Deliverable 1.8

Description of the vegetation in different stages of secondary succession according to parameters of structure (high, diameter, density etc) and floristic composition and main types of human disturbance.

The report will include discussions based on comparative analysis on the role of the different types of vegetation in water and soil conservation

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TITLE

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KEYWORDS

vegetation parameters, biomass

ABSTRACT

This report describes the parameters of vegetation structure and floristic composition.

Project Leader

IST - Instituto Superior Técnico
Secção de Ambiente e Energia - Dep. de Mecânica
Av. Manuel da Maia nº 36 3ºEsq., 1000-201 Lisboa
PORTUGAL

INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

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AUTHOR(S)

Enrico Feoli, Cristina Simonetti, Paola Almeida, Laura D'Aietti, Rossella Napolitano

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Vegetation of the Santos estuary drainage basin: description of the main vegetation types

Introduction

The region known as *Baixada Santista*, the political-administrative area that comprises Santos estuary's drainage basin, is an extensive coastal plain traversed by numerous meandering rivers channels over vast plains molded from marine and/or continental detrital sediments, occasionally interrupted by isolated mountains. The coastal plain is limited inland by the border of the Atlantic Plateau, the coastal highlands, a vast set of scarps named *Serra do Mar*, which rises up to 1000 meters above sea level.

This humid tropical landscape is composed of rain forests, mangrove wetlands, an extensive industrial complex, mainly of heavy chemical industries, one of the largest Latin America's international ports, *Porto de Santos*, densely populated urban areas, continuous or patchy on forest matrixes, and a dense net of railways, highways, roads, transmission lines, gas and oil ducts and other linear features, most of them crossing the forest remnants.

The current characteristics of the natural forests are thus products of fragmentation and related edge effects, selective logging, and of heavy industrial pollution –which has not been controlled until 1983. The vast set of scarps that limits the industrial area, a natural barrier to the predominant and highly humid south winds, is also an effective obstacle for the dispersion of air pollutants, which severely damaged a considerable part of the natural forests, as those along Mogi and Cubatão river valleys.

In 1962 the forests of the Serra do Mar were not severely degraded by air pollution. Primary and secondary forests covered 53% and 30% of Cubatão area, respectively. In the following years, the unfavorable conditions for the atmospheric dispersion of the industrial emissions and the growing levels of atmospheric pollutants promoted drastic changes in the composition and structure of the natural forests, which soon lost most of their emergent and canopy trees, not able to survive in such highly polluted environment. In 1977 virtually all the natural forests of the Serra do Mar in Cubatão were affected by air pollution (SANTOS *et al*., 1994 *apud* POMPÉIA, 1997).

Situation is slowly changing since the mid eighties, when the state environment department begun to control the industrial emissions. The forests, however, are not recovering, since the atmospheric pollution restricts the establishment or hampers the development of most native species, favoring the proliferation of a few tolerant pioneer species (POMPÉIA, 1997).

The present report describes floristic and structural characteristics of some of the main vegetation types of Santos estuary drainage basin, mostly degraded as a result of the high levels of atmospheric phytotoxic pollutants and/or of the prolonged human disturbance.

Vegetation descriptions

The following descriptions of the main vegetation types of the *Baixada Santista* are based on the available data and on the preliminary results of a post-doctorate research developed within the ambit of the project Ecomanage. Most of the information is based on quantitative surveys (LEITÃO FILHO *et al.*, 1993; POMPÉIA, 1997; MKR/EMBRAPORT, 2003; post-doctorate research).

Table 1 presents the described vegetation types and the sources of information. Figure 1 shows the study sites. Annex 1 presents a list of the species identified in the study sites.

Table 1. Vegetation types described in the present report and sources of data

land form	terrains and environment	vegetation	references
Coastal highlands (Serra do Mar)	slopes of slightly polluted areas	intermediate seral stage secondary forests	1. LEITÃO FILHO *et al*. (1993) 2. POMPÉIA (1997)
	slopes of heavily polluted areas	degraded; early to intermediate seral stages secondary forests	1. LEITÃO FILHO *et al*. (1993) 2. POMPÉIA (1997)
Coastal plain	natural terrains	mangrove wetlands	3. MKR/EMBRAPORT (2003) 4. COSIPA/CONSULTORIA PAULISTA (2004)
		early serial stage secondary forests	3. MKR/EMBRAPORT (2003)
	waste lands	early seral stage secondary forests	4. COSIPA/CONSULTORIA PAULISTA (2004) 5. post-doctorate research (preliminary data)
		pioneer herbaceous vegetation	4. COSIPA/CONSULTORIA PAULISTA (2004) 5. post-doctorate research (preliminary data)

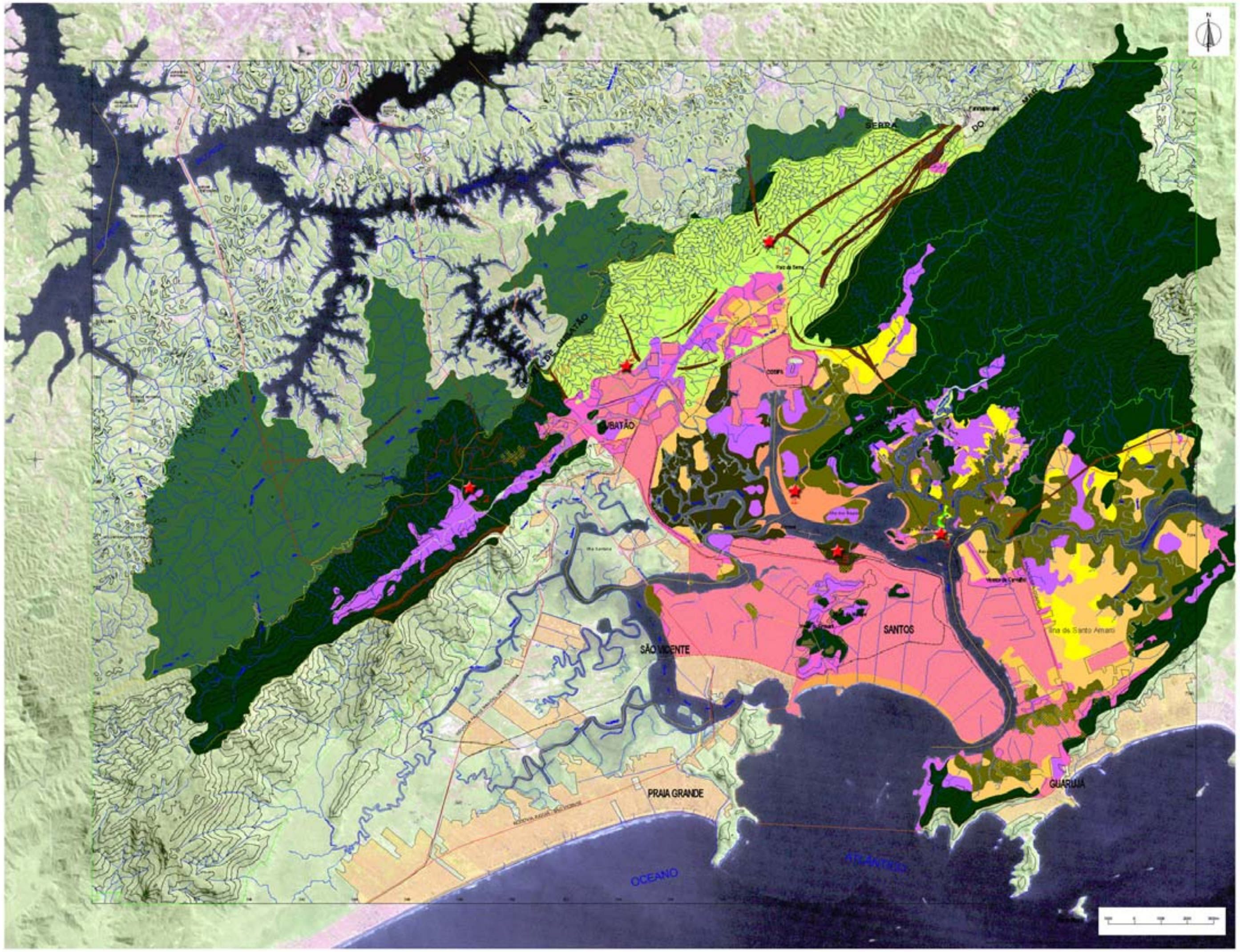

Figure 1. Baixada Santista - vegetation and urban areas
(adapted from MKR/EMBRAPORT 2003)

★ phytosociological and/or floristic data

1. LEITAO FILHO et al. (1993)
2. POMPEIA (1997)
3. MKR/EMBRAPORT (2003)
4. COSIPA/CONSULTORIA PAULISTA (2004)
5. post-doctorate research (unpublished data) - preliminary data

Coastal Plain

- open mangrove wetlands
- closed mangrove wetlands
- secondary forests (initial/intermediate seral stages)
- secondary forests (intermediate/late seral stages)
- pioneer vegetation

Coastal Highlands (Serra do Mar)

- secondary forests (initial/intermediate seral stages)
- primary and secondary forests (intermediate/late seral stages)

Atlantic Plateau

- primary and secondary forests (intermediate/late seral stages)

- exposed soils
- degraded areas
- urban and industrial areas
- mines
- other anthropic areas

- highways
- railways
- rivers
- Serra do Mar State Park
- Serra do Mar Natural Area

1. Coastal highlands (Serra do Mar)

1.1 Slopes of slightly polluted areas - intermediate seral stage secondary forests

LEITÃO FILHO *et al.* (1993) and POMPÉIA (1997) analyzed the composition and structure of a secondary remnant of the Atlantic rain forest on Pilões river valley, in Cubatão (figure 1). According to the authors, the sampled forests have closed canopies and apparently are not affected by air pollution, but present some evidences of past disturbance, such as the lack of hardwood species and of adult forms of *Euterpe edulis*, a palm tree typical of the Atlantic dominium, intensively exploited due to its commercial value –in spite of the illegality of heart-of-palm trade.

LEITÃO FILHO *et al*. (1993) located 40 100 square meters plots (10 x 10 m) along the Pilões river valley in three sample sites: ten contiguous plots on the foot slope in a relatively disturbed patch (site 1), ten plots 200 meters above in a better preserved forest (site 2), and twenty plots on another slope, also in a rather disturbed forest (site 3). All trees ≥ 6.5 centimeters in diameter at breast height (DAP; 1.30 meters) were included in the survey.

The authors sampled 777 trees belonging to 145 species and 42 families (Annex 1), besides 144 standing dead trees, a number relatively high. Alpha diversity (Shannon index, *H'*)[1] was 4.31 (site 1, 3.77; site 2, 3.92; site 3, 3.64). The average height of the sampled trees was 9.37 meters, tree height varied from 2.0 to 25.0 meters; approximately 84% of the sampled trees were less than 12 meters high.

Families Myrtaceae, Lauraceae, Rubiaceae, Euphorbiaceae, Sapotaceae, and Melastomataceae, in this order, were the richer in species; Rubiaceae, Euphorbiaceae, Melastomataceae, Sapotaceae, Myrtaceae, Nyctaginaceae, and Lauraceae were the most abundant. The results are coherent with other studies of the Atlantic rain forest along the scarps of the Serra do Mar (*e.g.* LEITÃO FILHO *et al*., 1989; SILVA and LEITÃO FILHO, 1982; MANTOVANI, 1993; MELO and MANTOVANI, 1994; SILVA, 1994; SIMONETTI, 2001), except for the remarkable abundance of individuals of the family Melastomataceae, which is rich in pioneer species.

The most important species[2] were *Guapira opposita* (Nyctaginaceae; IVI = 17.38), *Eriotheca pentaphylla* (Bombacaceae; IVI = 16.97), *Pera glabrata* (Euphorbiaceae; IVI = 16.25), *Mabea brasiliensis* (Euphorbiaceae; IVI = 10.44), *Chrysophyllum flexuosum* (Sapotaceae; IVI = 9.62), and *Miconia cabucu* (Melastomataceae; IVI = 9.46).

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[1] $$H' = -\sum_{i=1}^{S} pi \,.\, \ln pi \quad \textbf{(I)}$$

pi = ni/N
ni = number of individuals of the species *i*
N = number of individuals
S = number of species

[2] Considering the Importance Value Index (IVI), which is the sum of the relative values of density, frequency, and dominance.

The percentages of typical pioneer and early secondary species varied from 59.7 to 74.6 of the total number of species and from 73.0 to 87.1 of the total number of individuals. At the set of plots located in the less disturbed forest, pioneer species represented 5.9% to 22.5% of the sample trees; the percentage of late secondary species varied from 12.8 to 26.8.

In the same area, POMPÉIA (1997) surveyed 32 100 square meters sample plots (2 x 50 m); all shrubs and trees with DAP ≥ 2.5 centimeters were included in the survey.

The author identified 77 species belonging to 36 families. Alpha diversity (*H'*) was 3.43. Total density was 2522 individuals per hectare. The average diameter at breast height was 9.4 centimeters (minimum 2.5 cm; maximum 55.1 cm); average height was 7.9 meters (minimum 2.0 m; maximum 25.0 m).

Families Melastomataceae, Nyctaginaceae and Euphorbiaceae were the richest in species. The most important species were *Tibouchina pulchra* (Melastomataceae; IVI = 8.9), *Guapira opposita* (Nyctaginaceae; IVI = 8.7), *Miconia cinnamomifolia* (Melastomataceae; IVI = 8.3), and *Chrysophyllum flexuosum* (Sapotaceae; IVI = 6.9).

1.2 Slopes of heavily polluted areas - early to intermediate seral stages secondary forests

LEITÃO FILHO *et al.* (1993) and POMPÉIA (1997) analyzed the forests along Mogi river valley in Cubatão, mostly degraded by the prolonged exposition to high levels of atmospheric pollutants. According to POMPÉIA (*op. cit.*), the forests lack bromeliads, orchids, gesneriaceans and other epiphytes, remarkably abundant and diverse in the Atlantic rain forest. As in the previous sites, *Euterpe edulis* is extremely rare. Under storey tree ferns, caespitose palms and several Piperaceae are fairly common, especially in forests gaps.

In one 0.2 hectare sample site (40 x 50 m), LEITÃO FILHO *et al.* (1993) located 20 100 square meters plots (10 x 10 m) and surveyed all trees with DAP ≥ 6.5 centimeters. Forty months after the survey, all the sampled trees were measured again.

In the first survey, the authors sampled 203 trees belonging to 30 species and 19 families, besides 50 standing dead trees. The number of standing dead trees, extremely high in the first survey, increased considerably after 40 months, growing to 75. Alpha diversity (*H'*) was remarkably low, only 2.14. Average height was 4.39 meters (minimum 2.0 m; maximum 7.0 m).

The families with the greatest numbers of individuals were Fabaceae, Melastomataceae and Palmae, each one represented by 10% of the sample. *Tibouchina pulchra* (Melastomataceae), a pioneer specie, was extremely abundant in the study site, occurring in 95% of the sample plots. Other four species, all common pioneer trees, were common in the area: *Bactris setosa* (Arecaceae), *Syagrus* *romanzoffiana* (Arecaceae), *Cecropia glaziouii* (Cecropiaceae), and *Miconia cinnamomifolia* (Melastomataceae). Pioneer species represented 72.9% of the total sampled trees and late secondary species, only 2.0%.

Based on the data gathered in the second survey, the authors noted that the number of trees with DAP ≥ 6.5 centimeters is decreasing and concluded that the forest is not recovering as it would be expected in areas free of atmospheric pollution. A considerable number of trees belonging to the most common species *Tibouchina pulchra* or *Bactris setosa* develop an abnormally number of additional trunks, suggesting the premature death of the main trunk and basal branching.

POMPÉIA (1997) surveyed two sample sites on Mogi river valley, one very close to that described above (named site VM), and other near the *Caminho do Mar*, the old São Paulo – Santos road (site CM). The survey was carried in 32 100 square meters sample plots (2 x 50 m); all shrubs and trees with DAP ≥ 2.5 centimeters were included in the survey.

In sample site CM, the author sampled 73 species and 37 families. Alpha diversity (*H'*) was 3.09. Total density was 2141 individuals per hectare. Approximately 42% of the sampled shrubs and trees had diameters at breast height ≤ 6.0 centimeters; heights varied from 1.2 to 13.0 meters. Typical emergent trees, such as *Eriotheca pentaphylla* (Bombacaceae), *Pterocarpus rohrii* (Leguminosae), were shorter than the pioneer species.

The families Myrtaceae, Melastomataceae, Rubiaceae, and Apocynaceae were the richest in species; the same families were also the most abundant in the survey, but not in the same sequence. The most important species were *Miconia cinnamomifolia* (Melastomataceae; IVI = 26.4), *Malouetia arborea* (Apocynaceae; IVI = 13.3) and *Cousarea nodosa* (Rubiaceae; IVI = 7.0). Pioneer species, as *M. cinnamomifolia*, *M. arborea*, *Tibouchina pulchra* and *T. mutabilis* (Melastomataceae), were very frequent in the surveyed site.

In site VM, the forest is open and notably more affected by the atmospheric pollution. POMPÉIA (1997) sampled 44 species, belonging to 24 families. Alpha diversity (*H'*) was remarkably low, 2.14. Total density was very low, only 1206 individuals per hectare

The most important species were the pioneer *T. pulchra* (IVI = 22.8) and *M. cinnamomifolia* (IVI = 18.5), followed by the early secondary *Guarea macrophylla* (Meliaceae; IVI = 8.6), all of them very frequent in the area surveyed and found in all phases of their life cycles, from sapling to adults, which dominate the canopy. The families richer in species were Rubiaceae, Melastomataceae and Arecaceae.

Several species relatively common in well preserved forests occurred in low frequencies, such as *Amphyrrhox latifolia* (Violaceae), *Ecclinusa ramiflora* (Sapotaceae) and *Psychotria* spp. (Rubiaceae), typical umbrophyllous species, or *Persea pyrifolia* (Lauraceae), *Ocotea acyphylla*

(Lauraceae), and *Sloanea monosperma* (Elaeocarpaceae), common canopy species, all of them with small basal areas in the surveyed site.

According to the author, it is possible that these species are able to grow relatively well until they reach the canopy, when they become more vulnerable to the phytotoxic effects of the atmospheric pollutants. At this stage, most of the typical canopy and emergent trees die and are replaced by tolerant and fast-growing pioneer species.

Air pollution thus promotes the retrogressive succession of the natural vegetation. The atmospheric pollutants, highly concentrated over the scarps of the Serra do Mar in Santos and Cubatão, reduce the floristic diversity, the density and basal area of trees and shrubs, promote high levels of mortality of common canopy species and emergent trees, and restrict the development of most native species, while favor the proliferation of a few tolerant pioneer species.

2. Coastal plain

2.1 Natural terrains

2.1.1 Mangrove wetlands

Information on mangrove wetlands is based on two environmental impact assessments (EIAs), one of a new harbor along Piaçaguera channel, on the opposite margin of *Porto de Santos* (MKR/EMBRAPORT, 2003), and the other of the dragging of an inland portion of the same channel that leads to important industrial plants (COSIPA/CONSULTORIA PAULISTA, 2004).

Only the first EIA presents quantitative data. The area directly affected by the construction of the new harbor, at the confluence of Jurubatuba and Diana rivers (figure 1), include early secondary forests, mangrove wetlands and herbaceous pioneer vegetation.

Mangrove wetlands were analyzed in eight 100 square meters (4 x 25 m) sample plots; the survey considered all shrubs and trees with DAP ≥ 3.2 centimeters. The EIA included also a floristic survey, which yielded 116 species, and an estimative of the woody biomass of the sampled vegetation.

The authors sampled 116 trees belonging to three typical and widespread mangrove species, *Avicennia schaueriana* (Verbenaceae), the most abundant and frequent species of the survey, *Laguncularia racemosa* (Combretaceae) and *Rhizophora mangle* (Rhizophoraceae). Density varied from 1000 to 3300 individuals per hectare.

The same species were also the most frequent in the area surveyed in the second EIA (COSIPA/CONSULTORIA PAULISTA, 2004), followed by other common mangrove species, such as *Talipariti tiliaceum* var. *pernambucense* (Malvaceae), *Acrosticum aureum* (Pteridophyta, Polypodiaceae), and *Crinum kunthianum* (Amaryllidaceae).

2.1.2 Early secondary forests

Early secondary forests of natural terrains, *i.e.* Quaternary alluvial-marine deposits, were investigated in the EIA of a new harbor along Piaçaguera channel (MKR/EMBRAPORT, 2003). The forests were analyzed in three 100 square meters (4 x 25 m) sample plots; the survey considered all shrubs and trees with DAP ≥ 3.2 centimeters.

The survey yielded 16 species, most of them typical pioneers, such as *Syagrus romanzoffiana* (Arecaceae), the most abundant and frequent in the survey, *Schinus terebinthifolius* (Anacardiaceae) and *Citharexylum myrianthum* (Verbenaceae).

2.2. Waste lands

The vegetation of extensive deposits of waste material and contaminated alluvial-marine sediments is the object of a post-doctorate research developed within the ambit of the project Ecomanage and was also described briefly in the environment impact assessment of the dragging of Piaçaguera channel (COSIPA/CONSULTORIA PAULISTA, 2004).

Only the post-doctorate research includes quantitative data. The research, a quantitative analysis of the vegetation structure and composition, is being carried out on a thick deposit of waste material, which overlies a considerable portion of a mangrove remnant within the *Porto de Santos* area; the deposit includes several toxic substances (NORFOLK/ESSENCIS, 2005).

The forests were surveyed in twelve 250 square meters (5 x 50 m) sample plots; all trees, treelets and shrubs with heights ≥ 1.30 meter were included in the survey. The research comprises also a floristic survey of herbaceous species. All the presented results are preliminary.

2.2.1 Early secondary forests

Until now the survey yielded 28 species belonging to 16 families (858 individuals sampled). The most abundant species are *Acnistus arborescens*, *Cestrum intermedium*, both common pioneer solanaceans, and *Guarea guidonia* (Meliaceae), an early seral stage specie. Density of woody plants is extremely variable, ranging from 1200 to 4960 individuals per hectare.

The early secondary forest described in the EIA (COSIPA/CONSULTORIA PAULISTA, 2004) is also dominated by pioneer species, such as *Leucaena leucocephala* (Leguminosae), *Schinus terebinthifolius* (Anacardiaceae) and *Citharexylum myrianthum* (Verbenaceae), also recorded in the previous area.

2.2.2. Pioneer herbaceous vegetation

The vegetation of the waste deposits includes different herbaceous patches. In the *Porto de Santos* site, some areas are completely covered by a dense creeping herb, *Cissus verticilata* (Vitaceae), also a climber on the woody vegetation. Others areas are formed exclusively by *Alternanthera philoxeroides* (Amaranthaceae) or *Ageratum conyzoides* (Asteraceae).

In Cubatão, the waste land includes different types of hygrophilous fields, each one formed by one or a few dominant species. *Eleocharis acutangula* (Cyperaceae), *Paspalum vaginatum* and *P. maritimum* (Poaceae) dominate the lower and wettest parts and of the deposits. Extensive moist areas are covered by a sole pteridophyte, *Acrostichum aureum*, while patches of *Hibiscus* *pernanbucescens* (*Talipariti tiliaceum* var. *pernambucense*; Malvaceae) mark the transition to the higher and less humid zones.

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Vegetation parameters for all sites

Many parameters are taken into consideration in the following tables, seeking to collect a complete dataset from the current bibliography. Vegetation biomass (leaf, stem, root), Leaf Area Index (LAI), Specific Leaf Area (SLA), Crown Index and allometric relationships are used in most current dynamic vegetation models (DVMs) (e.g. Foley et al., 1996; Kucharik et al., 2000). The importance of such models and vegetation analysis is explained considering that vegetation affects climate by modifying the energy, momentum, and hydrologic balance of the land surface. The influence of vegetation on climate takes place via physiological and structural (LAI, root depth and distribution, height and albedo) properties. In particular, due to the ecological importance of root biomass to understand and predict ecosystem functioning (carbon and water fluxes) and the role of the soils in carbon storage, many studies are focused on the plant rooting distribution, considering specific species (Rao et al, 1996) and for terrestrial biomes (Whittaker and Likens, 1975, Jackson et al., 1996, 1997, Canadell et al., 1996, Vogt et al. 1985 and 1996, Cairns et al., 1997). Indeed, were analyzed the efficiency of ecosystems through the net primary productivity (NPP), above and belowground productivity (Jackson et al., 1996; Canadell et al., 1996; Cairns et al., 1997; Vogt et al., 1996), as reported on the table.

In forest ecosystems there may be a close relationship between the distribution of the organic compartment and the distribution of inorganic nutrients. Factors which affect the biomass and production of forested ecosystems usually also affect the patterns of nutrient distribution, particularly in intrasystem nutrient cycles. The influence of the organic compartment on the distribution of nutrients is probably at a maximum in the moist tropics where a majority of the exchangeable nutrients in the ecosystems are held in the living biomass (Greenland and Kowal, 1960).

Root profile may be resumed considering the following information: root biomass in the topsoil, root vertical distribution, maximum rooting depth, surface root density, tree root form. As showed in the table, there is a distinction between dead and live biomass roots, where total root living biomass should be considered as an approximation of the sum of the weights of tree and grass fine and suberised roots.

A possible competition between the species as the positive effects on the fertility of the soil from others may further explains the root pattern and biomass distribution. In general, roots can contribute an important amount of nutrients to the system through the decomposition-mineralization of roots and nodules and by nutrient exudation. Furthermore, deeper root systems allow for both improved resource capture and more carbohydrate reserves for a rapid growth, even during the dry season. In fact, Canadell et al. (1996) clearly demonstrate how this root pattern is related to the plants that grow well into the summer drought and, such as desert plants with minimal or no rainfall, for many years. Nepstad et al., (1994) explain how half of the closed forests of Brazilian

Amazonia depends on the deep root systems to maintain green canopies during the dry season. In many case the difference in root patterns are related to the physical conditions: nutrient deficiencies, low pH cause a relative reduction of shoot production (specially the stem fraction) and specific leaf area, as well as a shift in the carbon partitioning, favoring the root development (Rao et al., 1993). Thus, it may suggests a possible consideration of the changing root biomass as a possible bioindicator of the ecological status of the forest. As underlie Vogt and his colleagues (1996), even though fine roots may contribute less than 2% of the total ecosystem biomass, they may contribute up to 40% of the total ecosystem production. This mean that, when examining carbon allocation in forests, the fine root component (similar to the foliage in the aboveground), may be very sensitive to environmental change and thus may respond most strongly to a disturbance.

In general, root biomass is considered resided in the upper 1-2 m of soil, while the root surface area is important for resource uptake, that is limited primarily to the small diameter roots (< 2 mm) of the superficial layers. Vance and Nadkarni (1992) founded < 1 mm size class to be the most represented, often three times the biomass as roots in either of the two size classes (1-2mm and 2-5mm). High fine root biomass is a common feature in tropical forest, but the wide range of values suggest that not all tropical forests have large superficial fine root biomass, as shown in the table.

Indeed, Vance and Nadkarni (1992) point out as the canopy may provides a second habitat for roots in moist tropical montane forest in Costa Rica, which seems to act as an important nutrient conserving mechanism by trapping a portion of these nutrients inputs before they reach the forest floor, leading an increment in the productivity.

To obtain a more realistic representation of belowground processes the roots distribution data may be incorporate in the biome or global models that in some cases are linked to a GCM (general circulation or global change model) to quantify the feedbacks between vegetation and climate (in particular water fluxes and carbon sequestration). Global change may induce strong environmental feedbacks between plant rooting distribution and climate. Despite their importance for nutrient cycling, resource capture, and global biogeochemistry, fine roots are poorly represented in global models.

Many authors (Sundarapandian and Swamy, 1996; Jackson et al.,1997) have focused their studies in particular on fine roots. These are the primary pathway for water and nutrient uptake by plants, the same role that leaves play for carbon and energy uptake. Fine roots are also a prominent, possibly the prominent, sink for carbon acquired in terrestrial net primary productivity. Primary production allocated below ground is often greater than that allocated above ground, and annual carbon and nutrient inputs to the soil from fine roots frequently equal or exceed those from leaves (Jackson et al 1997). It is important underlying how many authors consider differently the diameter of fine roots, for instance, Vance E.D. and Madkarni N.M. (1986), < 2mm, Nepstad et al., 1994, < 1mm, Jackson

R.B. et al., (1997) ≤ 2mm, Sundarapandian S.M. and Swamy P.S., (1996) very fine ≤ 1mm and fine 1-3 mm. Another consideration is related to the concept of root density: Vance and Nadkarni (1992) express root biomass density in Mg root cm3 soil, while Cairns et al., (1997) summarized and reviewed the root biomass density in Mg ha -1. Concerning fine-root biomass, Jackson et al., (1997) used Kg m-3, Nepstad et al., (1994), Mg cm-3 while Arora V.K. and Boer G. (2003) in Kg m-2.

Sundarapandian and Swamy (1996) compare the differences in level of fine root biomass under deciduous and evergreen forests, the root distribution and the effects of open canopies on the level of fine root biomass under the two different forest type located in south of India. The results show clearly an increase in fine root biomass and related productivity, in the closed canopy of evergreen and semi-evergreen tropical forest where was revealed a consistent in litter accumulation. The canopy such as high tree density, basal area and the plant litter on the surface improve the microclimate and contribute to a greater fine root biomass.

Another parameter that explains the ecosystems is called root/shoot ratio (R/S), the relative biomass allocation between root and aboveground plant parts. Various factors have an influence on R/S such as stand/tree age, or is a function of tree species and differs between Gymnosperms and Angiosperms, while Cairns et al., (1997) showed no apparent relationships with any independent variables tested (e.g. ABD, age, latitude, soil texture, temperature, precipitation and tree type). Indeed several biotic factors such as decreasing soil moisture, produces higher R/S and also nutrient availability, soil texture. Specially, inverse relationships between soil fertility and either root biomass density (RBD) or R/S have been reported particularly in extremely nutrient-poor spodosols.

Jackson et al. (1996) underlie that only few studies include a complete series of information (not just total biomass, but fine roots alone, coarse roots, the distribution root length and surface area with depth, the proportion of live and dead roots and roots distribution for ecosystems and individual species). How generally applicable the conclusions of the articles studies to the world's forests is not clear because most of the studies were done over a relatively narrow range of biotic and abiotic conditions (Cairns et al., 1997).

Indeed, to improve the collection and the analysis of the data it is important a better documentation of the sampling methods (e.g. excavated soil pits, cores soils) enables the data to be converted (such as between the soil-density and soil surface area basis). Studies should be specific whether root mass included dead roots, a subset of roots size classes, or total root biomass. One chronic problem, for example, is the underestimation of fine roots biomass (Jackson et a., 1996).

The total amount of carbon accumulated in the different forests in the form of soil organic matter, live and dead phytomass, is approximately the same. In contrast, in temperate and cold climate, the accumulation takes place in the form of humus, and in tropical forests the largest amount of carbon is found in the form of living phytomass, mainly wood, and only a small amount in the form of litter

(Ajtay, 1979). Consequently, human impact (e.g. clearing) has different effects on carbon cycle in the ecosystems. The biogeochemical consequences concern also the more indirect contribution to phytomass reduction and erosion to the increased transfer of nutrient from land surface to rivers and oceans. Reducing the volume of the vegetation caused pollution or direct human activities, results in increased water yield by way of stream outflow, but this greater outflow is accompanied by greater losses of nutrients, which may also produce adverse effects at the water quality (e.g. anoxic conditions and downstream eutrophication, increase of turbidity) with consequent ecological problems (e.g. ight limited conditions for phytoplankton communities) .

Considering wetlands, selection for traits allowing survival in environments with high salinity and low soil oxygen may create low-diversity, high productivity communities without the involvement of mechanisms such as competition.

Suspended soil and sediments (SSAS) yield has important implications for water quality and water resources. Sediments concentrations are positively related to the organic matter of the vegetation related to the decomposition rate that in a tropical rain forest, Schulze (1967) found be of 0.43 gC m -2 per hour. Lieth (1975) considering reefs and estuaries as a vegetation unit, reported mature biomass (kg m -2) between 0.04-4. The vegetation may have positive effects on sedimantation particles, holding the materials with a reduction of the tranport energy (Rey et al.,2004), increasing the SDR (Sediment Delivery Ratio). Martinez-Mena et al. (1999) studied the influence of vegetation cover on sedimentation, comparing two plots, one covered by natural vegetation and in the other the vegetation was removed. The different conditions point out the prevailing detachment limited condition in the natural plot and the increasing ability of the flow to detach sediments and competence to transport coarser sediments as runoff increases in the disturbed plot. Some studies have been conducted on leaching of organic substances from tree canopies, but information on total amounts under natural conditions is scarse (Ajtay, 1979).

Santos, Brazil

Parameters	**Mata Atlantica of lowlands** (secondary) **Mixed-Forest (FRST)**	**Mata Atlantica of highlands (**primary) **Forest Ever-green (FRSE)**	**Restinga** *(Spartina, alterniflora, tillandsia sps., Aechmea, vàrzeas)* **Wetland-Forested (WETF)-Saltmarshes**	**Mangroves-Apicum** *(Avicennia s., Rhyzophora m. Lagumcularia r.) Wetlands-Mixed (WETL) Swamp forest*
Root depth (m)	**3.7±0.5** *tropical deciduous forest* (Canadell, et al., 1996)	**7.3±2.8** (Canadell, et al., 1996) **18** (Nepstad et al., 1994) **5** (Poels, 1987)	**7.2 ± 0.7** (Bertness, 1987)	
Live fine root length (km m^{-2})		**4.1**-evergr. (Jackson, et al., 1997) **3.5**-decid. (Jackson, et al., 1997)		
Total root Biomass (ton ha^{-1}) (kg m^{-2}) *(Mg ha^{-1}) **(g m^{-2}) closed canopy: a (0-5 cm) b (5-15 cm)	***16.7** (Saldarriaga *et al.*, 1998) (secondary forest-30ys) **a 482.15 b 596.99** **(Sundarapandian and Swamy, 1996)	***27.9** (Nepstad, 1989) (primary forest) ***40.0** (Klinge, 1973) (primary forest) **1.17** (Mensah and Jenik (1968) **2.10** Huttel (1975) ****4010** (**1550-7220**) Vance and Nadkarni (1992) **4.9**-evergr. (Jackson, et al., 1996) **4.1**-decid. (Jackson, et al., 1996) **a 547.93- 404.10** **b 819.26 – 2159.13** **(Sundarapandian and Swamy, 1996)	***61.7** (primary forest-floodplain) (Frangi and Lugo, 1985) ***36.2** (secondary forest-40 ys floodplain) (Cattanio, 2004)	***509.5** (Komiyama et al.,1987)
Total fine root Biomass (≤ 2 mm) (Kg m^{-2}) **(g m^{-2}) closed canopy: a (0-5 cm) b (5-15 cm) * (≤ 1 mm) (Mg cm^{-3})	****930** Inceptisol ****389** Oxisol (Vogt et al., 1996) **a 56.60 b 25.09** **(Sundarapandian and Swamy, 1996)	**0.57**-evergr. (Jackson, et al., 1997) **0.57**-decid. (Jackson, et al., 1997) ****840-940** (Vance and Nadkarni, 1992) **a 49.50-58.41** **b 27.44 -25.91** **(Sundarapandian and Swamy, 1996) ***0.07-1.2** up to 2m (Nepstad et al., 1994) ****749** Inceptisol ****61** Mollisol ****937** Oxisol ****2270** Spodosol ****638** Ultisol (Vogt et al., 1996)		
Live fine root Biomass (Kg m^{-2}) *(g m^{-2})		**0.33**-evergr. (Jackson, et al., 1997) **0.28**-decid. (Jackson, et al., 1997)		
% Root Biomass * in upper 30 cm	**8** Inceptisol **15** Oxisol (Vogt et al., 1996)	***69**-evergr. (Jackson, et al., 1996) ***70**-decid. (Jackson, et al., 1996)		

		13 Entisol **12** Oxisol **14** Spodosol **7** Ultisol (Vogt et al., 1996)		
% Fine Root Biomass * in upper 30 cm	**2** Inceptisol **1** Oxisol (Vogt et al., 1996)	***57**-evergr. (Jackson, et al., 1997) ***42**-decid. (Jackson, et al., 1997) ****20-40** (Vance and Nadkarni, 1992) **3** Spodosol **5** Oxisol (Vogt et al., 1996)		
Root Biomass Density RBD **(Kg m^{-2})** *** (mg/cm^3)** **H: 0-15cm** **** (mg/ha)**	**** 17** (Koopmans and Andriesse, 1982)	**** 1-9** (Buschbacher et al., 1988; Uhl et al., 1988) **** 6** (Koopmans and Andriesse, 1982) **1.17** (Mensah&Jenik, 1968) **2.10** (Huttel, 1975) **4.01** (Vance and Nedkarni, 1992) ***9.9** (Vance and Nadkarni, 1992) ***fine roots**<2mm: **3.8** (Vance and Nadkarni, 1992) ***fine roots**<1mm: **0.3-2** (Nepstad et al., 1994)		
Root standing crop (* 10^3 kg ha^{-1})	**3.9-15.9** (Sundarapandian and Swamy, 1996)	**6.6-16.6** (Sundarapandian and Swamy, 1996)		
Root production (* 10^3 kg ha^{-1} $year^{-1}$)	**24.2-31.5** (Sundarapandian and Swamy, 1996)	**23.8-30.2** (Sundarapandian and Swamy, 1996)		
Kg root kg^{-1} leaf	**1.038** (Sundarapandian and Swamy, 1996)	**1.7-2.3** (Sundarapandian and Swamy, 1996)		
Live fine root area index (m^2· m^{-2})		**7.4**-evergr. (Jackson, et al., 1997) **6.3**-decid. (Jackson, et al., 1997)		
Root/Shoot Ratio		**0.19**-evergr./ **0.34-**decid. (Jackson et al., 1996) **0.24** (Cairns et al.,1997)		
Aboveground Biomass density (Mg/ha) * (t ha^{-1}) ** (Kg m^{-2}) ABD	**32** (Koopmans and Andriesse, 1982) **398** Inceptisol **305** Oxisol (Vogt et al., 1996)	**5-88** (Buschbacher et al., 1988; Uhl et al., 1988) **81** (Koopmans and Andriesse, 1982) **69** Entisol **309** Spodosol **288** Oxisol **354** Ultisol (Vogt et al., 1996) **292** (Waring and Schlesinger, 1985)		

Belowground biomass (Mg/ha) ** (Kg m^{-2})	**36** Inceptisol **54** Oxisol (Vogt et al., 1996)	**10** Entisol **41** Inceptisol **61** Spodosol **45** Oxisol **27** Ultisol (Vogt et al., 1996)		
Total above-ground dead phytomass (g m^{-2} dry weight)		**760** (Klinge, 1973) **1387** (Urlich et al., 1974)		
Forest floor biomass (Mg ha^{-1})	**9** Inceptisol **2** Oxisol (Vogt et al.,1996)	**3** Entisol **7** Inceptisol **34** Spodosol **16** Oxisol **9** Ultisol (Vogt et al.,1996)		
Litter Biomass (g m^{-2}) *(Mg ha^{-1})	**441.63** (Sundarapandian, et al., 1996)	**553.14** (Sundarapandian, et al. 1996) **523.44** (Sundarapandian, et al., 1996) ***27.3** (Waring and Schlesinger, 1985)		
Total Biomass (ton/ha) * (Kg m^{-2}) ** dry matter (g m^{-2})	**293.44** (Röhrig, 1991) **143-176** (Alves et al.,1997) **200** (Steininger, 2000) ***20** (Box et al., 1989) ****6-60** (Lieth and Whittaker, 1975)	**450** (Röhrig 1991) **291-398** (Alves et al.,1997) **356** (Laurence,1999) **318** (Fujisaka,1998) **300-400** (Brown and Lugo,1992) **414** (Brown and Lugo,1992) **227** (Brown and Lugo,1992) ***32-56** (Box et al., 1989) ****6-80** (Lieth and Whittaker, 1975)	****3-50** (Lieth and Whittaker, 1975)	**150** (Röhrig,1991)
Leaf litterfall (t ha^{-1} year^{-1}) *Mg ha^{-1} year^{-1})	**7.66** (Sundarapandian, et al., 1996)	**5.61 – 3.51** (Sundarapandian, et al., 1996) ***5.6** Klinge and Rodrigues (1968) ***4.0** Klinge et al. (1975) * **6.5** Flanken et al. (1979) ***4.7** (Silva 1984) ***5.4** (Luizão 1989) ***4.7** (Luizão 1989)	***4.3** (Flanken et al. 1979)	***5.3** (Adis et al., 1979) ***5.2** (Franken et al., 1979) **5.75** (Twilley, 1986)
Wood litterfall (t ha^{-1} year^{-1}) **Branches** *Mg ha^{-1} year^{-1})	**1.32** (Sundarapandian, et al., 1996)	**1.58 – 1.0** (Sundarapandian, et al., 1996) ***1.1** Klinge and Rodrigues (1968) ***3.0** Klinge et al. (1975) * **1.0** Franken et al. (1979) ***1.4** (Silva 1984) ***1.6** (Luizão 1989) ***1.2** (Luizão 1989)	***1.1** (Flanken et al. 1979)	***1.0** (Adis et al., 1979; Franken et al., 1979)
Reproductive part fall (t ha^{-1} year^{-1}) **Flower and Fruits**	**0.26** (Sundarapandian, et al., 1996)	**0.95-0.81** (Sundarapandian, et al., 1996) ***0.4** Klinge and	***1.0** (Flanken et al. 1979)	***0.5** (Adis et al., 1979; Franken et al., 1979)

*(Mg ha^{-1} year^{-1})		Rodrigues (1968) ***0.2** Klinge et al. (1975) * **0.5** Franken et al. (1979;Silva 1984) ***0.4** (Luizão 1989; Luizão 1989)		
Total litterfall (t ha^{-1} year^{-1}) *(Mg ha^{-1} year^{-1}) ** (g m^{-2} yr^{-1})	****1050** Oxisol (Vogt et al., 2006)	***7.3** Klinge&Rodrigues (1968) ***7.2** Klinge et al (1975) ***8.0** Franken et al(1979) ***6.6** (Silva 1984) ***8.3** (Luizão 1989) ***7.4** (Luizão 1989) ****1850** (Ajtay et al., 1979) ****1070** Inceptisol ****737** Spodosol ****844** Oxisol ****750** Ultisol (Vogt et al.,1996) **1.0-27.0** (Protcor, 1984)	**6.4** (Franken et al 1979) **8.6** (Silva and Lobo, 1982) **10.7** (Klinge 1978) **13.8** (Cattanio, 2004)	**6.8** (Adis et al., 1979) **6.7** (Franken et al.,1979) **7.7** (Silva and Lobo, 1982) **8.6** (Klinge, 1978) **7.51** (Twilley, 1986) ****600** (Ajtay et al., 1979)
Soil organic matter Content (Mg ha^{-1})	**199** Inceptisol **76** Oxisol (Vogt et al., 1996)	**300** Oxisol **216** Spodosol **90** Ultisol **41** Entisol (Vogt et al.,1996)		
Net Primary Productivity (NPP) * (ton ha^{-1} yr^{-1}) **(g m^{-2} yr^{-1})	****1260** (Box et al.,1989) ****740-2100** (Olson,1975) ***6-16** for tropical dry forest (Murphy and Lugo, 1986)	***22** (Röhrig, 1991) ****1273-3101** (Box et al.,1989) ****2500**-tropical forests (Saugier et a., 2001) ****1000-3500** (Whittaker and Likens, 1975; Lieth 1975) ***11-21** (Murphy, 1977)	***20** (Röhrig, 1991) ****800-6000** (Whittaker and Likens, 1975) ****800-4000** (Lieth 1975)	****930** (Golley et al., 1962)
Total Production (NPP) 10^9 t /yr		**49.4** (Whittaker and Likens, 1975) **34** (Lieth 1975)	**4.0** (Whittaker and Likens, 1975; Lieth 1975)	
NPP-aboveground (g m^{-2} yr^{-1}) (ANPP)	**1258** Ultisol (Vogt et al., 1996)	**950**-tropical forests (Saugier et a., 2001) **761** Oxisol (Vogt et al., 1996)		
NPP-belowground (g m^{-2} yr^{-1}) (BNPP)	**488** Ultisols **500** Unknownl (Vogt et al., 1996)	****1400**-tropical forests (Saugier et a., 2001) **619** Spodosol **111** Ultisols **379** Oxisol (Vogt et al., 1996)		
NPP-belowground % below-ground NPP of total (BNPP)		**0.44**-tropical forests (Saugier et a., 2001) **49** Oxisol (Vogt et al., 1996)		
LAI	**4** (Box et al., 1989) **5** (Lieth and Whittaker, 1975)	**9-12** (Box et al., 1989) **6-16** (Lieth, 1975) **8** (Lieth and Whittaker, 1975)	**11-23.3** (Lieth, 1975) **7** (Lieth and Whittaker, 1975)	
Tree density (tree ha^{-1})	**700** (Sundarapandian and Swamy, 1996)	**916-2010** (Sundarapandian and Swamy, 1996)		

Puerto Aysén, Chile

Parameters	**Deciduous temperate forest** *Nothofagus pumilio*	**Evergreen forest** *Nothofagu s Betuloides*	**Evergreen forest** *Pilgerodendron uviferum* *Fitzroya cupressoides*
Root depth (m)	**2** (Schulze, et.al, 1996) **2.9 ± 0.2** (Canadell, et al., 1996		
Live fine root length (km m^{-2})	**5.4** (Jackson, et al., 1997)		**6.1** (Jackson, et al., 1997)
Total root Biomass (ton ha^{-1}) (kg m^{-2}) *(Mg ha^{-1}) **(g m^{-2}) closed canopy: a (0-5 cm) b (5-15 cm)	**4.2** (Jackson, et al., 1996)		***75** *Pilgerodendron* ; ***80** *Fitzroya* (Battles, 2002) **4.4** (Jackson, et al., 1996)
Total fine root Biomass (≤ 2 mm) (Kg m^{-2}) **(g m^{-2}) closed canopy: a (0-5 cm) b (5-15 cm) * (≤ 1 mm) (Mg cm^{-3})	**0.78**(Jackson, et al., 1997) ****546** Alfisol ****633** Inceptisol ****747** Spodosol (Vogt et al., 1996)		**0.82** (Jackson, et al., 1997) ****544** Alfisol ****912** Andisol ****323** Inceptisol ****525** Spodosol ****97** Histosol (Vogt et al., 1996)
Live fine root Biomass (Kg m^{-2}) *(g m^{-2})	**0.44** (Jackson, et al., 1997)	***1438-6116** (Moreno-Chacón, 2004)	**0.50** (Jackson, et al., 1997)
% Root Biomass * in upper 30 cm	***65** (Jackson, et al., 1996) **19** Alfisol **25** Inceptisol **17** Spodosol (Vogt et al., 1996)		***52** (Jackson, et al., 1996) **13** Alfisol **28** Andisol **19** Inceptisol **22** Spodosol **17** Ultisol (Vogt et al., 1996)
% Fine Root Biomass * in upper 30 cm	***63** (Jackson, et al., 1997) **4** Alfisol **5** Inceptisol **7** Spodosol (Vogt et al., 1996)	***69** (Moreno-Chacón, 2004)-Dombey	***45** (Jackson, et al., 1997) **4** Alfisol **7** Andisol **0.4** Inceptisol **5** Spodosol (Vogt et al., 1996)
Root Biomass Density RBD **(Kg m^{-2})** *** (mg/cm^3)**	**** 34** (Andersson, 1971)		**0.8-0.9-1.27-2.0-** (12-,22-,45-80,yr-old coniferous forests (Wright, 1955)

H: 0-15cm **** (mg/ha)**			
Live fine root area index (m^2· m^{-2})	**9.8** (Jackson, et al., 1997)		**11.0** (Jackson, et al., 1997)
Root/Shoot Ratio	**0.23** (Jackson, et al., 1996) **1.26** *N. antartica* (Austin and Osvaldo, 2002; Schulze et al., 1996) **0.26** (Cairns et al.,1997) **0.44** *N. pumilio* (Austin and Osvaldo, 2002; Schulze et al., 1996)		**0.18** (Jackson, et al., 1996)
Leaf biomass (Mg/ha)	**4.2** at 220m slm; **4.1** at 440m; **2.1** at 540 m **2.9** at 640m (Frangi et al., 2005)		
Stem biomass (ton/ha)	**247.1** (Caldentey, 1999-2000)		
Aboveground Biomass density (Mg/ha) * (t ha^{-1}) ** (Kg m^{-2}) ABD	**201** (Andersson, 1971) **217** Inceptisol **175** Spodosol **221** Alfisols (Vogt et al., 1996) **151.9** (Waring and Schlesinger, 1985) **492.8** (Frangi et al., 2005) ** **34.08** *N.pumilio* (Austin and Osvaldo 2002; Schulze et al., 1996) * **329.7** (Caldentey, 2000) ** **10.82** *N. antartica* (Austin and Osvaldo 2002; Schulze et al., 1996)		**373** Alfisol **211** Andisol **360** Inceptisol **244** Spodosol **554** Utlisol (Vogt et al., 1996) **275** *Pilgerodendron*; **576** *Fitzroya* (Battles, 2002) **307.2** (Waring and Schlesinger, 1985)
Belowground biomass (Mg/ha) ** (Kg m^{-2})	**52** Alfisol **45** Inceptisol **25** Spodosol (Vogt et al., 1996) ** **13.64** *N. antartica* (Austin and Osvaldo, 2002; Schulze et al., 1996) ** **14.84** *N.pumilio* (Austin and Osvaldo, 2002; Schulze et al., 1996)		**61** Alfisol **81** Andisol **70** Inceptisol **47** Spodosol **113** Ultisol (Vogt et al., 1996)
Total above-ground dead phytomass (g m^{-2} dry weight)	**458** (Lossaint and Rapp, 1971) **2184** (Ovington et al.,1963) **833** (Ulrich et al.,1974)		**815, 860, 998** (Ulrich et al., 974)
Forest floor biomass (Mg ha^{-1})	**6** Alfisol **14** Inceptisol **34** Spodosol (Vogt et al.,1996)		**45** Alfisol **99** Andisol **46** Histosol **38** Inceptisol **41** Spodosol (Vogt et al.,1996)
Litter Biomass (g m^{-2}) *(Mg ha^{-1})	***21.6** (Waring and Schlesinger, 1985) ***10** (Frangi et al., 2005)		***74.8** (Waring and Schlesinger, 1985)

Total Biomass (ton/ha) * (Kg m^{-2}) ** dry matter (g m^{-2})	**300** (Röhrig,1991) ***11-37** (Box et al., 1989) ****6-60** (Lieth and Whittaker, 1975)	***39** (Box et al., 1989)	**350** *Pilgerodendron*; **656** *Fitzroya* (Battles, 2002, Röhrig, 1991) ***11-85** (Box et al., 1989) ****6-200** (Lieth and Whittaker, 1975)
Leaf litterfall (t ha^{-1} $year^{-1}$) *Mg ha^{-1} $year^{-1}$)	**1.451** (Caldentey, 2001) *N. pumilio* stands ***2.97** at 220m;**1.93**-440m slm; **2.20** at 540m; **2.30** at 640m (Frangi et al., 2005)		
Total litterfall (t ha^{-1} $year^{-1}$) *(Mg ha^{-1} $year^{-1}$) ** (g m^{-2} yr^{-1})	**21.6** (Frangi, 2005) **2.017** (Caldentey, 2001) **3.3± 0.5** .(Perez et al., 2003) **420** Alfisol **436** Inceptisol **628** Spodosol (Vogt et al., 1996)		***2±0.5** (Perez et al., 2003) **276** Alfisol **185** Andisol **255** Inceptisol **290** Spodosol **657** Ultisol (Vogt et al.,1996) ****850** (Ajtay et al., 1979)
Belowground litter transfers (g m^{-2} yr^{-1})	**326** Alfisol **439** Inceptisol **371** Spodosol (Vogt et al., 1996)		**534** Alfisol **823** Andisol **520** Histosol **685** Inceptisol **315** Spodosol **310** Ultisol (Vogt et al., 1996)
Soil organic matter Content (Mg ha^{-1})	**141** Alfisol **213** Inceptisol **145** Spodosol (Vogt et al.,1996)		**247** Andisol **139** Inceptisol **145** Spodosol **96** Alfisol **773** Ultisol (Vogt et al.,1996)
Net Primary Productivity (NPP) * (ton ha^{-1} yr^{-1}) **(g m^{-2} yr^{-1})	****1440-1780** (Olson,1975) ****864-1900** (Box et al.,1989) ****1550**- temperate forests (Saugier et a., 2001) ****600-2500** (Whittaker and Likens, 1975)	****1000** (Box et al.,1989)	****650-2487** (Box et al.,1989) ****600-2500** (Whittaker and Likens, 1975) ****600-3500** (Lieth 1975) ****1480-2100** (Olson, 1975) ***13** (Röhrig, 1991)
Total Production (NPP) 10^9 t /yr	**14.9** (Whittaker and Likens, 1975) **11.3** (Lieth 1975)		
NPP-aboveground (g m^{-2} yr^{-1}) (ANPP)	**1267** Alfisol **1180** Inceptisol **855** Spodosol (Vogt et al., 1996) **600**- temperate forests (Saugier et a., 2001) **428** *N. pumilio* (Sala et al., 1988) **360** *N. pumilio* (Knapp and Smith, 2001) **315** *N. pumilio* (Austin and Osvaldo, 2002; Schulze et al., 1996)	**339** *N. antartica* (Austin and Osvaldo, 2002 ;Schulze et al., 1996) **278** *N. antartica* (Sala et al., 1988) **268** *N. antartica* (Knapp and Smith, 2001)	**844** Alfisol **332** Andisol **1086** Inceptisol **2605** Ultisol **877** Spodosol (Vogt et al., 1996)
NPP-belowground (g m^{-2} yr^{-1}) (BNPP)	**314** Alfisol **265** Inceptisol **498** Spodosol (Vogt et al., 1996) **950**-temperate forests (Saugier et a., 2001)		**277** Alfisol **875** Andisol **378** Histosol **399** Inceptisol **441** Spodosol **410** Ultisol (Vogt et al., 1996)

NPP-belowground % below-ground NPP of total (BNPP)	**27** Alfisol **18** Inceptisol **41** Spodosol (Vogt et al., 1996) **0.39**-tropical forests (Saugier et a., 2001)		**24** Alfisol **54** Andisol **20** Inceptisol **38** Spodosol **13** Ultisol (Vogt et al., 1996)
Canopy Cover (%)	**89** (Veblen, et al., 1977)	**4** (Veblen, et al., 1977)	
Canopy Area (%)	**92** (Veblen, et al., 1977)	**4** (Veblen, et al., 1977)	
Canopy Density (%)	**97** (Veblen, et al., 1977)	**100** (Veblen, et al., 1977)	
LAI	**3-7** (Box et al., 1989) **2.9** (at 220m slm-440); **3.1** at 540 m **3.3** at 640m(Frangi et al., 2005) **5** (Lieth and Whittaker, 1975)	**4** (Box et al., 1989)	**5-12** (Box et al., 1989) **6-10** (Lieth, 1975) **12** (Lieth and Whittaker, 1975)
Mean Tree Basal Area (m^2 ha^{-1})	**68.2**-matureForest (Davis, 2002) **80** at 220m slm; **67** at 440m slm; **39** at 540m **56** at 40m (Frangi et al., 2005) **79.3**-Natural-N.pumilio-**35.8** Shelterwood system (Caldentey et al., 2001)		

Argentina, Bahia Blanca

	maize	sorghum	soybean	sunflower	Wheat spring	Wheat winter	grass	Pasture	Spartina Alterniflora	Juncus gerardi
(1) Max root depth (m)	1.5-2	1.4-1.8	1.4-1.8	1.7-2.2	1.2-1.6	1.5-2	0.8	0.74 (3)	7.2 ± 0.7 (Bertness, 1987)	10.2±0.8 (Bertness, 1987)
(1) Max LAI m^2 m^{-2}	4-7 (1)	6-10 (1)	4-7 (1)	4-5 (1)	4-6 (1)	5-8	4(1)			
(1) Biomass transpiration coefficient ((kg m^{-2})kPa)/m	6.0-8.5	6.0-8.5	3.5-6.0	3.5-6.0	3.5-6.0	3.5-6.0	3.5-6.0			
(1) Water stress sensitivity	Medium	Low	Medium	Medium	Low	Low				
Critical live biomass (kg m^{-2})	-	-	-	-	-	-				
(2) Max Root Depth (m)	1.52	1.5	1		0.30	0.30				
(1) Root/Shoot	0.25	0.25	0.25	0.25	0.25	0.25				
(2) Max Root biomass (kg m^{-2})	-	-	-	-	-	-				
(2) Max canopy height (m)	2.60	1.01	1.01		0.91	0.91				
(2) (2) Max rate of residue decay	0.0065	0.0074	0.0130		0.0085	0.0085				
Max LAI potential	3.5	5	5		5	5				
(1) Plant specific tolerance to moisture stress	0.25	0.25	0.25	0.25	0.25	0.25				
NPP T ha^{-1} yr^{-1}	65 (for cultivated areas)									

NPP: Net Primary Production

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