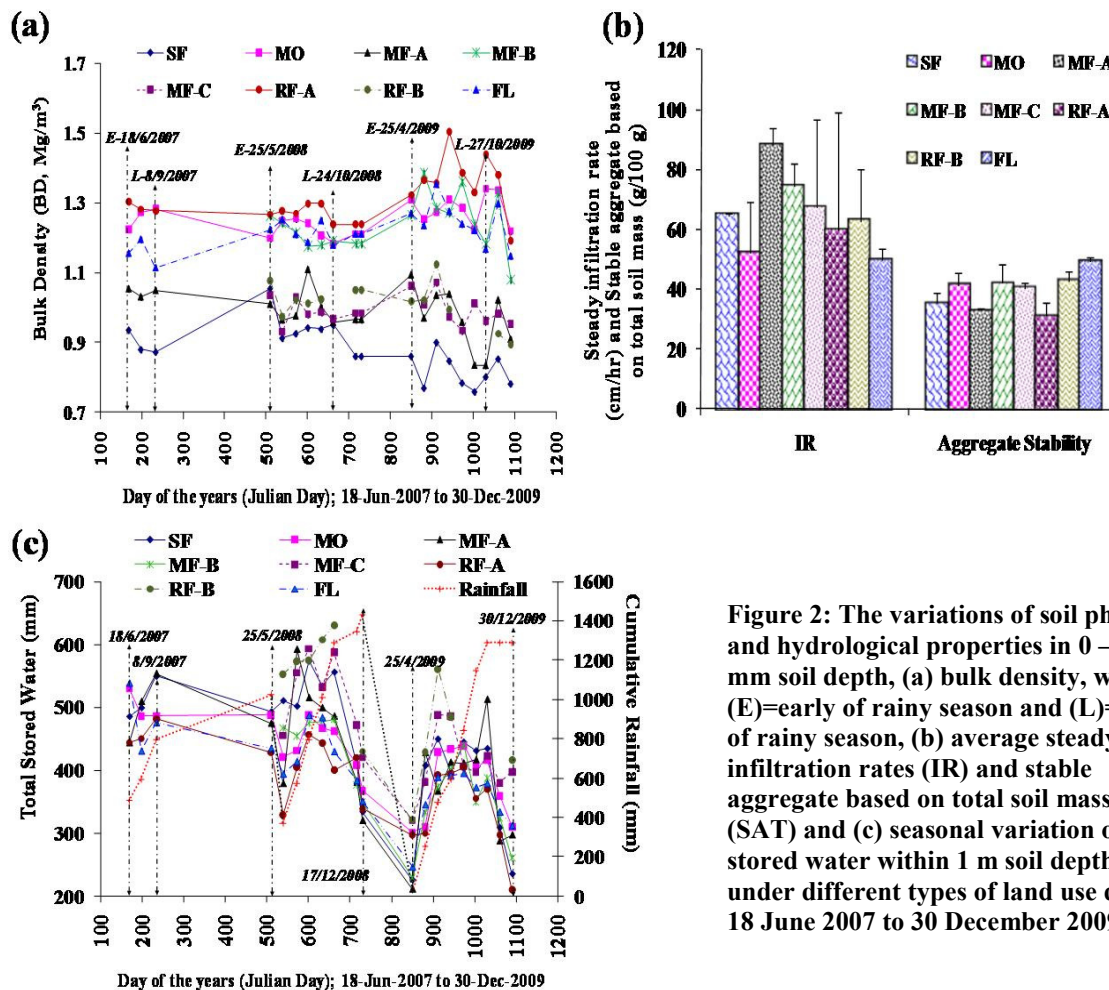


Figure 2: The variations of soil physical and hydrological properties in 0 – 200 mm soil depth, (a) bulk density, when (E)=early of rainy season and (L)=late of rainy season, (b) average steady infiltration rates (IR) and stable aggregate based on total soil mass (SAT) and (c) seasonal variation of total stored water within 1 m soil depth under different types of land use during 18 June 2007 to 30 December 2009.

*Soil translocation*

Calculated soil translocation rates under different land use systems during the study period displayed negative and positive values. These values were interpreted as soil deposition and soil loss (soil erosion), respectively. High translocation rates were found in MF-A, MF-B, MF-C, RF-A and RF-B, especially in RF-A, with the rates of -19.1, 23.4 t/ha and -25.2, 23.8 t/ha and -21.0, 32.1 t/ha observed in 2007, 2008 and 2009, respectively (Fig 3a-c). Soil translocation in SF was not significantly different from MO and FL. It tended to be low, although, MO produced relatively high rates of erosion in 2007 due to water supplied from the upper part. Soil translocation rates in MF-C and RF-B in 2008 were significantly lower than in 2009, because GT measurements were interrupted due to destruction by animals. Limestone soils (MF-A and MF-C) were more prone to soil erosion, than soils from claystone (MF-B) in 2008 and 2009, even though, in 2007 MF-A tended to have a high rate of soil deposition. These might be due to rainfall event different from year to year. RF-A and RF-B tended to produce the same rates of soil deposition and soil erosion in 2008 and 2009. In general, conventional agricultural practice produced remarkably high rates of soil translocation during the early rainy season caused by plot preparation, rainfall distribution, and rainfall intensity and

growth stage of plant. Later in the rainy season, translocation rates decreased after the soil surface was protected by increased crop density.
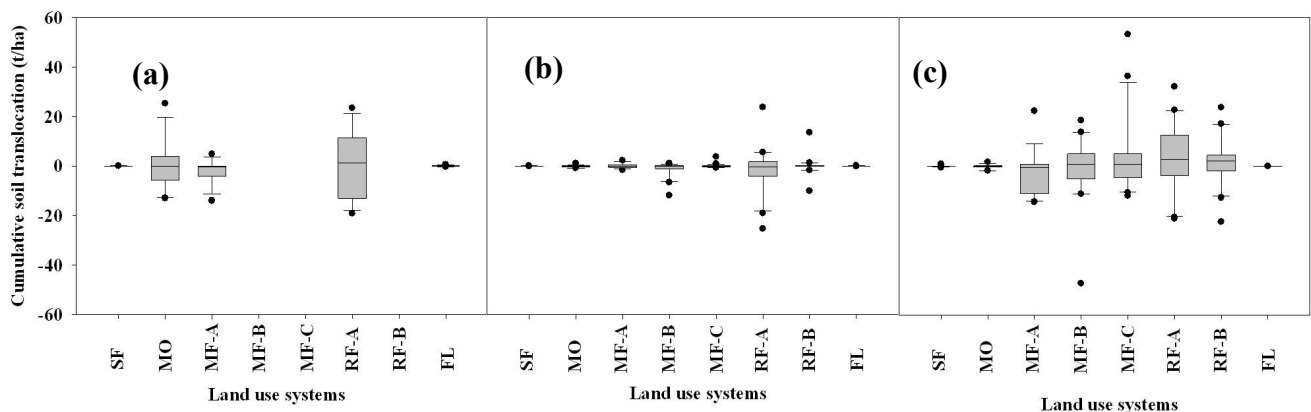


**Figure 3. Cumulative values of soil translocation (t/ha) under different types of land use from May 2007 to October 2009 (a) 2007, (b) 2008 and (c) 2009.**

**Conclusion**
The results indicated that agricultural land use types such as upland rice (RF) and maize fields (MF) tended to enhance soil erosion and poor soil properties. These may lead to degraded both soil and crop productivity. To have a sustainable land use system, SF and MO should be kept as permanent growing trees, otherwise a long period of FL must be applied. Furthermore, annually upland rice and maize should be cultivated under soil conservation practice only.

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