B-1,5 Estimation of carbon cycling in the *Sasa* type floor vegetation of cool-temperate forest ecosystem (Final Report)

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Abstract The purpose of this study is to clear missing sinks on the terrestrial ecosystems, and establish a full-filled compartment model of carbon cycling in the *Sasa* type floor vegetation of cool-temperate forest ecosystem. The study area was situated at 1400 m a.s.l. on a northwest slope of Mt. Norikura in Takayama, Gifu Prefecture. Vegetation of study area was a secondary deciduous forest established after *Fagus crenata* forest was clear-cut. Presently vegetation was dominated by *Quercus mongolica* var. *grosseserata* and *Betula platyphylla* var. *japonica* and with forest floor of *Sasa senanensis* community. In this time we measured net production, root biomass, deposition rates and soil respiration of the studied forest ecosystem. Especially we estimated carbon cycling within *Sasa* community. Biomass of *Sasa* community in the study area was: 2.86 t.C/ha of above ground and 2.50 t.C/ha of below ground, and its net Assimilation was estimated as 1.09 t.C/ha per year. Annual total soil respiration was inferred as about 6.23 t.C/ha/year, where soil respiration was about 6,600 $mgCO_2/m^2/day$ in May and 14,900 $mgCO_2/m^2/day$ in July. It was clear that during snow period there was 110~500 $mgCO_2/m^2/day$ CO_2 flux released from snow surface, however, at the same time there was about 1,130 $mgCO_2/m^2/day$ CO_2 flux released from soil surface which was 2~10 times more than that from snow surface. This study has achieved remarkably in (1) to clear that the studied *Sasa* community being at a stable situation according to its biomass and net assimilation, and (2) to estimate quantitatively about the total soil respiration of the studied forest ecosystem. In spite of these, further studies are necessary for a full-filled compartment model of carbon cycle in this forest ecosystem.

Key Words Carbon cycling, Floor vegetation, *Sasa* community, Soil respiration

1. Introduction

Until recently, there are still many missing sinks on globe carbon cycling. It is important to clear the missing sinks within arctic and temperate forest ecosystems, since these ecosystems play key roles on globe carbon cycling. However, few studies paid attention to the importance of floor vegetation on carbon budget of cool-temperate forest ecosystems. We noticed this case and chose a cool-temperate forest ecosystem with *Sasa* type floor vegetation as object of study. It is saying that 70% of cool-temperate forests in Japan, their floor vegetation are *Sasa* type and more than 50% of such *Sasa* type floor vegetation are dominated by *Sasa senanensis.* Moreover, it is possible to apply our results in abroad, since *Sasa* genus is one characterized species in southeast Asia and *Sasa* generally has large biomass.

2. Research Objective

The purpose of this study is to understand missing sinks on the terrestrial ecosystems, and establish a full-filled compartment model of carbon cycling in the *Sasa* type floor vegetation of cool-temperate forest ecosystem. The surveys and experiments began from 1993. Surveyed forest was a secondary deciduous forest established after *Fagus crenata* forest was clear-cut. Presently vegetation was dominated by *Quercus mongolica* var. *grosseserata* and *Betula platyphylla* var. *japonica* and with forest floor of *Sasa senanensis* community.

3. Research Field and Methods

1) Location, vegetation and climate of the study area

The study area was situated at 1400 m a.s.l. on a northwest slope of Mt. Norikura in Takayama, Gifu Prefecture(36°09'N,137°26'E), the central region of the main island Honshu of Japan. Vegetation of study area was a secondary deciduous forest established after *Fagus crenata* forest was clear-cut about 40 years ago. In present, *Quercus mongolica* var. *grosseserata* and *Betula platyphylla* var. *japonica* dominate the canopy and the floor vegetation is dominated by *Sasa senanensis*. Vegetation is classified into *Lindera umbellata-Quercus mongolica var. grosseserata* association that is substitutive vegetation of *Fagus crenata-Aucuba japonica* var. *borealis* association.

The climate of study area belongs cool-temperate climate, and geographical location is at the transitional zone between Pacific type and Japan Sea type climate. Annual mean temperature is 7.2°C. From December to March monthly mean minimum temperature is less than 0°C. Annual precipitation is 2439 mm. Mean temperature and precipitation are 19.9°C and 250 mm in the warmest month(August) while they are -4.8°C and 200 mm in the coldest month(January).

2) Methods

In this time, we estimated quantitatively about carbon cycle of *Sasa* community in the forest floor. As to soil respiration, it was measured as the total soil respiration of the whole forest ecosystem. Biomass increment of trees and mass of litter fall were also investigated for estimating carbon budget of the whole forest ecosystem in the future. Detail description of these measuring methods were omitted in here. Staffs and students of the Institute for Basin Ecosystem Studies, Gifu University: Noboru Nishimura, Yoshisuke Matsui, Wenhong Mo, Tadakatsu Okubo, Yoshimichi Saijoh, Tatsuo Ando and Satoshi Tsuda shared the different parts of investigations.

4. Results and Discussion

1) Species composition of studied forest

Vegetation of studied forest is mainly composed of 29 tree species. The dominant species are *Betula ermanii* and *Quercus mongolica* var. *grosseserata* , which are 34% and 23% of total stem volume. The subdominant species is *Magnolia obovata* that is 10% of total volume, and *Betula platyphylla* var. *japonica* that is 9% of total volume. *Acer rufinerve* and *Prunus sargentii* each is 5% of total volume. Vegetation survey was carried out in 1992, and the experimental plots were set in 1993 and measured stem volume increment every year using Aruminum Band Dendrometer.

2) Results of *Sasa* community

Biomass: Seasonal changes in biomass of *Sasa* community were shown in Fig.1. No significant difference was found in annual changes of biomass in *Sasa* community if compared with the biomass of the beginning and the end of *Sasa* growth period. It showed that this *Sasa* community was at a stable situation in biomass on the whole. Fig.2 showed seasonal changes in biomass of *Sasa* above ground organs, and incidated that this *Sasa* community was in an equilibrium status through the whole year. Moreover, results showed that through the growth period, percentage of new organs increased and old organs decreased in this *Sasa* community(Fig.3).

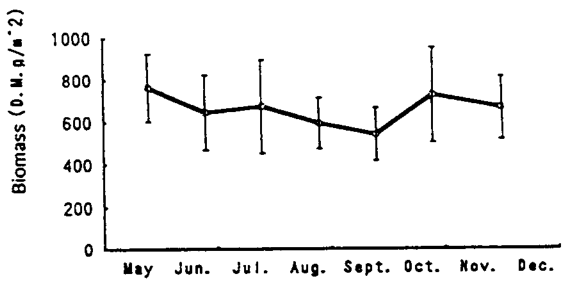

Fig.1. Seasonal changes in above ground biomass of *Sasa senanensis* community. (1993)

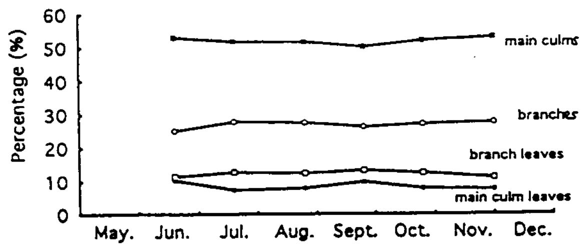

Fig.2. Seasonal changes in biomass of above ground organs (in percentage) of *Sasa senanensis* community. (1993)

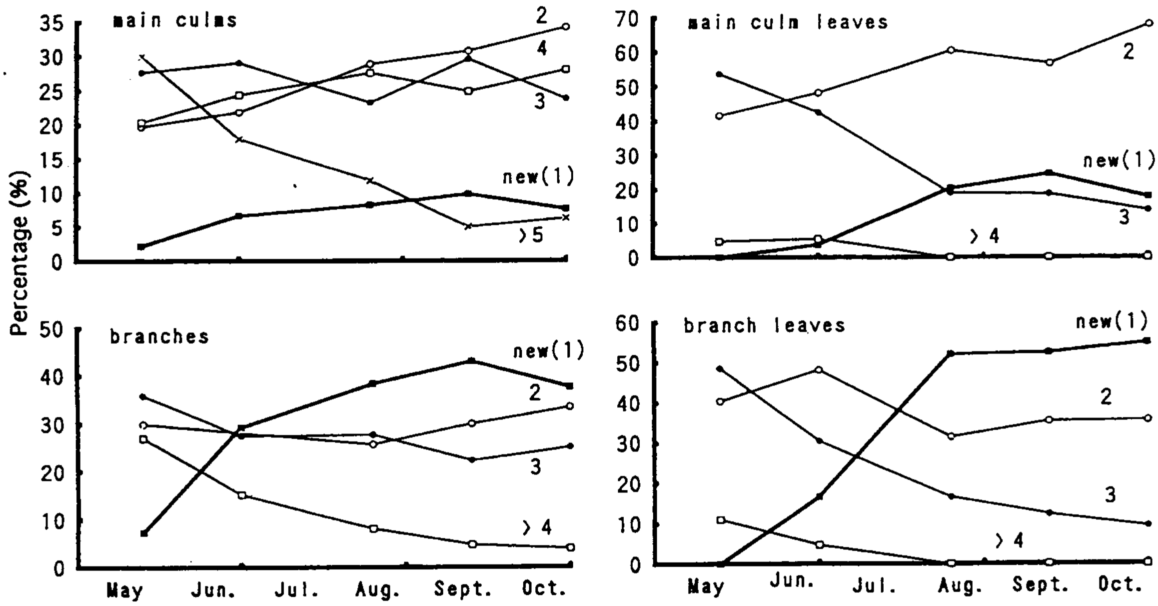

Fig.3. Seasonal changes in biomass of above ground organs with different ages (in percentage) of Sasa senanensis community. (1 9 9 4)

Seasonal changes in biomass and net assimilation of this *Sasa* community were shown in Fig.4 to Fig.9. The net assimilation was calculated by TAC (Total Available Carbohydrates) accumulation and consumption in old organs. Before leaves of trees extending (from May to June) and while leaves of trees beginning to fall down in September, the net assimilation of this *Sasa* community was plus(Fig.9). We assumed that until the early of December the net assimilation might be plus. The net assimilation of this *Sasa* community was minus during summer(from July to August), since high temperature and low irradiation in the floor of forest caused by high canopy trees extending their leaves. During snow period in winter, *Sasa* net assimilation under snow was also minus. Above results showed the productive characteristics of *Sasa* type floor vegetation. Annual net assimilation presumed as biomass of new organs, while hypothesized that this *Sasa* community was in a stable balance situation. At the end of growth period, total biomass of new organs above ground: culms were 17-25% and leaves were 9% of total above ground biomass. Total biomass of new organs below ground was about 5% of total below ground biomass. In addition, Total biomass was about 670 g/m^2 above ground and about 620 g/m^2 below ground. Then the net assimilation of this *Sasa* community might be calculated as 230 g/m^2/year if presumed the composition rates were 30% in above ground and 5% in below ground biomass, respectively.

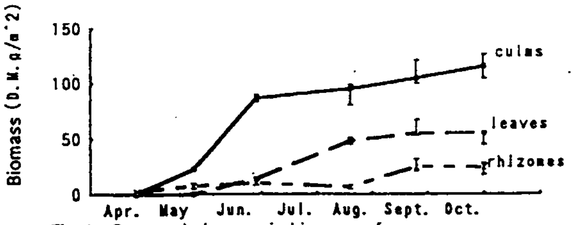

Fig.4. Seasonal changes in biomass of new organs of Sasa senanensis community.

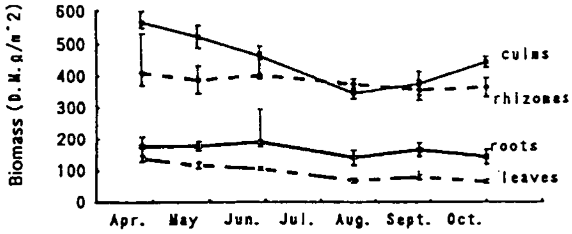

Fig.5. Seasonal changes in biomass of old organs of *Sasa senanensis* community.

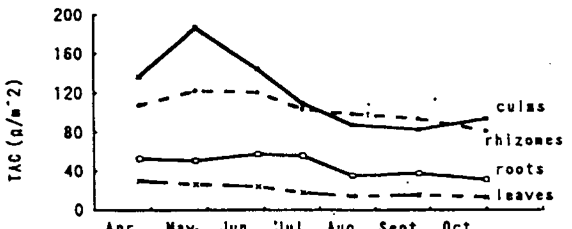

Fig.6. Seasonal changes in amounts of total available carbohydrates(TAC) in old organs of *Sasa senanensis* community.

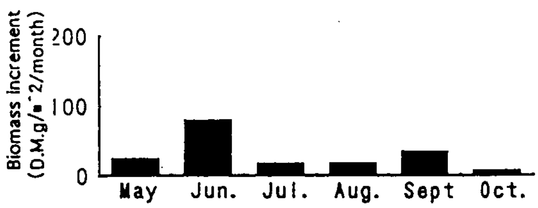

Fig.7. Seasonal changes in monthly biomass increment of new organs *Sasa senanensis* commmunity.

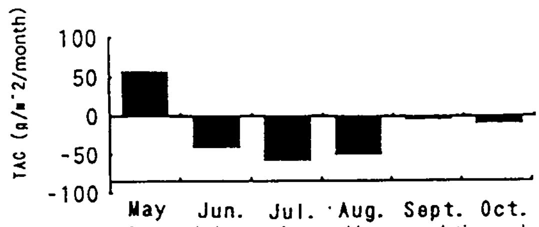

Fig.8. Seasonal changes in monthly accumulation and consumption of total available carbohydrates(TAC) in old organs of *Sasa senanensis* community.

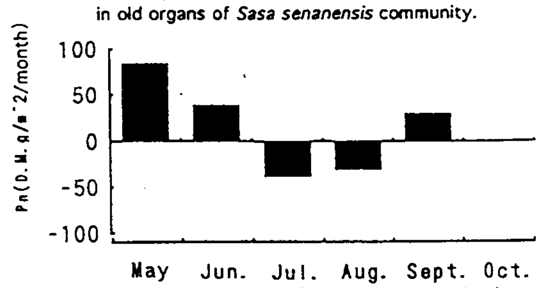

Fig.9. Seasonal changes in monthly net production of *Sasa senanensis* community.

Litter deposition: Numbers of *Sasa* new spouting culms were 9.7 culms/m^2/year. 26% of total new culms might die during summer and 8% of total might die during winter. After winter about 14% of total old culms also dead during summer and during winter 2% of total old culms were inferred to die. We suggested that such dead culms would fall down to litter layer. Although there were seasonal and annual changes of stand litter, all culms would fall down after spouting for every 5 years and all leaves would fall down after grown for every 3 years. Leave fall of this *Sasa* community would depose 50% after 1 year while measured by litter bag method.

Carbon budget: Biomass of this *Sasa* community was shown as before. Then the net assimilation of this *Sasa* community might be calculated as 230 g/m^2/year. We suggested that the same carbon contents of *Sasa* net assimilation, that was, 1.09 t.C/ha carbon flow running to soil from this *Sasa* community.

3) Results of trees

Litter and its deposition: To measure leaf and branch fall were necessary for estimating carbon budget of whole forest ecosystem. 14 litter traps (1mx1m) were set in the study area and investigated. The results showed that about 2.2 t.C/ha carbon accumulated per year from leaf and branch fall although there were seasonal changes.

Leaf fall of 14 tree species were deposed 58% of total (in average) per year. Branch fall were deposed 22% per year and this results were from 4 tree species. On the other hand, dead fine roots ($\leq$ 1 mm, including absorbing roots) were deposed 38% per year, and $\geq$ 10 mm dead roots were deposed 18% per year.

Carbon in soil: Carbon contents in soil were 223.1 t.C/ha in north slope, 240.2 t.C/ha in south slope, 231.7 t.C/ha in average and all results were measured from soil surface to depth of 65 cm).

Soil respiration: Soil respiration of the studied forest ecosystem showed in Fig.10. Every month measured 3 times using the flow-through chamber method. There was 6.23 t.C/ha/year CO_2 flux released to atmosphere from soil surface (including respiration of litter layer).

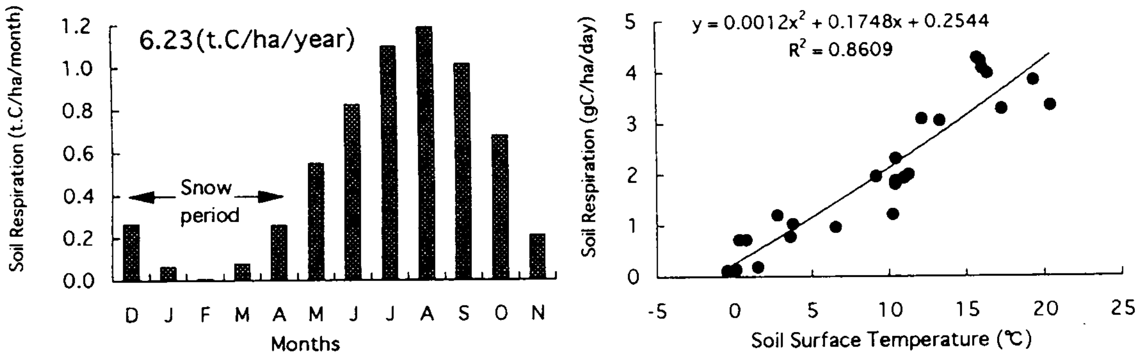

Fig.10 Seasonal changes in soil respiration and its relationship of soil surface temperature in the cool-temperate forest with *Sasa* type floor vegetation.

About methods for measuring soil respiration, mainly we used the the flow-through chamber method like Nakadai (Nakadai et al., 1993 and Koizumi et al., 1991). We set two sites in south and north slope and each site set 4 chambers for measurement, since contents of litter and organic matter in soil were differing between slopes. Results showed that soil respiration (including respiration of litter layer) was 292.0 $mgCO_2/m^2/day$ in the bottom of valley, 558.6 $mgCO_2/m^2/day$ in the upper of south slope and 395.3 $mgCO_2/m^2/day$ in the upper of north slope. We estimated that respiration of litter layer was 27% of total mean soil respiration.

In the end, results showed that soil respiration was deferring in different slopes, places and periods. During summer soil respiration and organic matter deposition were higher in south slope, on the contrary, soil respiration was higher in north slope during winter. The causes of such difference were in discussion, we suggest that our results might be not so much misestimation because they were similar to the values of Nakane (Nakane,1980; 1986).

5. Conclusions

We estimated net production, root biomass, deposition rates and soil respiration of the studied forest, cool-temperate deciduous broad leaves forest. On particular, we estimated carbon cycling within *Sasa* community, the floor vegetation of the studied forest.

Biomass of *Sasa* community in the study area was: 2.86 t.C/ha of above ground and 2.50 t.C/ha of below ground, and its net assimilation was estimated as 1.09 t.C/ha per year. Soil respiration was about 6,600 $mgCO_2/m^2/day$ in May just before *Sasa* sprouting new culms and was 14,900 $mgCO_2/m^2/day$ in July while *Sasa* finished sprouting new culms. It was clear that during snow period there was 110~500 $mgCO_2/m^2/day$ CO_2 flux released from snow surface, however, at the same time there was about 1,130 $mgCO_2/m^2/day$ CO_2 flux released from soil surface which was 2~10 times more than that from snow surface. Then total soil respiration was inferred as about 6.23 t.C/ha/year. Fig.11 showed the compartment model of carbon cycling in cool-temperate deciduous broad leaves forest with *Sasa* type floor vegetation.

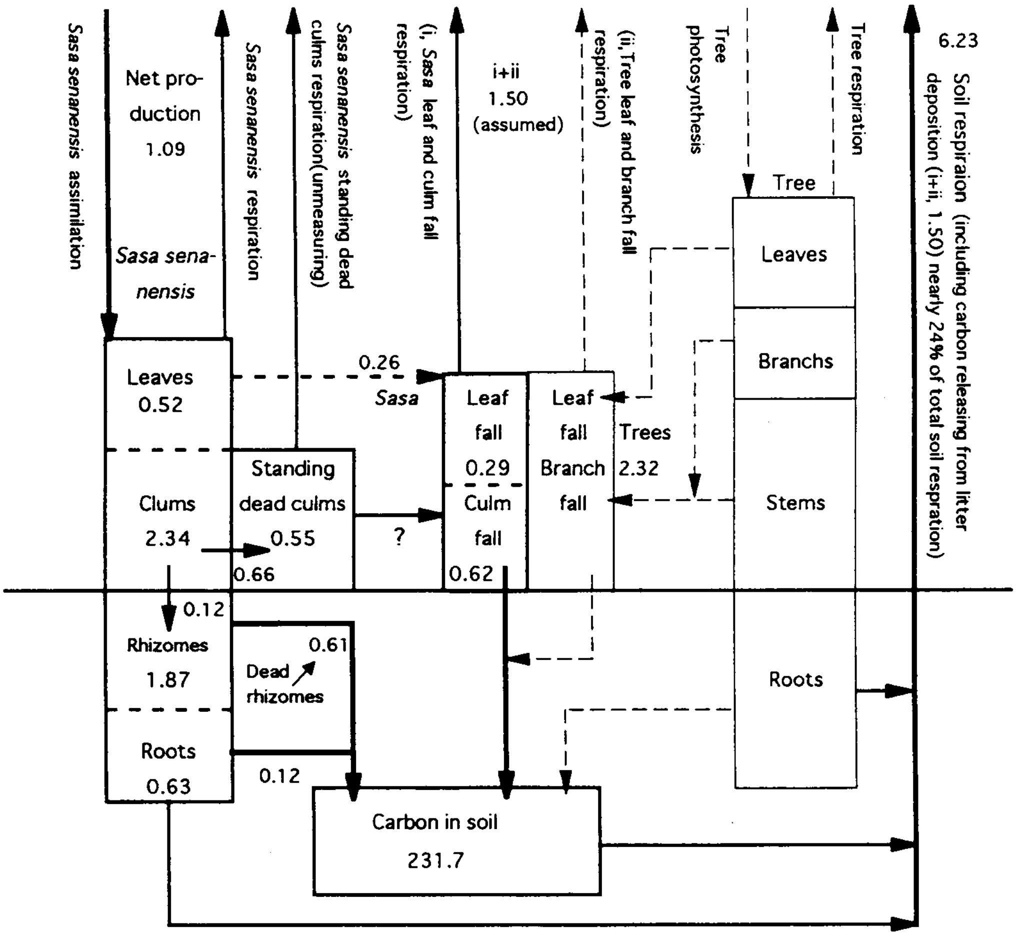

Fig.11 Compartment model of carbon cycle in deciduous broad leaves forest with *Sasa* type floor vegetation in cool temperate zone. (Biomass data was measured in May,1993; Unit: t.C/ha/year)

This study has achieved remarkably in (1) to clear that the studied *Sasa* community being at a stable balance situation according to its biomass and net assimilation, and (2) to estimate quantitatively about the total soil respiration of the studied forest ecosystem. In spite of these, monitor started from two years ago and such monitor period was too short to get the completed results of carbon cycling of the whole forest ecosystem. Further studies are necessary for a full-filled compartment model of carbon cycle in this forest ecosystem.

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