Sino-German cooperation Project on Innovative Technologies and Service Capacities of Multifunctional Forest Management
(CAFYBB2012013-Lin2value)

Development of silvicultural models for multi-functional forest management:

Systematic consideration and application in the tropical forestry experiment center, Southwestern China

Yuanchang LU, Xianzhao LIU

YLu@caf.ac.cn;

Institute of Forest Resource Information Techniques(IFRIT)

Chinese Academy of Forestry (CAF)

2012-12-3

Contents

1. Objects and the joint study of Multi-functional Forest Management

2. Present situation of the plantation management in China

3. Systematic Approaches of silvicultural regime for MFFM

4. Silvicultural models for multi-functional forest management in Experimental center of tropical forestry (ECTF).

5. Conclusion

1. Objects and the joint study of Multi-functional Forest Management

- MFFM is an important topics with the "ecological civilization" denvelopment set by Chinese leadership now and before.

Objects in Chinese Project

（1）Species and single tree level relationship for MFFM

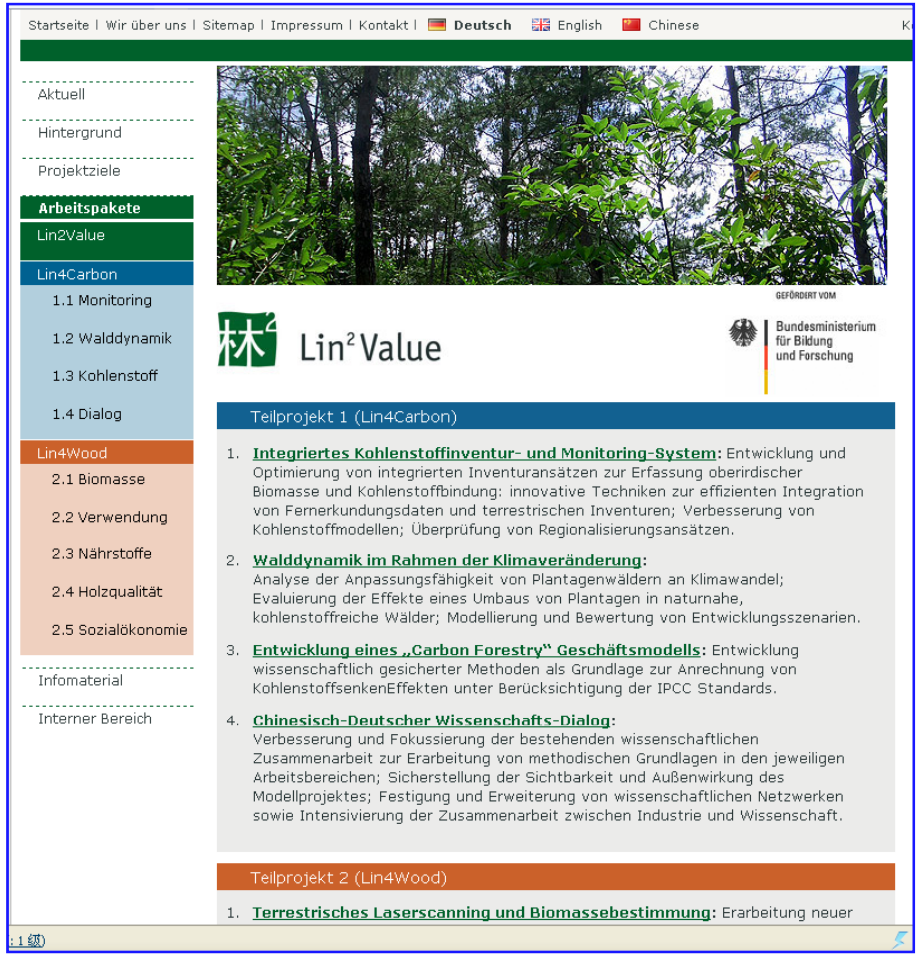
Individual difference, completion relationship etc.

（2） Stand level silvicultural models for MFFM

（3）Landscape level planning techniques of MFFM

（4）Integrated theory and techniques of MF to Carbon sequestration and climate changes

1. Objects of joint study on Multi-functional Forest Management



Teilprojekt 2 (Lin4Wood)

1. **Terrestrisches Laserscanning und Biomassebestimmung:** Erarbeitung neuer Methoden zur Beschreibung und Quantifizierung von dreidimensionalen Waldstrukturen, Entwicklung und Evaluation von innovativen Techniken für eine exakte und genaue Biomassebestimmung als Grundlage für die Quantifizierung der Biomasseproduktion und der Kohlenstoffbindung.
2. **Ernte und Holzverarbeitung:** Ermittlung von geeigneten Methoden der Holzernte, sowie Einführung und Anpassung von modernen teilmechanisierten Holzerntetechnologien als Alternative zu den bisher angewandten motormanuellen Verfahren. Entwicklung von Nutzungskonzepten für Rundholz kleinerer Dimensionen und Bambus zur Herstellung sekundärer Energieträger, namentlich Pellets, für eine kosteneffiziente und klimaneutralere Versorgung mit Bioenergie.
3. **Standortsevaluation und Nährstoffkreisläufe:** Ausarbeitung von Methoden zur modellunterstützten Abschätzung von Bodenkohlenstoff- (Humus) und Nährstoffvorräten. Entwicklung eines waldtypen- und bewirtschaftungsspezifischen Kohlenstoff- und Nährstoffkreislaufmodells zur Einschätzung der Nachhaltigkeit von Biomasse- und Holznutzung.
4. **Analyse der Qualität der Holzbiomasse:** Analyse von neuen Methoden für die Bestimmung der Holzdichte als Schlüsselparameter für die Holzverwendung. Durch weiterführende Analysen können Rückschlüsse auf Brennverhalten, Biomasseproduktion und Kohlenstoffbindung sowie zu Auswirkungen auf den Nährstoffkreislauf gezogen werden.
5. **Soziale und ökonomische Aspekte der Biomasseproduktion**: Analyse der wichtigsten Faktoren einer nachhaltigen Holzbiomasseproduktion unter besonderer Berücksichtigung steuerlicher Förderungen, staatlicher Subventionen und Anreize, sowie der Rolle des Kohlenstoffmarktes und der Einbeziehung einer Risikobewertung.

Concept and classification of Multi-Function of Forest

Multi-functional forest is the one which more then one function or services are needed in a same time.

This is new charaters of plantation and make some changes in FM.

（1）Production function： timber, food, fuel, fiber, water etc.
（2）Regulating function： adjust air condition , precipitation, etc.
（3）Cultural Service： science and educational, entertainment, etc
（4）Life supporting function： carbon sink, wind resistance , etc

Above are the first layer for MFFM,
The next step is to make sure the main function, and other function of the stand. Then use function zone, species selection, operation intensity, and silvicultural model .

2. Present situation of plantation management in China

- Less species, coniferous species.
- Even-aged, pure forest with single structure.
- Large area with **low productivities: average standing volume is 84 m³/ha(Germany 320 m³/ha, BMBF 2005), and plantation 45 m³/ha.**
- Other problems such as forest health, vitality, and ROI(return on investment) etc. which causing Various contradictions between land utilization, society and environment. (Portucel and Silva 2008; Lu, et al2009)

Lacking of suitable silvicultural regime

Silvicultural model is the weakest and simplest task in Chinese forest management.

Clear-cutting apply in most region, sometimes with confused technical and executive routine.

Due to lack of practical experience, the concept and technical of silvicultural model system is disordered.

Silvicultural operation classification oriented not by the overall goal but stage target, and composed by four tending operation types (lighting cutting, thinning, increment felling and sanitation felling) and harvest operation types (clear-cutting, shelterwood cutting and selection cutting).

3. Systematic Approaches of silvicultural regime for MFFM

3.1 Systematic consideration:

What is plantation? Integrity, relativity, collectivity, purpose, adaptability etc.

- **Definition of objects: a new plantation concept**
- **Target analysis:** goals and principles of multi-functional forest management
- **Element and relationship:** composition, index, process, action
- **Structure:** level, space, element, time etc.
- **Function quantification:** completeness, technical parameters, relational model
- etc... ...

3.2 Objectives definition: a new concept of plantation

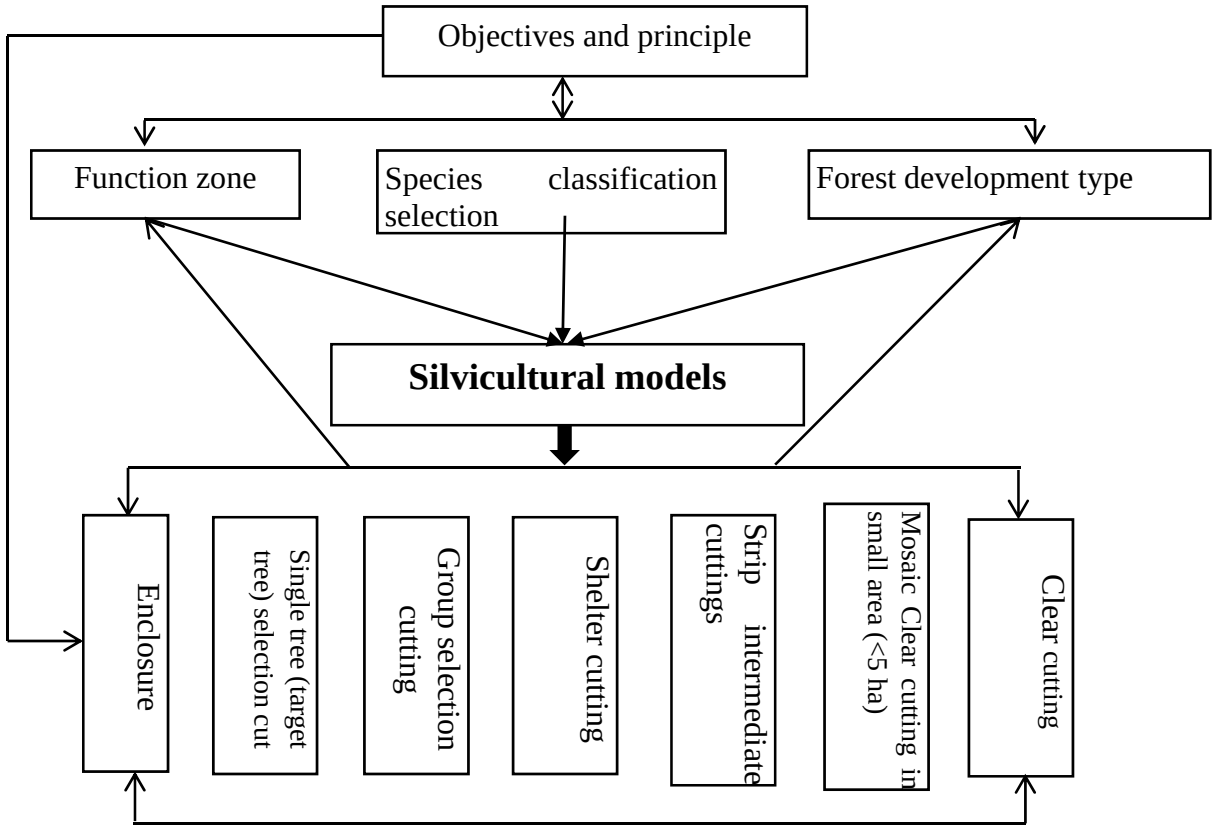
- new plantation concept：

“Plantation are：all or partly afforested by seeds or seedling，species used can be site suitable introduced or native， single or mixed，stand can be even or uneven aged，and one or multi－layer structured.

- This definition contain a series, from signal structure plantation to complexity structure near natural forest, It the expand under the target of multi-functional forest management(Figure right).

Frame of silvicultural models designing

systems thinking of the framework silvicultural models：
Constrains and pre-conditions are functional zoning, species selection, and FDT, all regulated by MF principles and aimed on managing goal.



Logical frame of silvicultural models designing

3.3 Goal and principle of multi-functional forests

- Identical with the international standard of sustainable development

- The goal of multi-functional forest management could express as “maintain the health and vitality of forest, and developing possibly the functions of supplying, regulating, recreation and supporting.

Principles:

Dividing the Goal of MFFM into following 7 points:

(1) Pursuing the maximization growth of forest in quantity and quality.

(2) Maintain the stability and productivity of forest.

(3) Take timber production as the dominant function and keep other service function at the same time. Give priority to material production and economic benefit, while take the environmental service as limitations (WWF 2009).

(4) Keep the high conservation value of forest at both stand and landscape level (Portucel and Silva 2009).

(5) Hold the integrity of ecosystem, including the primary community and landscape structure.

(6) Paly the function of carbon sink, in order to response to global climate change(Mead 2001)

(7) Keep close cooperation with stakeholder (Portucel and Silva 2008)

3.4 Function Zoning as pre-condition for multi-functional forest management

- Definition: Divide the forest into different function types following regulation standards in the management unit.
- Purpose: Realize the classification of multi-function forest management and use different intensity operations in corresponding function types.
- Classification based on geographical, site, biotope, preservation area etc.

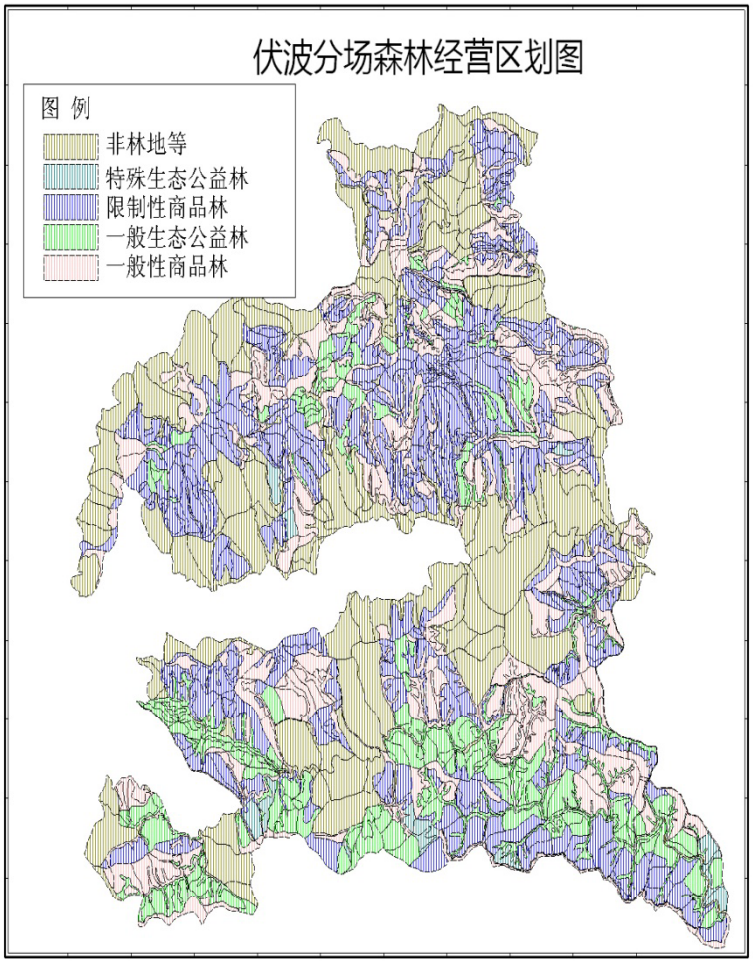
- 4 function types in Experimental center of tropical forestry (ECTF) :

I: strict protection ecological forest zone: forests have special function and value, need strict protect, commercial felling is forbidden.

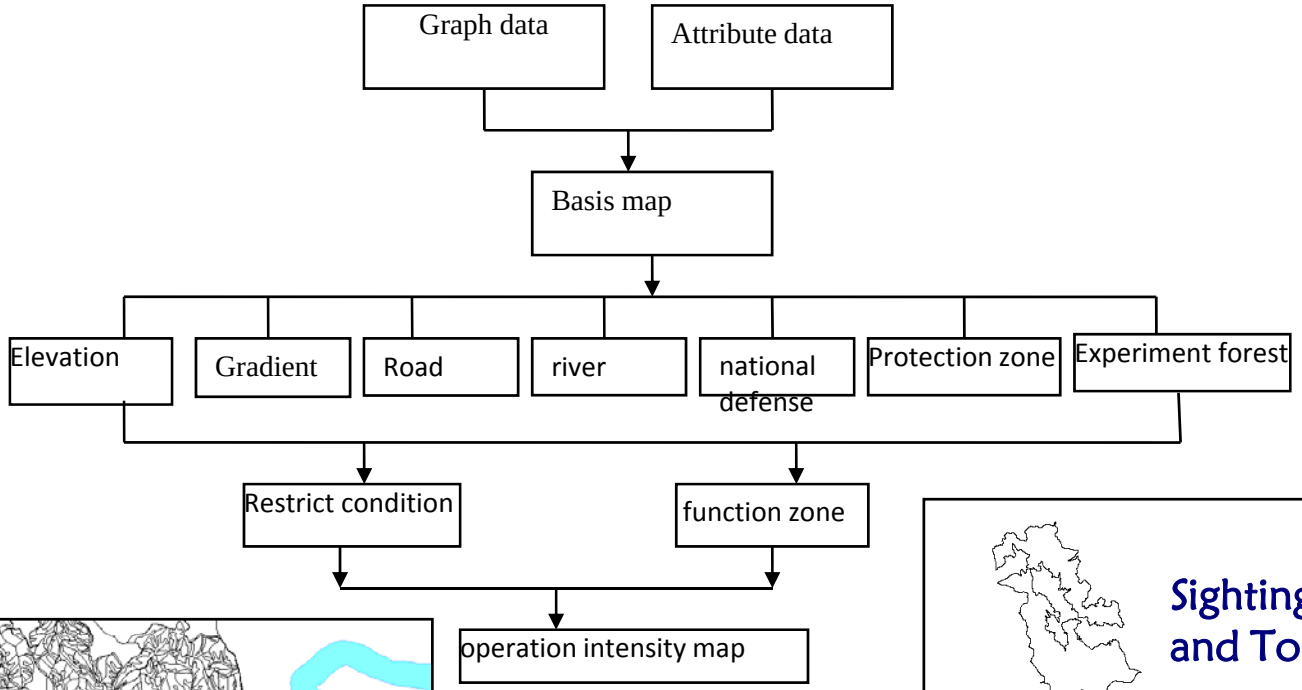
II: ecological forest zone with some optimization tending, low intensity operation activity.

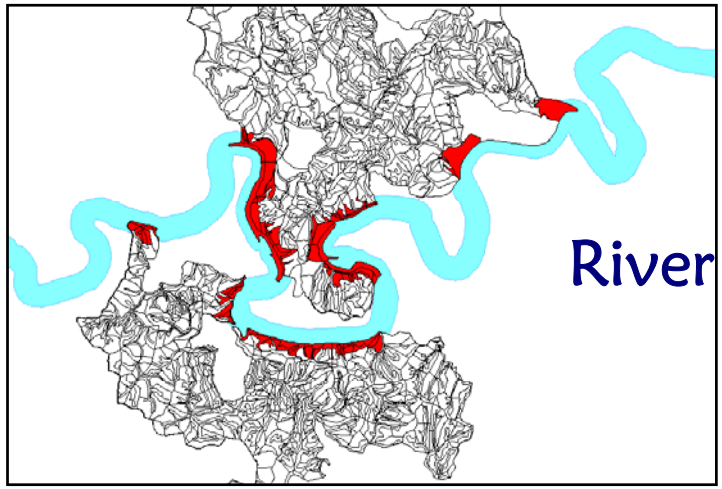
III: Commercial forest zone with restricted felling: low intensity felling for timber production, clear-cutting is forbidden.

IV: Commercial forest zone: production orented with general operation intensity.

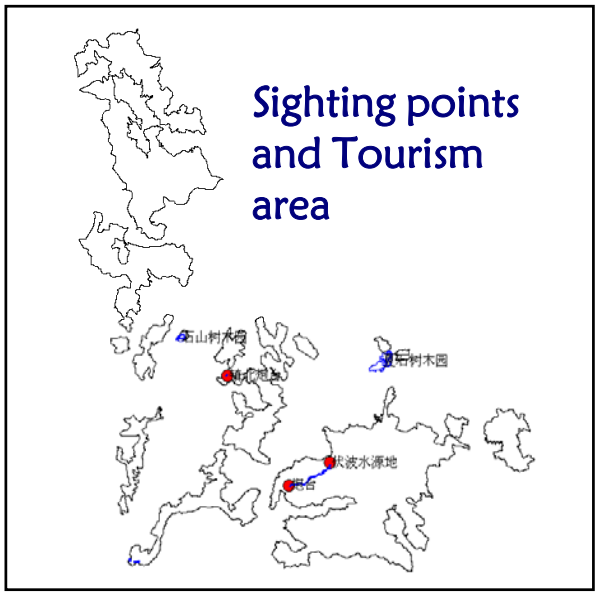


Methods and operation steps of Functional Zoning





River buffer zone



3.5 Species consideration for multi-functional forest management

- Tree species (species groups) are the basic elements for multi-functional forest management.
- Species features such as growth environment (altitude, soil type, and mother rock), economic value, growth cycle, nutrient preserving capability, water and soil conservation, drought-enduring, fire resistance, and landscape aesthetics etc. have close relationship with the design of silvicultural models.
- **5 types of species in ECTF : all species classified into：**

1) pioneer tree species (*Eucalyptus spp., Mytilaria laoensis*… …),

2) long-life pioneer tree species (*Pinus massoniana, Cupressus sp. Etc.*),

3) opportunist tree species (*Styrax roseus*， *etc.*),

4) sub-climax tree species(*Schima superha, Erythrophloeumfordii*),

5) climax tree species(*Dalbergia odorifera, Castanopsis hystrix*).

Species characters

total 63 tree species under management in ECTF, Guanxi Prov.

specie		Target and function	Environment description	Succession types	Regeneration estimate		Site condition		Mixed species	Suitable FDT
code	Latin name			1,2,3,4,5	sprout	plant	Mother rock and soil	Altitude 1,2,3		
1	*Eucalyptus robusta*	Fast growing Pup wood		1	√	√	Fertile, Good water permeate, sand soil?	1	Acacia species	Mixed FDT with fast growing species
2	*Bambusastenostachya*	Defend wind		1				1		
3	*Phyllostachyshetero cycla cv.*			1			valley, soil layer>50 cm, fertile	1	*Pinus massoniana Cunninghamia Lanceolata*	
4	*Citrus sinensis*			1				1		

Note: 1. Clear cutting, 2. Mosaic Clear cutting in small area (<5 ha), 3. Strip intermediate cuttings, 4. Shelter cutting, 5. Group selection cutting, 6. Single tree (target tree) selection cut, 7. Enclosure.

*** indicate the suitable FDTs.**

Combination of function regionalization, species classification for forest development type in Experimental center of tropical forestry (ECTF)

species	Code	Succession process	Altitude	Forest development type in Function zones			
				IV	III	II	I
Eucalyptus robusta	EuRo	1	1	**FDT 1 EuRo-BeAl**		**FDT 2 EuRo-DaOd**	
Teektona grandis	TeGr	1-2	1		**FDT 3 TeGr**		
Pinus massoniana	PiMa	2	1-2	**FDT 4 PiMa- MyLa**	**FDT 5 PiMa- CaFi-CaHy**		**FDT 6 PiMa-CaHy**
Cunninghamia lanceolata	CuLa	2-3	2-4	**FDT 7 CuLa- MyLa**	**FDT 8 CuLa-CaFi-CaHy**		**FDT 9 CuLa-CaHy**
Mytilaria laoensis	MyLa	2-3	1-3	**FDT 4, FDT 7, FDT 10 Fast-BL**			
Castanopsis fissa	CaFi	2-3	2-4	**FDT 5, FDT 8, FDT 10**			
Betula alnoides	BeAl	1-3	1-2	**FDT 10**			
Erythrophloeum fordii	ErFo	1-2	1-2	**FDT 11 ErFo- BL**		**FDT 12 ErFo- CaFi-CaHy**	
Dalbergia odorifera	DaOd	4-5	1-2			**FDT 2**	
Castanopsis hystrix	CaHy	5	1-3		**FDT 6, FDT 8**		

Note: Succession process and shade-tolerance: 1. pioneer tree species; 2. long-life pioneer tree species; 3. opportunist tree species; 4. sub-climax tree species; 5. climax tree species.

Altitude (m): 1. <350、2. 350-750、 3. 750-1050、4. > 1050;

4. Developing silvicultural models for FDTs

Silv. Model is a prescription of all operation with technical parameters from forest establishment to the end-harvest. **A Life-circle management plan of forest**.

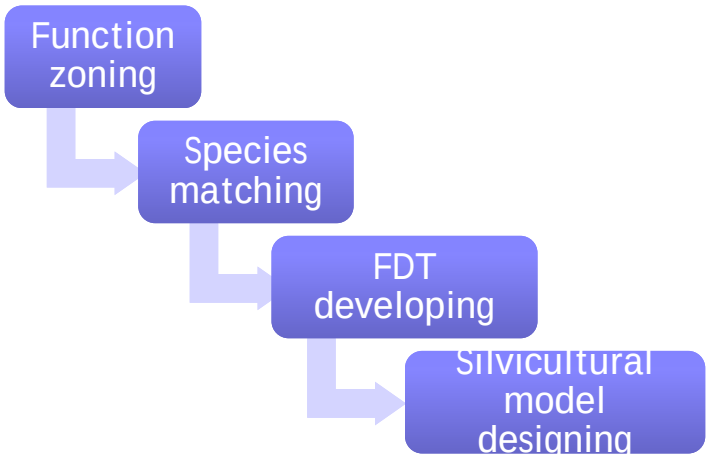
Different silvicultural models for the given forest development types

Forest development type	Dominant species	Associated species	Silvicultural models						
			1	2	3	4	5	6	7
FDT 1	EuRo	BeAl	*	*					
FDT 2	EuRo	DaOd					*	*	
FDT 3	TeGr	—		*					
FDT 4	PiMa	MyLa	*	*					
FDT 5	PiMa	CaFi	*	*					
FDT 6	PiMa	CaHy					*	*	*
FDT 7	CuLa	MyLa	*	*					
FDT 8	CuLa	CaFi	*	*					
FDT 9	CuLa	CaHy					*	*	*
FDT 10	MyLa, CaFi, BeAl			*	*	*			
FDT 11	ErFo	BL species		*	*				
FDT 12	ErFo	CaFi,CaHy						*	*

Note: 1. Clear cutting, 2. Mosaic Clear cutting in small area (<5 ha), 3. Strip intermediate cuttings, 4. Shelter cutting, 5. Group selection cutting, 6. Single tree (target tree) selection cut, 7. Enclosure.

*** indicate the suitable FDTs.**

FDT Euca-DaOd 3：*Eucalyptus robusta* - *Dalbergia odorifera* succession management type



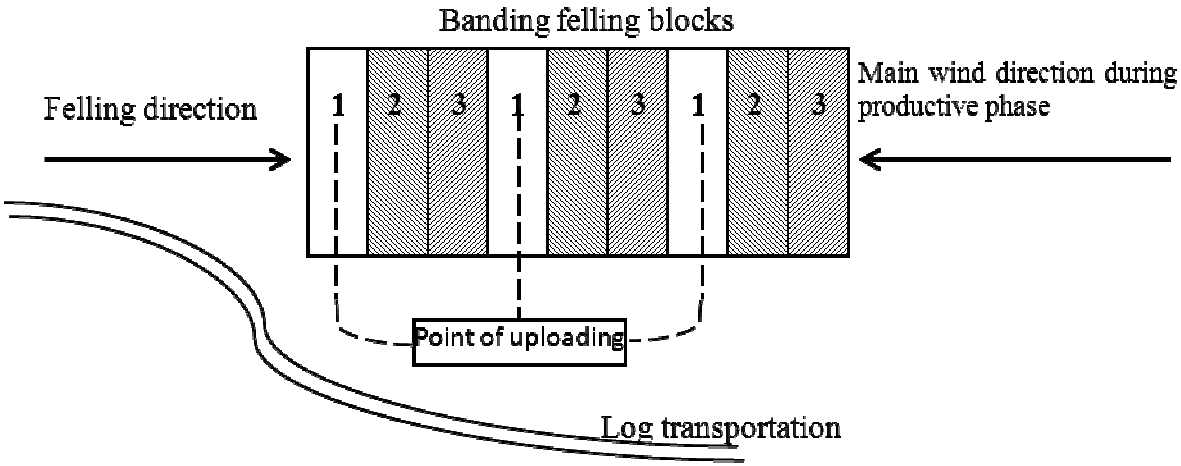
FDT Euca-DaOd 3：*Eucalyptus robusta* - *Dalbergia odorifera* succession management type, main storey is *Eucalyptus* and *Dalbergia odorifera* is planted under them.

4.1 Model of clear cutting (the highest managing intensity)

Operating requirement in ECTF

- the operation is restrained by some terrain condition:

1) flat terrain with gradient≤5°,the largest area of clear-cutting <30 hectares.
2) low mountain or hill with gradient between 6° and 15°, the area < 20 hectares;
3) gradient between 15° and 25°, the area < 5 hectares.
4) Moreover, clear cutting with continuous band felling blocks is applied where the gradient is larger than 25°, dividing the cutting area into 3-5 banding (200 meter width), cut these blocks in order (Figure below).



4.2 Mosaic clear cutting

Concept:

Mosaic clear cutting, and the cutting area is less than 5 hectares. The largest width and length of cutting banding are100 and 500 meters when the gradient is more than 15° . Reforestation in the cutting blocks should be finished in two years after the felling.

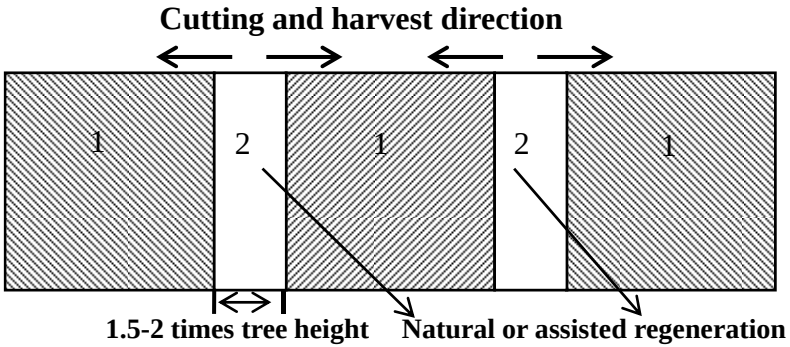
- the cut area is strict less than 5 hectares.
- The cutting blocks should be arranged like mosaic grids, and the regeneration (artificial or natural) in the cutting blocks can be protected by the adjacent stands (Figure).
- The width of retained banding is more than the average stand height; the boundary of cutting block should be selected where stands have better wind resistance.

Tree species consideration and Function regionalization: suitable for the Ⅲ and Ⅳ function zones.

4.3 Strip intermediate cutting

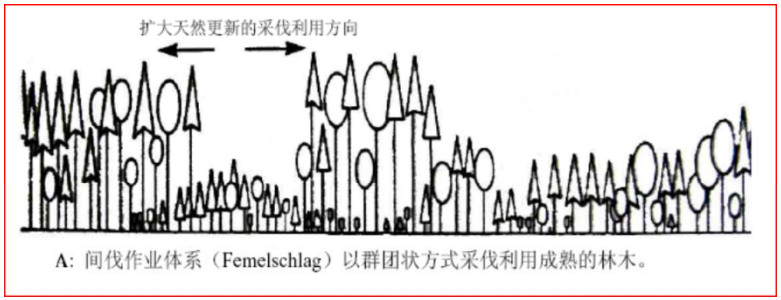
Concept:

Harvest the mature woods in banding, and use the gap effect to promote the natural regeneration. Different from mosaic clear-cutting, the banding width of this operation is designed as1.5- 2 times average tree height. Strip cuts are used to harvest a stand over a period of three to seven years by removing several strips rather than harvesting the entire stand at once. Strip cutting was developed to take advantage of natural seeding from the leave-strips



Tree species consideration: native broad-leaved tree species with fast or medium -fast growing feature.

Function regionalization: this model is suitable for the II and III function zones.



Operating requirement:

- Felling a banding (width=1.5- 2 times average tree height) in stand, and use artificial assistant regeneration or natural regeneration the restore the cutting-blank.
- It can be seemed as a silvicultural model for high-quality woods.
- According to characters of natural regeneration, the target of harvest should change together with the promotion and expansion of regeneration.

4.4 Shelter cutting

Concept:

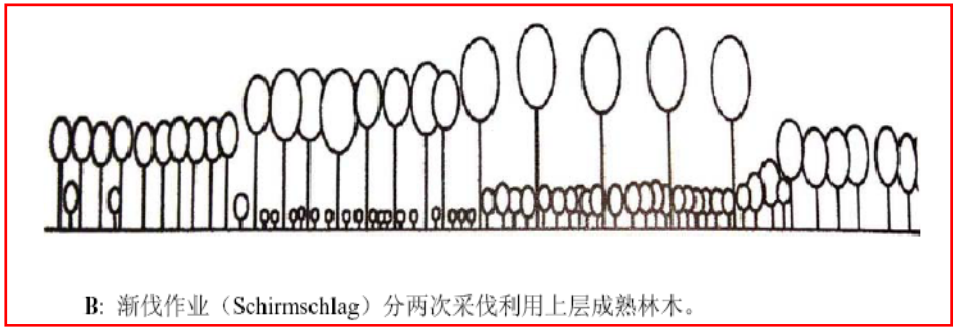
Also known as the 'Shelter wood system', is a silvicultural model in which over story trees are removed in a series of cuts designed to achieve a new, even-aged stand under the shelter of remaining trees (DeLong 1995).

The number and size of trees removed in this system is based on the amount of light reaching the forest floor required to regenerate a cohort of intolerant and/or mid-tolerant species, while leaving sufficient basal area and trees per area to mitigate harmful environmental conditions on the forest floor.

Tree species consideration: Medium fast-growing species such as *Mytilaria laoensis*, *Castanopsis fissa* and *Betula alnoides* .

Function regionalization: this model is suitable for the Ⅱ and Ⅲ function zones.

- Preparatory cutting: Number and accumulation are 20% and 25%～30% of the whole stand respectively. The canopy density is 0.6-0.7 after this operation
- Seed cutting: Number and accumulation are 30% and 10%～25% respectively. The canopy density is 0.4-0.6 after this operation.
- Accretions cutting: Number is less than 40%, and accumulation is 10%～25%. The canopy density is 0.24-0.4.
- Cleaning cutting: Remove all residual canopy trees once the secondary generation grow up.



B: 渐伐作业（Schirmschlag）分两次采伐利用上层成熟林木。

4.5 Group selection cutting

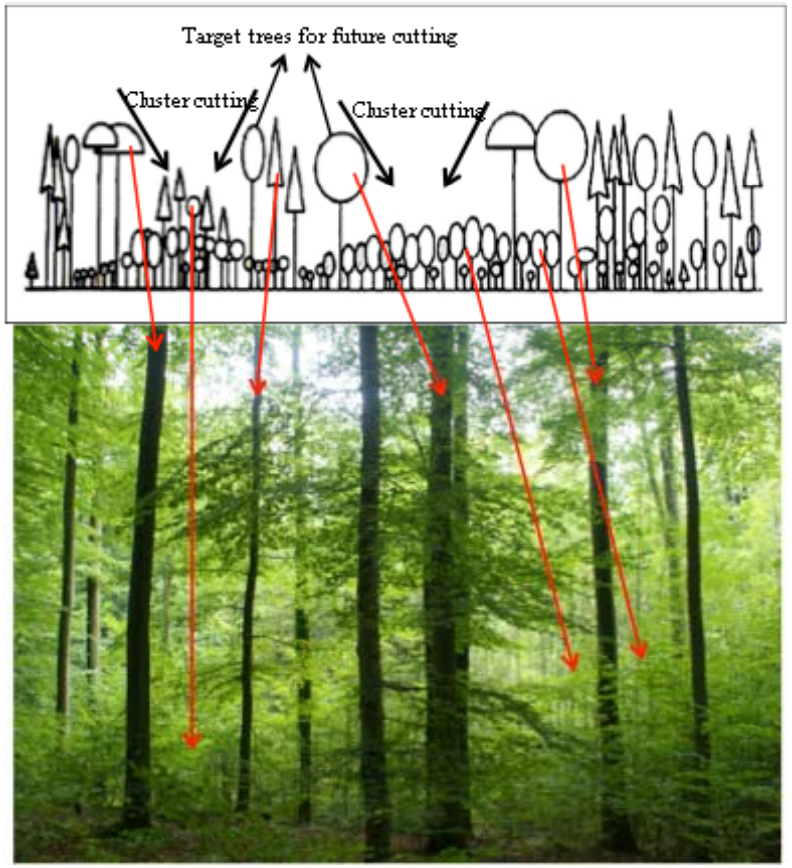
Concept:

Continuous cut the inferior individuals or mature individuals in group. Under this system, a number of 'groups', or small openings created by the removal of several adjacent trees, are created in complement to the harvest of scattered individual trees. If the groups created are large enough, and if seed-bed conditions are favorable, this can allow species which are intolerant of shade to regenerate (Anderson *et al* 1990; Wedeles *et al* 1995;Nyland 1996).

Group selection is designed to mimic larger, multi-tree mortality events, which in some environments may represent natural disturbance regimes.

Tree species consideration: shade tolerant tree species such as *Erythrophloe umfordii*, *Dalbergia odorifera*, and *Castanopsis hystrix*.

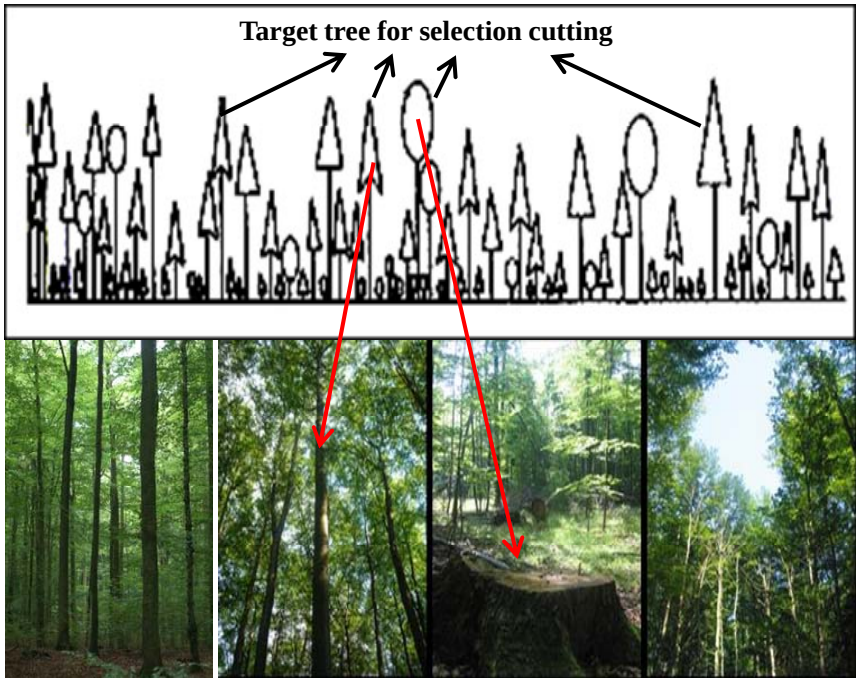
Function regionalization: this model is suitable for the Ⅱ and Ⅲ function zones.



4.6 Single tree selection cutting

Concept:

Cut the individual trees of mature and/or unhealthy. Leaves most of the trees and a variety of age classes to grow and regenerate an uneven aged forest. Single tree selection results in a stand that is composed almost entirely of species with moderate to high shade tolerance. Single-tree selection is commonly used where visual quality is a strong concern or recreational values are high(Klinka *et al* 1990; Navratil 1995).



Tree species consideration: shade tolerant tree species such as *Erythrophloe umfordii*, *Dalbergia odorifera*, and *Castanopsis hystrix*.

Function regionalization this model is suitable for Ⅰ and Ⅱ function zones (gradient between 25°～35°), and could also use in the place where fragile ecological environment and serious soil and water loss for the aim of ecological restoration. It can transform the forest to near-natural forest.

4.7 Enclosure protection

(1) Concept:

Leave the forest with no felling activity; only make some tending operation on target trees (select and mark target tree, cut rattan etc.)

(2) **Operating requirement**:

This model main use in the places where the terrain is steep (gradient>45°) and complexity. In these regions, forest is difficult to recovery after it is destroyed which causing a series of ecological problems such as soil erosion, vegetation deterioration.

(3) **Additional remarks**:

Tree species consideration: usually shade tolerant tree species

Function regionalization: this model is suitable for Ⅰ (gradient >45°), and could also use in the place where fragile ecological environment and serious soil and water loss for the aim of ecological restoration.

An Example for Silvicultural models application

1）Subcompartment analysis

Afforestation time：1993.

Forest type：*Pinus massoniana* immature timber

Average DBH:19.7cm

Average tree height:14.2 m

Accumulation: 83.3m^3

Density: 600N/hm^2,

Elevation: 401 meter,

Gradient: 30°,

Soil thickness: 150 cm,

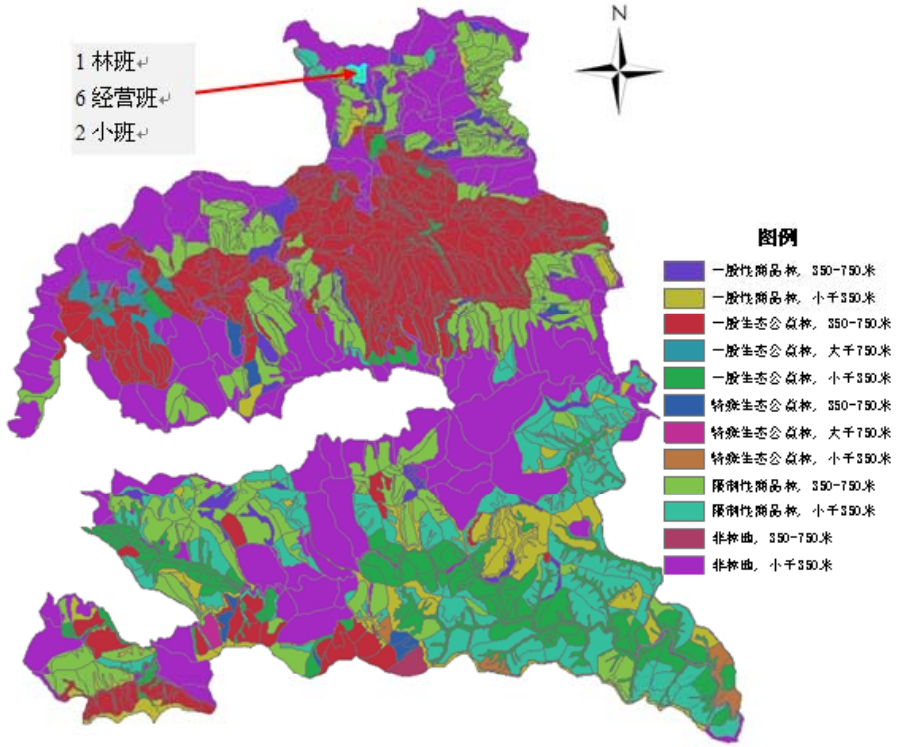
Mother rock and soil : magmatic rock, latosolic red soil.

2）function regionalization

Type III: Commercial forest zone with restricted felling, low intensity felling for timber production, clear-cutting is forbidden.

3）Target analysis

“timber production—landscape—ecological consideration”



4）Species configuration and FDT

FDT 5 PiMa- CaFi-CaHy

5）Silvicultural model

Group selection cutting

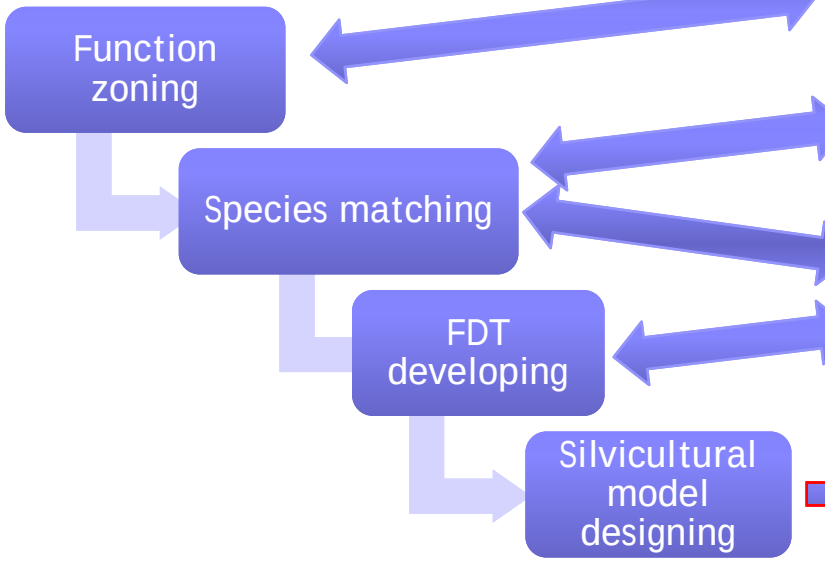
FDT 5： PiMa- CaFi-CaHy

Content

1. Forest scene
2. Development goal
3. Timber production
4. Nature conversation
5. Species mixing ratio
6. Mixing type
7. Silvicultural model： Group selection cutting
8. Recent operation methods

5. Conclusion

1. Under the new concept of plantation，a series of forest types from Simple Structured fast-growing plantation to complex structured forest are involved in MFFM.
2. In a systematic consideration of MFFM and based on the control of operation intensity，7 key silvicultural models are difined to meet need of rich form of plantation management.



species	Code	Succession process	Altitude	Forest development type in Function zones IV	III	II	I
Eucalyptus robusta	EuRo	1	1	FDT 1 EuRo-BeAl		FDT 2 EuRo-DaOd	
Teektona grandis	TeGr	1-2	1		FDT 3 TeGr		
Pinusmassoniana	PiMa	2	1-2	FDT 4 PiMa- MyLa	FDT 5 PiMa- CaFi-CaHy		FDT 6 PiMa-CaHy
Cunninghamia lanceolata	CuLa	2-3	2-4	FDT 7 CuLa- MyLa	FDT 8 CuLa-CaFi-CaHy		FDT 9 CuLa-CaHy
Mytilaria laosensis	MyLa	2-3	1-3	FDT 4, FDT 7, FDT 10 Fast-BL			
Castanopsis fissa	CaFi	2-3	2-4	FDT 5, FDT 8, FDT 10			
Betula alnoides	BeAl	1-3	1-2	FDT 10			
Erythrophleum fordii	ErFo	1-2	1-2	FDT 11 ErFo- BL		FDT 12 ErFo- CaFi-CaHy	
Albergia odorifera	DaOd	4-5	1-2			FDT 2	
Castanopsis hystrix	CaHy	5	1-3		FDT 6, FDT 8		

Forest development type	Dominant species	Associated species	Silvicultural models 1	2	3	4	5	6	7
FDT 1	EuRo	BeAl	*	*					
FDT 2	EuRo	DaOd					*	*	
FDT 3	TeGr	—		*					
FDT 4	PiMa	MyLa	*	*					
FDT 5	PiMa	CaFi	*	*					
FDT 6	PiMa	CaHy					*	*	*
FDT 7	CuLa	MyLa	*	*					
FDT 8	CuLa	CaFi	*	*					
FDT 9	CuLa	CaHy					*	*	*
FDT 10	MyLa, CaFi, BeAl			*	*	*			
FDT 11	ErFo	BL species		*	*				
FDT 12	ErFo	CaFi,CaHy						*	*

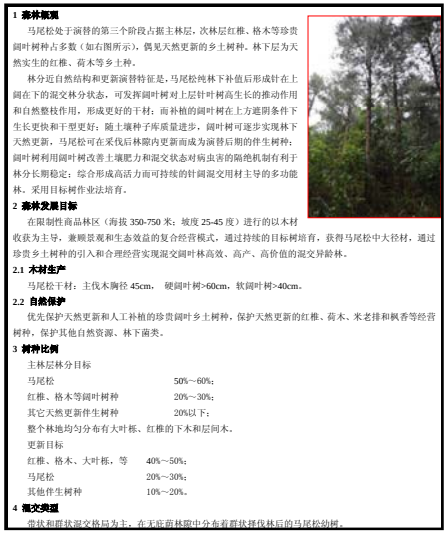
Further study on parameters of silv. Model

Teilprojekt 2 (Lin4Wood)

1. **Terrestrisches Laserscanning und Biomassebestimmung:** Erarbeitung neuer Methoden zur Beschreibung und Quantifizierung von dreidimensionalen Waldstrukturen, Entwicklung und Evaluation von innovativen Techniken für eine exakte und genaue Biomassebestimmung als Grundlage für die Quantifizierung der Biomasseproduktion und der Kohlenstoffbindung.
2. **Ernte und Holzverarbeitung:** Ermittlung von geeigneten Methoden der Holzernte, sowie Einführung und Anpassung von modernen teilmechanisierten Holzerntetechnologien als Alternative zu den bisher angewandten motormanuellen Verfahren. Entwicklung von Nutzungskonzepten für Rundholz kleinerer Dimensionen und Bambus zur Herstellung sekundärer Energieträger, namentlich Pellets, für eine kosteneffiziente und klimaneutralere Versorgung mit Bioenergie.
3. **Standortsevaluation und Nährstoffkreisläufe:** Ausarbeitung von Methoden zur modellunterstützten Abschätzung von Bodenkohlenstoff- (Humus) und Nährstoffvorräten. Entwicklung eines waldtypen- und bewirtschaftungsspezifischen Kohlenstoff- und Nährstoffkreislaufmodells zur Einschätzung der Nachhaltigkeit von Biomasse- und Holznutzung.
4. **Analyse der Qualität der Holzbiomasse:** Analyse von neuen Methoden für die Bestimmung der Holzdichte als Schlüsselparameter für die Holzverwendung. Durch weiterführende Analysen können Rückschlüsse auf Brennverhalten, Biomasseproduktion und Kohlenstoffbindung sowie zu Auswirkungen auf den Nährstoffkreislauf gezogen werden.
5. **Soziale und ökonomische Aspekte der Biomasseproduktion**: Analyse der wichtigsten Faktoren einer nachhaltigen Holzbiomasseproduktion unter besonderer Berücksichtigung steuerlicher Förderungen, staatlicher Subventionen und Anreize, sowie der Rolle des Kohlenstoffmarktes und der Einbeziehung einer Risikobewertung.

silvicultural model designing

- clear cutting
- Mosaic clear cutting
- Strip intermediate cutting
- Shelter cutting
- Group selection cutting
- Single tree selection cutting
- Enclosure protection



1 森林概况

马尾松处于演替的第三个阶段占据主林层，次林层红椎、格木等珍贵阔叶树种占多数（如右图所示），偶见天然更新的乡土树种。林下层为天然实生的红椎、荷木等乡土种。

林分近自然结构和更新演替特征是，马尾松纯林下补值后形成针在上阔在下的混交林分状态，可发挥阔叶树对上层针叶树高生长的推动作用和自然整枝作用，形成更好的干材；而补植的阔叶树在上方遮阴条件下生长更快和干型更好；随土壤种子库质量进步，阔叶树可逐步实现林下天然更新，马尾松可在采伐后林隙内更新而成为演替后期的伴生树种；阔叶树利用阔叶树改善土壤肥力和混交状态对病虫害的隔绝机制有利于林分长期稳定；综合形成高活力而可持续的针阔混交用材主导的多功能林。采用目标树作业法培育。

2 森林发展目标

在限制性商品林区（海拔 350-750 米；坡度 25-45 度）进行的以木材收获为主导，兼顾景观和生态效益的复合经营模式，通过持续的目标树培育，获得马尾松中大径材，通过珍贵乡土树种的引入和合理经营实现混交阔叶林高效、高产、高价值的混交异龄林。

2.1 木材生产

马尾松干材：主伐木胸径 45cm， 硬阔叶树>60cm，软阔叶树>40cm。

2.2 自然保护

优先保护天然更新和人工补植的珍贵阔叶乡土树种，保护天然更新的红椎、荷木、米老排和枫香等经营树种，保护其他自然资源、林下菌类。

3 树种比例

主林层林分目标

马尾松	50%—60%；
红椎、格木等阔叶树种	20%—30%；
其它天然更新伴生树种	20%以下；

整个林地均匀分布有大叶栎、红椎的下木和层间木。

更新目标

红椎、格木、大叶栎，等	40%—50%；
马尾松	20%—30%；
其他伴生树种	10%—20%。

4 混交类型

带状和群状混交格局为主，在无疏前林隙中分布着群状择伐林后的马尾松幼树。

FDT Euca-DaOd 3：桉树-降香黄檀演替动态集约经营发展类型

森林概况：主要应用于立地条件一般的低中山地带，或经过第二代桉树纯林经营立地的导引改进经营，通过桉树林下补植珍贵硬阔叶树种降香黄檀，并周期性经营桉树林和萌生林来实现由速生林向顶级群落森林演替动态经营，桉树快速生长形成的庇荫环境为降香黄檀的生长创造良好的生长条件，如右图 5-2 所示。

经营目标和主要技术指标：经营目标是珍贵硬阔叶树种林分。本发展类型是后续发展类型“FDT DaOd—EuCa1：降香黄檀-桉树阔叶混交林”的前期经营阶段，主要经营指标相同，不再赘述。

图 5-2. 桉树-降香黄檀演替动态集约经营模式，主林层为桉树萌生林，林下为补植的降香黄檀幼树。

Teilprojekt 1 (Lin4Carbon)

1. **Integriertes Kohlenstoffinventur- und Monitoring-System:** Entwicklung und Optimierung von integrierten Inventuransätzen zur Erfassung oberirdischer Biomasse und Kohlenstoffbindung: innovative Techniken zur effizienten Integration von Fernerkundungsdaten und terrestrischen Inventuren; Verbesserung von Kohlenstoffmodellen; Überprüfung von Regionalisierungsansätzen.
2. **Walddynamik im Rahmen der Klimaveränderung:** Analyse der Anpassungsfähigkeit von Plantagenwäldern an Klimawandel; Evaluierung der Effekte eines Umbaus von Plantagen in naturnahe, kohlenstoffreiche Wälder; Modellierung und Bewertung von Entwicklungsszenarien.
3. **Entwicklung eines „Carbon Forestry" Geschäftsmodells:** Entwicklung wissenschaftlich gesicherter Methoden als Grundlage zur Anrechnung von KohlenstoffsenkenEffekten unter Berücksichtigung der IPCC Standards.
4. **Chinesisch-Deutscher Wissenschafts-Dialog:** Verbesserung und Fokussierung der bestehenden wissenschaftlichen Zusammenarbeit zur Erarbeitung von methodischen Grundlagen in den jeweiligen Arbeitsbereichen; Sicherstellung der Sichtbarkeit und Außenwirkung des Modellprojektes; Festigung und Erweiterung von wissenschaftlichen Netzwerken sowie Intensivierung der Zusammenarbeit zwischen Industrie und Wissenschaft.

Teilprojekt 2 (Lin4Wood)

1. **Terrestrisches Laserscanning und Biomassebestimmung:** Erarbeitung neuer

Thank you for your attention!

Nursing China's Ailing Forests Back to Health

A lauded effort to create mixed forest stands is giving villagers and loggers a chance to make a living while restoring ecosystem vitality

PINGXIANG, CHINA—The swath of hilly terrain looked like a man's face after a poor shave. A few days earlier, villagers had clear-cut a fir forest and burned the stumps. Soon they will uproot the charred stubble and repopulate the barren land with eucalyptus, a fast-growing Australian import. "The timber is low quality," says Lu Yuanchang, a forester at the Research Institute of Forest Resource Information Techniques of the Chinese Academy of Forestry (CAF) in Beijing. But after 5 years or so, the villagers who manage this community forest in southern China's Guangxi Zhuang Autonomous Region, near the border with Vietnam, will hack down the eucalyptus and pulp it for paper. "They should turn a quick profit," Lu says.

Ecological expediency of this sort has been rampant in sections of southern China, as villagers and local governments conspire to transform vibrant forests into plantations for money-spinners such as eucalyptus, rubber, and oil palm. "In recent decades, no other country in the world has established more forest plantations than China," says Heinrich Spiecker, director of the Institute for Forest Growth in Freiburg, Germany. Yet forests cover only about 18% of China's landmass, and timber yield and quality are lower than in many other places.

China's enthusiasm for monocultures has taken a heavy toll. "Converting large areas into single-species plantations is destroying the environment," Lu says. "There has been large-scale degradation of China's forests." Monocultures are often susceptible to pests and diseases, Spiecker notes. According to Lu, the most insidious effects stem from soil degradation, which destabilizes ecosystems. Monocultures, he says, were largely to blame for widespread forest losses inflicted by last year's ice storms (*Science*, 7 March 2008, p. 1318).

The problem is likely to get worse before it gets better. In 2003, the central government approved a regulation that grants Chinese citizens an extension of how long they can farm or manage a community forest—from 30 to 70 years. That enormous policy change effectively grants people land ownership for their lifetimes. "The policy is meant to stimulate families to take care of the land," says Cai Dasxiong, director of CAF's Experimental Center of Tropical Forestry in Pingxiang. However, notes Bernhard von der Heyde, director of the sustainable forest management project of the German nonprofit development group GTZ in Beijing, "there is a big rift between national will and local implemen-