DEAD WOOD INVENTORY AND ASSESSMENT IN SOUTH KOREA

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Abstract—Dead wood (DW) plays a critical role not only in maintaining biodiversity but also in stocking carbon under UNFCCC. From the 5th national forest inventory (NFI5; 2006-2010) in South Korea, field data relevant to the DW including standing and downed dead trees by four decay class, *etc.* were collected. Based on the NFI5 data, the average volume of DW over the country is estimated to be 12.3m^3/ha of which the total carbon stock accounts for 10.9 Tg C. Recently, NFI6 (2011-2015) has been implemented into monitoring and assessing forest resources including DW over time. We are to analyze relationship between DW and stand structure for sustainable forest management.

INTRODUCTION

From an economic point of view, dead wood means natural loss for timber production. Since 1996, the dead wood has been recognized as one of carbon pools under UNFCCC (IPCC, 2000) and has played a crucial role in maintaining biodiversity. From the 5th national forest inventory (NFI5) of South Korea (Kim et al., 2010), field data relevant to the dead wood including standing and downed dead trees have been collected. Additionally, to assess Greenhouse gas Inventory in forest sector, biomass conversion/expansion factors for biomass and dead organic matter at a national level have been developed. The objectives of this research are to estimate tree mortality with annual inventory system and to assess carbon stock for dead wood with developed carbon factors by decay classes.

MATERIAL AND METHODS

In South Korea, national forest inventory system has been changed to support sustainable forest management at the national level and to report national forest resources to international institutes including the FAO, UNFCCC, *etc*. The first new inventory was conducted during 2006-2010. In this study, field data from the 5th NFI was used to assess tree mortality and carbon stock with developed carbon factors by decay classes.

Dead wood inventory

Sampling design

With the NFI5 design, a systematic sampling with clusters was adopted. As shown in Fig. 1, the total of 4,000 sample clusters was systematically distributed with a square grid of 4km and 20% of the clusters were surveyed each year (Kim *et al*., 2010).

Plot design

In this inventory system, a cluster plot having 4 subplots was applied. Each subplot consists of the three concentric circles for collecting stand variables (Fig. 1). Dead wood inventory was implemented at the center subplot with a plot size of 400 m^2. On each center subplot, forest variables were collected relevant to dead wood (standing and downed trees) such as tree species, diameter (DBH or DCH), length or height, decay classes by 4 classes, dead cause, *etc*.

In order to convert mortality into carbon stock, biomass conversion factors (BCF) and carbon factors (CF) by forest groups and decay classes were developed (Yoon, *et al*., 2011; KFRI, 2014) as shown in the Table 1. In the case of BCFs, those of non-conifer tree species were slightly higher than those of conifer tree species, whereas CFs of conifer tree species were higher.

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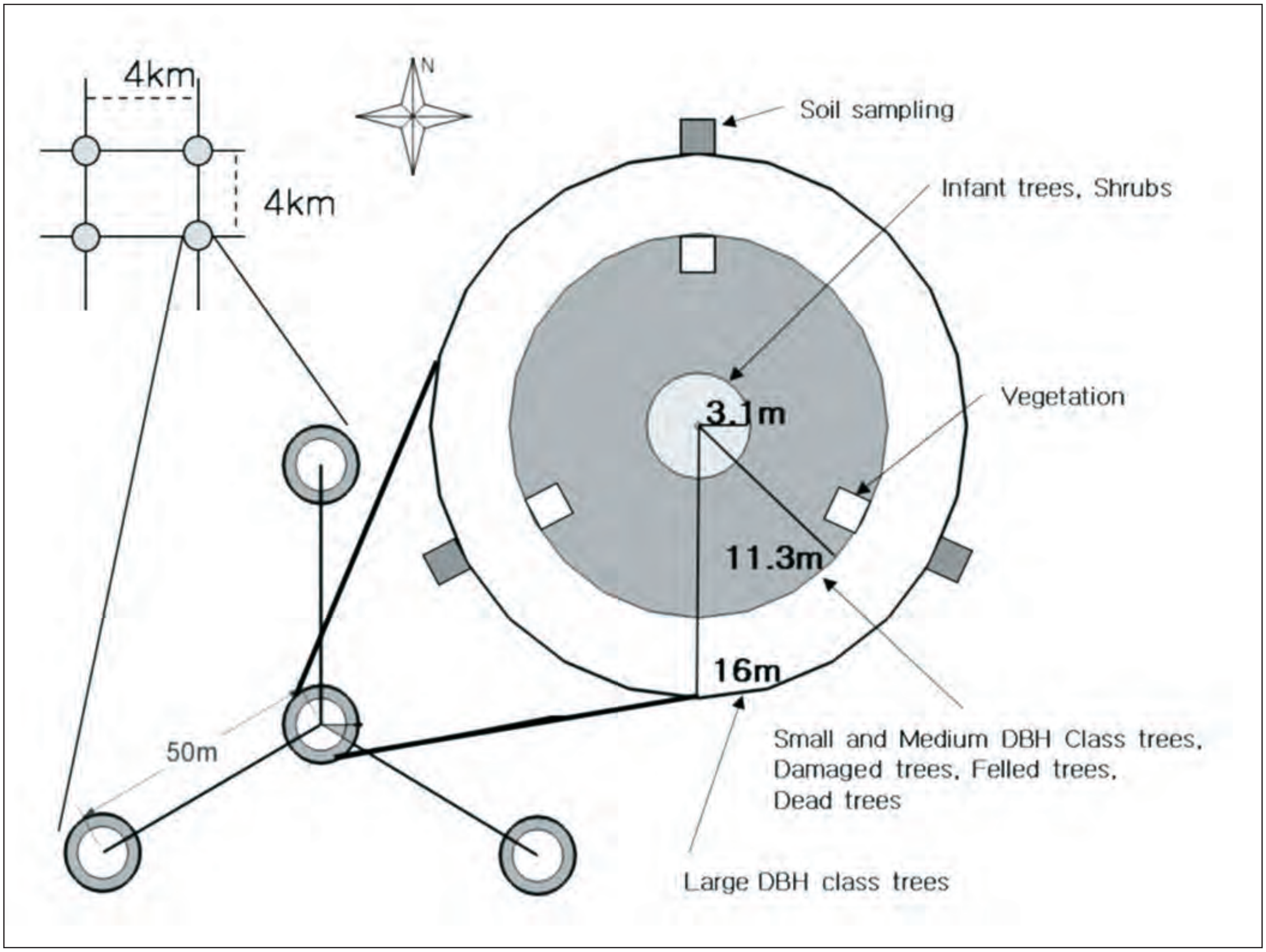

Figure 1—Sampling and plot design for the 5th National Forest Inventory in South Korea.

Table 1—Carbon conversion factors of dead wood by decay classes and tree groups.

	Biomass conversion factors (g/cm3)				Carbon factors (percent)			
Classification	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Conifer	0.38	0.34	0.26	0.15	49.5	50.2	50.2	51.6
Non-conifer	0.48	0.37	0.29	0.16	48.6	48.6	48.6	48.3

Dead wood assessment

Mortality estimation at the subplot level

In order to estimate growing stock volumes for each standing dead tree and felled dead wood, there are two equations that are similar to equations for standing trees. The mortality at a subplot level was estimated by Eq. (2).

$$m_s = f(dbh, height)$$
$$m_f = f(dch, length), \qquad \text{Eq. (1)}$$

$$y_i = \frac{\sum_{s=1}^{n_s} m_s + \sum_{f=1}^{n_f} m_f}{a_i'} \qquad \text{Eq. (2)}$$

where m_s : the mortality of standing dead tree s,
m_f : the mortality of felled dead tree f,
n_s, n_f : the number of standing dead tree (s) and felled dead wood (f) per subplot i,
y_i : total mortality per subplot i , and actual plot size at a subplot i.

Carbon stock estimation at the subplot level

In this study, estimating carbon stock for each dead wood was done with the following equation:

$$c_s = m_s \times cf_s, \; c_f = m_f \times cf_f \qquad \text{Eq. (3)}$$

where c_s, c_f : carbon stock of standing dead tree s and felled dead tree f, cf : carbon factor by decay class and tree group

The total carbon stock at the subplot can be estimated by Eq. (2).

Combining of annual estimates

As mentioned above, field data were annually collected. To combine annual data, we assumed that field data are collected at a same period which is so-called Temporally Indifferent Method (Kangas, 1993; Bechtold and Patterson, 2005; Yim *et al*., 2012). The estimators for simple random sampling were applied (Cochran, 1977).

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}, \quad \hat{\text{var}}(\bar{y}) = \frac{s^2}{n} \quad \text{where}$$
$$s^2 = \frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n-1} \qquad \text{Eq. (4)}$$

RESULTS AND DISCUSSION

Mortality by tree groups

As most forests in South Korea were reforested during in 1970-1980s, current forest areas by age classes are included in 40-50 years (KFS, 2011). The stand density is relatively high accounting for 1,305 trees per hectare on average. Based on NFI5, the average volume of DW over the country is estimated to be 12.3 m^3/ha as shown in Table 2. The total mortality accounts for about 75 million m^3 and the mean mortality is about 12.3 m^3/ha. Mortality could be divided into standing dead tree and felled wood, of which were 3.5 m^3/ha and 8.8 m^3/ha, respectively. As most forests in South Korea were reforested during in 1970-1980s. Recently, numerous trees felled by "the Forest tending project (2004-2008)", however the felled trees left in the forest due to a low forest road density.

Carbon stock in dead wood

The observed total number of DWs accounts for about 50,457 trees. When decay classes divided, the three and four classes comprised about 70 percent of the total DW. Especially, felled woods were about 70 percent. For this reason, the total carbon stock in DW at 2010 year is estimated to be 10.9 Tg C (Table 2). Regard to decay classes, the classification is not clear, that is overly dependent on surveyor's subjective decisions. There is necessary for more clear definitions of decay classes for field survey.

Recently, the NFI6 (2011-2015) has been implemented for monitoring and assessing forest resources including the DW over time and we aim to analyze relationship between DW and stand structure for sustainable forest management from a economic point of view. In order to improve uncertainty of DW carbon pool under UNFCCC, wood density and carbon conversion factors by decay classes for each tree species at the national level should be developed.

ACKNOWLEDGMENT

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Table 2—Tree mortality and carbon stock for dead wood in South Korea.

Mortality			Carbon stock in dead wood		
Mean (m3/ha)	SE (m3/ha)	Total(103m3)	Mean (Mg C/ha)	SE (Mg C/ha)	Total (Tg C)
12.3	±0.30	75,654	1.76	±0.04	10.9

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