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**MODEL PENDUGA PERTUMBUHAN DAN HASIL
TEGAKAN HUTAN TANAMAN SEUMUR
Pinus merkusii Jungh. et de Vriese**

O l e h

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SUMMARY

PRABOWO PUDJO WIDODO. A Growth and Yield Prediction Model for Even-aged Stand of Pinus merkusii Jungh. et de Vriese. (Advisory committee ISHEMAT SOERIANEGARA, Chairman, HERMAN HAERUMAN, SETYONO SASTROSOEMARTO and MOELYARNO DOJOMARTONO, members).

This study aims to formulate a quantitative model that can be used to predict the growth and yield of even-aged stands of Pinus merkusii. The desired model is the one which meets a set of criteria : simplicity, practicability, powerfulness, flexibility, consistent and its capability to reflect the stand structure dynamics.

The data used in this study were taken from a series of measurements conducted by the Center of Forest Research and Development from 1973 to 1984. All sample trees and stands are located in Java, distributed in all provinces possessing Pinus merkusii even-aged stands.

In formulating the tree-volume estimation model, 476 sample trees were selected from those that are healthy, with full grown canopies and straight stems. They were selected from East Java (133 trees or 28 %), Central Java (194 trees or 41 %) and West Java (149 trees or 31 %). By age, they were grouped into 6 classes; 82 trees or 17 % in the class 5 - 10 years, 128 trees or 27 % in the class 11 - 15 years, 215 trees or 45 % in the class 16 - 20 years, 33 trees or 7 % in the class 21-25 years, 12 trees or 3 % in the class 26 -

30 years and 6 trees or 1 % in the class 31 - 35 years.

Sample stands did not represent normal stands, but were selected from relatively healthy stand. They came from the 1960's to the 1970's plantations with 2 m x 3 m spacing, in areas with slopes ranging from 2 to 60 %, with altitudes ranging from 100 to 1500 m above sea level. The soil types consist of latosol, andosol, regosol, grumusol and mediterranean. According to the Schmidt and Ferguson climatic classification, those areas belonged to the A, B and C rainfall types.

In total, 259 stand measurements from 67 permanent experimental plots were used as sample stands. The experimental plots were in square forms of 0.16 to 0.25 ha. Two to six measurements were taken from each plot sequentially with 2 years intervals.

Data from 33 sample plots (115 series of measurements) were used for the estimation of the upper height and nine stand characteristics growth models, while the rest were utilized for testing the validity of the growth and yield stand prediction model. Data separation was conducted intentionally, in such a way that :

- a. Province representation was held properly.
- b. Sample plots were used as the smallest separation units.

Data separation produced :

- a. Data for model formulation, consist of 36 measurements (31 %) from West Java, 53 measurements (46 %) from Central Java and 26 measurements (23 %) from East Java.

b. Data for validity test, consist of 36 measurements (25 %) from West Java, 58 measurements (40 %) from Central Java and 50 measurements (35 %) from East Java.

Stand age sample stands varies from 6 to 26 years for the group for model formulation, and 6 to 28 years for model validation. Stand upperheight varies from 7 to 31 m for the former group, and from 10 to 34 m for the latter. The following are the other parameters for the two groups of data : number of trees per hectare varies between 100 to 1675 and 100 to 1150, mean diameter varies between 11.5 - 43 cm and 18.5 - 43 cm, mean height of sample stands varies between 5.5 to 29.5 m and 8.5 to 32.5 m, basal area of sample stands varies between 15.5 to 43.5 m²/ha and 11.5 to 47.5 m²/ha, and volume of sample stands varies between 25.0 to 425 m³/ha and 75.0 to 475.0 m³/ha.

The research methodology can be outlined as follow : Population of trees in Pinus merkusii even-aged stands was assumed to be represented by tree diameter and height variables which were distributed in a certain joint probability density function, notated by S_{BB} . Stand dynamics with respect to growth and stand thinning were expressed in nine stand characteristics :

- a. The largest tree diameter
- b. The smallest tree diameter
- c. The maximum tree height
- d. The minimum tree height

- e. The frequency mode of tree diameter
- f. The frequency mode of tree height
- g. Deviation of tree diameter
- h. Deviation of tree height, and
- i. Correlation between diameter and height.

All of the nine stand characteristics are studied integratedly with the dynamics of the parameters of S_{BB} .

Stand growth was analyzed catagorically by site. Site quality was determined indirectly applying the relationship between upperheight, stand age and base age (25 years). The Pinus merkusii plantations were planted on 6 site classes and the remain constant through time.

Thinning practices prescribed in the stand management of Pinus merkusii were based on stand basal area/number of trees either by adopting spacing rearrangement (row thinning) or thinning from below.

The mean diameter, mean height, stand basal area, stand volume and thinning product at a given age and site were estimated by moment technique applied to the probabylity distribution functions of S_B and S_{BB} . The frequency of trees by diameter and or height classes was derived from the interval probability of the respective class. Moments and interval probabilities were determined by Gauss quadrature numerical integration.

The growth and yield prediction model for even-aged stand of Pinus merkusii was formulated as a simulation model. For

practical purposes, the model was designed in a computer program. To examine the power of the model, a test of validation was conducted. In measuring model flexibility, the simulation output was contrasted to existing stand table (prepared by the Forest Research Institute, 1975).

The study comes to the following conclusions :

1. The growth and yield prediction model for even-aged of Pinus merkusii can be broken down into 6 sub models, as follow :
 - a. The sub model for upperheight estimation
 - b. The sub model for stand characteristics estimation
 - c. The sub model for parameters estimation of joint probability density function S_{BB} .
 - d. The sub model for growth and yield prediction
 - e. The sub model for stand structure projection, and
 - f. The sub model for stand thinning.

The demonstration of this model i.e. validation and flexibility model tests, have shown and satisfactory results.

2. By FORTRAN IV, the six of the formulated sub models were designed into a computer program, namely the BOWO.COM, which has been broken down into 3 elements, as follows : the main program, 8 functions and 13 sub-routines.
3. The growth and yield prediction model for even-aged stands of Pinus merkusii is a deterministic simulation

model, which meets the following set of criteria :

- a. Quantitative, simplicity, practicability, powerfullness, flexibility and consistent.
 - b. Having a capability to express the stand structure dynamics.
 - c. Can be used to replace the existing growth and yield stand tables.
 - d. Considers biological factors only.
4. The application constraints of the model are :
- a. Can be applied in Java only.
 - b. At the age range 6 to 27 years old the standard error of estimation of upperheight, number of trees, mean tree diameter, mean tree height, basal area and volume stand estimations are 1.2 m, 49 tree/ha, 1.5 cm, 1.4 m , 0.6 m²/ha, and 15.8 m³/ha respectively.

Accordingly, the present growth and yield prediction model for even-aged stands of Pinus merkusii is a temporary model.

5. By the proper application of the model, it is expected :
- a. To increase the effectiveness and efficiency of Pinus merkusii even-aged stand management.
 - b. To support the forest research and development, especially for Pinus merkusii even-aged stands.

In order to strengthen its role in the management, the model needs further improvements, such as extending the data base variation and/or research methodology.

RINGKASAN

PRABOWO PUDJO WIDODO. Model Penduga Pertumbuhan dan Hasil Tegakan Hutan Tanaman Seumur Pinus merkusii Jungh. et de Vriese (Di bawah bimbingan ISHEMAT SOERIANEGARA, sebagai Ketua, HERMAN HAERUMAN, SETYONO SASTROSOEMARTO dan MOELYARNO DJOJOMARTONO, sebagai anggota).

Tujuan penelitian adalah untuk merumuskan model kuantitatif yang dapat digunakan untuk menduga pertumbuhan dan hasil tegakan hutan tanaman seumur Pinus merkusii. Model yang diinginkan adalah model yang bersifat sederhana dan praktis, handal, luwes, ajek serta mampu memberikan gambaran dinamika struktur tegakan.

Data yang digunakan dalam penelitian ini adalah data hasil pengukuran yang dihimpun oleh Pusat Penelitian dan Pengembangan Hutan mulai tahun 1973 hingga 1984. Semua pohon dan tegakan contoh berasal dari Jawa, yang tersebar di setiap propinsi yang mempunyai tegakan hutan tanaman seumur Pinus merkusii.

Pohon contoh yang digunakan untuk menyusun model penduga volume per pohon adalah pohon-pohon yang sehat, tidak cacat, bertajuk sempurna dan berbatang lurus. Semua pohon contoh berjumlah 476 pohon; berasal dari Jawa Timur (133 pohon atau 28 %), Jawa Tengah (194 pohon atau 41 %) dan Jawa Barat (149 pohon atau 31 %). Pohon-pohon contoh tersebut dikelompokkan ke dalam 6 kelas umur; 82 pohon (17 %) di dalam kelas 5 - 10 tahun, 128 pohon (27 %) di dalam kelas 11 - 15 tahun,

215 pohon (45 %) di dalam kelas 16 - 20 tahun, 33 pohon (7 %) di dalam kelas 21 - 25 tahun, 12 pohon (3 %) di dalam kelas 26 - 30 tahun, dan 6 pohon (1 %) di dalam kelas 31 - 35 tahun.

Tegakan-tegakan contoh yang terpilih bukan berasal dari tegakan normal, tetapi dipilih dari tegakan yang relatif sehat. Tegakan-tegakan contoh tersebut berasal dari tanaman tahun 1960-an hingga 1970-an dengan jarak tanam 2 m x 3 m, berada pada lokasi yang berkemiringan antara 2 hingga 60 % dengan ketinggian antara 100 hingga 1500 di atas permukaan laut. Jenis tanahnya ada yang termasuk tanah latosol, andosol, regosol, grumusol dan mediteran. Berdasarkan klasifikasi iklim dari Schmidt dan Ferguson, lokasi-lokasi tersebut termasuk ke dalam daerah bercurah hujan yang bertipe A, B dan C.

Data tegakan contoh yang digunakan dalam penelitian ini adalah 259 hasil pengukuran dari 67 petak coba tetap. Bentuk petak coba adalah bujur sangkar dengan luas antara 0.16 ha hingga 0.25 ha. Pengukuran dilakukan dua 2 hingga enam kali dengan selang waktu dua tahunan.

Data tegakan contoh dari 33 petak coba (115 seri pengukuran) digunakan untuk menyusun model penduga pertumbuhan peninggi dan sembilan karakteristik tegakan, sedang sisanya digunakan untuk menguji kesahihan model penduga pertumbuhan dan hasil tegakan. Pemisahan data dilakukan secara sengaja, yakni dengan mengupayakan agar :

- a. Wilayah propinsi sedapat mungkin masih terwakili.

b. Petak coba digunakan sebagai unit pemisahan terkecil.

Dengan cara pemisahan seperti itu diperoleh hasil :

- a. Data penyusun model, terdiri dari 36 pengukuran (31 %) berasal dari Jawa Barat, 53 pengukuran (46 %) dari Jawa Tengah dan 26 pengukuran (23 %) dari Jawa Timur.
- b. Data uji kesahihan, terdiri dari 36 pengukuran (25 %) berasal dari Jawa Barat, 58 pengukuran (40 %) dari Jawa Tengah dan 50 pengukuran (35 %) dari Jawa Timur.

Umur tegakan contoh yang termasuk ke dalam kelompok data penyusun model bervariasi antara 6 hingga 26 tahun, dan dalam kelompok data untuk uji kesahihan bervariasi antara umur 6 hingga 28 tahun. Peninggi tegakan dalam kelompok data yang pertama bervariasi dari 7 hingga 31 m, sedangkan dalam kelompok berikutnya bervariasi dari 10 hingga 34 m. Parameter-parameter yang lain dari kedua kelompok data tersebut adalah jumlah pohon per hektar bervariasi antara 100 hingga 1675 batang dan 100 hingga 1150 batang, rata-rata diameter pohon bervariasi antara 11.5 hingga 43 cm dan 18.5 hingga 43 cm, rata-rata tinggi pohon bervariasi antara 5.5 hingga 29.5 m dan 8.5 hingga 32.5 m, luas bidang dasar tegakan bervariasi antara 15.5 hingga 43.5 m²/ha dan 11.5 hingga 47.5 m²/ha, serta volume tegakan contoh bervariasi antara 25.0 hingga 425 m³/ha dan 75.0 hingga 475 m³/ha.

Metodologi penelitian ini diuraikan sebagai berikut :

Pohon-pohon di dalam tegakan hutan tanaman seumur Pinus merkusii diasumsikan sebagai populasi yang berpeubah ganda dia-