ABOUT STANDARDS: POTENTIAL AND LIMITATIONS IN FOREST DESIGN

Normalización en la Práctica Forestal: limitaciones y potencialidades

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Abstract

Standardization has been defined as the development of procedures to achieve a required level of compatibility. In ISO terminology, standards are technical agreements which provide the framework for compatible technology worldwide. Standards may be accepted for convenience, or they may be used because of legal provisions or contracts. However, the plurality of standards-issuing organizations means that in many cases, a document purporting to be a "standard" does not necessarily have the support of many parties. In an engineering context, standardization is the process of establishing a technical norm among different (and sometimes competing) entities, where this will bring mutual benefits. In a Forest Design context, a standard may be an agreed upon unit of measurement, a generally accepted model for estimating the response of a system, or a principle of behaviour or doctrine. Using standards has many advantages, and the strategic significance of technical standardization is generally accepted. There are also economic benefits associated with standardisation. Standard units of measurement, standard reference models, standard datasets and standard calculation procedures are needed for effective forest management and planning. The same cannot be said about silvicultural programs, however. Experience has shown that neither the need for certain products and services nor the growth-relevant conditions are constant. Longterm silvicultural standards may be undesirable because such standards produce a mix of services which are only required for a limited period of time. The negative effects of using standard silvicultural programs may outweigh the advantages and it is necessary therefore to continuously adapt silviculture, often several times within the life of a tree.

Keywords: *Silvicultural doctrine, Reference model, Normal forest, Potential density*

Resumen

La estandarización o normalización se define como el desarrollo de procesos orientados a alcanzar el nivel adecuado de compatibilidad. De acuerdo a la terminología ISO, estándares son las bases de acuerdo técnico que permiten el establecimiento de una tecnología compatible a nivel mundial. Los estándares pueden usarse bien por conveniencia, bien por obligaciones de tipo legal o contractual. En cualquier caso, la existencia de numerosas organizaciones certificadoras de estándares implica que, en muchas ocasiones, un documento presentado como estándar no tiene es apoyo de todas las partes implicadas. En el contexto de la ingeniería, la estandarización es el proceso de establecimiento de una norma técnica entre entidades diferentes (e incluso competidoras), al objeto de obte-

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ner beneficios mutuos. En el contexto de la gestión forestal, un estándar puede ser un acuerdo sobre la utilización de una unidad de medida determinada, la aplicación de un modelo para predecir la respuesta de un sistema, o la aceptación de un principio de comportamiento o una ley general. La utilización de estándares conlleva numerosas ventajas, estando aceptado tanto el interés estratégico de la normalización técnica como los beneficios económicos asociados. Para una planificación y gestión forestal eficaz se requiere asumir estándares en unidades de medición, estructura de las bases de datos, modelos de referencia y procedimientos de cálculo. Sin embargo, en el caso de los planes de intervención selvícola la estandarización es más compleja. La experiencia ha demostrado que ni la demanda de un producto determinado, ni los objetivos de la gestión, ni las condiciones de crecimiento de las masas se mantienen constantes en el tiempo. Establecer estándares de selvicultura para largo plazo no es deseable, siendo necesario definir sistemas que permitan adaptar de forma continua la selvicultura, incluso repetidas veces a lo largo del ciclo vital de un árbol.

Palabras clave: *Doctrina selvícola, Modelo de referencia, Bosque normal, Densidad potencial*

INTRODUCTION

The common use of the word standard implies that it is a universally agreed upon set of guidelines for interoperability (http://en.wikipedia.org/wiki/standardization: Interoperability refers to the ability of a unit to provide services to and accept services from other units to enable them to operate effectively together). Standards may be accepted for convenience, or they may be used because of legal provisions or contracts. However, the plurality of standards-issuing organizations means that in many cases, a document purporting to be a "standard" does not necessarily have the support of many parties. There are many worldwide standards developed and maintained by the ISO (International Organization for Standardization), the IEC (International Electrotechnical Commission) or the ITU (International Telecommunication Union). Regional standards bodies also exist, such as the European Telecommunications Standards Institute (ETSI) and the Institute for Reference Materials and Measurements (IRMM). Most countries have a single recognized National Standards Body.

In an engineering context, standardization is the process of establishing a technical norm among different (and sometimes competing) entities, where this will bring mutual benefits. For example, European countries now use the “Global System for Mobile Communications” (GSM) mobile phone standard, and (at least officially) measure lengths in metres. Standardization may also be defined as the development of procedures to achieve a required level of compatibility . In ISO terminology, standards are technical agreements which provide the framework for compatible technology worldwide (see Wikipedia, May 2007).

Based on reports published by the United Nations Food and Agricultural Organisation, it can be assumed that most of the world’s forests are utilized by man in some way or other. Thus, the forests are controlled by management, and current management is usually based on long- and medium-term “designs”. Forest design is a more appropriate term than its common synonym forest planning because it refers to the spatio-temporal organisation of a forested landscape. Such spatio-temporal organisation is a much more challenging task than subdivision, resource assessment and harvest scheduling. Of course, the aim is not only to produce a design, but eventually to achieve acceptance by the public. This often requires particular policy mechanisms and special commitments to clients and the general public, as exemplified by the State Forest Service in the Netherlands (http://www.Publiekverantwoorden.nl/). But that is another problem altogether.

STANDARDS IN FOREST DESIGN

In a Forest Design context, a standard may be an agreed upon unit of measurement, a generally accepted model for estimating the response of a system, or a principle of behaviour or doctrine.

Units of Measurement

During the past 200 years, numerous technical standards of measuring attributes of individual trees and forest stands have been developed. Important attributes are diameters and heights; stem forms, volumes and biomass; the shape of live tree crowns and the amount of foliage; the structure and volume of root systems; merchantable volumes and size class distribution; damage and quality attributes of individual trees and forest stands. These dendrometric attributes are measured in agreed upon standard units, such as metres, feet, cubic metres, cunits, or square metres per hectare. Important attributes are the breast height diameter and the height of a tree. The exact location of breast height needs to be defined for all possible tree shapes, and for even and sloping terrain. Tree height is usually defined as the perpendicular distance between the top and base of a tree (Figure 1).

Standardization facilitates data exchange and communication, and most field measurement devices, like calipers or hypsometers, use some standard unit, like metres or feet (Refer to Forest Mensuration textbooks, for example KRAMER & AKÇA (1987), AVERY & BURKHART (1994), VAN LAAR& AKÇA (2007)).

Standard Models

Modeling is an important part of forest management. We may differentiate between reference models which are used to compare a given situation with some theoretical ideal, and statistical models for estimating the response of trees to particular treatments and environmental conditions.

Reference Models

For many decades, the two most important reference models used in forest planning and harvest control were the Yield Table and the Normal Forest. A yield table estimates the development of the growing stock, and the volume of the removed trees, for forests which are managed in some standard way (Table 1).

The yield table format has remained surprisingly constant during the past 200 years (PAULSEN, 1795; SCHWAPPACH, 1890; WIEDEMANN, 1949; SCHOBER, 1975; MADRIGAL et *al*., 1992). The system of pre-defined thinning grades and yield tables, in combination with periodic inventories of the growing stock, represented a simple and effective planning framework.

Another example of a reference model is the Normal Forest. The model of the Normal Forest is an idealized standard which allows comparisons between the current and some "normal" age class areas, growing stock volumes, growth rates and harvest volumes (HUNDESHAGEN, 1826; OSMASTON, 1968; SPEIDEL, 1972). The model is defined by two conditions: a) a yield model which estimates the development of the growing stock over age and b) a rotation.

The effect of the rotation on the normal growing stock volume and the annual sustainable harvest has been illustrated using specific examples of industrial forests (CLUTTER et *al*., 1983; GADOW & PUUMALAINEN, 2000). The growing stock which is available for the final harvest increases with increasing rotation age, which affects the annual sustainable cutting area, the required total area, the total growing stock volume, the relative sustainable harvest rate and the mean annual increment. The age of culmination of the MAI represents the minimum-landbase-rotation, i.e. the rotation where the area required

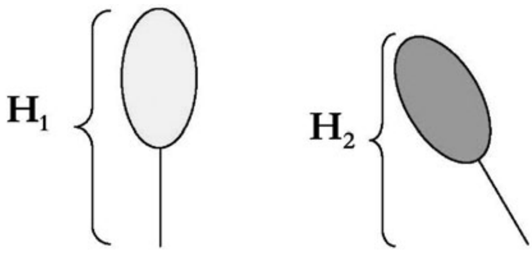

Figure 1. *Tree height is usually defined as the perpendicular distance between the top and base of a tree*

age	Before thinning							Thinned			Total		
	Ho	N	Dg	G	crown	V	Pinas	N/ha	G	V	V	MAI	CAI
(years)	(m)	/ha	(cm)	(m²/h	(m²/tree	(m³/ha	(kg/ha)	ext	(m²/ha	(m³/ha)	(m³/ha)	(m³/Y/ha)	(m³/Y/ha)
15	4,3	625	14,0	9,7	6,2	20,7	33,5	84	0,7	1,6	20,7	1,4	0,0
20	5,5	541	16,1	11,0	8,1	30,0	47,5	72	0,8	2,3	31,6	1,6	2,2
25	6,6	469	18,0	11,9	9,8	38,8	60,4	59	0,8	2,8	42,6	1,7	2,2
30	7,6	410	19,8	12,6	11,3	46,7	72,4	49	0,8	3,2	53,4	1,8	2,1
35	8,5	361	21,4	13,0	12,7	53,6	83,5	40	0,8	3,4	63,4	1,8	2,0
40	9,3	321	22,9	13,3	14,0	59,4	93,7	34	0,8	3,6	72,6	1,8	1,8
45	10,0	287	24,3	13,4	15,2	64,1	103,1	27	0,7	3,4	80,9	1,8	1,7
50	10,7	260	25,6	13,4	16,2	68,1	111,6	24	0,7	6,6	88,3	1,8	1,5
55	11,3	236	26,8	13,3	17,2	71,0	119,5	19	0,6	3,3	94,9	1,7	1,3
60	11,8	217	27,9	13,3	18,0	73,6	126,6	17	0,6	3,3	100,7	1,7	1,2
65	12,2	200	28,9	13,1	18,8	75,4	133,2	14	0,5	3,0	105,9	1,6	1,0
70	12,6	186	29,8	13,0	19,5	76,9	139,2	13	0,5	3,1	110,4	1,6	0,9
75	13,0	173	30,7	12,8	20,2	77,8	144,9	10	0,4	2,6	114,3	1,5	0,8
80	13,3	163	31,5	12,7	20,8	78,7	149,9	10	0,4	2,8	117,8	1,5	0,7
85	13,6	153	32,2	12,5	21,3	78,9	154,7	8	0,4	2,4	120,7	1,4	0,6
90	13,9	145	32,9	12,3	21,8	79,2	158,9	7	0,3	2,2	123,4	1,4	0,5
95	14,1	138	33,5	12,2	22,3	79,3	162,8	7	0,3	2,3	125,7	1,3	0,5
100	14,3	131	34,1	12,0	22,7	79,0	166,6	6	0,3	2,1	127,7	1,3	0,4
105	14,5	125	34,6	11,8	23,1	78,7	170,0	0	0,0	0,0	129,4	1,2	0,0

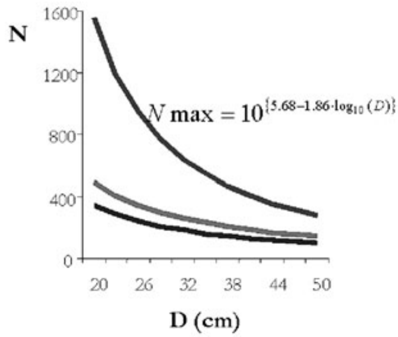

***Table 1**. The yield table on the left, for Pinus pinea, site index 13, medium density, by Montero et al. (2004) includes estimates of pine cones (here designated as piñas). The density guide curves associated with the yield table are shown in the diagram at right; The upper line estimates maximum density, the middle line the desirable density when the objective is soil protection combined with mixed production of pine nuts and timber; the lower line represents the recommended density for pine nut production when soil protection is not an issue*

for supplying a fixed amount of roundwood per year is at a minimum (which is not necessarily the most economical one).

Another important kind of reference models are Potential Density Models. Populations of trees growing at high densities are subject to density-dependent mortality or self-thinning. For a given average tree size there is a limit to the number of trees per hectare that may co-exist. The relationship between the average tree size (increasing over time) and the number of live trees per unit area (declining over time) is difficult to estimate, especially since data from untreated, fully-stocked stands are very rare. An example of two such "limiting relationships" is shown in figure 2. Potential Density Models are useful, and sometimes even considered essential, for developing management schedules. Hinrichs (2006) defined his management paths for mixed stands of Spruce and Beech in Germany with reference to an assumed maximum density. A similar approach was used by García-Gonzalo (2007) when developing management alternatives for Pine and Spruce stands in Finland.

Unmanaged Reference Forests may also be used as standards for evaluating the "near naturalness" of a managed ecosystem. Such referen-

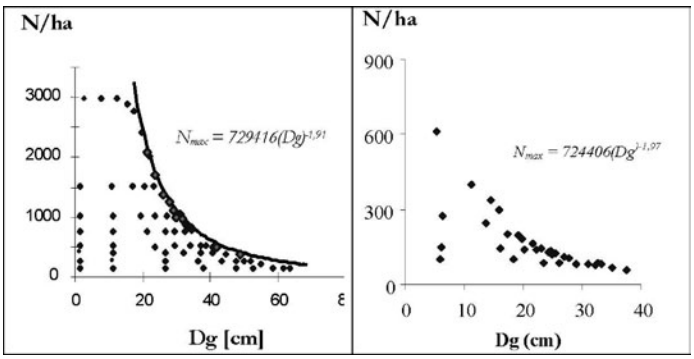

***Figure 2**. Left: limiting relationship for 8 plots of the Pinus radiata CCT experiment "Tokai" South Africa. The exponent –1,91 is typically quite different from the Reineke-constant (1,605). Right: corresponding development of the Eucalyptus grandis CCT experiment "Langepan" in South Africa*

ce forests are used in the municipal forests of Lübeck in Germany (FÄSHER, 1997). However, some research needs to be done to measure the “distance” to some assumed natural ecosystem.

One of the problems is the fact that the unmanaged reference area is not static but subject to continuous change which is difficult to mimic. Another problem concerns the method of measuring the “distance” between a managed forest and the reference, considering different species and size distributions.

Statistical Models

A growth model is a particular representation of a specific data set of empirical observations. The forest modeling approaches are very similar. The modeler tries to get hold of some field measurements, fits a model and publishes the results. The data are usually from some experiments that just happen to be available, and the parameters are valid for that particular dataset. Changing the dataset will produce new parameters because the model is only a “mirror” of the observations. For this reason, none of the many existing growth models is capable of providing reasonable estimates of the system response to any arbitrary combination of initial age, treatment and growing site. This is true for most if not all of our tree species. Different models can be used for a given dataset and clearly the dataset is more important than the models (Figure 3). The most valuable data are usually those which represent growth rates in response to extreme densities, ages and site conditions.

Therefore, the development of standard datasets is an important task of forest research. HESSENMÖLLER (2002) compiled a common model of European yield tables for beech while GADOW (2002) proposed and initiated a project to establish a common data matrix for Fagus sylvatica covering a wide range of sites, densities and ages, and different geographical regions in Europe. The idea was to create a set of reference data that will show where there is a lack of empirical information, and concentrating on change rates of basal area, height and stems/ha. Institutions would benefit by helping to establish such a common data set which can be shared by the growth modelling community.

Standard Methods

When referring to standard methods, a distinction can be made between a standard calculation procedure which allows objective comparisons of alternative management treatments (“how to calculate a carbon balance”) and a principle of behaviour or morality which is intended to coerce people to act in a specific way (“no clearfelling”).

Standard Calculation Procedures

It is often useful to develop standard procedures of calculation, to avoid misunderstanding and to allow comparisons. The carbon balance is a good example. There are several possible ways to calculate the carbon balance of a stand, for example, following DIAZ-BALTEIRO & ROMERO (2003), the carbon balance of a forest for the period t_1–t_2 can be calculated as follows: $C_{t_1,t_2}=$ß$\cdot(V_{t_2}-V_{t_1}+H_{t_1 \cdot t_2})-P_{t_1,t_2}$, where C_{t_1,t_2} is the carbon balance for the period t_1–t_2, *ß* is the proportion of carbon in the biomass (usually around 0.5), V_{t_2},V_{t_1} is the biomass in the forest at t_1 and t_2, respectively, $H_{t_1 \cdot t_2}$ is the biomass of trees harvested or dead during period t_1–t_2 and P_{t_1,t_2} is the amount of carbon released through the decomposition of dead biomass and timber products during the period t_1–t_2. A detailed carbon balance includes the

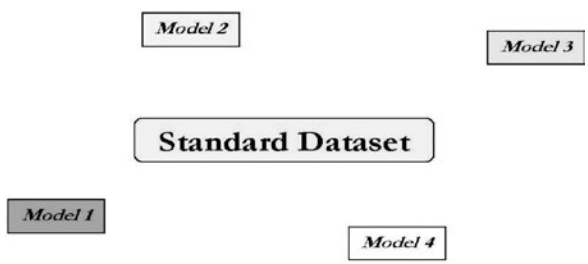

Figure 3*. Different models can be used for a given dataset and clearly the dataset is more important than the models*

change in the living biomass, natural mortality, cutting residues and the amount and stage of decomposition of wood products originating from the forest and manufactured before the planning period. The carbon balance of a forest is equal to the sum of the carbon balances of the individual stands.

Principles of Behaviour: Silvicultural Doctrines

Over the years, foresters have been developing many silvicultural standards as universally agreed upon sets of instructions for managing a forest. There are numerous examples of treatment programs prescribing a series of particular silvicultural events for the entire life of a forest from planting to the final harvest. The optimization of such standard treatment schedules was an important research topic during the 1960's until the 1980's. Silvicultural standards were sometimes prescribed like doctrines, often without scientific foundation. SPEIDEL (1972) refers to such prescriptions as "Götterblick" decisions.

Tree species choice and silviculture are influenced by changing policies, and changing economic and environmental conditions. Therefore, standard silvicultural programs which are designed for conditions which are assumed to remain constant, may be outdated before the trees reach maturity. Research has shown that cyclic changes of forest policy are quite common, and that the phase-length of the cycles of policy changes is usually much shorter than the lifespan of the trees (AMLING, 2005; KOCH, 2005). The policy changes may affect the type of harvesting practice (clearfelling vs selective harvesting), species selection (deciduous species vs conifers) and preferred forest structures (even-aged monocultures, even-aged or uneven-aged multi-species forests). It is not surprising, therefore, that many forests are in constant transition from one policy to another. This is a paradox, because, in theory, forest management is supposed to be committed to longterm strategies.

Thus, standardisation is not always meaningful. Simulations in pure Spruce stands (EINSIEDEL, 2004) and multi-species Beech stands (WAGNER, 2004) have shown that different management paths may have virtually the same value if several criteria are simultaneously taken into account. These and other findings show quite clearly that silvicultural paradigms are not only short-lived, but also ambiguous. Generating multiple options, and evaluating them with regard to the services that they produce, is an important new paradigm. Besides experience-based, intuitive path generation, where a qualified expert defines several (usually between 1 and 5) sequences of activities for each stand in the field, there are more sophisticated techniques, including rule-based methods (VILČKO, 2005; SÁNCHEZ-OROIS, 2003), all-possible-paths methods (SEO et *al*., 2005; HINRICHS, 2006) and single tree methods (ZIEGELER & VILČKO, 2005).

CONCLUSIONS

Using standards has many advantages, and the strategic significance of technical standardization is generally accepted. There are also economic benefits associated with standardisation. Standard units of measurement, standard reference models, standard datasets and standard calculation procedures are needed for effective forest management and planning.

The same cannot be said about silvicultural programs, however. Experience has shown that neither the need for certain products and services nor the growth-relevant conditions are constant. Longterm silvicultural standards may be undesirable because such standards produce a mix of services which are only required for a limited period of time. The negative effects of using standard silvicultural programs may outweigh the advantages and it is necessary therefore to continuously adapt silviculture, often several times within the life of a tree.

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