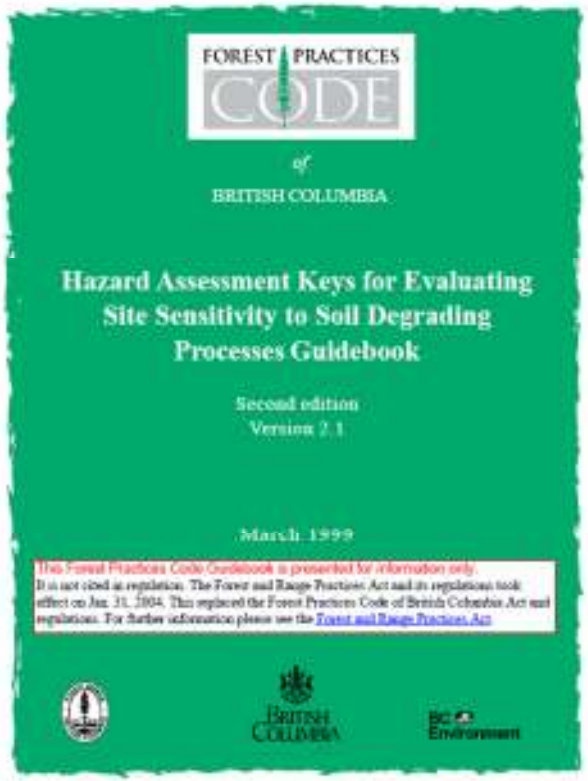
Risks of Soil Erosion and Soil Compaction



FORRISK

SUDOE
Interreg IV B

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Risk of Soil Erosion

Soil erosion hazard key

Site factors	Degree of contribution of factors			
	Low	**Moderate**	**High**	**Very high**
Climate precipitation factor **(points)**	low **2**	moderate **4**	high **6**	very high **8**
Topography slope gradient (%) **(points)** length/uniformity **(points)**	0-10 **1** short broken **1**	11-20 **3** short uniform **2**	21-50 **6** long broken **3**	>50 **9** long uniform **4**
Depth to water-restricting layer (cm) **(points)**	>90 **1**	61-90 **2**	30-60 **3**	<30 **4**
Surface soil detachability (0-15 cm)[a] **(points)**	SC,C,SiC **1**	SiCL,CL,SCL **2**	SL,L **4**	Si,SiL,fSL,LS,S **8**
Surface coarse fragments (0-15 cm)[a] **(points)**	>60 **1**	31-60 **2**	16-30 **3**	<16 **4**
Subsoil permeability (16-60 cm)[a] texture **(points)**	S,LS,SL,fSL **1**	L,SiL,Si **2**	CL,SCL,SiCL **3**	C,SC,SiC **4**

Soil erosion hazard rating[b] (point total)	Low	Moderate	High	Very high
	<16	16-22	23-31	>31

Soil Erosion risk = High

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Harvesting: skidder

3 different site preparations:

- Manual
- Scalping
- Ripping

Risk of Soil Erosion

	Autumn 2002	Spring 2003	Autumn 2003	Autumn 2004
Manual	26*	0	0	11
Scalping	389	1031	631	162
Ripping	423	1273	1136	457

* Soil loss (kg/ha constant weight)

Gonzalez-Arias A, N. Gartzia-Bengoetxea, M. Onaindia, I. Martinez de Arano. 2006. The effect of site preparation on water and soil protection in *Pinus radiata* plantations in the Basque Country. Ecosystem Goods and Services from Planted Forests. International Congress on Cultivated Forests

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Risk of Soil Compaction

Soil compaction and puddling hazard key

Soil texture[a] (0-30 cm)		Hazard rating[b] moisture regime: Xeric-subhygric[c] (H horizons <20 cm)	Subhygric[d]-subhydric (H horizons ≥20 cm)
Fragmental (coarse fragments >70%)		L	M
Coarse fragments (<70%)	Sandy S, LS	L	VH[e]
	Sandy loam SL, fSL	M	
	Silty/loamy SiL, Si, L	H	
	Clayey SCL, CL, SiCL, SC, SiC, C	VH	

Soil Compaction risk = Very High

	Bulk density (Mg m^{-3})	Soil Penetration Resistance (MPa)	Available water content (%)	Saturated hydraulic conductivity (cm h^{-1})
Manual	1.25 (0.0)[a*]	1.63 (0.48)[a]	17.9 (0.44)[a]	3.79 (0.14)[a]
Scalping	1.50 (0.0)[b]	3.73 (0.89)[b]	16.9 (0.11)[b]	0.46 (0.17)[b]
Ripping	1.49 (0.81)[b]	3.23 (0.51)[b]	15.4 (0.13)[c]	0.98 (0.36)[b]

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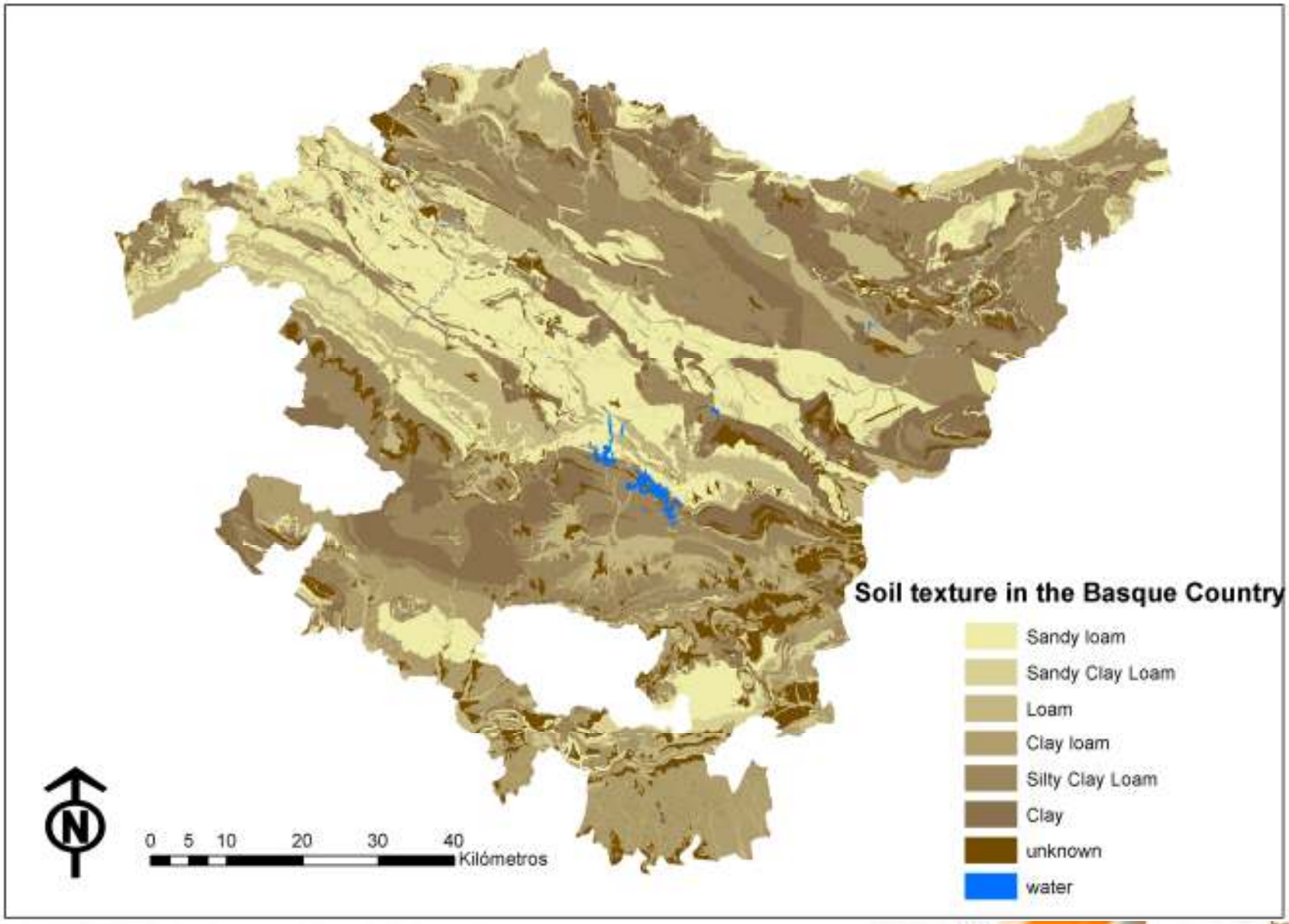
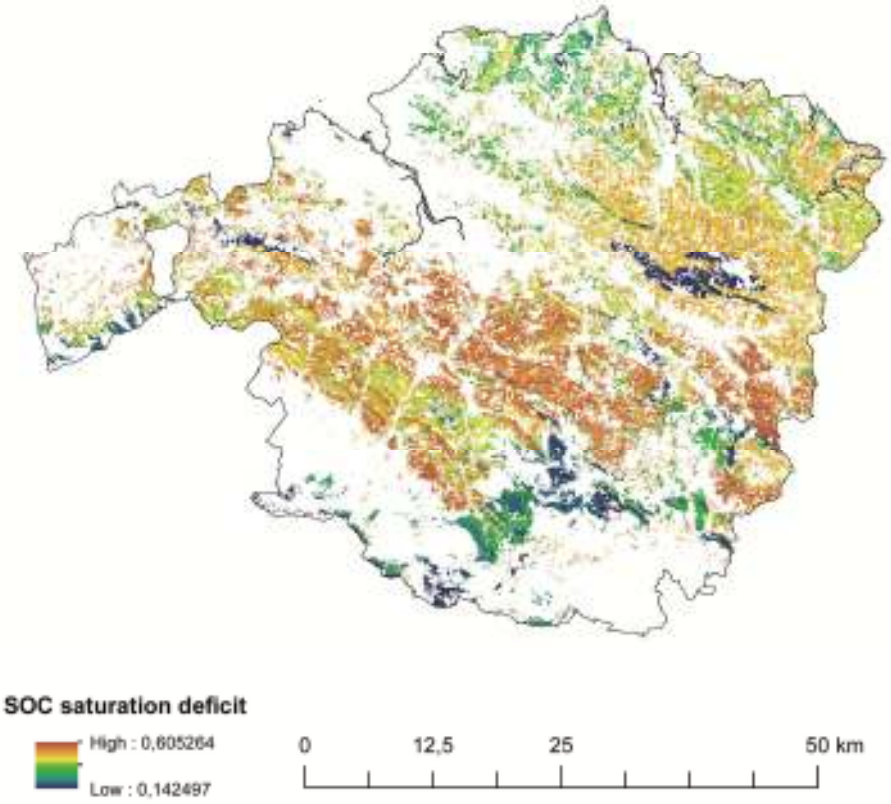


Risk of Soil Organic Matter decline

Calvo de Anta, R., Luís, E., Matilla, N., Casás, F., Macías, F., Camps, M., Vázquez, N., Galiñanes, J.M. 2014. Mapa digital de carbono en suelos del norte de España (Galicia y Cornisa Cantábrica). VI Congreso Ibérico de la Ciencia de Suelo.



Gartzia-Bengoetxea, N. and González-Arias, A. 2012. Protective capacity of soil organic carbon of forest soils and sequestration potential for forestry. I workshop on GHG from the Spanish agroforestry sector

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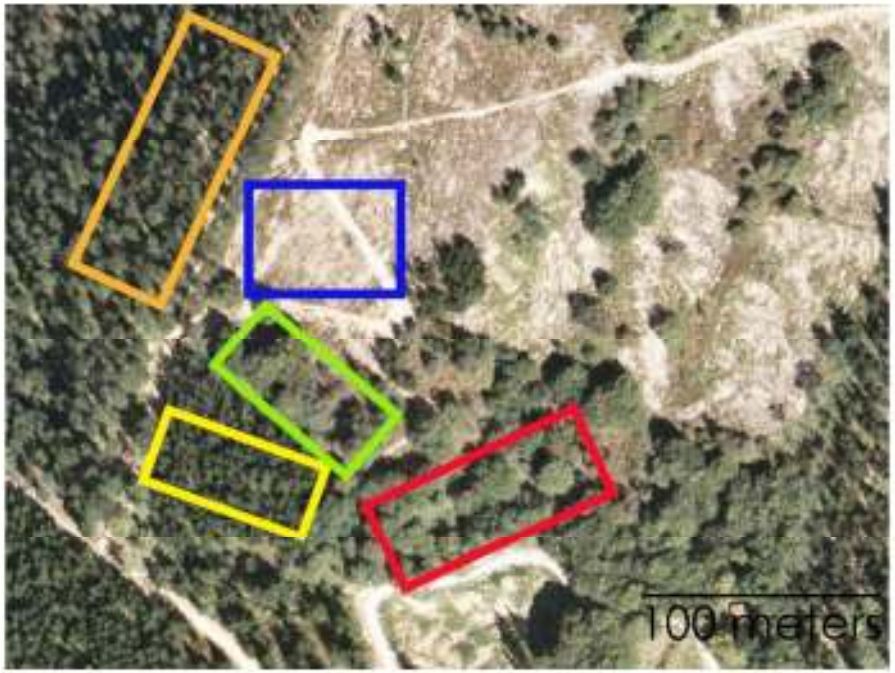

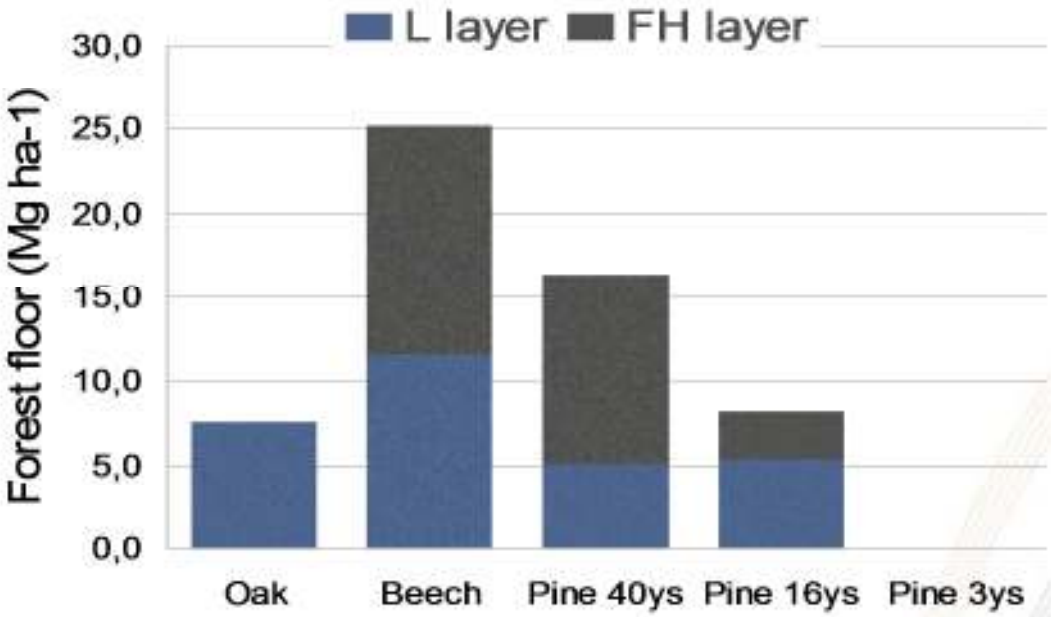

Pinus radiata D.Don
mechanized 3ys ago

Pinus radiata D.Don
mechanized 16ys ago

Pinus radiata D.Don
non mechanized

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Canadian Journal of Forest Research, 2009, 39(7): 1302-1312, 10.1139/X09-053

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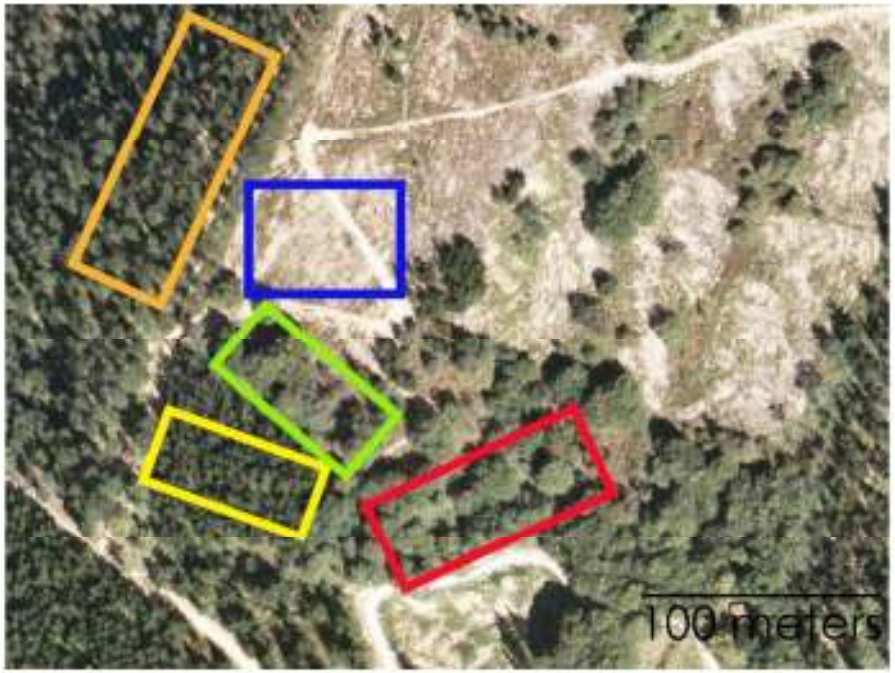

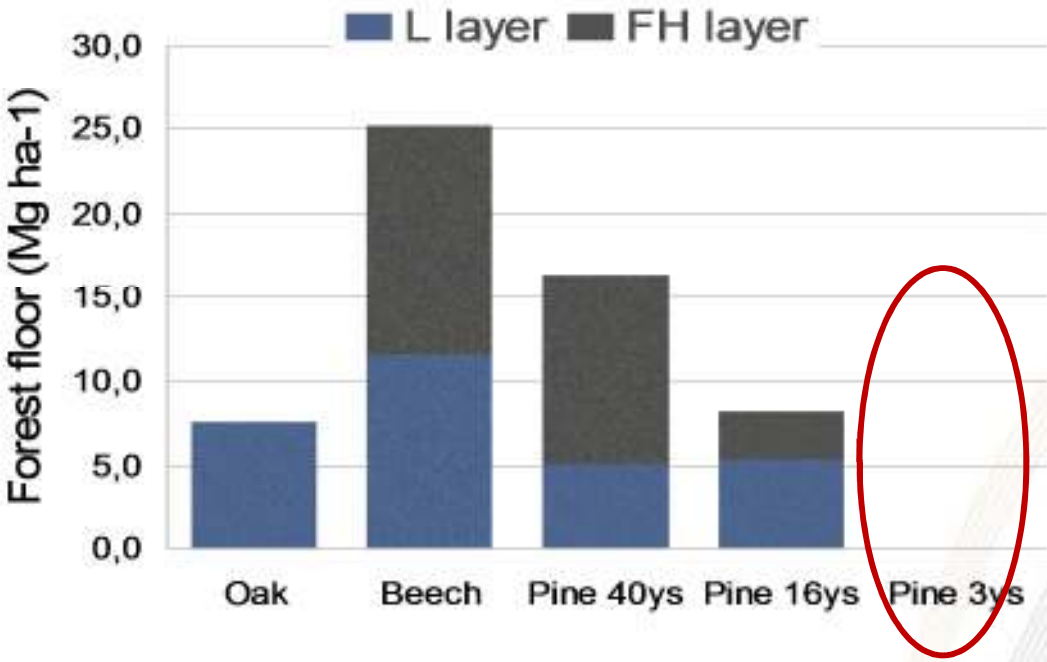

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Loss of Soil Organic Matter

1. Nutrient loss (kg/ha)

N	195
P	7
Mg	25
Ca	56
K	62

2. Reduction of carbon stocks, more than 6 Mg C ha^{-1} lost: direct effect on Climate Change

3. Reduction in water holding capacity of the soils, a reduction of 300% in least limiting water range for plant growth: loss of forest productivity due to water stress

4. Increment of surface soil erosion risk due to compaction, 23% increase in bulk density: loss of water quality

Gartzia-Bengoetxea, N., González-Arias, A., Kandeler, E., Martínez de Arano, I. Potential indicators of soil quality in temperate forest ecosystems: a case study in the Basque Country
Annals of Forest Science, 2009, 66: 303p1-p12

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Loss of Soil Biodiversity

Table III. Particulate organic matter (mg C g^{-1} soil), microbial, bacterial and fungal biomass (nmol PLFA g^{-1} soil), Gram-negative (Gram–) and Gram-positive (Gram+) biomarkers (%mole PLFA) and Shannon diversity index *H* at 0–5 cm and 5–15 cm in the soil profile of semi-natural oak and beech stands, and cultivated 40-year-old, 16-year-old and 3-year-old pine stands.

	Oak	Beech	40 y Pine	16 y Pine	3 y Pine
0–5 cm					
POM	6.52 (0.27)^{a}	6.43 (1.58)^{a}	3.25 (0.25)^{b}	5.40 (0.01)^{ab}	1.63 (0.15)^{b}
Microbial biomass	210.59 (28.84)^{a}	221.12 (10.64)^{a}	239.21 (23.72)^{ac}	304.06 (26.09)^{c}	136.51 (4.0)^{b}
Bacterial biomass	115.67 (16.12)^{ab}	117.43 (3.83)^{ab}	125.02 (14.11)^{ab}	159.29 (13.43)^{a}	80.64 (1.08)^{b}
Gram+	23.95 (0.37)^{a}	25.47 (0.99)^{a}	23.59 (0.74)^{a}	23.00 (0.39)^{a}	34.49 (1.3)^{b}
Gram–	29.43 (0.93)^{a}	25.79 (0.34)^{b}	26.44 (1.58)^{ab}	27.75 (0.58)^{ab}	22.64 (0.35)^{bc}
Gram+/Gram–	0.82 (0.04)^{a}	0.99 (0.03)^{b}	0.90 (0.04)^{ab}	0.83 (0.03)^{ab}	1.53 (0.08)^{c}
fungal	6.63 (1.0)^{a*}	7.97 (1.21)^{ac}	12.85 (2.53)^{b}	12.05 (1.13)^{bc}	3.17 (0.84)^{a}
Shannon diversity *H*	2.50 (0.03)^{a}	2.58 (0.02)^{b}	2.65 (0.02)^{b}	2.65 (0.02)^{b}	2.61 (0.01)^{b}
5–15 cm					
POM	1.64 (0.05)^{a}	1.43 (0.13)^{a}	3.24 (0.51)^{b}	1.95 (0.48)^{a}	1.54 (0.11)^{a}
Microbial biomass	168.34 (6.81)^{ab}	147.03 (20.08)^{ab}	185.51 (20.56)^{a}	203.71 (27.75)^{a}	90.13 (4.52)^{b}
Bacterial biomass	89.90 (3.36)^{a}	82.11 (9.11)^{ab}	99.86 (7.09)^{a}	111.20 (14.47)^{a}	50.62 (2.86)^{b}
Gram+	27.08 (0.16)^{ab}	28.08 (0.76)^{ab}	25.68 (1.8)^{a}	24.41 (1.2)^{a}	30.91 (0.83)^{b}
Gram–	24.74 (0.67)^{a}	26.16 (1.12)^{ab}	26.71 (0.72)^{ab}	28.65 (0.91)^{b}	23.13 (0.44)^{ac}
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Bacterial biomass	115.67 (16.12)^{ab}	117.43 (3.83)^{ab}	125.02 (14.11)^{ab}	159.29 (13.43)^{a}	80.64 (1.08)^{b}
Gram+	23.95 (0.37)^{a}	25.47 (0.99)^{a}	23.59 (0.74)^{a}	23.00 (0.39)^{a}	34.49 (1.3)^{b}
Gram–	29.43 (0.93)^{a}	25.79 (0.34)^{b}	26.44 (1.58)^{ab}	27.75 (0.58)^{ab}	22.64 (0.35)^{bc}
Gram+/Gram–	0.82 (0.04)^{a}	0.99 (0.03)^{b}	0.90 (0.04)^{ab}	0.83 (0.03)^{ab}	1.53 (0.08)^{c}
fungal	6.63 (1.0)^{a*}	7.97 (1.21)^{ac}	12.85 (2.53)^{b}	12.05 (1.13)^{bc}	3.17 (0.84)^{a}
Shannon diversity *H*	2.50 (0.03)^{a}	2.58 (0.02)^{b}	2.65 (0.02)^{b}	2.65 (0.02)^{b}	2.61 (0.01)^{b}
5–15 cm					
POM	1.64 (0.05)^{a}	1.43 (0.13)^{a}	3.24 (0.51)^{b}	1.95 (0.48)^{a}	1.54 (0.11)^{a}
Microbial biomass	168.34 (6.81)^{ab}	147.03 (20.08)^{ab}	185.51 (20.56)^{a}	203.71 (27.75)^{a}	90.13 (4.52)^{b}
Bacterial biomass	89.90 (3.36)^{a}	82.11 (9.11)^{ab}	99.86 (7.09)^{a}	111.20 (14.47)^{a}	50.62 (2.86)^{b}
Gram+	27.08 (0.16)^{ab}	28.08 (0.76)^{ab}	25.68 (1.8)^{a}	24.41 (1.2)^{a}	30.91 (0.83)^{b}
Gram–	24.74 (0.67)^{a}	26.16 (1.12)^{ab}	26.71 (0.72)^{ab}	28.65 (0.91)^{b}	23.13 (0.44)^{ac}
Gram+/Gram–	1.10 (0.02)^{a}	1.08 (0.04)^{a}	0.96 (0.04)^{ab}	0.86 (0.06)^{b}	1.34 (0.06)^{c}
fungal	5.56 (0.84)^{a}	4.57 (0.83)^{a}	8.74 (3.47)^{a}	5.41 (0.42)^{a}	2.99 (0.44)^{ac}
Shannon diversity *H*	2.55 (0.05)^{a}	2.64 (0.02)^{ab}	2.60 (0.01)^{ab}	2.66 (0.02)^{ab}	2.71 (0.04)^{b}

* Significance level, $P < 0.1$. Values are the means of three replicates, with standard errors in parentheses. Different letters in the same row indicate significant differences at $P < 0.05$.

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Loss of Soil Biodiversity

Table III. Particulate organic matter (mg C g^{-1} soil), microbial, bacterial and fungal biomass (nmol PLFA g^{-1} soil), Gram-negative (Gram–) and Gram-positive (Gram+) biomarkers (%mole PLFA) and Shannon diversity index *H* at 0–5 cm and 5–15 cm in the soil profile of semi-natural oak and beech stands, and cultivated 40-year-old, 16-year-old and 3-year-old pine stands.

	Oak	Beech	40 y Pine	16 y Pine	3 y Pine
0–5 cm					
POM	6.52 (0.27)^{a}	6.43 (1.58)^{a}	3.25 (0.25)^{b}	5.40 (0.01)^{ab}	1.63 (0.15)^{b}
Microbial biomass	210.59 (28.84)^{a}	221.12 (10.64)^{a}	239.21 (23.72)^{ac}	304.06 (26.09)^{c}	136.51 (4.0)^{b}
Bacterial biomass	115.67 (16.12)^{ab}	117.43 (3.83)^{ab}	125.02 (14.11)^{ab}	159.29 (13.43)^{a}	80.64 (1.08)^{b}
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Shannon diversity *H*	2.50 (0.03)^{a}	2.58 (0.02)^{b}	2.65 (0.02)^{b}	2.65 (0.02)^{b}	2.61 (0.01)^{b}
5–15 cm					
POM	1.64 (0.05)^{a}	1.43 (0.13)^{a}	3.24 (0.51)^{b}	1.95 (0.48)^{a}	1.54 (0.11)^{a}
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fungal	5.56 (0.84)^{a}	4.57 (0.83)^{a}	8.74 (3.47)^{a}	5.41 (0.42)^{a}	2.99 (0.44)^{ac}
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* Significance level, $P < 0.1$. Values are the means of three replicates, with standard errors in parentheses. Different letters in the same row indicate significant differences at $P < 0.05$.

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Risk of Soil Sealing

Surface (ha)	NFI 2010	NFI 2005	
Forest soils	491526	494470	**-2944**
Agricultural soils	179682	180730	**-1048**
Sealed soils	45863	41684	**4179**
Water	5368	5555	
Total	722439	722439	

source: National Forest Inventory

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Future perspective

1. Basque society is demanding more and more services to the forests

Future perspective

2. Basque society is also demanding more and more greener products

3. But also Europe with Europe 2020 strategy in which a low carbon economy is reinforced

4. And the changes in temperature and rainfall that climate change is expected to bring about will make soils increasingly more vulnerable and forest soils will not be an exception.

Future perspective

If we want to satisfy the **demands of the society**, we need to diversify our forest production and assure sustainability in intensification.

For what:

Forest soils and their risks to degradation, all the risks not only erosion, need to be taken into account in the **forest policies**. It is important the implementation of a **soil protection strategy** based on the knowledge.

Forest managers need to know more about soils and forest researcher needs to **increase the awareness** of soils and help managers to manage them

And the society will have to **pay for all the services** is asking to the forests

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basozaintza@neiker.net