# SPECIES COMPOSITION, PRODUCTION AND NUTRIENT DYNAMICS IN TROPICAL FOREST OF SUNSARI DISTRICT, EASTERN NEPAL

A THESIS SUBMITTED TO THE

**CENTRAL DEPARTMENT OF BOTANY**

**INSTITUTE OF SCIENCE AND TECHNOLOGY**

**TRIBHUVAN UNIVERSITY**

**NEPAL**

**FOR THE AWARD OF**

**DOCTOR OF PHILOSOPHY**

**IN BOTANY**

BY

**TILAK PRASAD GAUTAM**

**APRIL 2015**

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# RECOMMENDATION

This is to recommend that **Tilak Prasad Gautam**has carried out research entitled **"Species composition, production and nutrient dynamics in tropical forest of Sunsari district, eastern Nepal"** for the award of Doctor of Philosophy (Ph.D.) in **Botany** under my supervision. To my knowledge, this work has not been submitted for any other degree.

He has fulfilled all the requirements laid down by the Institute of Science and Technology (IOST), Tribhuvan University, Kirtipur for the submission of the thesis for the award of Ph.D. degree.

**…….**
**Dr. Tej Narayan Mandal**
**Professor,**
**Supervisor,**
Department of Botany, Post Graduate Campus
Tribhuvan University
Biratnagar
Nepal

**[April 16, 2015]**

# LETTER OF APPROVAL

Date:15/06/2015

On the recommendation of Prof. Dr. **Tej Narayan Mandal**, this Ph. D. thesis submitted by Tilak Prasad Gautam**,** entitled**"Species composition, production and nutrient dynamics in tropical forest of Sunsari district, eastern Nepal"** is forwarded by Central Department Research Committee (CDRC) to the Dean, IOST, T.U.

……

**Dr. Pramod Kumar Jha**
Professor,
Head,
Central Department of Botany,
Tribhuvan University
Kirtipur, Kathmandu
Nepal

# DECLARATION

Thesis entitled **"Species composition, production and nutrient dynamics in tropical forest of Sunsari district, eastern Nepal"** which is being submitted to the Central Department of Botany, Institute of Science and Technology (IOST), Tribhuvan University, Nepal for the award of the degree of Doctor of Philosophy (Ph.D.), is a research work carried out by me under the supervision of Prof. Dr. Tej Narayan Mandal, Post Graduate Campus, Tribhuvan University, Biratnagar.

This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

**……..**

(Tilak Prasad Gautam)

Research Scholar

**[April 16, 2015]**

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Tilak Prasad Gautam

April 16, 2015

# ABSTRACT

Tropical forests provide a variety of goods and services to human beings;maintain diverse flora and fauna, and influence climate and carbon cycle. Accelerating rate of deforestation and forest degradationhas reduced the carbon sequestration capacity of tropical forests. In these contexts, understanding and quantifying the tropical forest's functioning is urgently essential. Present study aims to quantify the soil physicochemical properties and microbial biomass, species composition and forest structure, biomass and net production, and nutrient storage and flux in moist tropical forest ofSunsari district, eastern Nepal.

Forest was divided into two parts: central part treated as undisturbed forest (UF) and peripheral as disturbed forest (DF). The soil was sandy loam. The soil organic carbon (SOC), total N, total P and K were higher in UF than DF. The C stock (Mg $ha^{-1}$ soil) in 0–30 cm soil depth was 88.1in UF and 59.3 in DF. Annual mean soil microbial biomass C, N and P were 558.4, 50.7 and 12.3 μg $g^{-1}$, respectively in UFwhich decreased to 438.5, 39.9 and 9.7 μg $g^{-1}$, respectively in DF. Microbial biomass showed distinct seasonality with maximum value in summer season.

Species number of herbs and shrubs increased while that of trees decreased with forest disturbance. Among 60 species of trees belonging to 51 genera and 32 families, 11 were canopy trees, 22 middle storey trees and rest 27understorey trees. Shannon-Wiener index and species richness of herbs and shrubs increased, while that of trees decreased from 3.08 to 2.80 and 9.11 to 6.78, respectively with disturbance. Conversely, Simpson's index for herbs and shrubs decreased (from 0.08–0.05 and 0.18–0.13, respectively) while that for trees increased (from 0.08–0.11) with forest disturbance.

Stand density of herbs and shrubs increased; while that of trees decreased (466–234 individual $ha^{-1}$) with forest disturbance. Similarly, basal area of trees ($m^2$ $ha^{-1}$) also decreased from 111.6 to 52.3. The large diameter trees (> 460 cm gbh) were present only in UF. Based on species IVI, *Shorearobusta*(Sal) occupied the top rank with*value* of 60.4 in UF and 60.9 in DF. In terms of family importance value, Dipterocarpaceae occupied the top rank (53.6 in UF and 53.9 in DF).

The total stand biomass decreased due to forest disturbance from 960.4 to 449.1 Mg $ha^{-1}$. The total biomass (Mg $ha^{-1}$) of the tree layer was 948.0 in UF, which decreased to 438.4 in DF. The biomass of shrubs increased from 4.4 Mg $ha^{-1}$ at UF to 6.1 Mg $ha^{-1}$ at DF. The aboveground herbaceous biomass contributed 0.1% in UF and 0.3% in DF. The annual fine root biomass was 6.6 Mg $ha^{-1}$ in UF and 3.4 Mg $ha^{-1}$ in DF. Total annual litterfallin UF was 11.8 Mg $ha^{-1}yr^{-1}$ which decreased by 54.2% in DF. Fresh litter mass accounted 64% of the total litter mass in both forest stands.

The total net primary production (NPP) of vegetation was 26.58 Mg $ha^{-1}yr^{-1}$ (equivalent to 12.26 Mg C $ha^{-1}yr^{-1}$) in UF and 14.91 Mg $ha^{-1}yr^{-1}$ (i.e. 6.88 Mg C $ha^{-1}yr^{-1}$) in DF. Total C input into soil through litter plus root turnover was 6.78 and 3.35 Mg $ha^{-1}yr^{-1}$ in UF and DF, respectively; indicating substantial retention of C in the vegetation over the annual cycle (45% in UF and 51% in DF). This budget shows that the present forest is C accumulating system.

The nutrient concentrations and their storage in vegetation were in the order: N > K > P in both forest stands. The concentrations of all nutrients were highest in leaves. The quantities (kg $ha^{-1}$) of nutrients in total vegetation in UF were 5738.2 N, 537.7 P and 5232.1 K while in DF they were 2704.4 N, 252.9 P and 2470.8 K. The gross uptakes of nutrients (kg $ha^{-1}yr^{-1}$) in vegetation ranged from 156.8–282.4 N, 16.5–30.1 P, and 124.2–217.7 K while net uptake (kg $ha^{-1}yr^{-1}$) ranged from 116.8–207.7 N, 10.7–19.4 P and 100.5–164.2 K, with minimum in DF and maximum in UF.

Litterfall returned about 1.5 times greater amount of nutrients than fine roots in both forest stands. The nutrient-use efficiencies were in the order: trees > shrubs > herbs. The turnover time (year) for nutrients in standing vegetation of both forest stands was maximum for K (19.9–24.0) followed by N (17.2–20.3) and minimum for P (15.3–17.9). Standing state of nutrients in litter mass followed the order: N > K > P in both forest stands but it decreased with forest disturbance. Total returns of nutrients with respect to net uptake were 60–69% for N, 54–60% for P and 51–62% for K, and rest amount were retained in vegetation.

In conclusion, various types of disturbance activitiesaltered the structure and functioning particularly, carbon sink capacity and nutrient cyclingof Sal dominated forest.

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| | |
|---|---|
| BD | Bulk density |
| DF | Disturbed Forest |
| FRP | Fine Root Production |
| FRT | Fine Root Turnover |
| GBH | Girth at Breast Height |
| GPP | Gross Primary Production |
| ha | Hectare |
| IVI | Importance Value Index |
| K | Potassium |
| MB-C (MBC) | Microbial Biomass Carbon |
| MB-N (MBN) | Microbial Biomass Nitrogen |
| MB-P (MBP) | Microbial Biomass Phosphorus |
| Mg | Mega Gram (1Mg = 1000 kg) |
| msl | Mean Sea Level |
| NEP | Net Ecosystem Production |
| NPP | Net Primary Production |
| Pg | Petagram (1 Pg = $1\times 10^{12}$ kg) |
| pH | Potential of Hydrogen Atom |
| SOC | Soil Organic Carbon |
| Soil mois | Soil Moisture |
| SOM | Soil Organic Matter |
| TotN | Total Nitrogen |
| TotP | Total Phosphorus |
| UF | Undisturbed Stand |
| WHC | Water Holding Capacity |