Effects of Timber Harvesting Activities on Litter Decomposition Dynamics of Fir

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Abstract:

Increasing emissions of greenhouse gases are now widely acknowledged by the scientific community as a major cause of recent increases in global mean temperature (about 0.5 °C since 1970) and changes in the world’s hydrological cycle, including a widening of the Earth’s tropical belt. Before industrial development and high increase in human population, the level of CO₂ in the air was about 280 ppm. It was estimated 379 ppm in 2005, 381 ppm in 2006. It is noted that it increased about 1.93 ppm per year between 2000 and 2006. By the middle of the 21st century, it is expected that these values could be doubled (500-600 ppm). Forest ecosystems are the main systems which can reduce the increase of atmospheric CO₂. Forest ecosystems only cover 30% of the land areas, but contain 81% of the terrestrial carbon biomass. In addition, forests accumulate 20 to 100 times as much carbon per unit area as agricultural land and are 20 times more productive than grassland. After plant organs die and fall on the forest floor, the carbon stored in plant bodies forms litters which later decay and either release CO₂ to atmosphere or leached into soil and stored there. On the other hand, plant biomass is removed out of the ecosystem by harvesting the wood material and by collecting the other plant productions. There are some evidences in the literature that the removal of wood materials from the ecosystem, the activities of humans during these operations and the remaining tree parts on the forest floor after harvesting can influence litter decomposition dynamics. This present study has been therefore set up to investigate the effects of harvesting on fir litter decomposition rates. We set up litter decomposition experiment in the field and observed fir litter samples for 1 year. The litter samples placed on (1) skid roads, (2) under remained plant residues, (3) on forest floor removed sites and (4) no harvesting sites as control and collected 6 month intervals.

Key Terms: Fir, litter, decomposition, timber harvesting, skid roads.

Introduction:

Increasing emissions of greenhouse gases are now widely acknowledged by the scientific community as a major cause of recent increases in global mean temperature (about 0.5 °C since 1970) and changes in the world’s hydrological cycle, including a widening of the Earth’s tropical belt. Before industrial development and high increase in human population, the level of CO₂ in the air was about 280 ppm. It was estimated 379 ppm in 2005, 381 ppm in 2006. It is noted that it increased about 1.93 ppm per year between 2000 and 2006. By the middle of the 21st century, it is expected that these values could be doubled (500-600 ppm) (Neftel vd. 1982; Indermuehle vd. 2000). Many scientists believe that increasing the presence of amount of carbon dioxide in the atmosphere could increase the greenhouse effect. Other environmental features and decomposers with same conditions, can have a positive correlation between decomposition and an increase in temperature (Hobbie 1996). A study made by Vitousek et al. (1994) shows that a 10 °C increase in the temperature making an increase to decomposition 4 to 11 times.

Forest ecosystems are the main systems which embody 30% of terrestrial areas and 81% of terrestrial carbon biomass and can reduce increased carbon dioxide in the atmosphere. Forest ecosystems can accumulate carbon 20 to 100 times more than agricultural areas from per unit area, and 20 times more than grassland areas. Carbon stored in plants by turning CO₂ into the atmosphere or into the soil through the decomposition of dead organs. On the other hand, the production of wood raw material and collection of other plant-based products getting out of the ecosystem.

From now on, three main factors that affect the decomposition and nutrient release, put forward in the studies. These are climatic characteristics of the environment where the decomposition occurs (especially rain and temperature), number – type – activity of micro-organisms and soil organisms and
chemical components of dead cover (especially the total carbon, nitrogen, hemicellulose, lignin and concentrations of nutrients or their the rates of each other C: N, lignin: N, etc.). Generally, climate properties are more effective to the decomposition of dead cover in different geographical areas, and on local areas effect of the chemical structure of decomposed dead cover getting more forward (Sarıyıldız et al. 2010). Over thousand studies on relationship between the decomposition rate and quality of material decomposition broadly emphasized (Sarıyıldız, 2002). In addition to that, studies conducted on effects of interventions, for the silvicultural needs of the forest and for sustainable forestry activity, to decomposition were not found in the literature.

Decomposition is influenced by relationship between chemical and biological factors in a sequential order. Climate is limiting of overall decomposition by putting pressure to activity of microorganisms. Biochemical quality of material determines the rate of decomposition of organisms which are working under climate pressure to perform their functions. Studies have shown that climate factor getting forward on studies where had done in large areas, biochemical structure of the material is the most important factor of the decomposition (Sarıyıldız, 2002).

In this study possible effects of harvesting to decomposition of litter were aimed to investigate in Kastamonu region on fir stands. For this purpose, fir litter decomposition experiment was performed on the field. Samples of the decomposition were put to forest skid roads, under waste productions, top soil damaged areas with a slope of 20% and non-production areas (control) and the decomposition were examined for 18 months.

Soil formation mechanism is examined under three main headings. These are the physical, chemical and biological events. Decomposition of soil organisms evaluated as decomposition of plant roots activities and the decomposition of dead organic materials.

Minerals dissolves carbon dioxide (CO₂), which are produced from a respiratory of plant roots, reacting with water (H₂O) (Türüdü, 1992). In this sense, the decomposition of carbon released into the environment not only important for the formation of the nature, it is also very important for the carbon cycle. Carbon cycle consists three main parts in different time frames and different amount of carbon storage.

Period of leaf decomposition consists on biologic period, which has fastest carbon period, and soil period which has middle level storing (Sarıyıldız, 2002). In addition to this, many scientists expressed that the release of carbon in the atmosphere can cause a greenhouse effect. The decomposition activities in forest, where has maximum carbon stock area, is also important. Decomposition of leaves play an important role as a source of energy, as a source of nutrients and activities for soil organisms to the structure and function of natural ecosystems. Many studies focused on the decomposition of the leaves for several species (Sarıyıldız et al. 2004).

The study of decomposition for litter on mixed forests with water conservation function in the south-west of Germany, beech, oak, pine and cherry leaf mass loss over time compared with each other. In this study, the leaves of oak are more than leaves of beech, compared with 75% to 34,6% have been identified. Also cherry leaves have more mass loss than pine needles (94.6% versus 68.3%). In addition to the amounts of nitrogen and phosphorus and C / N ratios of the litter were evaluated in this study (Lorenz et al. 2004).

In recent studies, both global and regional scale climate changes that occurred, have been reported to have a significant effect on litter decomposition. This situation is important because of litter decomposition is an important part of the global carbon budget (Aerts 1997). Raich and Schlesinger (1992), has estimated that litter decomposition including roots constitutes about 70% of the total annual flow of carbon. This value is about approximately 68 Pg C yr⁻¹ (PG = 1015 g) (Aerts 1997). Therefore, any change in the factors affecting the decomposition of litter, occupy an important
place in the calculation of the global carbon budget (Sarıyıldız et al. 2008).

Litter has a very important influence on the process of the circulation of nutrients in forest ecosystems and soil properties, such as erosion and water budget. For this reason, a large number of studies have been done on litter. A large part of the researches, are from foreign origin and were directed to determine the amount and the separation of litter. In our country there are studies on the course of the decomposition of litter in Artvin region by Sarıyıldız and his friends since 2000. Studies carried out on this subject in Bartın region.

In forest ecosystems, leaves compose approximately 60-75 % of total falling litter, rest part of falling litter are a consist of woody materials, seed and flowers (Barnes et al. 1998). Various factors can change the fallen organic material such as: (1) tree species (2) the degree of frequency and forest age , (3) climate, (4) soil quality. In a study done in scots pine stands area with the same climatic conditions but with the different soil properties, it is expressed that, places with poor nutrients and arid soil properties are less have fallen litter than places with moisture and rich nutrients (Çakıroğlu, 2011).

Dynamics of litter are one of important part of energy transfer and nutrient cycle in forest ecosystems (Maguire 1994). Litter is an important way for the organic matter’s entry into the soil in forest ecosystems( Swift et al. 1979). Decomposing of forest litter plays an important role through the continuation of the function and structure of the forest ecosystems. Because the decomposition of these materials plays a critical role in nutrient cycling. The amount of essential nutrients that are involved to the ecosystem every year, is generally lower than the amount of nutrients in the cycling in this ecosystem(Yıldız ve İlhan 2004). Litter decomposition in forest ecosystems is an energy source for living soil micro and macro organism besides being nutrient store that is required for development of forest trees in the process of nutrient cycles (Heal et al. 1997).

Lignin, which is decomposing much harder and late, are decomposing by decaying fungi. Thus, decomposed layer gradually loses textural structure and became undetectable humus which has colloidal amorphous character (Kantarci, 2000). Leaves, decays and humus are cover the litter layer. Decomposing litter and exposing nutrients has a critical role on forest biochemistrial cycle. Many studies were done on the importance of decomposing litter (Çakıroğlu,2011).

First decomposition of bag technique was used by Bocock and Gilbert in 1957. After this study more than 1000 study was conducted on the decomposition (Prescott, 2005). In this technique is chemical composition of newly fallen leaves determined in laboratory, before microorganism’s decomposition. Later, these leaves were put in to plastic bag with different sizes (10 × 10 cm, 10 cm or 20 × 15 × 20 cm) which have smaller pores than 1 mm and these bags were leaved on the field, after that the loss of mass the chemical compositions are determined. Most effective components for decomposition rates and decomposition, are identified with the result of statistical analysis between rates of mass loss and chemical components (Sarıyıldız, 2002).

One of the most important element of litter decomposition is nitrogen (N). Because the nitrogen sets development and transformation of the microbial biomass which mineralize organic carbon. Carbon (C) and nitrogen (N) are the compounds in woody plants litter which have C / N ratio less than 10-15% are often susceptible to microbial attack (Berg ve Ekbohm 1983; Mcclaugherty ve Berg 1987). Plants which have a concentration of lignin in more than 20% , lignin is reducing enzymatic activities of bacteria and fungi and limiting the activity of soil fauna nutrition. For this reason it is expressed that lignin is a better indicator for decomposing ligno-cellulose or lignin / nitrogen ratio (Meetemeyer, 1978; Sarıyıldız, 2002; Çakıroğlu, 2011).

In this study, possible effects of production activities on to litter decomposition on stands of fir. For this purpose litter decomposition samples were put to(1) forest skid roads, (2)
under waste productions, (3) top soil damaged areas with a slope of 20% and non-production areas (control) and the decomposition were examined for 18 months.

Materials and Methods

Study Area:

This study was conducted leaf samples taken from fir stands where production activities were done a year ago, located in Kastamonu Regional Directorate of Forestry, Karadere Forestry Administration, within Handüzü chieftaincy boundaries. This study area is on 1630 m altitude and is through to North-West aspect.

Field and Laboratory Work:

During field studies, on production activities completed areas fallen fir needles were collected by hand, put in plastic bags, labeled and brought to the laboratory, by the end of autumn in October and November. These needles were ventilated for being free from moisture and other foreign materials were cleaned from these needles. Cleaned needles were put in to opened plastic bags which have a size of 20 × 20 cm and have smaller pores than 1 mm, on laboratory with the help of digital weighing scale 3 g of fir needles placed in to each decomposition bag.

To determine effects of harvesting to decomposing in other words determining mass loss of needle samples on field, 240 decomposing plastic bags were put on to forest skid roads, under waste productions, top soil damaged areas with a slope of 20% and non-production areas (control) on three places in fir stands. Bags were put 3 different area with 4 conditions, with 4 number of 6 months intervals and study were done 5 times (3*4*4*5 =240). Thus, prepared 20 decomposing bag were put for each location.

In addition to that, to identify the moisture content of samples, weight of defined amounts of samples were measured and leaved in the oven 80 °C for 24 hours, and weight difference were recorded, one day before field work.

Decomposing constant (k) will be calculated with Olson’s (1963) formula \( W_t/W_0 = e^{-kt} \) which is widely used in his decomposing model. In this formula \( W_t \) equals to remaining mass per time, \( W_0 \) equals to starting mass. Still, for calculating time of loss mass with %95 Olson’s formula \( T_{95} = 3/k \) were used. Thus, the loss of mass will be followed in the period of the decomposition.

Results and Discussion:

During the study, even putting decomposing bag with six-month periods with four times, some bags were not found in these areas. The main reason for this situation is, being human and animal disturbance on these areas while harvesting. Thus, total of 180 decomposing bag have fetched to laboratory and mass loss has been determined. The distribution of mass loss were given on Table 1, Figure 1, Figure 2.

Table 1. Mass change during Six-month with third-period (gr, %)

<table>
<thead>
<tr>
<th></th>
<th>Average Weight on 6th month (gr)</th>
<th>Average Weight on 12th month (gr)</th>
<th>Average Weight on 18th month (gr)</th>
<th>Average Weight on 6th month (%)</th>
<th>Average Weight on 12th month (gr)</th>
<th>Average Weight on 18th month (gr)</th>
<th>Average Weight on 6th month (gr)</th>
<th>Average Weight on 12th month (gr)</th>
<th>Average Weight on 18th month (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.3116</td>
<td>2.174778</td>
<td>1.8126</td>
<td>77.05333</td>
<td>72.49259</td>
<td>60.42</td>
<td>2.3116</td>
<td>2.174778</td>
<td>1.8126</td>
</tr>
<tr>
<td>Slope</td>
<td>2.336867</td>
<td>2.0312</td>
<td>1.282933</td>
<td>77.89556</td>
<td>67.70667</td>
<td>42.76444</td>
<td>2.336867</td>
<td>2.0312</td>
<td>1.282933</td>
</tr>
<tr>
<td>Under waste productions</td>
<td>2.358467</td>
<td>1.950533</td>
<td>1.768467</td>
<td>78.61556</td>
<td>65.01778</td>
<td>58.94889</td>
<td>2.358467</td>
<td>1.950533</td>
<td>1.768467</td>
</tr>
<tr>
<td>Skid road</td>
<td>2.336667</td>
<td>2.030017</td>
<td>1.728317</td>
<td>77.88889</td>
<td>67.66722</td>
<td>57.61056</td>
<td>2.336667</td>
<td>2.030017</td>
<td>1.728317</td>
</tr>
</tbody>
</table>
Decomposing constant (k), amount of remaining decomposing material and required time for %95 decomposing (T95) are given in Table 2.

Table 2. Decomposing constant (k), amount of remaining decomposing material and estimated time for %95 decomposing (T95) (year)

<table>
<thead>
<tr>
<th>Decomposing Area</th>
<th>k</th>
<th>Remaining Mass (%)</th>
<th>T95 (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.316±0.195</td>
<td>83.266±8.930</td>
<td>9.49</td>
</tr>
<tr>
<td>Slope</td>
<td>0.227±0.150</td>
<td>87.612±7.575</td>
<td>13.22</td>
</tr>
<tr>
<td>Under Waste Productions</td>
<td>0.279±0.165</td>
<td>80.93±17.630</td>
<td>10.75</td>
</tr>
<tr>
<td>Skid Road</td>
<td>0.336±0.201</td>
<td>82.307±9.590</td>
<td>8.93</td>
</tr>
</tbody>
</table>

In a study done by Çakıroğlu (2011) it is expressed that decomposing constant value “k” were found for fir species as -0.254 due to $Wt=WO_0e^{-kt}$ formula. Remaining decomposing time is found as 11.8 years for fir due to $T95=\frac{3}{k}$ formula. Mass loss is expressed as % 36.1. In addition to that, in a study were done by Sarıyıldız ve Küçük (2008) decomposing constant value “k” were found for north mountain skirts, hill and slope as -0.369, -0.393, -0.420 and remaining decomposing time were found as 8.1, 7.6 ve
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7.1 years. A study with same factors but done for North aspect, the decomposing constant value “k” were found as -0.314, -0.335, -0.387 and remaining decomposing time were found as 9.6, 9 and 7.6 years.

**Conclusion:**

In this study differences of decomposing values were determined due to decomposition rate and required time for %95 decomposition in a productive forest area for fir species. Similar studies were also evaluated. With continuation of the study chemical properties of the needle litters due to organic C values of fir, the total N values, lignin, lignin / N ratio, C / N ratio will be determined and will be compared with similar studies.

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