Evaluating the long-term effect of harvest on soil carbon dynamics of *Pinus densiflora* stands in Korea using modeling approach

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Abstract

- We simulated changes in soil carbon (C) density under different harvest conditions for 400 years to evaluate long-term effect of harvest on forest soil C density.
- The simulation was conducted in *Pinus densiflora* S. *et* Z. stands in central Korea, and twelve harvest scenarios were tested by altering harvest intervals (50, 80, and 100-year interval), intensities (partial-cut: 30% and clear-cut: 100% of stand volume), and the post-harvest residue managements (collection: 0% and retention: 100% of aboveground residue).
- As a result, the soil C density in depth of 30cm after 400 years ranged from 50.3 to 55.8 Mg C ha^{-1}, corresponding to 98.1 to 108.9% of the C density at present.
- The soil C density under the residue retention scenario was 2.5-11.0% higher than that under residue collection scenario. However, there was no significant impact of harvest interval and intensity on the soil C density.
- The soil C dynamics depended on the dead organic matter (DOM) dynamics derived from the growth pattern and amount of harvest-induced DOM after harvest.

Introduction

- Harvest is one of the major disturbances affecting the soil C dynamics in forests.
- The pattern of disturbance through harvest varies with harvest regime (harvest interval, intensity and post-harvest management of residue).
- Researches about the long-term impact of harvest regime on the soil C dynamics are usually limited, however, the impact might be evaluated easier by mathematical forest carbon models.
- Recently, the Korean forest soil carbon model (KFSC model) was developed based on local forestry statistics.
- Thus, we adopted the modeling approach to determine the long-term impacts of periodic harvest on the soil C dynamics by using the KFSC model.

Materials and methods

◆ KFSC model description

- KFSC model is a process-based model, simulating the soil organic C only using growth and yield table, site index, stand age, and temperature (Yi *et al.*, in press).
- The model can simulate C flows among live biomass C pools and dead organic matter C pools using turnover rates and decay rates of the pools (Fig. 1).

◆ Study site

- Simulation was conducted in *P. densiflora* stands in central Korea (37° 47′ 01″ N, 127° 10′ 37″ E, 410 – 440 m a.s.l.).
- The initial value of soil C pool was determined by field work (Lee *et al.*, 2009) and those of other pools were estimated by ratio of C pools at simulated steady-state.

◆ Model simulation

- The annual soil C density was simulated for 400 years by altering harvest intervals, intensities, and the post-harvest residue (Table 1).
- Several assumptions were made for illustrating forest growth after harvest

1) The future forest cover is the same as the current forest cover.
2) There are no other disturbances except the periodic harvest.
3) Forest are regenerated promptly on the cleared space after the harvest and the pattern of forest growth will not be changed.
4) Target trees were not selected by their volume; the same portion of trees were harvested among each diameter class when periodic partial-cut harvest was conducted.
5) Harvest does not alter the physical, chemical, and biological soil conditions.

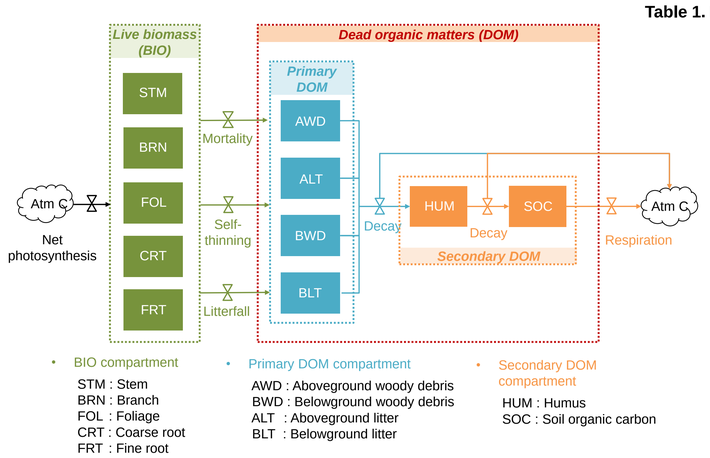

Figure 1. The schematic diagram of the KFSC model (Yi *et al.*, in press)

Table 1. Description of the 12 harvest scenarios simulated using KFSC model

Scenario	Intensity[1]	Residue[2]	Interval (year)
CC50	Clear-cut	Collection	50
CC80	Clear-cut	Collection	80
CC100	Clear-cut	Collection	100
CR50	Clear-cut	Retention	50
CR80	Clear-cut	Retention	80
CR100	Clear-cut	Retention	100
PC50	Partial cut	Collection	50
PC80	Partial cut	Collection	80
PC100	Partial cut	Collection	100
PR50	Partial cut	Retention	50
PR80	Partial cut	Retention	80
PR100	Partial cut	Retention	100

[1] clear-cut: 100% and partial cut: 30% of stand volume
[2] retention: 100% and collection: 0% of aboveground biomass are remained on the forest floor after harvest

Result and discussion

- The soil C density in depth of 30cm after 400 years ranged from 50.3 to 55.8 Mg C ha^{-1}, corresponding to 98.1 to 108.9% of the C stock at present (Fig. 2).
- The soil C stock under the residue retention scenario was 2.5-11.0% higher than that under residue collection scenario. However, there was no significant impact of harvest interval and intensity on the soil C density.
- The soil C density was influenced by the amount of primary DOM produced during simulation.

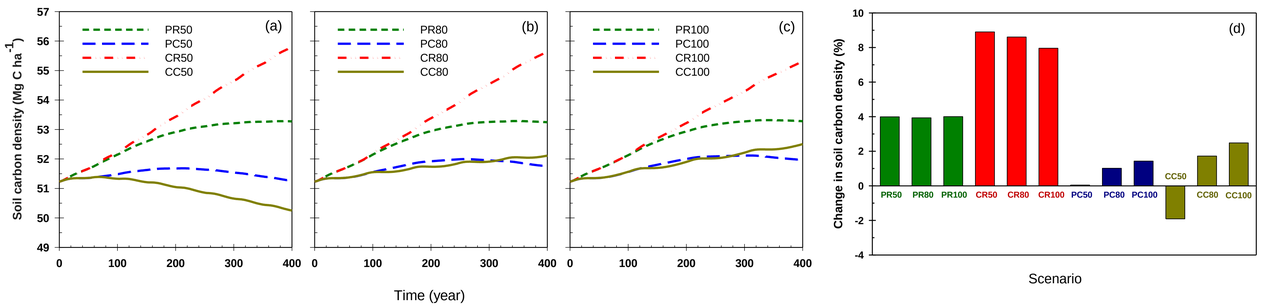

Figure 2. Simulated soil carbon density in depth of 30cm for 400 years (a, b, and c), and the changed value after 400 years compared with present

◆ Impact of harvest interval

- A shorter interval induced a larger soil C density under the residue retention and clear-cut scenario (Fig. 2d; red), and it might be derived from the frequent production of large quantity of primary DOM.
- However, a longer interval induced a larger soil C density under the residue collection scenario (Fig. 2d; blue and yellow), and it might be derived from the decreased input of primary DOM from mature forests.
- The amount of primary DOM were reduced at the end of rotation under the long interval scenario by lowered growth ratio of mature forests (Fig. 3a).

◆ Impact of harvest intensity

- A heavier intensity induced a larger soil C density under the residue retention scenario (Fig. 2d; green and red).
- The amount of harvest-induced primary DOM was getting decreased during the repeated partial harvest since the part of mature forest is remained until the end of simulation (assumption 4) (Fig. 3a).
- Clear-cut harvest produced more primary DOM than partial cut harvest (Fig. 3b).

◆ Impact of post-harvest residue management

- The residue retention management induced a larger soil C density (Fig. 2abcd).
- More C in aboveground residue on forest floor transferred to soil C through decaying process (Fig. 3d).

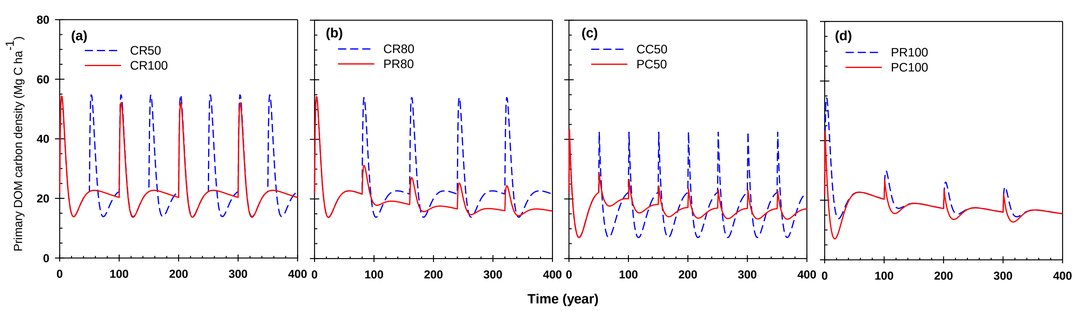

Figure 3. Simulated carbon change in primary dead organic matter pools for 400 years

Conclusion

- The soil C density was higher when the post-harvest residue are retained on the forest floor.
- The impact of harvest interval and intensity varies with other harvest factors.
- DOM dynamics derived from the growth pattern after harvest and the amount of harvest-induced DOM are important factor determining the soil C density.

References

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