FODE 007 Notebook

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Contents

Introduction

This is where you can write your introduction.

Module 1: General Principles of Plantation Design

The task of plantation design primarily is focusing on matching species to the site and developing the first step of a plantation establishment plan. The introduction part will explain the concept of plantation, and why we need a plantation. Through site inventory and tree species inventory, one can match species to the site, which establish a foundation for the plantation design. By integrating with forest function and forest type, an afforestation (or plantation) model can be developed to match the site ecologically and meet people's objective.

Topic 1.1 Introduction

1.1.1 Definition of a plantation

It is not easy to define the word of “plantation”, because there are many words related to it, such as artificial forest, man-made forest, planted forest, afforestation, reforestation, deforestation. FAO (2001) define s plantation as: “Forest stands established by planting or /and seeding in the process of afforestation or reforestation.” The basic criterion for plantation is artificial regenerated.

Why definition is important? Need to compare forest resource statistics from different sources.

See online APFNet Course 5: Restoration of Degraded Forest Ecosystems & Forest Plantation Development (http://blogs.ubc.ca/apfnet05/), Module III, Topic 1: What is a forest plantation?

1.1.2 Importance of plantation

People need forest products, ecological conservation, the demand increasing.

Table 2.1 Current and future forecast global forest production/consumption by products, 1996 and 2010.

Natural forests could not meet the demand.

- In the last 150-200 years has net destruction of forest taken place in almost every country. In recent years, the rate of resource depletion has increased sharply in most tropical countries while forest cover is stable or even increasing in many temperate areas. Examples, Haiti, Tailand.
- Difficulty of access to existing natural forest
- Natural forests conserve biological diversity, store carbon for mitigation of global climate change, protect fragile ecosystems in mountains and dry areas reducing soil erosion and providing clean water.

Plantation is the choice

High productivity: one species, high volume/unit area, cheaper harvest costs. Match species with site conditions for optimum growth.

Fast growth:

Table 2.2 Average growth rates attained in some tropical plantations.

Table 2.3 Growth rates of managed forest and plantation.

Forest Plantation in tropics play a very important role in future world wood supply. They also have great potential to improve the livelihoods of rural communities through providing a range of products and services locally and to meet the international objectives for conservation of biodiversity, protection of the environment and mitigation of climate change.

Topic 1.2 Site Inventory and Site Classification

1.2.1 Site and Site Classification

The ideal goal of silviculture is to place the right tree in the right place. Therefore, to understand the tree, place and their interactions is the main principle of silviculture.

A site means a whole environment of a special place. A forest site is a place where trees and other organisms live and interact. Generally, a site includes three aspect(s). That is (They are) geographic condition, climatic condition and biological condition.

See online APFNet Course 6: Forest Resource Management and Protection (http://blogs.ubc.ca/apfnet06/) Module I, Topic 1 Principles of silviculture, 1.1.1 Forest site. From that course you will know exactly what is forest site, how to know forest site, how to make a site classification.

Site Classes reflect the basic information for

- identification of the ***Natural Potential Vegetation***, which would grow without human impact – only driven by the regional and local ecological conditions.
- ***Tree & Shrub Species*** selection as well as further on for the design of ***Afforestation Models***;
- focusing on the interests of human society the site conditions also are defining the ***Forest Functions***.

1.2.2 Technology of site classification

The main criteria & indicators defining the Site Classes are

- ***Elevation***: Sub-compartment's (SC) average and range by 10m accuracy: e.g. 2,450/2,300-2,500m; taken from Digital Terrain Model (DTM) or on site by GPS (Global Positioning System);
- ***Aspect***: N, NE, E, SE, S, SW, W, NW by SC's main aspect/followed by the range of sub-dominant aspects: e.g. SW/S,SE,W; taken from DTM or on site by GPS;
- ***Slope-Inclination***: SC's average /range by 1 °degree; taken from the DTM or on site by inclinometer;
- ***Mother-rock / pH-range***: limestone; acidic rock; sediments (alluvial, dilluvial, aeolic/ Loess);

identified from field survey or from reliable geologic data base;

- ***Soil Type, Depth, Texture & Moisture***: identified from reliable soil data base or from field survey analyses to be taken on each SC – once at a representative location of all of the 6 topographic units (as below), if occurring within a SC:
    - type: e.g. “natural loess” or “chestnut-soil”;
    - depth: by 10cm accuracy; also indicates the fertility/concentration of nutrients of the site;
    - texture: (rocky), stony gravel, sandy, loamy sand, sandy loam, loam;
    - moisture: dry, moderate dry, moderate moist, moist.

Alternatively the soil depth & fertility, soil texture as well as soil moisture and erosion category as basic criteria of site classes need not to be measured at each SC,- it can also be concluded from the topographic micro-sites and slope aspects taken by (satellite image or aerial photograph based) DTM-remote sensing interpretation.

- ***Erosion category***: taken from reliable erosion data base or from field survey according to the national standards given by the Soil & Water Conservation Department/ Bureau and calculated from soil type, inclination and vegetation cover.
- ***Topographic Micro-Sites*** (TMS; *Fig.1*) – 6 units: taken from DTM
    - convex 1 – specific slope area: “ **ʌ** ” (ridges; high – low diff. > 5m),
    - convex 2 – general slope area: “ **Ç** ” (high – low diff. > 2m),
    - concave 1 – general slope area: “ **È** ” (high – low diff. > 2m),
    - concave 2 – specific slope area: “ **?** ” (slope foot),
    - un-structured slope area: “ \ “ (high – low diff. < 2m),
    - plain, flat land: “ → “ (inclination < 5°)

Based on the topographic micro-sites the ***Site Classes*** can be concluded if including the ecological effects of the slope aspect, because the general topography-related site conditions are modified by the slope aspect concerning soil moisture: S-facing slopes are drier than N-facing slopes. So – we can assume, that N-facing convex slopes showing similar conditions like S-facing un-structured slopes, and N-facing un-structured slopes are similar to S-facing concave areas, et.

[Figure 1 goes here.]

Figure 1: Topographic micro-sites as simple indicator for Site Classes, Species Selection and Afforestation Model Design

[Figure 2 a,b goes here.]

Figure 2 a,b: in general soil depth, soil texture, soil moisture and soil quality/fertility are corresponding relatively

to the topography; S-facing slopes are shifting moisture zones down-hill; example for developed soils on mother rock (a) and on sediments e.g. loess (b).

The scientific proved relation between topographic micro-sites and site-classes makes the silvicultural planning process much easier and efficient – especially for Tree & Shrub species selection and designing Afforestation Models (see *Tab. 1, 3*).

If also the Erosion Categories/Forest Functions (see chapter 1.4.1) are taken into consideration seven Site Classes have been identified: 5 based on topographic micro-sites with and 2 without Soil-&Water Conservation Function.

- ***Site Class (SCL) 1***: very dry S-facing hill-top ridge – prone to (water) erosion
- ***Site Class 2***: dry N-facing hill-top ridge or dry S-facing convex slope – prone to erosion
- ***Site Class 3***: moderate dry N-facing convex slope or moderate dry S-facing un-structured slope area – prone to erosion
- ***Site Class 4***: moderate moist N-facing un-structured slope area or moderate moist S-facing concave slope – prone to erosion
- ***Site Class 5***: moist N-facing concave slope – prone to erosion
- ***Site Class 4-1***: moderate moist S-facing slope foot – without erosion
- ***Site Class 5-1***: moist N-facing slope foot or plain valley bottom area – without erosion

Note !: “S”-facing – stands for SE, S, SW, and W exposition/slope aspect

“N”-facing – stands for NW, N, NE, and E exposition/slope aspect.

For management purposes also the ***Boundary & Area of SC*** are taken from

- the satellite image/aerial photo based Digital Terrain Model/DTM, or
- on site exactly by GPS, or
- from the topographic map 1:2,500.

[Table 1 goes here.]

Table 1: Site Classification based on topographic micro-site units, slope aspect and erodibility of the soil

Here in this course is to guide you found out the site condition in your local area.

1. Select a site suitable for establish a plantation.
2. Develop a site inventory plan which include: topographical factors (elevation, slope direction, slope

inclination, slope position), soil conditions (soil depth, humus thickness, soil texture, content of rocks, pH, parent rock type, groundwater level, soil moisture), plant factors (coverage, height, diameter of dominant species, major pests and diseases).

3. Conduct an investigation to the site and data analyze.
4. Complete a site classification part for the assignment 1

Topic 1.3 Match Species to the Site

1.3.1 Foundations and Principles of Tree Species Selection

Tree species selection for plantation should, first, follow ecological principle, forestry principle and economic principle. Second one, species selection for timber forest should consider growth speed, yield, timber quality and forest stability. Last one is the methods of fitting species to the site include selection and modification, but selection is more important, more basic one.

See online APFNet Course 6: Forest Resource Management and Protection (http://blogs.ubc.ca/apfnet06/) Module I, Topic 1 Principles of silviculture, 1.1.2 Species selection. From that course you will know the principles of species selection.

1.3.2 Species survey

List local species according to the following features: tree/shrub, main uses, resistance (to poor nutrition, drought, flood, wind, freeze/frost), N-fixation, root system (intensive or not), foliage decay (good or not), growth rate (high or low), timber (high or low), non timber value (high or low), acid/lime-stone, suitable soil pH, suitable elevation, suitable slope aspect, landscape visual effect, suitable topography.

Taking “Xining Greening and Environmental Protection Project” (XGEP-Projet) Qinghai Province, PR China as an example, see table of species characteristics (Annex 1).

1.3.3 Match species to the site

Now, we know the site and we know the species, match species to the site means put the species to the proper site. Under the guidance of the plantation objective, one can select the most suitable tree species for a site or the most suitable site for a tree species.

Example XGEP-Project, compare tow tables to show how to match species to the site, site class (table 1), tree species characteristics (Annex 1)

Topic 1.4 Plantation Design

There are three main aspects have to be considered for a plantation design: forest function, forest type, afforestation model

1.4.1 Forest function

For a SC or a specific area of land with certain ecological site conditions Forest Functions are reflecting

- the demands of nature: to keep natural eco-systems alive or to restore “close to nature” eco-systems, as well as
- the land-use expectations/demands of human society on forests/forest types.

Forest Functions are determining the theoretical ***Target Forest Type/TFT*** (defined by tree qualities (!) only – not by tree species (!), which finally will define the ***Forest Types/FT***) necessary, in order to influence natural (erosion, flood, climate, etc.) or human (quality of life, recreation, education, etc.) processes according to natural and/or human demands.

Forest functions are therefore guidelines for the design of the Forest Type and so also the basis for the ***Afforestation Model/AM*** (see 1.4.3)

Three functions can be classified:

- general – regional/zonal Environmental Forest Services (RES): to expect the forest
    - to become an *harmoniously well balanced, most self-regulating* **“Close to Nature” Eco-system** (including flora and fauna), sustainably and stable serving to multiple forest functions, with high vitality and resilience against natural and human impacts,
    - to contribute to the *improvement of* **Environment** (climate change, air-pollution, desertification);
- specific – local Environmental Forest Services (LES): to expect the forest
    - to contribute to **Soil- & Water Conservation** (wind- & water erosion, flood, water supply to local people);

- specific – local Social Forest Services (LSS): to expect the forest
    - to contribute to the visual **Landscape Attraction** for the city population,
    - to serve as location and subject for **Recreation and Health Care**,
    - to provide **timber and other forest products.**

For the XGEP-Project forests primarily have to serve to the regional climate and eco-system function (RES), secondly to the local soil & water conservation function (only on slopes > 15°) and thirdly/secondly (on slopes <15°) to the human interests of visual landscape attraction, recreation and forest products (*Table 2*).

[Table 2 goes here.]

Table 2: Forest Functions/Categories under the XGEP-Project identified by Topographic Site Classes

1.4.2 Target Forest type

Target Forest Types are models theoretically reflecting and describing their function-orientated/aiming qualities concerning

- tree & shrub species composition (bio-diversity)
- structure of the forest stand (horizontal, vertical, according to age)
- species specific qualities of the individual tree/shrub (crown, trunk, root system).

The goal of a theoretical Target Forest Type is to allow target oriented silvicultural decisions and management/ activities.

Technology of target forest type design:

For the Forest Functions under the XGEP-Project (outlined in 1.4.1) the Target Forest Types are defined as below:

Ecosystem Function: *to increase "close to nature" biodiversity (flora & fauna);*

- tree & shrub species composition: (nearly) all main species native to Qinghai Province shall be involved;
- structure of the forest stand: a "close to nature" stand shall horizontally be mixed in patterns/groups (in normal density – without gaps) according to site classes, showing multi-layer vertical structure and shall be uneven-aged;
- tree/shrub qualities:
    - crown: at least ¼ of tree height; healthy (no damage to leaves and branches); vital (high "Leaf-Area-Index/LAI"); showing good growth (annual increment: height),
    - trunk: no physical and/or biological damage,

    - root system: well adapted to the site class; no damage.

Climate & Air Quality Improvement Function: *to harmonize climate by increasing humidity and CO2-storage; to increase O2 ad reduce air-pollution;*

- tree & shrub species composition: site adapted species with high potential of growth (wood = CO2-sink), with high transpiration and evaporation capacity; mixed conifer & broadleaved;
- structure of the forest stand: full coverage with trees & shrubs (normal density); multi-layer vertical structure; uneven-aged;
- tree/shrub qualities:
    - crown: dense (high LAI; high vitality, good growth, high absorbing filter for air-pollutants = hairy leaves), at least ¼ of tree height; half conifer (function in winter) – half broadleaved (annual deposition of leaves including pollutants on soil surface),
    - trunk: no damage,
    - root system: well adapted to the site class; no damage.

Soil & Water Conservation Function: *to fix the soil against water erosion; to infiltrate rain-water into the soil, to clean water, to store and to release it in sustainable dosage;*

- tree & shrub species composition: site adapted species mixed (40-50% trees, 50-60% shrubs) with low transpiration activity and evaporation capacity;
- structure of the forest stand: two-layer stand with scattered tree cover (40-50%) shading 50-60% of shrubs, gaps < 3-4m; uneven-aged;
- tree/shrub qualities:
    - crown: big diameter preferable,
    - trunk: no damages,
    - root system: deep, strong & stable tree root systems + intensive network of fine shrub roots (not to crack/break up loess soil – especially along edges of terraces or gullies);

Recreation Function: *to attract people by specific qualities of stand, individual trees & shrubs via all senses (watching, listening, smelling, feeling, touching) when walking through the forest;* ***note****: for a recreation forest well maintained multiple-use infrastructure will be necessary: in steep slope area (> 15-20°) e.g. pathways, benches, toilets, refreshing zones, waste collection and management, first aid and fire-fighting stations, etc. !*

- tree & shrub species composition: multiple species conifer and broadleaved single trees, blocks/groups mixed with individual shrubs & shrub blocks;
- structure of the forest stand: dense shady multi-layer blocks changing to small sunny gaps with shrubs and single trees in not strict and regular but flexible order; offering a huge variety of sensual impressions (noises, smells, feelings; including visual observation of small animals, bees, birds);

uneven-aged;

- tree/shrub qualities:
    - crown: multiple shaped (to create imagination); the more unique the more attractive; multi-colourful and good smelling flowers in spring & summer; colourful leafs in autumn;
    - trunk: the more crocket and unique the more attractive; tending may support these shapes;
    - root system: suitable to the site classes.

Timber production Function: *to produce high quality timber, meet peoples demand;*

- tree & shrub species composition: single species, in monoculture;
- structure of the forest stand: one-layer stand; even-aged;
- tree/shrub qualities:
    - growth: fast growth for general timber species, or slow growth for precious wood species
    - yield: high timber yield;
    - quality: good in timber quality
    - trunk: no damages;
    - root system: suitable to the site classes;

1.4.3 Afforestation Model/AF

Afforestation Models are “best practise” guidelines, which show for each Site Class or Forest Function/Category

- the selected suitable Tree & Shrub Species composition (see 1.3.2) as well as
- the Silvicultural Technologies for detailed activities to be carried out.

Both components of the AF (as above) are serving to reach the goals of Forest Functions on different Site Classes. Afforestation Models are recommending species for planting based on their ecological requirements (Site Classes) for high vitality/good growth as well as high stability and resilience, and so for good survival percentage as well as for Forest Function oriented services the trees have to serve to.

Tree Species Selection is one of the two main components of the Afforestation Model Designs/AFD, which offer different options to reach the goals of the Forest Functions on different Site Classes. The final decision on tree & shrub species has to reflect a joint collaboration process balancing between limitations caused by

- the ***ecological preconditions*** of the site (natural Site Classes), and
- options of ***private and/or public benefit*** (Forest Functions).

Based on the potential natural vegetation or based on practical experience over previous decades about their good

site suitability tree species are selected for the Forest Types according to their experienced qualities (benefits, resistances; see *Annex 1*). The species have to meet the demands of the local site conditions and have to focus on the forest functions and reflecting the forest target types (*Annex 1*).

Under the XGEP-Project 15 site suitable ***main/dominant tree species (>60%)*** are found to be eligible for afforestation:

- 6 conifers
    - *Picea crassifolia*
    - *Picea wilsonii*
    - *Pinus tabulaeformis*
    - *Pinus silvestris mongolica*
    - *Sabina przewalskii*
    - *Platycladus orientalis*
- 9 broaleaved
    - *Populus cathayana*
    - *Populus simonii*
    - *Populus simonii fastigiata*
    - *Populus hopeiensis*
    - *Populus alba var. pyramidalis*
    - *Ulmus pumila*
    - *Ulmus laevis*
    - *Salix matsudana*
    - *Salix babylonica*

The species composition of the Afforestation Models will be completed by several Economic/Fruit trees (*Prunus spp, Malus spp, Armeniaca spp, Elaeagnus spp*, a.o.) as well as more than 15 mostly ornamental Shrub species (***minor shrub species < 40%***).

Table in *Annex 1* are referring carefully and detailed on the ecological site demands and the environmental as well as the functional benefits of each species prepared for selection.

Example XGEP-Project: Afforestation Models (*see Annex 2*)

In the Afforestation Models the species are grouped into two categories, which are reflecting more (main species) or less (minor species) the qualities of the tree species necessary to meet the requirements of the Forest Function. So more than 60% of species with best qualities shall be planted:

- Main / Dominant Species (> 60%; high effect / impact on the forest function)
- Minor / Accompanying Species (< 40%; low-medium effect / impact on the forest function).

[Table 3 goes here.]

Table 3: Afforestation Models based on the local site conditions (Site Classes) and also focusing to the function of Soil & Water Conservation (Soil Erosion); details see Annex 2.

See online APFNet Course 6: Forest Resource Management and Protection (http://blogs.ubc.ca/apfnet06/) Module I, Topic 1 Principles of silviculture, 1.1.3 Forest structure.

Module 2

Topic 2.1

Topic 2.2

Topic 2.3

Module 3

Topic 3.1

Topic 3.2

Topic 3.3

Module 4

Topic 4.1

Topic 4.2

Module 5

Case 1

Case 2

Case 3

Case 4

Case 5

Appendix

This is where you can add appendices or other back matter.