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# The cover-management factor (C) on woodlands of the hilly areas of the Loess Plateau in North China

## El factor cobertura-manejo (C) en áreas de vegetación leñosa de las zonas montañosas del Loess Plateau en el Norte de China

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**Abstract.** Soil erosion is one of most serious environmental and production problems on the Loess Plateau in China. The objectives of this study were to quantify the influence of forest vegetation on soil erosion on slope areas in the Loess Plateau. This was made by using the subfactor method to calculate the vegetation cover management factor (C) of the Universal Soil Loss Equation (USLE). Proper local subfactor parameter values were obtained to offer a theoretical basis and practical guidance for studying the relationship between vegetation and soil erosion on the Loess Plateau. Three subfactors including prior land use (PLU), canopy cover (CC), surface cover (SC), surface Roughness (SR), soil moisture (SM), and cover-management factor (C) were observed at three plant growth stages: initial, blooming and end of growing season. All observations and measurements were made on 13 runoff plots in the Caijiachuan Watershed. The annual runoff sediment volume, and the subfactor and indirect methods were adopted separately to calculate the vegetation cover and management factor C of each stand, and then carry out comparative tests and comprehensive analyses. The results showed that the cover-management factor (C) calculated by the subfactor and indirect methods were in good agreement. The order reflected was forest < *Robinia pseudoacacia* < *Robinia pseudoacacia* & Oriental arborvitae < *Pinus tabulaeformis* < orchard. Subfactors of PLU, CC, SC, SR and SM for soil loss rates of different stand types were not the same and the impact order was PLU>SC>SR>SM>CC. This indicated that plant roots, soil organisms in the surface soil layers and surface cover had a larger impact on soil loss fate than the other subfactors. Stand density was negatively correlated with vegetation cover and management factor C, suggesting that only stand density influenced soil erosion. The stand density of *Robinia pseudoacacia* ranged from 1200 to 2204 stems/ha. Management factor C ranged from 0.020 to 0.037. The subfactor method could be adopted to monitor

**Resumen.** La erosión del suelo es uno de los problemas ambientales y de producción en el Loess Plateau, China. Los objetivos de este estudio fueron cuantificar la influencia de la vegetación boscosa en la erosión del suelo en áreas de pendientes del Loess Plateau. Esto se hizo utilizando el método del subfactor para calcular el factor de manejo de la cobertura vegetal (C) de la ecuación de pérdida de suelo universal (USLE). Se obtuvieron valores apropiados de los parámetros locales para el subfactor para ofrecer una base teórica y guía práctica para estudiar la relación entre la vegetación y la erosión del suelo en el Loess Plateau. Se observaron tres subfactores incluyendo el uso previo de la tierra (PLU), la cobertura vegetal (CC), la cobertura de la superficie del suelo (SC), aspereza de la superficie del suelo (SR), humedad del suelo (SM), y factor cobertura-manejo (C) en tres estados del crecimiento vegetal: inicial, floración y final de la estación de crecimiento. Todas las observaciones y mediciones se hicieron en 13 parcelas de escorrentía en la Cuenca Caijiachuan. El volumen el sedimento de escorrentía anual y los métodos del subfactor e indirectos se adoptaron separadamente para calcular el factor de manejo y de cobertura vegetal C de cada sitio de muestreo, y luego efectuar pruebas comparativas y análisis comprehensivos. Los resultados mostraron que los valores obtenidos para el factor de cobertura-manejo (C) calculados por los métodos indirectos y del subfactor fueron similares. El orden obtenido fue bosque < *Robinia pseudoacacia* < *Robinia pseudoacacia* & Oriental arborvitae < *Pinus tabulaeformis* < huerta. Los subfactores de PLU, CC, SC, SR y SM para las tasas de pérdida de suelo de diferentes tipos de lugar de muestreo no fueron los mismos, y el orden fue PLU<SC<SR<SM<CC. Esto indicó que las raíces vegetales, los organismos del suelo en las capas superficiales del mismo y la cobertura de la superficie tuvieron un mayor impacto en la probabilidad de pérdida de suelo que los otros subfactores. La densidad del lugar de muestreo se correlacionó negativamente con la

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the amount of soil erosion in the Loess Plateau, with the parameters being Cb=0.951, Cur=0.004513kg/(ha.cm), Cus=0.001887kg/(ha.cm), Cuf=0.5, b=0.025. The vegetation cover and management factor C of different stands in the Loess Plateau varied between 0.009 and 0.062.

**Keywords:** Loess Plateau; Forest vegetation; Soil erosion; Universal Soil Loss Equation; Vegetation Cover and management factor.

cobertura vegetal y el factor de manejo C, sugiriendo que solo la densidad del stand influenció la erosión del suelo. La densidad del lugar de muestreo de *Robinia pseudoacacia* varió de 1200 a 2204 tallos/ha. El factor de manejo C varió de 0.020 a 0.037. El método de subfactor se podría adoptar para registrar la cantidad de erosión del suelo en el Loess Plateau, siendo los parámetros Cb=0,951, Cur=0,004513 kg/(ha.cm), Cus=0,001887 kg/(ha.cm), Cuf=0,5, b=0,025. La cobertura vegetal y el factor de manejo C de los diferentes sitios de muestreo en el Loess Plateau variaron entre 0,009 y 0,062.

**Palabras clave:** Loess Plateau; Vegetación de Bosque; Erosión del Suelo; Ecuación Universal de Pérdida del Suelo; Cobertura Vegetal y Factor de Manejo.

# INTRODUCTION

The Loess Plateau, on the middle and upper reaches of the Yellow River, is one of the regions in China where soil erosion is most severe. This area is famous for its highly erodible fine aeolian deposits, steep slopes, heavy storms, and sparse vegetation cover. This last biological factor has been the result of intensive cultivation and improper land use (Chen et al., 1998). Although the problem has been tackled for many years, soil erosion on the Loess Plateau still covers an area of 450000 $km^2$, 71% of the soil erosion in China. Soil erosion destroys land's natural productivity and damages the ecosystems (Jing et al., 1997). Therefore, studies on soil erosion and the relationship between vegetation and soil erosion (Liu, 1990; Luo, 1990; Liu, 1994), especially the determination of vegetation cover and the management factor (C) are of great significance on different stand types of the Loess Plateau.

The role of forest vegetation on soil erosion is widely recognized (Sun & Zhu, 1995; Ghidey & Alberts, 1997; Hou et al., 1997; Huang & Liu, 2002; Zhang et al., 2003; Shi et al, 2004; Wang, 1994; Zhao et al., 2004; Niu & Wang, 2013). Much research has been conducted on the Universal Soil Loss Equation (USLE) considering the situation on different regions (Wilschmeires, 1976; Wilschmeires & Smith, 1978; Gabriels, 2003; Ozhan, 2005; Martins et al., 2010; Lee, 2012). However, because of the study condition constraints, results are generally not universal, and are difficult to apply to large scales. Taking the research progresses on the China's soil erosion model into consideration, the current level of knowledge is similar to that in America in the 1950s (Xie, 2003). Despite lots of regional models have been built, there are no soil erosion models that could either be applied to a national scale or support basis for government-decision making (Xie, 2003).

Additionally, a large number of observation data has accumulated which needs to be analyzed and studied in a unified way for full utilization (Liu, 2001; Xie, 2003). This is especially true for calculating the vegetation cover and management factors (i.e., C). The widely used methods are (1) to calculate C indirectly in the USLE and (2) obtaining a multi-year average erosion (Liu, 2001; Zhang, 2002; Xie, 2003; Zhang, 2003). Some research estimates C by remote sensor data (Wu et al., 2012; Durigon, 2014). The disadvantage of using indirect methods is that they waste a lot of human and material resources, needing a relatively large project for calculation. Although it is still at an experimental stage, we propose using a subfactor method to calculate C, as long as every parameter is given properly. Our proposal will be more effective than the indirect methods in calculating the vegetation cover and management factor C. Besides, quantitative studies of the impact of forest vegetation on slope soil erosion, and gaining a better understanding of the erosion law and complementing USLE, both theoretically and practically, will have a greater significance.

For more than 60 years, many achievements have been attained in the role of forest vegetation for controlling soil erosion (Huang, 2002; Chen, 2003; Zhao et al., 2013; Wang et al., 2015). As early as 1936, researchers had already realized that vegetation cover plays a protective role for soil and made it an influencing factor for soil erosion (Cook, 1936). Smith also realized of the role of vegetation to slope soil erosion, and by quantifying the role of vegetation, he applied the factor into the Soil Loss Estimate Equation (Smith, 1941). Browning et al. (1947) introduced the management factor into the impact of vegetation and made it more comprehensive in quantifying the role of vegetation. Van Doron and Bartelli (1956) further took consideration of the crop rotation and management factors that affect vegetation, and made the application of vegetation impacts on soil erosion more mature. Systematic studies have been conducted in America about the estimation of C, and calculus programs have been designed to obtain the value of C in all types of land-use in America (Renard et al., 1997). The equation in the Revised Universal Soil Loss Equation (RUSLE) was adopted to calculate Factor C:

$$C = (SLR_1 EI_1 + SLR_2 EI_2 + \ldots\ldots SLR_i EI_i)/EI_t$$

Where C is the annual average; $SLR_i$ is the soil loss rate during the *i*th time period; $EI_i$ is the percentage of EI (Erosion Index) in the overall EI of the year; *i* is the number of time period; $EI_t$ is the total amount of EI (in %) during the whole time Period.

The direct application of the C-factor from the RUSLE is based on prior land use (PLU), canopy cover (CC), surface cover (SC), surface roughness (SR), and soil moisture (SM) (Renard et al., 1997). Using over 200 soil-loss ratios measured on 30 runoff-erosion plots under both natural and simulated rainfall events in the TGA, Cai (1998), Yang & Shi (1994) established relationships between soil-loss ratios and canopy-cover and surface-cover subfactors. Application of the subfactor method in the calculation of vegetation cover-management factor (C) is relatively easy for calculation. In this paper, we report it on a site of the Loess Plateau of north China (Zhang, 2002).

When using the subfactor method, the vegetation growing seasons were divided into three stages: initial, blooming and final growing stages. Thereafter, we separately observed and measured the subfactors at these three stages. Subfactors included Prior Land Use (PLU), Canopy Cover (CC), Surface Cover (SC), Surface Random Roughness (SR) and Soil Moisture (SM). Finally, we calculated the vegetation cover and management factor.

The objectives of this study were to have a (1) subfactor method for calculating the vegetation cover management factor (C) of the Universal Soil Loss Equation (USLE) on the Loess Plateau; this would quantitatively give out the influence of forest vegetation to soil erosion at the scale of slope, and (2) proper local subfactor parameter value to offer a theoretical basis and practical guidance for studies of vegetation on soil erosion in the Loess Plateau.

## MATERIALS AND METHODS

**Description of study area.** The study area was located at the Caijaichuan watershed (36° 14' - 36° 18' N, 110° 40' - 110° 48' E), Jixian County, Shanxi Province, in the Loess Plateau, China. The site is within the scope of the Jixian Station of the Chinese National Ecosystem Observation and Research network. Elevation varies from 904 to 1520 m.a.s.l. Annual mean temperature is 10 °C and the frost-free period is 172 days. Average annual precipitation is 579.5 mm, with extreme, absolute values of 828.9 mm (in 1956) and 277.7 mm (in 1997). Mean annual evaporation is 1729 mm. The soil belongs to loess-derived Cinnamon soil type (Xu et al., 2013; Wei et al., 2014). Vegetation includes plantation and natural forest. The main plantation species are Black Locust (*Robinia peseudoacacia*), Chinese pine (*Pinus tabulaefomis*), and Oriental arborvitae (*Platycladus orientalis*). Native species include David poplars (*Populus davidiana*) and East-Liaoning oak (*Quercus wutaishancia*), shrubs (*Rosa hugonis*, *Spiraea trilobata*) and grasses. The forest coverage in the watershed is 72%.

The Caijiachuan watershed is in the typical hilly areas of the Loess Plateau. Natural resources, land use patterns and population density in the study watershed are typical of the surrounding region. A typical hillslope in the experimental region was selected at the study site. The elevation ranges from 1050 to 1200 m.a.s.l. The results presented in this paper were derived from one of the watersheds in the hilly areas of the Loess Plateau. However, they are representative and give an indication of possible trends occurring throughout the hilly areas of the Loess Plateau. Study subjects were 13 runoff plots, each with an area of 20 m*5 m. See overview of the plots from Table 1.

**Rainfall–runoff and soil erosion measurement.** Rainfall was measured in the study watershed from 2004 to 2006. Rain gauges were also placed according to the area and geographical locations. Soil erosion was measured using long-term, on-site observations of runoff on plots at hillslopes. There were 13 runoff plots within a gradient of different slopes with vegetation to monitor runoff and sediment yields at a plot scale, and their influencing factors. All the experimental plots covered an area of 5 meter wide x 20 meter long. From 2004-2006, runoff and sediments were measured on each rainfall event. This method was conducted based on Forestry Standards "Observation Methodology for Longterm Forest Ecosystem Research" of People's Republic of China (LY/T1952-2011).

**Surface roughness measurement.** Using a pin contact roughness instrument, the surface roughness of the study 13 runoff plots was measured at 3 growth stages. Growth stages were (1) initial (April-May), (2) bloom (June-September), final growing stage (October - November). The instrument consisted of 50 isometric measuring pins and the spacing among them was 1 cm. Each pin was 60 cm long.

When measuring, the instrument was first located along the slope inside the plot, making both ends close to the ground. This formed the relative height difference basic point, examined by order to see if every pin contacted the ground. Then, the relative height difference with the basic point of all the pins was read out. Various sections within the plot were chosen to have replicates.

**Measuring method of root in soil.** Three sampling points in the observed runoff plot were chosen to determine roots in these points at the 0-10 cm from the soil surface. Roots were then dried and weighed, and converted to root content of the whole plot according to the surface area relationship. Then we followed the rule in RUSLE that root content at 10-20 cm soil depth was 80% of that at 0-10 cm. Thus, root content at 0-20 cm soil depth was obtained.

**Measurement of biomass in the un-decomposed and semi-decomposed litter layers.** Two 20cm*20cm sampling points were selected in the plot. The un-decomposed and semi-decomposed litter layers were separately collected, and their biomasses weighed after drying.

Table 1. Condition of the runoff plot in Caijiachuan watershed.
Tabla 1. Condición de la parcela de escorrentía en la cuenca Caijiachuan.

| Plot No. | Stand Type | Stand Density (plants/ha) | Dominant Species | Gradient (°) | Aspect | Forest Age |
|---|---|---|---|---|---|---|
| 1 | PD & CP | 1800/350 | *Populus davidiana, Pinus tabulaeformis* | 25 | South | 20 |
| 2 | PD & Oka | 1950/275 | *Populus davidiana & Quercus Wutaishanbcia* | 26 | North | 14 |
| 3 | BL1 | 2000 | *Robinia pseudoacacia* | 22 | South | 14 |
| 4 | BL 2 | 1400 | *Robinia pseudoacacia* | 18 | South | 14 |
| 5 | BL 3 | 2204 | *Robinia pseudoacacia* | 20 | South | 14 |
| 6 | BL 4 | 1400 | *Robinia pseudoacacia* | 29 | West | 14 |
| 7 | BL 5 | 2100 | *Robinia pseudoacacia* | 26 | West | 14 |
| 8 | BL 6 | 1200 | *Robinia pseudoacacia* | 26 | East | 14 |
| 9 | BL 7 | 1300 | *Robinia pseudoacacia* | 19 | West | 14 |
| 10 | BL & OA | 900/900 | *Robinia pseudoacacia & Platycladus orientalis* | 24 | West | 14 |
| 11 | CP | 1500 | *Pinus tabulaeformis* | 23 | 19 | 16 |
| 12 | Pear | 400 | *Pyrus* i.f.. | 10 | East | 14 |
| 13 | Plum | 200 | Plum | 15 | West | 14 |

BL: Black Locust, PD & CP: David poplars & Chinese pine, PD & Oak: David poplars & Quercus liaotungensis oak (Natural Secondary Forest), OA: Oriental Arborvitae.

**Measurement of soil moisture.** Three sampling points were randomly selected in the plot. Soil was dug out from the 0-20 cm soil depth. Soil samples were dried and weighed separately. Surface soil moisture content was calculated as the difference between the soil weight before and after drying.

**Calculating method of factor C according to subfactor.** Cover-management factor is not only based on the combined effect of vegetation cover and management but is also related to the amount of erosive rainfall during the growing period (Wischmeier & Smith, 1985; Liu et al., 2001). Thus, the distribution of erosive rainfall within a year becomes an important determinant of the cover-management factor. This research took into consideration that the forest stands grew as the usual S growing shape. This, together with the phenological characteristics of the study area led us to divide the C factor into 3 stages. The first stage was the initial growing stage, April to May; the second stage was at blooming, June to early October; the third stage was at the end of the growing season, middle October to late November.

Using equation from RUSLE to calculate factor C:

$$C= (SLR_1 EI_1 + SLR_2 EI_2 + \ldots\ldots SLR_i EI_i) / EI_t$$

where C is the mean annual or crop value, $SLR_i$ is the soil loss rate for time period $i$, $EI_i$ is the percentage of Erosion Index of the annual or crop EI occurring during that time period.

$i$ is the number of periods used in the summation, and $EI_t$ is the sum of the EI percentages for the entire time period. According to the latest research of soil loss (Laflen et al., 1985), soil loss rate follows.

SLR= PLU•CC•SC•SR•SM

where SLR is the Soil Loss Rate, PLU is the Prior Land Use subfactor, CC is the Canopy Cover subfactor, SC is the Surface Cover subfactor, SR is the Surface Roughness subfactor, and SM is the Soil Moisture subfactor.

**Determining subfactor values of the cover–management factor (C).** The Prior Land Use subfactor (*PLU*) is estimated. This was based on the soil loss prediction model (Liu et al., 2001).

The amount of residue both on the soil surface and within the soil, and the decomposition of each according to the climatic conditions and residue characteristics were taken into account as follows:

$$PLU= C_f \cdot C_b \cdot \exp\{2.268[(-C_{ur} \cdot B_{ur})+(C_{us} \cdot B_{us} / C_f^{Cuf})]\}$$

where *PLU* is the prior-land-use subfactor (which ranges from 0 to 1), $C_f$ is a surface-soil-consolidation factor, $C_b$ represents the relative effectiveness of the subsurface residue in consolidation, $B_{ur}$ is the mass density of live and dead roots found in the upper inch of soil [kg/(ha·cm)], $B_{us}$ is the mass density of incorporated surface residue in the upper inch of soil [kg/(ha·cm)], $C_{uf}$ represents the impact of soil consolidation on the effectiveness of the incorporated residue, and $c_{ur}$ and $c_{us}$, are calibration coefficients indicating the impact of the subsurface residues.

**Canopy Cover.** CC= 1-$F_c$· exp(-0.328·$H$)
where CC is the canopy-cover subfactor ranging from 0 to 1, $F_c$ is the fraction of the land surface covered by canopy, and H (ft) is the distance that raindrops fall after striking the canopy.

**Surface Cover.** Increasing surface cover affects erosion by reducing the transport capacity of runoff water (Foster, 1982), by causing deposition in ponded areas (Laflen 1983), and by decreasing the surface area susceptible to raindrop impacts. It is perhaps the single most important factor in determining SLR values. Surface cover includes crop residues, rocks, cryptogams, and other nonerodible materials that are in direct contact with the soil surface (Simanton et al., 1984; Box, 1981; Meyer et al., 1972).

$$SC= \exp[-b \cdot S_p \cdot (0.06096/R_u)^{0.08}]$$

where SC is the surface-cover subfactor, b is an empirical coefficient, $S_p$ is the percentage of land area covered by surface cover, and $R_u$ is surface roughness (in) as follows.
Surface Roughness.

$$SR= \frac{1}{m} \sum_{i=1}^{m} \sum_{j=1}^{p} \Delta z / (p - 1)$$

where $SR$ is the random surface roughness; $\Delta Z$ is the relative height difference of the pin; p is the number of measuring points (pins) of a certain section, and m is the number of measured sections.

**Estimate method of factor C according to indirect method.** As there are many factors needed for using the sub factor method to calculate vegetation cover and management factor C when using RUSLE researchers usually adopt indirect methods to calculate that factor. For example, C= A / (R•K•L•S•P), where A is the annual soil erosion, R is the rainfall erodibility factor, K is the soil erodibility factor, LS is slope length and gradient factor, and P is the soil conservation planning factor. R is the potential soil erosion ability caused by rainfall, and is a function of rainfall characteristics; K is the degree of soil (or its cross section) changes under the role of module erosivity; LS is the soil loss rate of certain actual terrestrial conditions compared to conditions which are basically the same, except for the 22.1m length and 5.14° gradient; P is the soil loss ratio of downhill plots under certain protective measures compared to that of plots which do not have any of these measures.

# RESULTS

**Subfactor Calculation Results.** Subfactors were calculated according to the measurements made in 2006. C values are shown in Table 2.

**Vegetation cover and management factor C of different stand types.** According to rainfall data, rainfall erosivity and soil loss rate of different stands in 2006, values of vegetation cover and management factor C are shown in Table 3 for the different stand types.

Table 2. Calculating the annual values of each subfactor to obtain soil loss rate.
Tabla 2. Cálculo de los valores anuales de cada subfactor para obtener la tasa de pérdida de suelo.

| Stand Type | PLU | CC | SC | SR | SM | SLR |
|---|---|---|---|---|---|---|
| PD & CP | 0.056 | 0.751 | 0.266 | 1.693 | 0.66 | 0.025 |
| PD & Oka | 0.039 | 0.828 | 0.251 | 4.02 | 0.68 | 0.022 |
| BL 1 | 0.090 | 0.941 | 0.299 | 2.807 | 0.57 | 0.038 |
| BL 2 | 0.137 | 0.957 | 0.312 | 3.323 | 0.57 | 0.046 |
| BL 3 | 0.086 | 0.883 | 0.285 | 2.007 | 0.57 | 0.035 |
| BL 4 | 0.145 | 0.942 | 0.345 | 2.449 | 0.61 | 0.049 |
| BL 5 | 0.095 | 0.921 | 0.288 | 2.349 | 0.61 | 0.041 |
| BL 6 | 0.133 | 0.940 | 0.312 | 1.751 | 0.63 | 0.059 |
| BL 7 | 0.141 | 0.931 | 0.322 | 1.640 | 0.63 | 0.041 |
| BL & OA | 0.168 | 0.906 | 0.368 | 2.353 | 0.64 | 0.085 |
| CP | 0.183 | 0.871 | 0.384 | 2.141 | 0.75 | 0.092 |
| Pear | 0.173 | 0.846 | 0.729 | 1.704 | 0.46 | 0.086 |
| Plum | 0.192 | 0.869 | 0.846 | 1.475 | 0.43 | 0.097 |

Table 3. Vegetation cover and management factor C of different stands.
Tabla 3. Cobertura de la vegetación y factor de manejo C de diferentes sitios de muestreo.

| Stand Type | PD & CP | PD & Oka | BL 1 | BL 2 | BL 3 | BL 4 | BL 5 |
|---|---|---|---|---|---|---|---|
| C | 0.016 | 0.009 | 0.024 | 0.029 | 0.020 | 0.027 | 0.025 |
| Stand Type | BL 6 | BL 7 | BL & OA | CP | Pear | Plum | |
| C | 0.037 | 0.028 | 0.055 | 0.058 | 0.051 | 0.062 | |

Value of vegetation cover and management factor C ranged from 0.009 to 0.062 in the different stands in the Loess Plateau. The order was natural forest < *Robinia pseudoacacia* < *Robinia pseudoacacai* & *Arborvitae* < *Pinus tabulaeformis* < Orchard.

Table 4. Linearity relation between density and C in different stands.
Table 4. Relación lineal entre la densidad y C en sitios de muestreo diferentes.

| SUMMARY OUTPUT | |
|---|---|
| Regression Statistics | |
| Multiple R | 0.393 |
| R Square | 0.154 |
| Adjusted R Square | -0.015 |
| Standard Deviation | 0.005 |
| Observations | 7 |

| Variance Analysis | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression Analysis | 1 | 0.00002 | 0.00002 | 0.91200 | 0.38344 |
| Residual | 5 | 0.00014 | 0.00003 | | |
| Total | 6 | 0.00016 | | | |

| | Coefficients | Standard Deviation | t Stat | P-value | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| Intercept | 0.03570 | 0.00909 | 3.92846 | 0.01109 | 0.01234 | 0.05906 |
| Stand Density | 0.00000 | 0.00001 | -0.95499 | 0.38344 | -0.00002 | 0.00001 |

**Vegetation cover and management factor C of the different density Black Locust.** According to the relative analysis of stand density and vegetation cover and management factor C in the 7 Black Locust (*Robinia pseudoacacia*) stands in the study area, Table 4 was obtained.

Stand density *versus* vegetation cover and management factor C were negative correlated, and $R^2$ was 0.154 (i.e., there was a low correlation coefficient between stand density and factor C). The stand density of *Robinia pseudoacacia* was in the range of 1200-2204 plants/ha, and the value of the vegetation cover and management factor C was 0.020-0.037.

**Comparison of vegetation cover and management factor C by either the indirect or the subfactor method.** There are many factors needed for using the sub-factor method to calculate vegetation cover and management factor C. This is because researchers usually adopt indirect methods to calculate that factor when using RUSLE.

According to the research (Keli Zhang, 2001) on terrestrial factor LS, the relation diagram of soil erosion factor with Nomogram approximation, the soil and water conservation planning factor P, and the observations of soil erosion on runoff plots in 13 different stand types in 2006, the indirect method was used to calculate the vegetation cover and management factor C as indicated in Table 5.

Table 5. Vegetation cover and management factor C of different stands by indirect calculation.
Tabla 5. Cobertura de la vegetación y factor de manejo C por cálculo indirecto.

| Stand Type | A t/(ha.a) | R (MJ.mm/ha.a) | K t.ha.h/(ha.MJ.mm) | LS | P | C |
|---|---|---|---|---|---|---|
| PD & CP | 0.314 | 339.83 | 0.024 | 3.85 | 0.50 | 0.020 |
| PD & Oka | 1.782 | 1784.86 | 0.02 | 4.16 | 1.00 | 0.012 |
| BL 1 | 0.85 | 558.45 | 0.021 | 3.02 | 0.80 | 0.030 |
| BL 2 | 1.46 | 954.01 | 0.03 | 2.65 | 0.55 | 0.035 |
| BL 3 | 0.549 | 445.41 | 0.025 | 2.84 | 0.62 | 0.028 |
| BL 4 | 2.571 | 741.99 | 0.035 | 4.4 | 0.75 | 0.030 |
| BL 5 | 0.894 | 927.09 | 0.023 | 3.63 | 0.55 | 0.021 |
| BL 6 | 0.626 | 362.94 | 0.028 | 3.52 | 0.50 | 0.035 |
| BL 7 | 1.245 | 436.11 | 0.026 | 3.66 | 1.00 | 0.030 |
| BL & AB (A) | 5.512 | 1335.69 | 0.032 | 3.2 | 0.65 | 0.062 |
| CP | 3.962 | 1582.11 | 0.035 | 2.65 | 0.50 | 0.054 |
| Pear Orchard | 3.003 | 1617.65 | 0.04 | 1.19 | 0.65 | 0.060 |
| Plum Orchard | 8.715 | 1706.41 | 0.048 | 1.9 | 1.00 | 0.056 |

The research demonstrated that the vegetation cover and management factor C calculated by the subfactor method was in good conformity with that calculated by using the annual soil erosion, the rainfall and soil erodibility factors, the length and gradient factors and the soil conservation support-practice factor. The ordering of vegetation cover and management factor C was reflected as: Natural Forest < *Robinia pseudoacacia* < *Robinia pseudoacacia & Arborvitae* < *Pinus tabulaeformis* < Orchard is basically the same. So the subfactor method can be used to observe and calculate soil erosion instead of using the indirect method. Where Cb= 0.951, Cur= 0.004513kg/(ha.cm), Cus= 0.001887kg/(ha.cm), Cuf= 0.5, b= 0.025 is reasonable.

However, we can use the sub factor method to calculate factor C, and further predict the amount of soil erosion, that is a good method for a direct calculation of the C factor.

# DISCUSSION AND CONCLUSIONS

(1) The extent of the impacts of PLU, CC, SC, SR and SM to soil loss rate is different in stand types which vary in slope. The impact is PLU>SC>SR>SM>CC, from where it is concluded that plant roots, biomass of the semi-decomposition layer in the soil, and surface cover have the greatest impact on soil loss rate.

Stand density and vegetation cover and management factor C were negatively correlated, where $R^2$=0.154. This indicates that stand density only plays a partial role among all factors that impact soil erosion. Stand density of *Robinia pseudoacacia* varied in the range of 1200-2204 individuals/ha, and its vegetation cover and management factor C ranged from 0.020-0.037.

(2) Vegetation cover and management factor C are in good conformity calculated by the subfactor and indirect methods, and the discipline of Factor C reflected as: Natural Forest < *Robinia pseudoacacia* < *Robinia pseudoacacia & Arborvitae* < *Pinus tabulaeformis* < Orchard is basically the same. Thus, the subfactor method can be used to monitor the soil loss in the Loess Plateau. Cb= 0.951, Cur= 0.004513kg/(ha.cm), Cus= 0.001887kg/(ha.cm), Cuf= 0.5, b= 0.025. The vegetation cover and management factor C of different stands in the Loess Plateau ranged from 0.009 to 0.062. So it is feasible to calculate the factor C in the Loess Plateau using the subfactor method.

(3) Besides, using the sub factor method to calculate factor C, we can predict the amount of soil erosion. That is a good method for direct calculation of the C factor. The advantage is that accuracy and dynamic can be gained to estimate the C-value of vegetation with different species. When calculating the C-value, the input data include rainfall, soil moisture, roots in the soil, surface roughness and biomass in the litter semi-decomposition layer. Cover-management factor is not only based on the combined effects of vegetation cover and management but is also related to the amount of erosive rainfall during the growing period. Thus, the distribution of erosive rainfall within a year becomes an important determinant of the cover-management factor. Subfactors methods also add accuracy and a dynamic estimation of the annual variation.

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