STEM BIOMASS MODELING OF
CINNAMOMUM INERS
AND
ROYSTONEA REGIA

NIGEL JONNEY J. BOKUKOP

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DECLARATION

I hereby declare that the work presented in this thesis, except where otherwise stated, is based on my own writing.

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HS2003-3130

VERIFIED BY

1. **SUPERVISOR**

   (MADAM NORAINI ABDULLAH)

2. **EXAMINER**

   (PROF. DR. ZAINODIN HAJI JUBOK)

3. **DEAN**

   (SUPT/KS ASSOC. PROF. DR. SHARIFF A. K. OMANG)

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ABSTRACT

In this research, a simple model for obtaining stem volume is developed for both tree species of Cinnamomum Iners and Roystonea Regia, based on two different types of volumetric equations, which are Newton's and Huber's formula. Variables that are taken into considerations in collecting the data are height of stem or trunk, height of tree, diameter at breast height, diameter at middle and diameter at top of the stem before the crown. Correlation test was done to screen as well select the possible variables including the interactions. Thereafter, curve estimation test was also done to get the model of best fit for linear, quadratic, cubic and logarithmic transformation. Finally, an eight criteria model selection process was done to get the best model. The best model for both equations for both species found to be in the form of multiple regressions.

ABSTRAK

Dalam kajian ini, satu bentuk model yang mudah untuk mendapatkan isipadu batang telah dibangunkan untuk kedua-dua spesis pokok iaitu Cinnamomum Iners dan Roystonea Regia berdasarkan dua bentuk formula isipadu, iaitu Newton's formula dan Huber's formula. Antara pembolehubah yang diambil kira adalah seperti ukur lilitan batang, ketinggian pokok, diameter paras dada, diameter tengah dan diameter atas batang pokok sebelum puncak. Pembolehubah serta interaksi yang terlibat ditapis dan dipilih berdasarkan ujian korelasi. Ujian penganggaran keluk juga dijalankan untuk mendapatkan model suaian terbaik bagi transformasi linear, kuadratik, kubik serta logaritmik. Akhir sekali ujian lapan criteria dijalankan bagi mendapatkan satu model terbaik diantara regresi berganda dengan regresi polinomial. Model terbaik bagi kedua-dua formula isipadu bagi kedua-dua spesies adalah didapati dalam bentuk regresi berganda.

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%	percentage
^{o}	degree
^{o}C	degree Celsius

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Currently, there is a lot of discussion concerning the possible effects of carbon dioxide and other "greenhouse gases" on the environment. Photosynthesis converts carbon dioxide from the air to carbohydrates and other kinds of "fixed" carbon and releases oxygen to the atmosphere. When wood is burned, ethanol or coal, oil and other fossil fuels, oxygen is consumed, and carbon dioxide is released back to the atmosphere. Thus, carbon dioxide which is in the atmosphere being replaced very quickly through our consumption of these fuels. The increase in carbon dioxide and related gases is bound to affect our atmosphere. Whether this change is large or small, and will it be harmful or beneficial, it all depends strongly on the effect of photosynthesis carried out by land and sea organisms.

As photosynthesis consumes carbon dioxide and releases oxygen, it helps to counteract the effect of combustion of fossil fuels. The burning of fossil fuels releases not only carbon dioxide, but also other hydrocarbons, nitrogen oxides, and other trace materials that pollute the atmosphere and contribute to long-term health and environmental problems. These problems are a consequence of the fact that nature has chosen to implement photosynthesis through conversion of carbon dioxide to energy-rich materials such as carbohydrates.

The relative abundance of carbon dioxide and other greenhouse gases (methane and nitrus oxide) is extremely important to the maintenance of the earth's temperature. Current concerns about climate change and global warming stem from the increases in the quantity of these gases, especially carbon dioxide due to human activities.

Photosynthesis in temperate and tropical forests and in the sea can affect the quantity of greenhouse gases in the atmosphere when a plant removes carbon dioxide from the atmosphere and replaces it with oxygen. Thus, it would tend to ameliorate the effects of carbon dioxide released by the burning of these fossil fuels.

1.2 PHOTOSYNTHESIS

Photosynthesis is the process by which light from the sun is converted into energy necessary for the vital functions of living things. The energy captured by photosynthesis ultimately feeds not only the photosynthetic organisms but also the animals that feed in turn on the photosynthetic organisms. Photosynthesis is essentially an energy transduction reaction. In this process, the energy of sunlight can be transduced to chemical energy which is the ultimate source of food for almost all living organisms.

The essential energetic processes of photosynthesis of higher plants and algae is the reduction of nicotinamide adenine dinucleotide phosphate ($NADP^+$) by electrons from water, the energy of which is provided by light. The overall equation for photosynthesis for green plants as proposed by the Dutch microbiologist van Neil is given by

$$CO_2 + 4H_2O \xrightarrow[\text{Chlorophyll}]{\text{light}} (CH_2O) + 3H_2O + O_2$$

$$C = 4.8 \times 10^5 \text{ J mol}^{-1} \text{ (114 kcal)}$$

which is a sum of three individual reactions.

(1) $4H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} 4\,(OH) + 4H$

(2) $4H + CO_2 \longrightarrow (CH_2O) + H_2O$

(3) $4\,(OH) \longrightarrow 2H_2O + O_2$

The reaction steps show that the oxygen is evolved from water and not from CO_2 (Mukherji & Ghosh, 1996).

1.3 LEAF AREA INDEX (LAI)

Difference in canopy structure will directly influence the amount of leaf surface area present to capture light energy. Forest ecologists use leaf area index (m^2 m^{-2}) to quantify differences in leaf surface area among forest ecosystem. This measure expresses the area of leaves (m^2) displayed over a unit of ground surface (m^{-2}) (Barnes *et al.*, 1997).

Leaf area indexes have been determined for a wide range of temperate forest ecosystems; they are typically greater that 5 m^2 m^{-2} during most (deciduous forest) or all (coniferous forest) of the growing season. In the regional forest 'De Inslag' in Brasschaat in the Campine region of the province of Antwerprn, Belgium, the entire stand of leaf area of the *Rhododendron* shrub understory is 1.25 m^2 m^{-2} (Nadezhdina, 2004). This indicates the importance of the leaf area of *Rhododendron* shrubs for the energy and mass exchange of the entire pine forest. In broadleaf trees, total leaf area is twice the one-sided value, whereas the total leaf area is 2.5 times the single-sided value for trees with needle-shaped leaves (Waring, 1982).

The leaf area index is particularly important ecosystem characteristic, because it is a direct measure of the photosynthetically-active surface area which can convert light energy into plant biomass (Bonan, 2002).

Besides that, there is a relative importance of LAI for canopy assimilation and growth in biomass under conditions of rising CO_2 and the need for satisfactory representation of LAI in plant productivity models. Interactions between LAI and CO_2 effects on canopy assimilation are relatively small (Ewert, 2004).

1.4 BIOMASS

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood.

Approximately 114 kilocalories of free energy are stored in plant biomass for every mole of CO_2 fixed during photosynthesis. Although photosynthetic energy capture is estimated to be ten times that of global annual energy consumption, only a small part of this solar radiation is used for photosynthesis. Approximately two thirds of the worldwide net global photosynthetic productivity is of terrestrial origin, while the remainder is produced mainly by phytoplankton (microalgae) in the oceans which cover approximately 70% of the total surface area of the earth. Since biomass originates from plant and algal photosynthesis, both terrestrial plants and microalgae are appropriate targets for scientific studies relevant to biomass energy production.

All biomass (plant, animal and microbial), originates through CO_2 fixation by photosynthesis. Biomass utilization is consequently included in the global carbon cycle of the biosphere. Biomass energy in developing countries, originates from fuelwood, animal wastes, and agricultural residues, and is primarily utilized for activities which are essential for survival, such as cooking and obtaining water.

Improvements in the living standards in these countries will result in the non-essential use of energy. Development of technologies that efficiently produce biomass, and convert it to more convenient forms of energy is therefore very important. Therefore, the increased use of biomass is essential to make a sizeable contribution towards reducing CO_2 emissions.

1.5 OXYGEN CYCLE

There is a continual exchange of oxygen between the atmospheric water, plants and animals as well as mineral matter which is called the oxygen cycle. It begins with the reservoir of carbon dioxide in the air. The process of photosynthesis uses carbon dioxide and water from the soil to produce cellulose, the material from which plants are made. This releases oxygen gas into the air. Photosynthesis ceases when darkness falls and plants then burn off some of the cellulose they have made in the day, thus returning carbon dioxide to the atmosphere.

Animals use oxygen in the atmosphere for respiration, oxidizing the sugars in their food to give energy and releasing carbon dioxide to the atmosphere. When dead tissue (carbon compounds) decays by a combination of oxidation and microorganism decay, carbon dioxide is released back to the atmosphere. A slower cycle occurs whenever mineral matter is oxidized, such as in the formation of rocks.

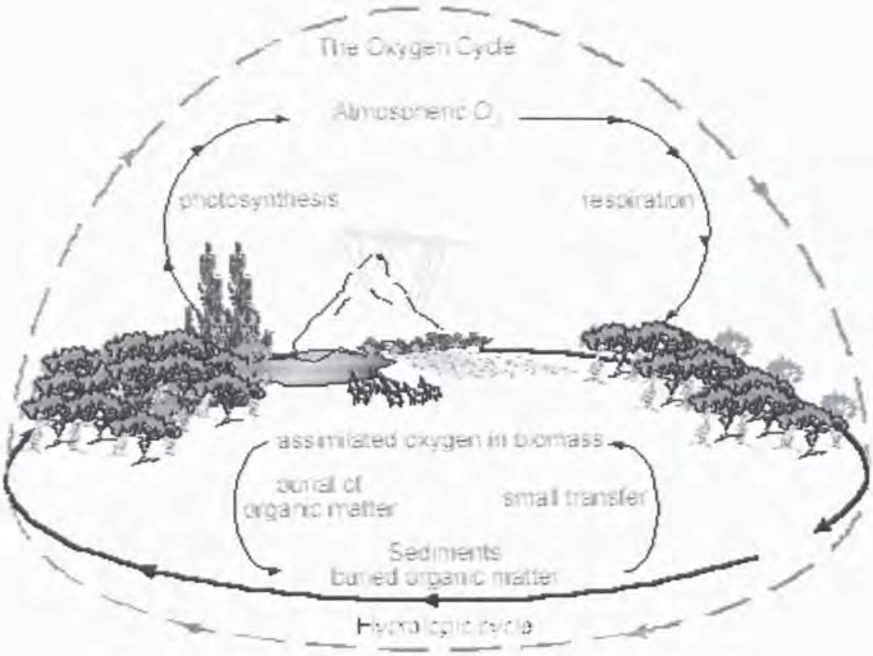

Figure 1.1 Oxygen cycle

Source: http://telstar.ote.cmu.edu/environ/m3/s4/cycleOxygen.shtml

1.6 PHOTOSYNTHETIC FIXATION OF ATMOSPHERIC CO_2.

The photosynthesis fixation of atmospheric CO_2 in plants and trees could be of great value in maintaining a CO_2 balance in the atmosphere. Deforestation has been partially responsible for the CO_2 buildup in the atmosphere. Reforestation could be a solution to the problem of the greenhouse effect as a result of continued growth in the utilization of fossil fuel by the world economy. A preliminary study suggests that the absorption and fixation of CO_2 could be accomplished by allocating and planting regional forested areas to counterbalance an equivalent amount of CO_2 emitted in those regions. Further assessments of plant and forest growth as it affects the atmospheric CO_2 balance should be made.

A preliminary study has indicated that the savings in land area for a forest plantation adjacent to a fossil-burning power plant due to the increased stack gas CO concentration is relatively small compared to planting in any area. It is estimated that a tract of 100 km^2 or 385 square mile (mi^2) planted with moderately growing trees is sufficient to fix all the CO_2 from a 1000-MW(e) coal-fired power plant over the lifetime of the plant (Halmann & Steinberg, 1999).

Aforestation appears to be a feasible method of reducing the concentration of CO_2 from the atmosphere. It uses solar energy and allows an economic fixation of CO_2 from the atmosphere which does not depend on concentrated CO_2 streams. Control of dispersed sources of CO_2 is also taken into account by photosynthetic extraction of CO_2 from the atmosphere.

Trees properly used in a landscape can increase property values by as much as 20 percent and provide food and shelter for birds and urban wildlife. Planted strategically, the right shade trees can reduce building cooling costs by as much as 50 percent. Trees reduce the temperature of streets and parking lots by 8 to 10 degrees in the summer (Burns, 2006), making paved surfaces last longer without repairs. Trees can also improve air quality by trapping dust, absorbing air pollutants and converting carbon monoxide to oxygen which is essential towards mankind environment.

1.7 CINNAMOMUM INERS

Cinnamomum iners or in short, C. iners is under the family of Lauraceae. As an Asian native, this tree is popular in the southern, southwestern and western United States

(USA). Its common name in Malaysia is 'pokok kayu manis' or 'kayu manis hutan'. C. iners is a medium-sized tree up to 24 m tall, bole up to 60 cm in diameter with its bark being surface smoothed, lenticellate and grayish-brown while its inner bark is pinkish. Its leaves are opposite or sub opposite measuring (5-) 7.5-30 cm x 2-13 cm and its base is cuneated, and rarely rounded. The apex shaped from blunt to acute, often glaucous below and 3-veined. The main veins are prominent with the tertiary venation changes from scalariform to scalariform-reticulate, faint to distinct below and its petiole is 1--2 cm long. Inflorescence with an axillary or terminal panicle measuring up to 18 cm long, the flowers sometimes are partly unisexual with densely silky hair. Its fruits are oblong to narrowly ovoid shaped and seated on a perianth cup with persistent perianth lobes (Lemmens *et al.* 1995).

1.7.1 ECOLOGY AND DISTRIBUTION

C. iners is common, occurring in primary and secondary lowland and hill forest, often in moist, rather open locations. C. iners in Sarawak is very tolerant of poor (alkaline and clay) soils and still grows fairly rapidly. This tree has escaped from cultivation from Florida to Louisiana and has become naturalized in Florida. Besides that, it also available in India, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and in the southern Philippines. Its biophysical limits can reach up to 1200(-2400) meters in altitude.

There are other types of cinnamomum for example Cinnamomum altissimum Kosterm., Cinnamomum celebicum Miq., Cinnamomum eugenoliferum Kosterm., Cinnamomum grandiflorum Kosterm., Cinnamomum grandis kosterm., Cinnamomum javanicum Blume, Cinnamomum mercadoi S. Vidal, Cinnamomum mollissimum Hook.f., Cinnamomum pendulum Cammerl., and Cinnamomum politum Miq. Basically there are not much differences between these species. What makes them different are just their distribution and some observations (Lemmens *et al*., 1995).

Picture 1.2 Cinnamomum iners

1.7.2 PROPAGATION AND MANAGEMENT

After depulping under propagation method, seeds should be dried for only a short time and then sown directly afterwards under shade. Viability of fresh seeds is about 40%. Stumping of C. iners has been found to be rather successful: 85% of the stumps of 20 cm long and 0.5 cm in diameter can develop into healthy plants.

In terms of tree management, all medang (Lauraceae species) must therefore be excluded from preferential treatment at present. A mixed plantation of C. iners and teak (Tectona grandis L.f.) was not satisfactory as C. iners did not nurse the teak trees to develop a longer clear bole. Seven years after planting the height of C. iners was only 2-3 m (World Agroforestry Centre, 2006). For germplasm management purposes, the seeds cannot be stored, as they very rapidly lose their viability. Besides that, the number of dry seeds per kg should be about 6400.

1.7.3 MAINTENANCE

There are only a few diseases and insects affecting Camphor-tree (*Cinnamomum*). Among its diseases are wilt, root rot, anthracnose, powdery mildew and thread blight. There are also insects that will attack for example scales and mites (Pirone *et al*., 1988).

1.7.4 FUNCTIONAL USES

C. iners can be manufactured into a product that has commercial values. For example, the bark is used as a medicine which is sometimes traded and called ""mesni"" in

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