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METHODS

Discussion on the construction of a standard system for forestry cultivation

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ABSTRACT

Based on the analysis of the development and present situation of the standardization of forest cultivation in China and combined with the characteristics of forest cultivation, the main basis, principles and methods of establishing forest cultivation standard system were discussed and put forward. A standard system of forest cultivation was established, which included six sub-systems, namely, forest cultivation foundation, prenatal planning, artificial afforestation, tending management, harvest renewal etc. The ideas and management suggestions for standardization of forest cultivation in China in the future were put forward, such as to establish an authoritative and complete database and a supporting management system.

Keywords: Forest Cultivation; Standard System; Artificial Afforestation

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1. Introduction

With the rapid development of the revolution of IT worldwide and the economic globalization marked by the WTO, standardization permeates almost every area in human activity. Applicable, advanced, scientific and reasonable standard system is the basis of standardization, and most developed countries have formed a relatively perfect agricultural standard system[1–3]. China's forest cultivation standards were basically equivalent to the technical standards of the former Soviet Union before the reform and opening up. Since the 1990s, there has been many progresses in forestry standardization, and many industry standards for forest cultivation have been formulated. With the continuous enrichment of the quantity and content of forest cultivation standards, there are also some problems, such as non-standard writing and outdated content, so it is difficult to form a system. Moreover, the existing forest cultivation standards are repetitive, chaotic and lack of systematization. Therefore, in order to improve the quality and level of forestry production, it is very necessary to construct the systematic and scientific forest cultivation system.

2. The significance of constructing the forest cultivation standard system

Standard system refers to the organic whole of science formed by standards within a certain range according to its internal connection[4]. Standard is the element of the standard system, and also the core of

standardization. Scientific and reasonable standard system are conducive to the efficient formulation of standards and standardization activities[5–7]. Forest cultivation standard system refers to related standards in the forest cultivation, and according to its internal connection form the scientific organic whole[7], which is one of the bases for the formulation and revision of relevant standards of forest cultivation, it is the basis to promote the clear hierarchy and reasonable structure of forest cultivation standards, and it is the blueprint covering the existing and expected development standards of forest cultivation. It constantly develops and updates with the development of the technology of forest cultivation.

For a long time, China's forest resources have insufficient total quantity, low quality, uneven distribution and other problems. For a long time in the future, forest cultivation is still the core content of forestry construction. At present, there are some problems in the forest cultivation, such as the non-standard management, the low forest quality and the low survival rate of afforestation. By April 2013, China had promulgated 1,386 forest cultivation standards for seed production, seedling cultivation, afforestation and tending management[8]. Many standards are repeated and crossed, the overall revision of forest cultivation standards is relatively low, and the number of revised standards is less than 10% of the total standards. Standards update slowly, with more than half of the standards used more than five years. Therefore, it is urgent to carry out the standardization research of forest cultivation[7,9,10].

The significance of constructing the standard system of forest cultivation in China lies in: (1) From the macro perspective, it can provide a general outline for standardization of forest cultivation. Under the guidance of this outline, standardization of forest cultivation can be carried out scientifically and orderly; (2) it can provide important technical basis and guarantee for forest cultivation in China, so that each link of forest cultivation can be followed with standards, which can promote the application and popularization of scientific and technological achievements of forest cultivation, improve the quality and benefit of forest cultivation and is also beneficial to establish the trade order of wood products at home and abroad; (3) it is helpful to grasp the status quo and problems of standardization of forest cultivation in China and makes up of the vacancy of the formation and revision of forest cultivation standard system; (4) as the basic research of standardization, the establishment of forest cultivation standard system provide a basis for standardization, such as standard formulation, revision and planning, making it more proactive, forward-looking, being able to drive the development of specific standards, and conducive to occupy the initiative of the global forest cultivation standard system.

3. The present situation and main problems of forest cultivation standardization

3.1 Composition and quantity of forest cultivation standard

Forest cultivation is mainly composed of seed production, seedling cultivation, afforestation and tending management. As of April 2013, the domestic standards for forest cultivation such as seed harvesting, seedling raising, planting and tending issued were 1,386 in total, including 58 national standards, 164 industry standards and 1,164 local standards. Local standards are far more than industry standards and national standards. Among these standards, the number of standards involving seedling cultivation is the largest, reaching 966, including 231 afforestation and camp forest, 109 tending and management, and 80 seed production. Among the 58 national standards, most are the seed production standards, with 24. The others are 13 standards of tending and management, 11 of seedling cultivation and 10 of afforestation[8].

3.2 Revision and standard age of forest cultivation standards

Standards have a certain timeliness. With time passing by and the developed science and technology and practical experience, the original standards may lag behind the current actual situation, and the standard may lose its effectiveness. The validity of China standard is 3–5 years[6]. The overall revision

level of China's forest cultivation standards is relatively low, and the number of revised standards is less than 10% of the total. Six of the 58 national standards have been revised, 23 for 164 industrial standards, and 108 for 1,164 local standards.

In terms of the age of the standards, there are 303 forest cultivation standards of more than 10 years, 589 from 5 to 10 years, and 494 less than 5 years. In the 58 national standards, that is 39, 10 and 9 respectively; in the 164 industry standards, that is 44, 16 and 104 respectively; and in the 1,164 local standards, that is 220, 536 and 381 respectively. In China's forest cultivation standard, less than half of the standards have an age that is less than 5 years.

3.3 The main problem of the standardization of forest cultivation

At present, there are very few foreign literatures on forestry standardization, and the forestry standard system is mostly included in the agricultural standard system. Most developed countries have formed a relatively perfect agricultural standard system. For example, implement the standardization of the whole process of agricultural production, and product quality standard becomes the barrier of product import and export; form a standardization system with strong operability and advanced inspection and testing means, and make standardization has legal guarantee. Compared with developed countries, the standardization of forest cultivation in China mainly has the following problems.

3.3.1 The standard system for forest cultivation has not yet been established

Before the reform and opening up, China's forest cultivation standardization borrowed more from the former Soviet Union. The real development started in the 1990s, but there is little basic research on the forest cultivation standard system, and a scientific forest cultivation standard system has not been established. Gu[11] has studied the development and existing problems of forest cultivation standards in China, and put forward the revision plan of forest cultivation technical standards, but it has not risen to the level of guiding standardization from the perspective of the construction of standard system. Standardization itself is a complex and systematic engineering, and forest cultivation has characteristics of public welfare, economic inefficiency and wide area, etc. Li *et al.*[1] pointed out the importance of the construction and basic research of forestry standard system in China by analyzing forestry standardization at home and abroad. Under the guidance of scientific and perfect forest cultivation standard system with the reasonable structure, the standard formulation can be more proactive and forward-looking, the advantages and role of standardization can show out. Therefore, it is urgent to establish a scientific forest cultivation standard system in China.

3.3.2 Standards are not coordinated and unified

The lack of coordination and unity among the existing forest cultivation standards is mainly reflected in the following aspects: Firstly, the standards with the same name consisted of the repeated content is common. Relevant local standards have still been formulated under the situation that the national standards or industrial standards have already been formulated. For example, in the *Afforestation Technical Planning, Tree Seed Inspection Regulations, Tree Seed Quality Classification* and *Main Afforestation Tree Quality Classification*, 5–8 standards with the same name can be retrieved. Secondly, some technical requirements among local standards, national standards, and industry standards are not unified, and there is a phenomenon of repeated definition. Too many standards are easy to make content crossed and repetitive. Therefore, the relevant state departments should establish a standardized and scientific standard system as soon as possible, control the number of similar standards, and guide the formulation of standards.

3.3.3 The standard content is old and poorly written

From the perspective of the revision of forest cultivation standards and standard age, China's forest cultivation standards are seriously old, and especially "aging" phenomenon of the national standard is the most serious, with more than 10 years of standard age accounting for 68.42%. Some of the standards were renumbered, but they were not re-

vised. Poor revision and low bid acquisition rate are the direct causes of standard aging.

Most of the standard texts of forest cultivation with a standard age of more than 10 years do not meet the provisions of GB/T 1.1–2009 *Directives for Standardization Part 1: Rules for the Structure and Drafting of Standards*. Most of these standards do not have covers or their cover are incomplete, the number is not standard, the basic format is not specified, such as preface and note are reversed [12].

Through the above study of the forest cultivation standard system, we can conclude that the forest cultivation standards have features of large quantity, low quality, untimely revision, low bid acquisition rate and uncoordinated standards. Therefore, it is very urgent to build the existing forest cultivation standard system and integrate the existing forest cultivation standards in China.

4. The idea of constructing the forest cultivation standard system

To introduce the whole process of forest cultivation into the standardization, we should focus on the development of forest cultivation and the construction of modern forestry, follow the basic principle of standardization of "unification, simplification, coordination and optimization", and "scientific, systematic, coordinated, advanced, compatible, advanced and scalable" principle[5,6]. The author believes that the construction of the forest cultivation standard system in line with the market demand in China, as the technical guarantee to guide forest cultivation, should follow the following points in addition to the compilation requirements of the general standard system.

4.1 Construction principles

4.1.1 The principle of comprehensiveness

The standard system of forest cultivation should include the various technologies and concepts involved in the whole process of forest cultivation and those that need to be coordinated and unified in their management, so that each link can be based on standards.

4.1.2 Coordination principle

The standards among the forest cultivation standard systems, within the standard system and outside should be coordinated to avoid the inconsistency of terms and technical parameters and disharmony of standards, such as the duplication, crossover and contradiction,.

4.1.3 Hierarchy principle

On the one hand, the standard system consists of different levels of national standards, industry standards, local standards and enterprise standards. On the other hand, the level reflects the scope of application of the standards. The standards with a large scope of application are at the top level of the standard system, while they are at the lower level when opposite is the case, and the specific custom-made standards are at the lowest level. Forest cultivation can be divided into different stages according to the timeline, and the corresponding standards are formulated for each stage. Different stages constitute different levels of the standard system. The standard system with clear framework and reasonable structure divides each standard into the appropriate level, so that each standard can restrict and complement each other, and they can be coordinated and unified.

4.1.4 Principles of sustainable development

The standard system of forest cultivation should have a mechanism to gradually develop over time. The forest cultivation standard system should be comprehensive, dynamic, prospective, and has timeliness. It should reflect the current level of science and technology and industry development, and fully consider the future development, especially forest cultivation technology and management methods, leaving enough space for the new standard.

4.2 Building basis

(1) Standardization Law of the People's Republic of China, Regulations for the Implementation of the Standardization Law of the People's Republic of China, Interpretation of the Provisions of Standardization Law of the People's Republic of China, Measures for the Administration of National Standards, GB/T 13016–2009 Principles and Requirements for Preparing Diagrams of Standard System, GB/T 1.1–2009 Directives for Standardiza-

tion, Part 1: Rules for the Structure and Drafting of Standards etc.

(2) Existing domestic and foreign forest cultivation standards. This is the basis of the systematic construction of the standard system of forest cultivation in China.

(3) The development status of forest cultivation technology in China. The standard system constructed should cover the different stages of the current forest cultivation and development, and the specific standards should meet the needs of practice.

(4) Research results of forest cultivation technology in China. Promot the application of high and new technology through standardization, and grasp its development direction which is conducive to construct a standard system with more room for development.

(5) Principles and methods for the construction of standard systems of relevant forestry and other industries.

4.3 Construction method

The construction of the standard system is generally first to regard the research object as a system, and then use specific methods according to the characteristics of the system to build the standard system. The whole process reflects the ideas and views of the system engineering. Common methods of building standard system include hierarchical analysis method, classification method, 3-dimensional coordinate method, modular method, and framework construction method, etc. Refer to domestic research on other standard systems, especially on the forestry industry standard system, combined with the complexity and systematization of forest cultivation itself, the author thinks that building forest cultivation standard system can use the system engineering method. By analysis of every standard of forest cultivation technology system and the forest cultivation process, we carry out systematic analysis of standard elements of forest cultivation, establishing a scientific and reasonable forest cultivation standard system combined with classification, hierarchy and process method[13–18].

5. Establish a standard system for forest cultivation

5.1 Composition and structure of the forest cultivation standard system

According to the above methods, after all the standards of forest cultivation are analyzed and reasonably sorted according to the forest cultivation, the author designs the forest cultivation standard system in China based with hierarchical and process analysis (see **Figure 1**). **Figure 2** shows the hierarchical framework of the structure of the forest cultivation standard system. The forest cultivation standard system is divided into six sub-systems: basic subsystem, prenatal planning subsystem, artificial afforestation subsystem, tending management subsystem, harvest update subsystem and other, Under the subsystem, it is divided into several subsystems, and then according to the characteristics and actual situation of the subsystem, the subsystem can be further classified, and the subsystems and classes are specific standards[3].

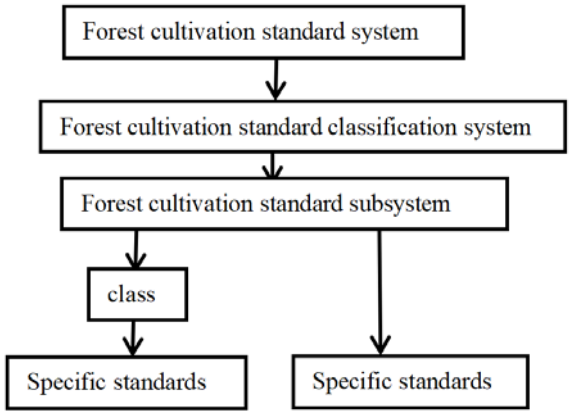

Figure 1. The hierarchy diagram of forest cultivation standard system.

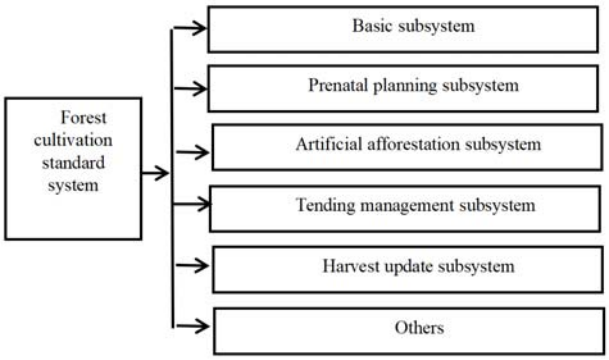

Figure 2. Hierarchical framework diagram of forest cultivation standard architecture system.

5.2 Hierarchical framework of each subsystem

The basic subsystem framework is shown in **Figure 3**. The subsystem of codes and terms should include specific standards, such as the basic terms of forest cultivation and the code of forest resources. The subsystem of the method should include the specific standards, such as forest site classification and type, forest site quality evaluation, forest classification, forest division, forest industry division system and nomenclature, determination of stand density and its relationship with forest formation, afforestation planning, design and construction, individual growth of forest trees, growth of forest groups, etc. The subsystems such as digitalization, management system and information dissemination system etc. should also formulate corresponding specific standards to regulate the contemporary forest cultivation under the background of informationization and economic globalization.

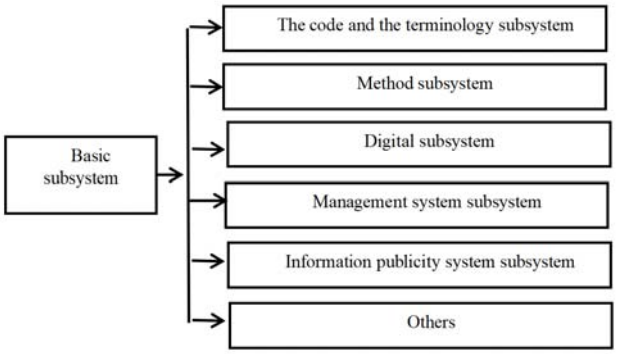

Figure 3. Tomographic frame diagram of the basic subsystem structure.

Prenatal planning in forest cultivation standard system is an important stage of forest cultivation, whose main technology includes site survey, tree species selection, forest species planning, seed production and seedling cultivation. The hierarchical framework of the subsystem structure of prenatal planning is shown in **Figure 4**. The subsystem of site investigation and selection evaluation mainly includes specific standards, such as site quality evaluation, afforestation species selection and forest species planning, etc. The seed production subsystem includes specific standards, such as seed division, classification, grading, inspection, seed processing, storage, transportation, collection, dormancy and bud promotion, improved seed base, improved seed breeding, etc. The nursery cultivation subsystem includes standards, such as nursery construction, sowing seedling, cutting seedling, container seedling, seedling nursery, seedling quality evaluation, etc. Each subsystem also contains specification standards in technical processes.

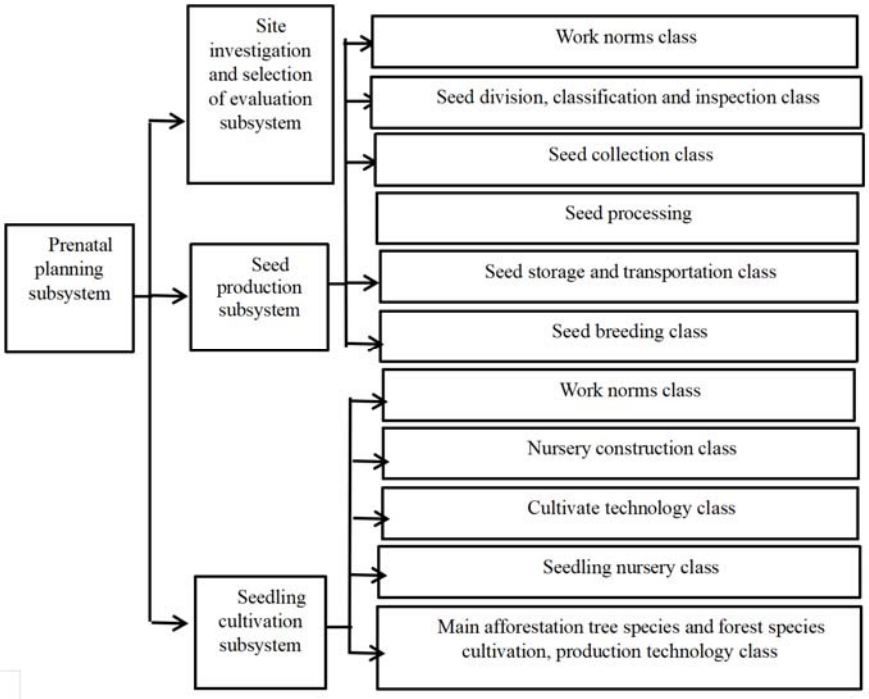

Figure 4. Frame diagram of subsystem hierarchy of prenatal planning.

The main technical work of artificial afforestation is natural enclosure, afforestation land cleaning and soil preparation, planting site allocation, seedling planting or planting and afforestation technology. The standard subsystem of artificial afforestation is mainly composed of four sub-systems: work norms, forest group structure regulation, forest land growth environment control and afforestation method (see **Figure 5**). The control subsystem of forest community structure includes artificial forest afforestation technology and mixed forest cultivation technology; forest growth environment control subsystems are mainly forest growth environment standard, etc.; afforestation subsystem includes specific standards, such as live afforestation technology, afforestation technology and subdivision afforestation technology.

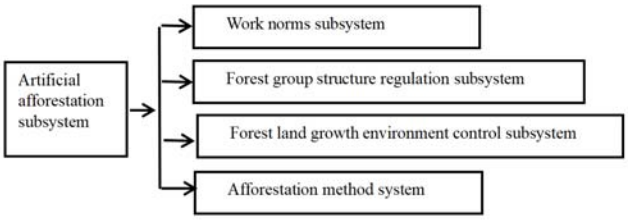

Figure 5. Frame diagram of subsystem structure of artificial afforestation.

Forest cultivation and management should constantly adjust the relationship among trees and between trees and the environment to ensure the growth of young trees according to the expected requirements. Therefore, the forest cultivation and tending management system includes six subsystems: work norms, forest land management, forest tending management, tending and felling (intermission), forest division transformation and management model (see **Figure 6**). Woodland management subsystem includes specific standards, such as forest fertilization, forest land reclamation and planned burning, etc.; forest tending management subsystem includes tree pruning, cutting of tree buds and tillers; tending and felling (intermission) subsystem includes light tending, growth tending and tending and felling (intermission) period; forest reform subsystem includes low-value plantation transformation technology, secondary forest management and transformation technology; management model subsystem includes various forest management model standards.

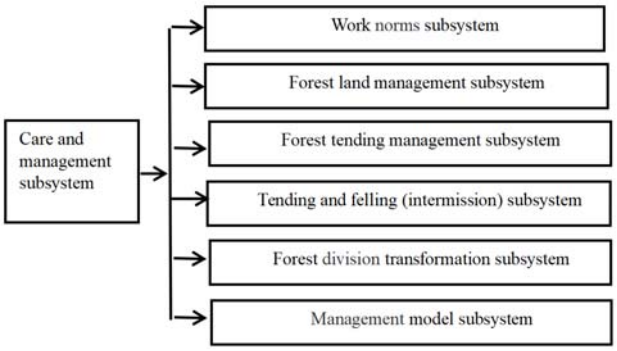

Figure 6. Framework of care and management subsystem structure.

The harvest renewal of the forest directly affects the renewal of the next generation and the sustainable development of the forest. Therefore, the forest harvest renewal is also a subsystem of the forest cultivation standard system, mainly including two subsystems of working norms and harvest methods. The harvest method subsystem includes the specific standards of different-age trees selective felling, complete felling of same-age trees, gradual felling of trees of relative same-age, updating felling of overmature old trees, dwarf trees operation method, middle trees operation method and post-disaster forest rescue, etc.

In addition to the forest cultivation standards mentioned above, some established forest cultivation standards cover the main process of forest cultivation, with different technical regulations of forest species for afforestation and engineering standards, which cannot be classified into the above 5 categories. There are also some forestry engineering standards, such as natural forest protection project, grain for green project, mountain closure and forest conservation project, and nature reserve project, etc., which are put into the sixth forest cultivation standard subsystem (see **Figure 7**).

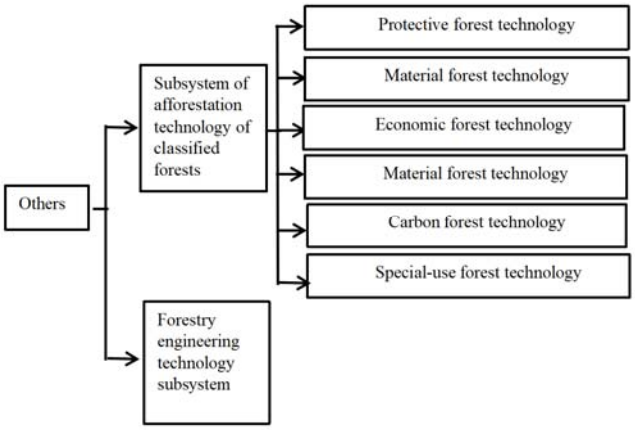

Figure 7. Other sub–architecture hierarchies.

6. Suggestions on the implementation of forest cultivation standard system

The standard system of forest cultivation established in this paper basically covers every link of forest cultivation production, which accords with the current development of forest cultivation and the trend of standard development. On the implementation of the standard system, some suggestions were put forward below.

6.1 Extensively carry out basic research, establish an authoritative and complete database

Timely include standard texts, and establish an authoritative and complete forest cultivation database for readers to use. The establishment of the database should be based on evidence, so as to facilitate information inquiry, duplicate check, etc. Standardization is a continuous and spiraling movement including the formulation of standards, the issuance of standards, the implementation of standards and the supervision of the implementation of standards, of which the core is the standard, the key link is the implementation of standards[4]. The authoritative and transparent standard database is helpful for the standard users to implement the standard and promote the standard. At the same time, it will digitize the standard information of forest cultivation in China, and more directly reflect the development and status quo of the current standard system of forest cultivation, which is beneficial to improve the standard system of forest cultivation and enhance the level of standardization.

6.2 Through the research of the standard system, drive the formulation and revision of specific standards

According to the forest cultivation standard system, rectify the existing national standards, industrial standards and local standards, merge or abolish some overlapping or conflicting standards, and revise the outdated standards. On the basis of the standard system of forest cultivation, we should check and fill in the gaps of the existing standards, accelerate the formulation and revision of specific standards, such as the basic standards and forestry ecological construction, forest tending management, forest harvesting and utilization, energy forests, etc. and realize the standardized production of all links in the whole process of forest cultivation as soon as possible. At the same time, we should adopt international standards and foreign advanced standards to formulate and revise our forest cultivation standards, and constantly improve the standard system to make the levels of the standard system clearer and the structure more balanced and reasonable.

6.3 Establish a supporting management system

On the one hand, the forest cultivation standard system not only includes the forest cultivation technology standards, but also should cover various things and concepts that need to be coordinated and unified in the forest cultivation technology and its management. A complete forest cultivation standard system should include the standards of management system and work norms. On the other hand, standardization is a complex system. To make the system operate orderly, we must establish an effective management system and operation mechanism. First, establish a full-time forestry standardization management organization; second, it should be clear to avoid the phenomenon of multiple forestry standards and separate governance; third, establish a standardized promotion system, increase the distribution and allocation of standards, and conduct extensive publicity and guidance through various news media, such as the network, radio, television, newspapers, etc.

As the core of forestry construction, forest cultivation is a complex and systematic engineering. This paper uses the thought of standardized system engineering to study and construct the forest cultivation standard system. On the basis of studying and analyzing forest cultivation technology system and each standard of forest cultivation, the framework of forest cultivation standard system designed basically covers the whole process of forest cultivation. As the research of forest cultivation standard system involves a wide range of areas, complex content and large workload, there are still many problems and contents to be studied. In the future, we should also pay attention to the research

of forest cultivation standard system, forest cultivation specific standard and forest cultivation standard system model, etc.

Conflict of interest

The authors declare that they have no conflict of interest.

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