Vegetation engineering methods and vegetation surveys

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PartI

I. The history of vegetation engineering

II. Definitions and subjects of vegetation

III. Conservation functions of vegetation

- ✧ Environmental adaptation functions of vegetation
- ✧ soil and water conservation functions of vegetation

I. The history of vegetation engineering

In early years

Taiwan's soil and water conservation and vegetation works are scattered in pit and trench stability and landslide site remediation projects, with the utilization of germination stake nailing or staking and burying branch method to stabilize slope surface.

In the 1960s

The main work focus that agricultural land soil and water conservation, vegetation coverage and grass cultivation, etc.

In the 1970s

When constructing Zhongshan Highway, a lot of foreign vegetation equipment, information, materials, and construction operational methods were introduced to carry out roadside slope stability with vegetation engineering.

After 1983

Vegetation technologies for special areas including red soil, mudstone and limestone mining areas, etc. were respectively experienced and explored.

In 1984

The Greening Implementation Team was established by the Taiwan Provincial Government at that time to promote environmental greening of roads, school campuses, factories and home environments.

After 921 Earthquake in 1999

In response to the greening and revegetation needs of wide areas of the country, ecology-based and safety-oriented ecological engineering as well as soil and water conservation vegetation works were confirmed as development direction to promote national land disaster prevention and revegetation task

In recent years

Due to the disasters and the impacts brought on by climate change, soil and water conservation work has promoted rural green vegetation resource and environment survey, encouraged extensive planting of trees, and constructed green belts with ecological and buffering functions as performing direction.

II. Definitions and Subjects of Vegetation

Vegetation refers to the total aggregation of plants grown in an area, especially the grasses, ferns, and higher plants such as shrubs and trees, etc. grown on the ground surface.

The vegetation of soil and water conservation field focuses more on the artificial importation of vegetation materials or artificial assistance of vegetation succession, as well as accelerating the establishment of vegetational structures that have slope disaster prevention, environment conservation and sustainability functions.

It consists of five parts:

1. Water conservation, ground erosion prevention
2. Shallow layer collapse prevention
3. Flood reduction
4. Air purification
5. Environment beautification

Vegetation engineering refers to the engineering methods and technologies designed for the purpose of vegetation through selecting vegetation materials suitable for growth, coordinating with the constructive foundation and protective engineering, and then carrying out with vegetative introduction construction and operation.

The scope of vegetation work includes as:

1. Vegetation preparing operation (vegetation base work)
2. Vegetation introducing operation (vegetation practices)
3. Vegetation maintenance and management, etc.

III. Conservation Functions of Vegetation

1. **Environmental adaptation functions of vegetation**

   (1). Microclimate adjustment

   (2). Air purification

   (3). Noise control

   (4). Traffic guidance

   (5). Water purification

   (6). Biological habitat creation

2. **Soil and Water Conservation Functions of Vegetation**

   (1) The interception effect of crown canopy

   (2) Ground surface protection

   (3) Increase of infiltration effect

   (4) Runoff mitigation

1. Environmental adaptation functions of vegetation

(1). Microclimate adjustment

- ✧ The vegetation structure can influence the sun's radiation effect on the ground.
- ✧ Plants can block direct sunlight and reflecte dlight, reduce wind speed, adjust summer atmospheric temperature through evapotranspiration and energy consumption, and then adjust the microclimate and alleviate the ground temperature difference.
- ✧ In addition, the temperature changes inside and outside the forest can even promote better airflow and create a more comfortable environment

(2). Air purification

- ✧ When plants breathe, they can absorb part of polluted gases into leaves, and then return them to the land via fallen leaves.
- ✧ So vegetation has air purification functions of oxygen supplementation, filtration, deodorization, absorption, and suction, etc.

(3). Noise control

- ✧ Plants have the effects of absorption, reflection, refraction, and deflection on noises, so they can effectively reduce the noise pollution of the environment.
- ✧ In particular, the establishment of green buffer strips or buffering belts around the development base can effectively control noise.

(4). Traffic guidance

- ✧ The application of vegetative green belts, green fences, or the planting of forest belts can effectively reduce glare interference.
- ✧ Design should avoid vegetation plants prone to cause glare, and provides passersby with a comfortable traffic environment.
- ✧ The street trees on the road and the green belt on the refuge island can also reduce the wind speed to adjust the microclimate and maintain the driving safety.

(5). Water purification

- ✧ The vegetation protection green belts set on the edges of natural rivers, stream areas, agricultural ponds or wetlands have the functions of stabilizing the waterfront, filtering sediment, and filtering pollutants in water purification.
- ✧ The construction of good forest form and vegetation cover in the water resource protection zone stabilizes and provides excellent water quality.

(6). Biological habitat creation

- ✧ The plant community having multi-layer canopy covers can provide plenty of foods, supply material energy circulation and create habitats for wild animals, and also provide places for people to relax or play.

2. Soil and Water Conservation Functions of Vegetation

(1)The interception effect of crown canopy

The crown canopy of trees can intercept rainfall and reduce the volume and rate of rainfall reaching the ground surface.

In areas with better forest vegetation coverage, about 30% of the annual rainfall can be intercepted.

For a single rainfall, the canopy interception rate can reach 100% when the rainfall is small.

When the rainfall is heavy, it can reach about 25%.(Lin Xinhui, 2004).

The canopy interception volume or rate is affected by tree species, tree age, degree of crown closeness, branch shape, bark roughness, and leaf shape characteristics.

(2)Ground surface protection

Vegetation cover can prevent soil separation and loss due to raindrop impact.

Through the protection of vegetation, surface hardening can be effectively prevented, and soil aggregate stability and

infiltration rate can be increased. In general, plant coverage rate will affect the degree of resistance to the impact of rainfall.

In the regions with the vegetation coverage rate of less than 70%, the runoff rate and erosion amount will rapidly increase due to the reduction of vegetation coverage. (Lin Xinhui, 2004)

(3)Increase of infiltration effect

A. The presence of horizontal root system and its above-ground backbone of plant's root base protruding from ground and dead branches, can increase ground surface roughness, and can extend the retention time of rainwater on the surface and increase the infiltration volume.

B. The topsoil forms a lower bulk density and a better aggregate structure, which can increase soil water preserving ability.

C. The crown canopy layer and the litter layer of plant can delay the time when the rain falls to ground surface, which can effectively increase the infiltration amount.

(4)Runoff mitigation

A. Plant canopy intercepts rainwater and reduces rainfall in the forest.

B. The litter layer and the ground cover plants have the function of absorbing rainfall moisture.

C. The soil under the litter layer is beneficial to the infiltration of runoff water into the soil due to the increase of humus and the aggregate structure and the residual pores of the corroded root group.

D. Plant roots can improve the properties of deep soils and increase soil water preserving and infiltration abilities.

E.The root systems of vegetation cover are particularly intertwined, reducing the development of surface erosion and gully.

PartII

I. Key Items of Vegetation Engineering Planning

II. Basic Types of Vegetation Engineering Design Objectives

III. Site Conditions and Corresponding Strategies of Vegetation Engineering

IV. Base Site Conditions and Vegetation Engineering Treatment

V. Guest Soil

I. Key Items of Vegetation Engineering Planning

When planning a vegetation engineering, it is necessary to first establish the expected goal of the vegetation engineering, so as to develop a vegetation engineering plan.

When studying and developing, it should consider as follows:

1. Vegetation pre-operation works

   Define:

   Refers to the engineering protection measures done before introducing vegetation in exposed slopes.

   Goal:

   To aim at reducing soil erosion, stabilizing slope, preventing the expansion of collapse area, enhancing the stability of slope foundation, and creating the environmental conditions helpful to the germination, growth, and succession of plants. When plants are introduced into slope, the premise is that the gradient and erosion control of the base, physicochemical properties of the soil matrix, and the

climatic conditions must be suitable for the growth and establishment of the target plant community.

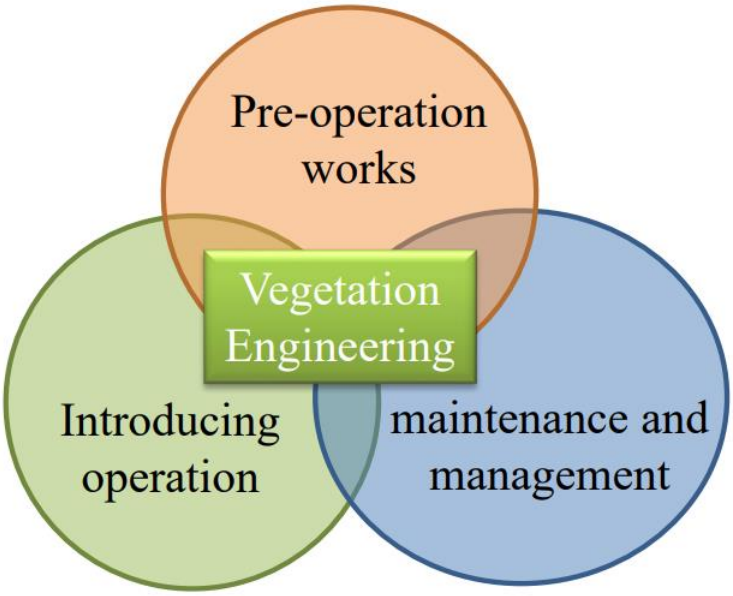
2. Vegetation introducing operation

   Refers to the suitable operational methods used to enable plants to proliferate and grow on the base according to slope conditions and the purpose of vegetation.

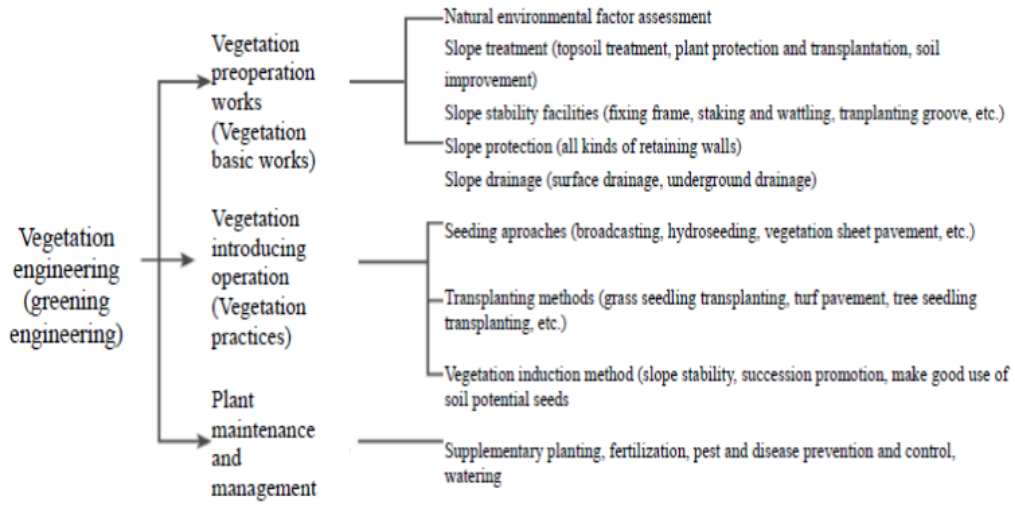
   The methods of vegetation introducing operation can be roughly divided into seeding method, transplanting method and vegetation induction method.

3. Vegetation maintenance and management.

   Refers to the measures required to ensure the effectiveness of the vegetation engineering.



Schematic diagram of the work items of vegetation engineering



II. Basic Types of Vegetation Engineering Design Objectives

1. Soil and water conservation type

The rapid vegetation covering method used in artificial development, vegetation destruction areas or exposed areas of natural disasters for the purposes of soil and water conservation, erosion reduction, disaster prevention, etc., Better effectiveness can be achieved if cooperates with soil and water conservation engineering.

2. Landscape green land type

Cooperating with artificial structures to carry out vegetation introducing operations. In principle, local plants and landscape plants are mainly used to create green land space and landscape beauty.

3. Nature conservation type

Natural plant succession to reach vegetation communities near its apogee with the use of native plants as principle, in order to restore the status of the existing vegetation, usually is used in natural forest park or conservation area.

4. Coordinating afforestation type

Mainly for forestry operation and management, reach artificial forest community in short term through the transplanting of economic forest tree species and artificial tending. Tree seedling and small seedling transplanting is often used to ensure that trees (roots) grow normally and the goal can be achieved with more economic operation.

Comparison of basic design types of vegetation engineering (Source: Soil and Water Conservation Handbook, 2005)

Type / Characteristics	Soil and water conservation type	Landscape green land type	Nature conservation type	Coordinating afforestation type
Plant materials	• Covering grasses • Herbaceous plants • Fast-growing tree species • Green manure plants	• Gardening plants • Landscape plants • Ecological greening plants • Ornamental plants • Habitat conservation plants	• Native plants • Potential vegetation cover (local seed seedlings) • Habitat revegetation plants	• Afforestation tree species • Economic forest tree species • Ecological greening plants
Applicable locations	• Green buffer strip • Earth and sand disaster area • Should be conserved area • Artificially developed	• Park • Garden landscaping • Urban green space • Road green space • Vegetation buffering zone	• Natural park • Primeval forest • Protection forest • Conservation area	• Compartment land • Coastal forest • Protection forest • Buffering forest belt
Transplanting and management	• Small quantity plant maintenance and management • Fast-growing plant seeding • Broadcasting, hydroseeding or seedling transplanting	• Plant competition control • Tree seedling transplanting • Mature tree transplanting • Clustering transplanting • Limiting harmful organisms	• Natural competition of plants • Natural plant succession • Human-assisted management	• Hazardous plant control (weeding, vine removal) • Small tree seedling transplanting • Long-term care management
Purpose and efficacy	• Vegetation covering • Soil erosion control • Sideslope stabilization • Rapid forest	• Landscaping and gardening • Environmental greening beautification • Artificial landscape beauty • Health care and self-cultivation • Atmospheric purification (urban forest)	• Habitat conservation • Soil and water conservation • Atmospheric purification (green resource conservation) • Natural beauty (primeval forest form)	• Wood production • Natural artificial beauty (economic forest form) • Forest recreation • Atmospheric purification • Carbon accumulation

Vegetation engineering plan flowchart

The first work is site environment exploration and investigation.

The second step is vegetation based investigation and analysis.

The three stages are planning stage, design phase, acceptance and maintenance management.

planning stage

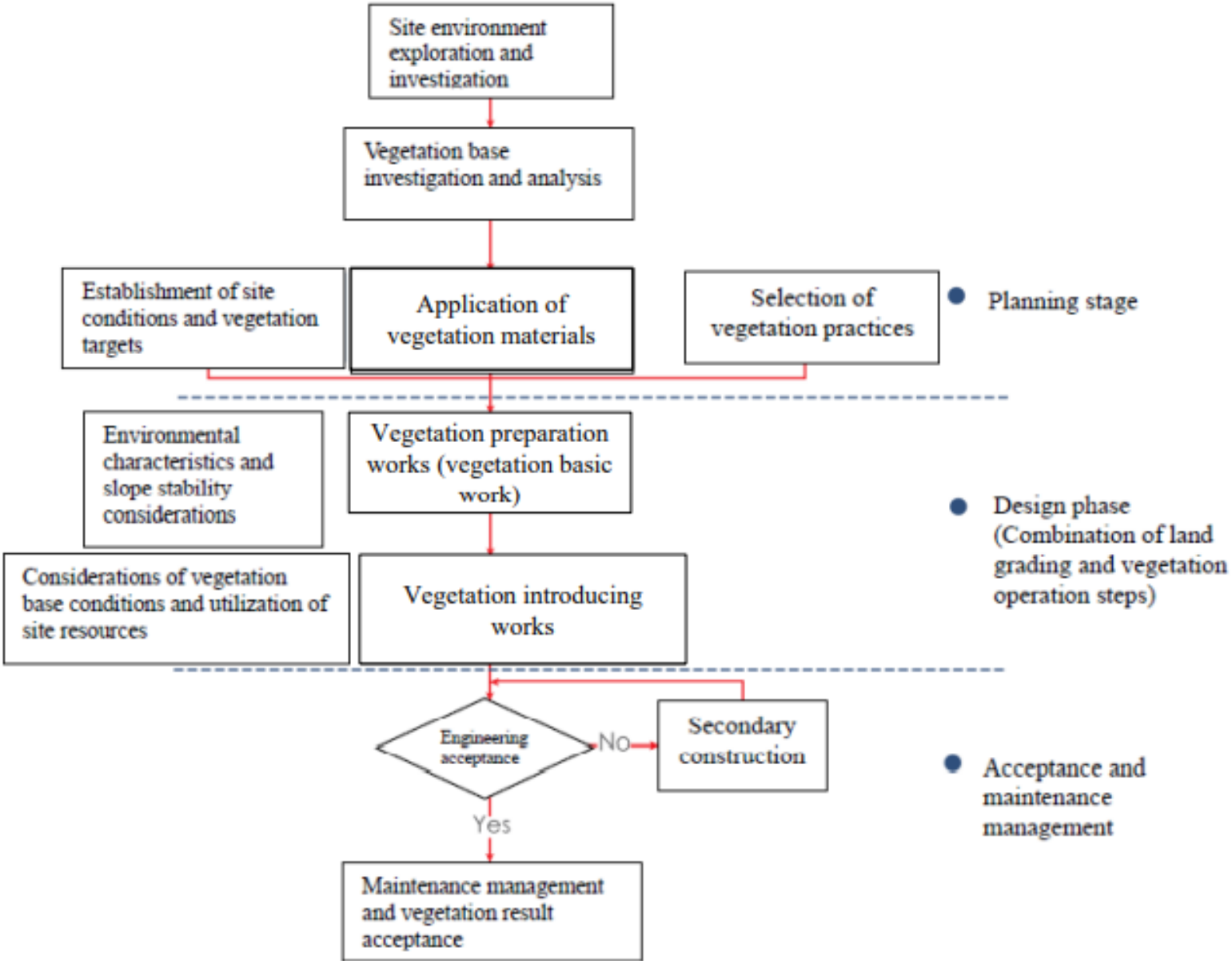
The first work is establishment of site conditions and vegetation targets, then is application of vegetation materials, finally work is selection of vegetation practices.

Design phase

We need to consider environment characteristic and slope stable, and considerrations of vegetation base conditions and utilization of site resources.

Acceptance and maintenance management

If it's okay maintenance management and vegetation result acceptance, but If the engineering acceptance is not real, we need to go back the design phase again


Site environment exploration and investigation
Vegetation base investigation and analysis
Establishment of site conditions and vegetation targets
Application of vegetation materials
Selection of vegetation practices
Planning stage
Environmental characteristics and slope stability considerations
Vegetation preparation works (vegetation basic work)
Considerations of vegetation base conditions and utilization of site resources
Vegetation introducing works
Design phase (Combination of land grading and vegetation operation steps)
Engineering acceptance
No
Secondary construction
Yes
Acceptance and maintenance management
Maintenance management and vegetation result acceptance

III. Site Conditions and Corresponding Strategies of Vegetation Engineering

Plant growth is affected by the surrounding environmental conditions, including as follows:

1. climatic factors

sunlight, atmospheric temperature, rainfall, strong winds, etc.

A. Sunlight

Plants need plenty of sunlight to thrive, under strong light conditions the plants robustly growing and developed are called sun plants.

Sun plants usually have the ability to withstand high temperature and drought, and they have the pioneer plant characteristics that are fast grow in early period and can firstly develop on exposed ground and survive.

B. Atmospheric temperature

The atmospheric temperature is affected by latitude, altitude, wind and terrain and topography, but when the latitude is similar, the altitude is an important factor affecting atmospheric temperature.

C. Rainfall

Due to the interaction of monsoon and topographic factors, Taiwan has abundant rainfall. The average annual rainfall is about 2500 mm, but the rainfall is unevenly distributed.

In the absence of rainfall, vegetation must choose drought-tolerant plants, otherwise plants will be stunted or die due to lack of water.

D. Wind

Drying effect: Moisture can be blown away from the surface of plant leaves, promoting evapotranspiration, which can lead to dry leaves and closed stomata, reducing the effectiveness of photosynthesis.

Mechanical effect: Plants would have the situations such as ruptured leaves, broken branches and causing flag and compression wood if they were blown and attacked by strong winds. Shallow rooted trees are easy to fall or incline because of the effect of wind.

2. soil factors

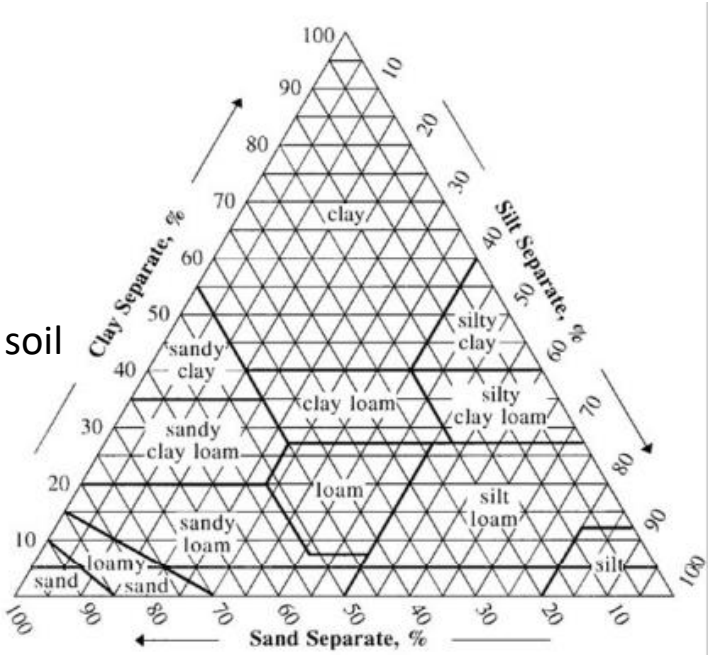
effective soil depth, physical properties of soil chemical properties of soil

A.Soil texture

In addition to affecting the maintenance and supply of nutrients and water, soil's physical properties also affect the development and distribution of system roots and the activities of microorganisms. When soil is in the natural state, its physical properties are very important to plant growth and soil fertility, in addition, the permeability rate and water preservation of the water conserved in the forest are also affected by the physical properties of the soil.

There are several soil physical properties that affect plant growth.

- ✧ Soil stone content
- ✧ Soil hardness
- ✧ Combination of three phases of soil
- ✧ Soil texture



B. Soil chemical properties

The chemical components of the nutrients required for plant growth in the soil include content, proportion, and properties, these are collectively referred to as chemical properties of soil. To maintain good plant breeding, needs the fertilizer three elements nitrogen, phosphorus, and potassium, coupling with calcium, and magnesium, the total five elements are most important.

The availability of the contents of these elements in the soil is comprehensively affected by soil reaction, water, and proportions of the amount of each element, therefore, when determining whether the plant nutrients are rich or not, must be evaluated from the overall chemical properties composition of the soil.

✧ **Soil pH value**

The soil solution often contains H+ and OH- ions, and the content of the two varies depending on soil type, which makes the soil acidic, neutral and alkaline, and is usually expressed by pH value. The large or small of pH value is related to whether

nutrients can be absorbed and utilized by plants. Too high or too low pH value may cause toxicity caused by certain nutrients. In general plants prefer to grow in the soil environment with a pH value of about 6.5.

✧ **Soil nutrients**

Deficiency or excess of soil nutrients will affect plant's growth, which may occur in the symptoms are described as follows:

- ✧ Nitrogen fertilizer: When it is lacking, the leaves will become a unclear yellow to green;when excessive, the leaves will be in dark green, the leaves will be juicy and soft, and the flowers will be delayed and fruits will be less.
- ✧ Phosphate fertilizer: When it is lacking, the cell division is declining, the plant is poorly developed, the leaves are narrow, and the old leaves appear red; when excessive, leaf flesh is thick and the trunk is short, the root grows poorly, fruit is excessively mature and yield reduces.

- ✧ Potassium fertilizer: When it is lacking, the planting stock is short, the tip of the leaf is brown, and in severe cases, gangrene is produced; when it is excessive, the new leaves tend to become larger and the planting stock is elongated and the growth energy is weak.

3. terrain and geology

gradient

IV. Base Site Conditions and Vegetation Engineering Treatment

1. Side slope gradient

Required coordinating engineering treatments when conducting vegetation on different gradients (Source: modified from Yoshinari Yamadera, 1988)

Gradient	Vegetation growth situation	Coordinating engineering treatment
Below 35°	1. Plants grow well. 2. Plants naturally invade and generally grow well. 3. May restore to arbor-based plant society.	1. Mainly based on drainage and slope treatment measures. 2. Can apply vegetation treatments such as turf pavement, vegetation sheet pavement, hydroseeding, etc. 3. Carry out vegetation treatment after simple foundation works of trench diggings and slope drainage
45°~ 60°	1. The main plant communities are shrubs and herbs. 2. Transplanting arbor is dangerous and easy to incur the instability of the breeding base. 3. If the gradient exceeds 35°, the plants' naturally invasion and breeding are slower.	1 . Vegetation after simple basic engineering treatment. 2. Retaining wall, retaining fence, staking and wattling, wire cylinder slope protection, digging planting pits, etc. 3. Net paving and hydroseeding, shaping frame, etc.
45°~ 60°	1. The main plant communities are shrubs and herbs. 2. 45°~50° is the critical gradient of planting arbor. 3. Slope stability is difficult, and the terrace surface of the whole slope is coordinated with transplanting plants.	1 . Fixing frame, retaining wall. 2. Laying 3D net, composite net coordinated with guest soil hydroseeding.
More than 60°	It is not easy to transplant plants or natural invasion and growth are difficult.	1. Retaining wall, free beam frame. 2. Setting buffering belt or rockfall prevention measures

1. Soil hardness

The measured value of Yamanak a hardness tester is usually used as standard of indicator of soil hardness. The Yamanaka hardness tester has a length of 23cm, a diameter of 5cm and a weight of 0.65kg. When inserting the tip of the cone into the soil, then the retraction length of the spring contained inside, which is of 8kg resistance strength, is the measured value of the soil hardness tester.

The Yamanaka hardness tester

Soil hardness measurement value (H)	Plant breeding situation	Coordinated with vegetation engineering
H<10mm	1. The soil is soft and dry, the water preserving ability of the soil is poor, and the plants germinate and grow poorly. 2. When the slope is not treated or is larger than the resting angle, it is easy to fall.	1. Measures for preventing drying such as covering with straw mats. 2. Fixing frame and guest soil vegetation. 3. Covering with straw mats after seed spraying.
10~20mm	1. The roots stretch well. 2. Seed germination and growth are good.	1. Woody plants can be planted. 2. Vegetation methods such as hydroseeding method, vegetation sheet, soil bag, net paving and guest soil hydroseeding can be used.
20~26mm	1. The plants grow well. 2. There may be a rapid decline in the hydroseeding of exotic grass species.	1. Woody plants can be planted, but the design of pit planting and guest soil volume are still needed to be strengthened. 2. Can be coordinated with the seeding practice of applying middle layer materials.
26~30mm	1. Root growth is blocked or may decline rapidly. 2. If the soil has big hole spaces , the growth of plant roots is still possible.	1. Improving soil hardness by drilling holes or digging trenches. 2. Avoiding the use of the vegetation methods such as transplanting, seed broadcasting and stem burying. 3. Better to use seed spraying after 4. drilling holes, or paving vegetation sheet, laying ne t and guest soil hydroseeding, fixing frame and guest soil vegetation and the like after thickening guest soil.
H> 30mm	1. The plant root system is unable to invade and grow. 2. Breeding is difficult.	1. Guest soil hydroseeding after drilling holes. 2. Wire cylinder coordinated with guest soil, shaping frame guest soil vegetation.

V. Guest Soil

Definition

Guest soils refer to the soils containing rich organic matters and better physicochemical properties casted in construction site in order to improve soil conditions of vegetation environment and facilitate growth of introduced plants. The natures of guest soil materials are usually different from those of the original soil of the slope, and after improving original ground topsoil or adding organic materials, and then casting on surface as vegetation base materials, the soil properties is different from the original surface soil, this also belongs to the operational method of guest soil.

Applications

In exposed area of large area slope development, slope of road cutting and filling, mudstone area or mining area, because of its innate site and soil conditions are poor, causing considerable difficulties in plant growth; in addition, seedling pit planting site or vegetation engineering construction site which needs fast

growth of dense turf, also needs guest soil treatment in order to reach expected results of vegetation.

Mudstone area

Mining area

PART III

I. Types of Vegetation Survey

II. Qualitative survey of plant communities

III. Quantitative survey of plant communities

- ✧ Key Points for Sample Area Sampling Survey Method
- ✧ Sample Area Sampling Survey Items and Methods
- ✧ No Sample Area Sampling Survey Method

IV. Analysis and Application of Vegetation Data

I. Types of Vegetation Survey

Purpose

The purpose of vegetation survey is to derive all clusters and their attributes of plant society within an area , study and analyze the composing individuals and their sizes , number, arrangement, etc. and mutual relationships of these plant communities , and further conjecture competitive situation of species, and possible succession development of the plant society.

Category Definition

Vegetation survey often uses sample area data to conjecture the attributes of the parent population, speculate the overall characteristics of the vegetation community with fewer survey data, and use them as a reference basis. Vegetation survey categories can be summarized into flora survey and plant community survey respectively.

1.Flora survey

Flora survey is using all plant species in a certain area as the target to conduct the collection and judgment and interpretation works of the plants, record or estimate basic data of each species, such as attributes, number of population, distribution and breeding environment, and conditions, etc., and study and analyze the characteristics such as size, number, arrangement and their mutual relationships of the composing individuals (specifically dominant species) of the plant community.

2.Vegetation community survey

Taking vegetation community as the survey target, set up sample areas of the vegetation community in a homogeneous environment, record species, composition structure, and distribution of the plants in the survey sample areas, and investigate tree height and chest height diameter of the main dominant plants as needed for the reference of analyzing vegetation community patterns, producing vegetation diagram and vegetation community sectional diagram, and conjecturing

plant succession, mutual relationships between populations. The vegetation community survey can be divided into a vegetation qualitative survey and a vegetation quantitative survey.

II. Qualitative survey of plant communities

Plant qualitative survey is to investigate the characteristics of plant society according to the degree of homogeneity and use dominant plant species as the representative of vegetation community. And it is usually done by subjective observation on the composition of a plant community to give the traits of the plants in accordance with the characteristics described, and afterward can indirectly understand local environmental characteristics through the plant traits.

1. Degree of clustering of the vegetative individuals (sociability)

The sociability of plant population refers to the degree of clustering of the individuals of the plant population , i.e., the relative gregariousness or clumping of the individuals of the plant population. The sociability can be divided into five grades as described in detail in plant population society grading table.

Plant population society grading table

Grade	Degree of Clustering	Growth Pattern
First Grade (soc.1)	Growing alone	Growing solitary, single
Second Grade (soc.2)	Growing in clusters	Forming clumps or dense groups
Third Grade (soc.3)	Growing in patches or cushions	Forming small patches or cushions
Fourth Grade (soc.4)	Growing in small groups	Growing in small colonies or forming larger carpets
Fifth Grade (soc.5)	Growing in large groups	Growing in larger, almost pure population stand

2. Structural (hierarchical) characteristic of vegetation community

Plant community generally has certain biological composition, hierarchies on biodistribution, circadian rhythm, seasonal changes, and increase and decrease phenomena in terms of time. In addition, various bios are mutually dependent, mutually influencing, and their respective environment and biological population has a close mutual influence relationship.

III. Quantitative survey of plant communities

1. Key Points for Sample Area of Sampling Survey Method

Vegetation quantitative survey method is to select appropriate sample areas in the survey region according to environment, life forms of plants, canopy structure and distribution and survey purposes and other conditions to conduct the investigation of the species, numbers and growth situations of plants, and then carry out combinatorial analysis in accordance with the parameters obtained from survey as a method for calculating the characteristics of vegetation community.

The setting of survey sample areas need to consider the area characteristic factors such as sample area shape, sample area orientation, distribution pattern of sample areas, minimum area of sample area, and minimum number of sample areas.

A. Selection of sample area shape

The selection of sample area may vary depending on the terrain and the convenience of the survey. Generally, square,

rectangular, strip-shaped cross-sectional areas or line-like sample area (line-intercept method) are commonly used shapes.

B. Orientation and distribution of sample areas

The setting of sample areas also must consider their orientation, i.e., the arrangement direction of long or short axis.

- ✧ If the plant society is homogeneous, the orientation has less influence, however, in general mountain areas has the flora slightly changes in gradient due to the topography, so the selection of long axis should cross the changed gradients in order to obtain accurate (smaller variation) data.
- ✧ If the survey region is a large-scale vegetation community and not a single plant society, then objective synthesis

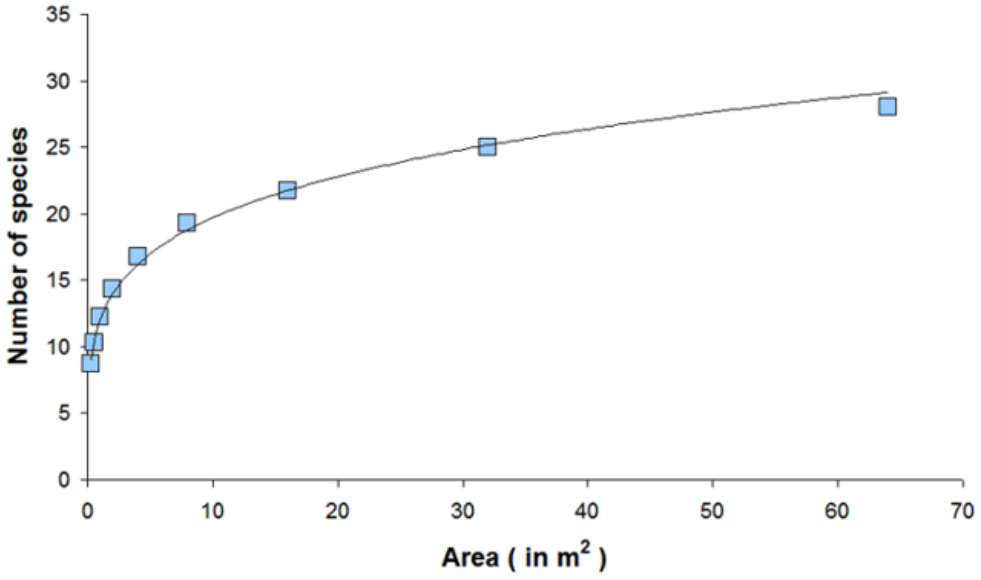
method is commonly used to set sample areas, and the obtained sample area data are classified in order to construct a mosaic structure.

C. Area of sample area

When conducting sampling survey, first must determine that how much the area of the sample areas should be set . In general, when selecting the area of the sample areas, in addition to considering whether the plant community composition is homogeneous, must also consider the life forms of the vegetation community. When selecting the size of the sample areas , can choose a appropriate method to determine the size of the sampling areas according to the rule of thumb (Lin Xinhui, 2008). When conducting vegetation community survey , the minimum required area of sample areas is determined by the richness of plant species.

✧ Species-area curves are ecologically the relationship between the number of species and the area of habitat in a given area. When the area is larger, the number of species also tends to be larger; experiments show that the relationship between the two follows a set of systematic mathematical relationships.

✧ When the area of the plot and the number of species are stable or change little, the number of plots can effectively represent the characteristics of the plot.



Species-area curves

(cited from https://math.hws.edu/~mitchell/SpeciesArea/speciesAreaText.html)

Minimum area of sample area of category vegetation community survey

Vegetation community category	Minimum area of sample area (m^2)
Herb layer	1-2
Low shrub and high herb layers	4
High shrub layer	16(4X4)
Arbor layer	100(10X10)

D. Number of sample areas

In general, the number of sample areas must be decided by changes in vegetation community logistic time, budget and manpower etc. However, in accurate vegetation community survey , the area of the sample areas accounted for the percentage of the research region should be determined first. At the same time, it should consider how many vegetation groups are seen during exploration , and each vegetation group should not only be covered at the time of sampling, but also should be repeated , because the number of sample areas will

affect the accuracy of the survey. And in the determination of the appropriate number of sample areas "the species number - sample area number curve method" is mostly used. This method is similar to the species number - area number curve method, i.e., using the plant relationship between the number of species and the number of sample areas to conduct the plotting, research and analysis.

2. Sample Area of Sampling Survey Items and Methods

A. Density

Refers to the number of plant individuals per unit area. Its calculation is usually expressed in terms of number of plants per m^2 or ha.

B. Frequency

Refers to the number of occurrences of a certain plant in each set sample area or sample point. It is usually expressed as the ratio of the number of plants recorded in the sample area during survey to the total number of plants recorded in total sample areas set.

C. Coverage

Coverage is the ratio of the projected area of canopy or branches of a plant to the area of the ground surface, often expressed as a fraction or percentage. It is usually used to compare the difference between the ratios of the spaces occupied by different plants within a vegetation community, and as a parameter of the dominance of plant in the breeding area.

Grade	Coverage area percentage (%)
Grade A	Less than 5
Grade B	6~25
Grade C	26~50
Grade D	51~75
Grade E	76~100

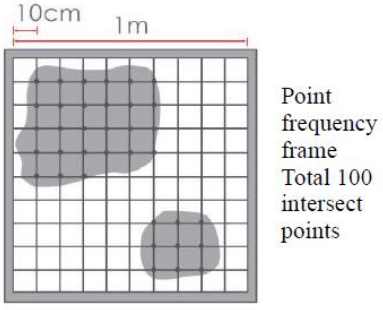
3. No Sample Area of Sampling Survey Method

✧ The point intercept method is also called the point quadrat method. Its principle is when estimate the plant coverage,

draw the covered profile of the plant onto a square grid paper, and then calculate the number of squares occupied by it, and the obtained result is calculated as the coverage of the plant.

✧ When measuring , the applicable tool is point frequency frame, this frame is usually made of wood (both height and length are 1m) and has ten wire pins with a length equal to bracket and interspersed from the holes. Because of being limited by height, this frame is only applicable to herbaceous plants or low lying shrub groups having a general height (20~50cm).

✧ When sampling, only location factor is necessary to be considered. Because no boundary and area restrictions, so it is the most simple, quick survey method, however, in general it is better used to investigate low layer plants.



Point frequency frame Total 100 intersect points

Description: Species A coverage = 36/100 = 36%

IV. Analysis and Application of Vegetation Data

1. Calculation of Importance value index (IVI)

The plant society parameter is expressed as important value index (IVI). The plant society is divided into upper and lower layers (the arbor layer and the ground cover layer), and the density, frequency and dominance of various plants in each sample area are calculated, and then converted into relative values.

The important value of the upper layer plant society is the sum of the relative values of the three.

The important value of the lower layer plant society is the sum of the relative frequency and relative dominance.

$$\boldsymbol{Relative\ density}(\%) = \frac{\boldsymbol{Density\ of\ certain\ plant}}{\boldsymbol{Sum\ of\ density\ of\ all\ plants}} \times \mathbf{100\%}$$

$$\boldsymbol{Relative frequency}(\%) = \frac{\boldsymbol{Frequency\ of\ certain\ plant}}{\boldsymbol{Sum\ of Frequency\ of\ all\ plants}} \times \mathbf{100\%}$$

$$\boldsymbol{Relative\ dominance}(\%) = \frac{\boldsymbol{dominance\ of\ certain\ plant}}{\boldsymbol{Sum\ of dominance\ of\ all\ plants}} \times \mathbf{100\%}$$

- ✧ **Arbor layer IVI = Relative density + Relative frequency + Relative dominance (total is 300)**
- ✧ **Ground cover IVI = Relative frequency + Relative dominance(total is 200)**

2. Analysis of Vegetation Communities

A. Vegetation community similarity

In order to compare the similarity of two plant communities, Motyka et al (1950) had used parameters such as species dominance to calculate Smo similarity index to compare two plant communities of the region.

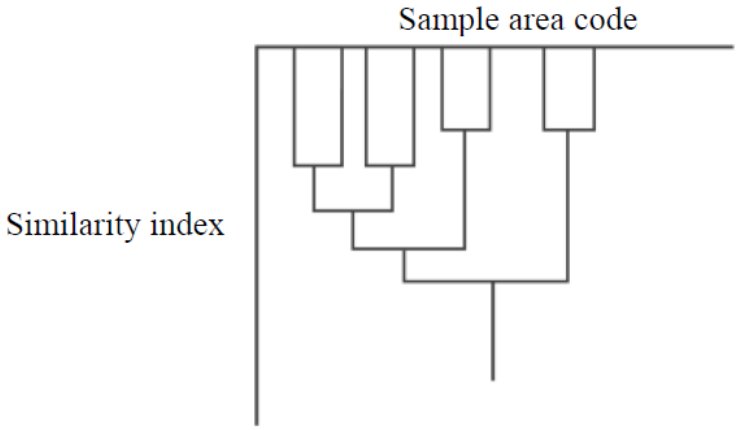
$$Smo = \frac{2Nw}{Na+Nb} \times 100\%$$

Na=Total number of individuals in the A sample area community
Nb = Total number of individuals in the B sample area community
Nw = Sum of the fewer individuals in the common species of the two sample areas

B. Matrix cluster analysis

Conduct matrix cluster analysis according to the above calculation of community similarity indexes between different survey sample areas. The vegetation communities

in the survey region can be grouped, and at last the distribution of vegetation communities in the survey region is expressed in a dendrogram.



Prototype of dendrogram