Protecting the Planetary Life-Support System : Placing a Value on Photosynthetic Biomass

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The loss of soil diversity and biomass means a reduction in our biological potential to survive, due to the fact that a large contribution to the biological quality of life is provided by the living component of the environment. Current land management trends indicate increasing rates of degradation in ecosystem stability (Senanayake and Jack 1998). The effect of increasing the intensity of impact on natural ecosystems is steadily converting them into depauperate systems. (Vitousek et al 1997, Sala et al 2000) . This loss is best seen in the loss of terrestrial biomass which has often been likened to a 'living skin'. Bradshaw (1993) states, 'the physiognomy and well being of our planet depends on its living skin, without which land would become unstable.

This 'living skin' or terrestrial biomass is most valuable when it is holding the maximum volume of mature biomass. It is significant that the most mature ecosystem in any terrestrial ecosystem is not only the one that contains the largest volume of living biomass, but it is also highest biodiversity in biodiversity. Usually represented by forests, these ecosystems provide the highest value in environmental services.

However, the loss of forest and the loss in living biomass is reaching critical proportions today (figure 1)

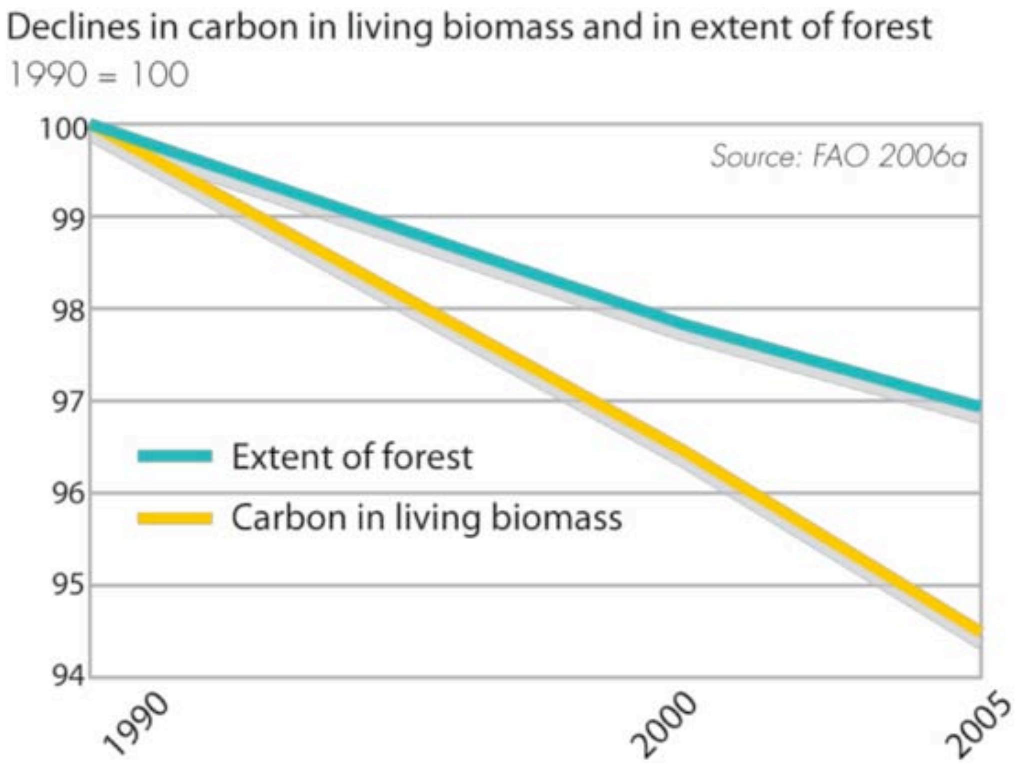

Figure 1. Rate of decline in living biomass and forest cover over 15years. (FAO 2006)

As it is the restoration of this ‘living skin’ that is critical for the life support system, there must be attention paid to the living biomass in Landscape Restoration design. Living Biomass is a measure that is being used in the evaluation of carbon stocks with increasing frequency (Ruesch 2000). Thus it is important to understand how biomass occurs and how we should view it. Biomass is generally regarded as the sum total of living or non living matter of biological origin.

For example the definition given by the Biomass Energy Center of the U.K : states : ‘Biomass is carbon based and is composed of a mixture of organic molecules containing hydrogen, usually including atoms of oxygen, often nitrogen and also small quantities of other atoms, including alkali, alkaline earth and heavy metals. These metals are often found in functional molecules such as the porphyrins, which include chlorophyll, which contains magnesium.’

While the value of Living Biomass has now been captured on most global models of the carbon budget, it role is generally relegated to the supply of food, fibre, energy and carbon bank. But there is a very fundamental difference between the components of living biomass that needs to be addressed urgently. The difference between photosynthetic and respiring biomass. Photosynthetic biomass is that which performs primary production, the initial step in the manifestation of life. The biomass so termed has the ability to increase in mass through the absorption of solar or other electromagnetic radiation. Respiring biomass is that which uses the primary production to make the complicated biological patterns of life, but does not have photosynthetic functions itself. This distinction would seem to be fundamentally important when assessing the value of biomass that is being addressed.

A figure of 56.4 billion tonnes C/yr has been estimated as the volume of terrestrial primary production (Field et al 1998). Such data seem not to be included as yet in the international processes such as the UNFCC, as in its newly published map (UNEP 2008) of living biomass (above and below ground). Although these maps suggest that the highest carbon density above (180 tons of Carbon per Hectare) is currently confined to the forests of Amazonia, Congo system, Indonesia and Papua New Guinea, A distinction between the photosynthetic component and the respiring component of living biomass is not made.

The consideration of biomass that contributes to terrestrial primary production as a distinct biomass pool is urgent. As discussed above, it is only photosynthetic biomass that powers carbon sequestration, oxygen generation and water transformation, actions essential for the sustainability of the life support system of the planet. In terms of the sequestration of Carbon by the photosynthetic biomass on the planet, it functions at about 426 $gC/m^2/yr$ for land and 140 $gC/m^2/yr$ for the oceans.

The photosynthetic biomass for terrestrial ecosystems is largely composed of the leaves of terrestrial vegetation. The leafy component varies greatly in size and temporality. Further, the adaptive architectural structure of shrubs was seen to vary greatly from trees (Prickett and Kempf 1980, Nicola and Prickett 1983) In a forest, it has been found that that shade-tolerant, late-successional tree species possess significantly larger leaves compared to early-successional, shade-intolerant species (White, 1983).

Understanding leaf phenology is important because it provides a measure of relative value in the photosynthetic biomass of leaves. Horn (1971) suggests 'the large leaf size of monolayer trees could represent an effective method of filling gaps between adjacent leaves within a single foliage layer, maximizing interception of radiation under limiting conditions'   Conversely, Small leaf size may confer drought resistance to early successional trees in drier environments and may be more effective in dissipation of heat by convection,

Fig2. Two types of leaves with different life strategies. Deciduous and Evergreen

In general, leaf sizes and leaf numbers tend to be negatively correlated, the larger the leaf size the less in number and vice versa. This relationship has been measured for some trees. Large leaved trees such as *Catalpa sp* having about 26,000 leaves while younger, small leaved *Citrus sp* had over 90,000 leaves (Kozlowski 1971). Although the numbers vary greatly, the mean mass of leaves produced does not seem to vary much between different plant groups. The measured mean annual leaf production has been reported as 2.8 metric tons/ha/yr for angiosperms and 2.7 metric tons/ha/yr for gymnosperms (Senanayake and Jack). This represents an approximate ratio of 10:1 between non-photosynthetic and photosynthetic biomass. These are initial approximations and finer measurements need to be undertaken urgently. For instance, there will be need of a variable that recognizes the functional and temporal difference between deciduous and evergreen species (figure 2). However, until that variable is developed, the current estimates of the total amount of Carbon sequestered in forest provides a start. Currently the total amount of carbon is approximately 359 billion tons, (Plantinga et al 2008). It is the forests and the savannas that comprise the aboveground, photosynthetic biomass , considering that 10% of this total biomass is leaves a figure of 35.9 billion tons of photosynthetic biomass in indicated, this sits well with other proposed estimates. The estimate of the annual sequestration rate of this biomass is 56.4 billion tons c/yr (Field et al 1998). The sheer power of operation of this system is seen when the volume of water released from photosynthetic biomass is considered, at a water release rate of 100:1, where over 100 molecules of water are released for each molecule of carbon dioxide absorbed by the leaf (Jones 1976). The quantity of water released annually by forests and grasslands are like ariel rivers, cycling about 5640 billion tons of water into the atmosphere annualy. Leaves are the ideal organs to carry out these functions effectively, as leaves present an extensive surface area to the environment. For example, 0.5 ha of Oak forest with a basal stem area of 5.5 sq m produced an aggregate leaf surface area of more than 2.03 ha (Rothacher et. al. 1954).

The leaf surfaces also provide another critical element in water cycling. The streams and rivers of water vapor that flow in the atmosphere as water vapor are generally invisible. It is made visible by the existence of minute particulate matter that condenses the water vapor into viable forms, called clouds. This particulate matter, termed Cloud Condensation Nuclei. (CCN) is comprised of bacteria and bacterial particles (Ahern et al 2006) and biotic chemicals like Di Methyl Sulphide (DMS) and plant aerosols (Charlson et al 1987). The largest sources of CCN from terrestrial sources are the leaf surfaces and pores of plants which harbor and release large quantities of bacteria and bacterial particles . the epiphytic communities of mature forests also create CNN from both leaf surfaces and community interstices. The contribution is significant. In forests of the Columbian Andes the epiphyte biomass was estimated at about 12 tonnes dry weight per hectare (Veneklaas et al 1990).

Thus it seems imperative that a real value be placed on photosynthetic biomass; initial computations can begin by considering the current values suggested for the global market.. The estimated volume of the Carbon market, was in excess of 125 billion in 2008 as reported in Environment Leader (2010) , with an estimated growth up to 3.2 Trillion dollars by 2020. As it is a matter of public discourse these figures provided by Governments are useful indicators. Thus if we consider a very low value of 1 Trillion dollars to contain climate change (Business Wire, Reuters) the value of photosynthetic biomass can now be addressed. Assuming that the market would bear at least the value of controlling climate change, on the ability to breathe, the 35.9 billion tons of photosynthetic carbon currently in stock would be roughly worth about 285 dollars per kilogram. This comes as a surprise when the current models of carbon sequestering to combat climate change is examined, these models discount the leaves and twigs which (FAO 2001, FAO 2002) are removed before the sequestered carbon is measured. photosynthetic biomass as too temporal, the most valuable component is discounted to nothing.

Slowing down the loss of global terrestrial Photosynthetic biomass stock is not an option it is a critical need! A massive investment must go towards incrementing the global photosynthetic biomass stock. The potential value of this stock can attract the investment to develop market growth. Thus a discussion of the models of high utility and high photosynthetic productivity is necessary.

The current approaches to tree farming and forest management needs to accept the potential of photosynthetic biomass and work towards realizing its value.

For management purposes, the photosynthetic biomass of a natural ecosystem has to be seen as a continuum of native species from the early seral stages represented by annuals and short-lived species to shrubs and bushes to emergent trees, to the mature tree dominated, old growth forests, each stage with as full complement of photosynthetic biomass. This will ensure that the management plans for any area that addresses the generation and maintenance of the optimal levels of Photosynthetic Biomass in each seral stage and gain the corresponding value. This process is the obverse of current land use trends that incrementally destroy biomass today (figure 3).

Fig.3 Amazonia, demonstrating the erosion of living biomass; from the mature forest in background to the exposed mineral soils in foreground

This perspective of a forest as a process, as well as the fact that, in terms of the biodiversity of a forest, trees account for 1% of a forests biodiversity or less, suggests that the inclusion of a non-crop biodiversity and a greater quantity of vegetation within the armature of established plantations could become a lucrative venture for plantation and woodlot owners.

The most effective, tested approach to creating such vegetational complexes within degraded and anthropogenic areas is Analog Forestry (Senanayake and Jack 1998). This approach, seeks to develop a tree dominated ecosystem analogous to the original climax community, but recognizes the other non-tree photosynthetic growth forms in any given ecosystem and includes them in the management area by design.

The recognition and evaluation of photosynthetic biomass must become a primary driver of such restoration processes. Restoration of Biodiversity and Environmental Services must be the other.

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