# $^{137}$Cs and $^{90}$Sr root uptake of pine saplings in a managed forest

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**Abstract.** Effects of liming (4000 kg calcium-magnesium carbonate per hectare) and soil preparation (with a disc plow) on $^{137}$C sand Sr uptake of pine saplings *(Pinus sylvestris)* were studied in a dry heath forest in western Finland. Four treatments were studied: liming, soil preparation, liming followed by soil preparation, and control. The trees were planted in 1987; one year after the soil management, on a site contaminated by Chernobyl derived $^{137}$Cs. Sampling of various tree parts and soil was carried out in 1991. Soil preparation increased highly significantly dry mass of the whole tree and branches and needles of C and C+1 year classes, and significantly masses of roots, stem, and older branches and needles. In all these fractions the content of Sr increased significantly. The $^{137}$Cs concentrations in all tree fractions were highest in samples from the control plots, but Sr differed from this pattern. Soil preparation decreased significantly the $^{137}$Cs concentrations in roots and living needles. The changes in $^{137}$Cs and Sr contents in trees may partially be traced back to increased nutrient mobility and root mass and changed root distribution in soil, and also to different relations of Cs-K and Sr-Ca in uptake and translocation processes of trees.

## 1. INTRODUCTION

Growth of trees in nutrient poor forests can be improved by, e.g., fertilisation, liming and soil preparation. Liming was used for mitigation of acidifying influence of atmospheric pollutants in forests especially in the 1980's [1,2]. Soil-to-plant transfer of both long-lived $^{90}$Sr and $^{137}$Cs may be influenced by soil amelioration. The objective of this study was to examine the influence of liming and soil preparation on uptake of $^{90}$Sr and $^{137}$Cs by pine saplings on a dry heath.

## 2. MATERIAL AND METHODS

Effects of liming (4000 kg calcium-magnesium carbonate per hectare) and soil preparation (with a disc plow) on radiocaesium uptake of pine saplings *(Pinus sylvestris)* were studied in a dry heath forest in western Finland. Four treatments with four replicates were studied: liming, soil preparation, liming followed by soil preparation, and control. The trees were planted in 1987, one year after the soil management. The ground was contaminated by Chernobyl -derived $^{137}$Cs, but the saplings were not directly exposed to atmospheric radiocaesium or -strontium.

Sampling of various tree parts for $^{137}$Cs analysis was carried out in 1991, three years after planting. The whole trees were sectioned into fractions as indicated in Figures 1 and 2.

$^{137}$Cs was determined in dried, homogenised samples using low-background high resolution gammaspectrometry [3]. $^{90}$Sr was determined in a set of combined samples representing each tree fraction studied and each treatment, using radiochemical separation and low-background liquid scintillation counting [4]. For statistical analysis the concentrations of Sr element in individual vegetation samples from each of the 16 plots were used. The linear regression between $^{90}$Sr and Sr concentrations in vegetation samples was tested.

## 3. RESULTS

The $^{137}$Cs concentrations in all tree fractions were highest in the samples from the control plots. In dry matter they were 580-1630 Bq kg$^{-1}$ in needles of three age classes, and 780 Bq kg$^{-1}$ in stem (Figs. 1, 2). Soil preparation caused a decrease in $^{137}$Cs concentrations which was highly significant ($p < 0.001$) in roots, stem, in current year (C) needles and in younger than C+2 branches), and significant ($p < 0.01$) in C+2 branches and C+1 needles, and almost significant in C+2 needles ($p < 0.05$). Liming decreased $^{137}$Cs concentration in stem and C and C+1 branches ($p < 0.05$). The combined effect of liming and soil preparation was very close to the product of single effects.

In the woody tree parts of trees from the control plots the Sr concentrations were lowest in roots, and increased slightly in the order: stem < current year (C) branches, C+1 branches < C+2 branches (Fig. 3). In needles from the control plots the Sr concentration was highest in C+2 year class (Fig. 4). Liming decreased Sr concentration highly significantly in roots, significantly in stem and C+2 branches, whereas a slight increase, not significant, was found in needles. Soil preparation caused an almost significant increase in Sr concentration of C and C+2 needles ($p<0.05$). Combined treatment decreased Sr concentration slightly more than was the multiple effect of single treatments on roots, on all needles and C and C+1 branches.

Soil preparation increased highly significantly dry mass of the whole tree, and also of branches and needles of C and C+1 year classes, and significantly dry mass of roots, stem, and branches and needles of C+2 year class. In all these fractions Sr content increased significantly.

## 4. DISCUSSION

The management influence on $^{137}$Cs uptake can be derived from increased nutrient mobility in soil, and dilution of caesium in tree tissues due to growth. Soil preparation also dilutes the $^{137}$Cs concentration in growing medium compared to undisturbed soil. The change in uptake may partially be traced back to increased root mass and changed root distribution in soil. The treatments influenced Sr in a differed way than $^{137}$Cs. The result could be expected as the relations of chemical analogues Cs – K and Sr – Ca in uptake and translocation processes of trees are different [5].

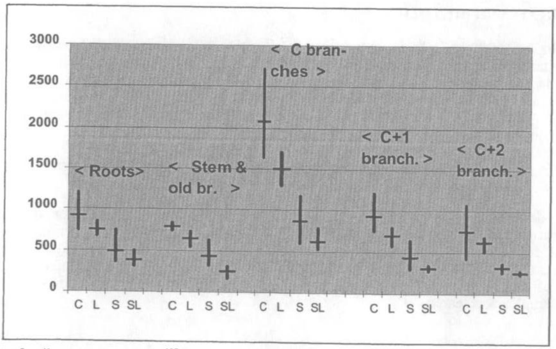


**Figure 1**: Effect of soil managements on $^{137}$Cs concentration (Bq kg-1 dw) in the woody tree parts (mean, min, max). [C = Control, L = Liming, S = Soil preparation, SL = Soil preparation & liming].

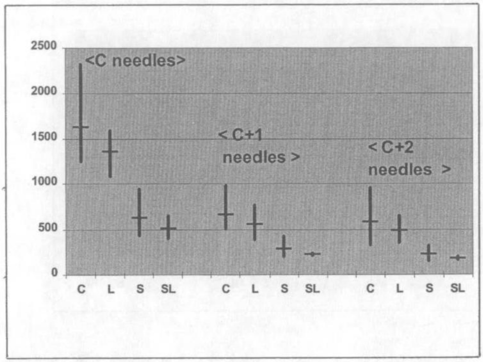


**Figure 2**: Effect of soil managements on $^{137}Cs$ concentration (Bq kg-1 dw) in needles (mean, min, max). [C = Control, L = Liming, S = Soil preparation, SL = Soil preparation & liming].

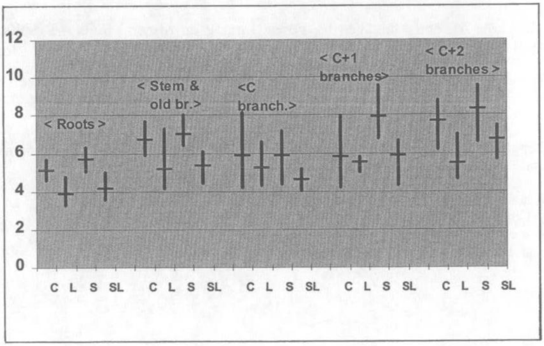


**Figure 3**: Effect of soil managements on Sr concentration (mg kg-1 dw) in the woody tree parts (mean, min, max). [C = Control, L = Liming, S = Soil preparation, SL = Soil preparation & liming].

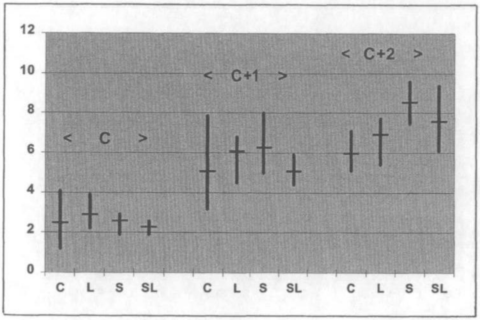


**Figure 4**: Effect of soil managements on Sr concentration (mg kg-1 dw) in needles (mean, min, max). [C = Control, L = Liming, S = Soil preparation, SL = Soil preparation & liming].


## Acknowledgments

The authors are grateful to Jarmo Mäkinen (METLA, Parkano) for performing the statistical calculations, and for Teuvo Levula (METLA, Parkano) for useful discussions. The careful sampling and sample treatments carried out by the personnel of Parkano Research Station (METLA) and the sample analyses at Ecology and Foodchain laboratory of STUK, Helsinki, are gratefully acknowledged.


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