# Adapting the Miyawaki Forest Methodology to Tropical and Other Climates

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Prof. Miyawaki in China, in 1985, with Prof. Fujiwara, his most knowledgeable and experienced practitioner of Miyawaki forest requirements and procedures

Biodiversity and Forests

Miyawaki Method: 6 steps

Biodiversity over course of forest development

Adapting Miyawaki to other climates

Why Miyawaki works – and supports biodiversity

# What is biodiversity?

**Numbers (richness) –**

**numbers of plant or animal species**

**but also intrinsic differences (diversity) –**

**different functional processes**

**different functional patterns**

**biotic relationships between taxa, etc.**

One way to get high species numbers is to have open, unstable vegetation.

It may be constantly changing, with new species coming in – but with many WEEDS.

But is this really what you want?

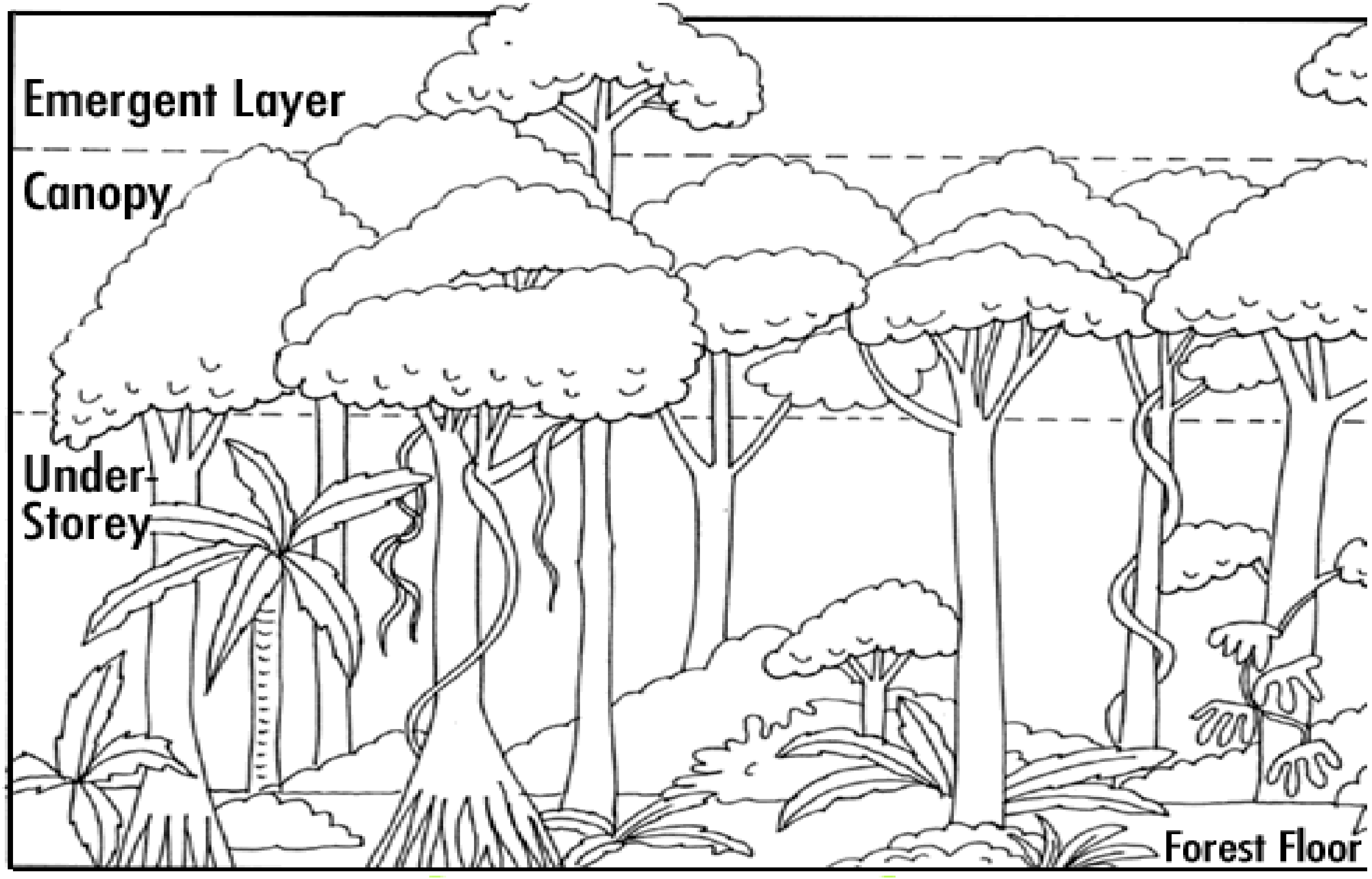
# What is a forest?　　森は、何ですか？

A stand of relatively **tall** trees with **crowns overlapping** (closed canopy), **large** enough in area to have a **shady interior** that sunlight (edge effect) does not reach

| | Closed | Open | Small Area |
|---|---|---|---|
| Tall | **forest** | woodland | grove |
| Short | woodland | woodland | grove/thicket |

# A Forest also has layers:

- The **canopy** is a sun environment, with more water stress and smaller, somewhat thicker "sun leaves"
- The **understorey** is a shade environment, with little water stress and thinner, usually darker "shade leaves"

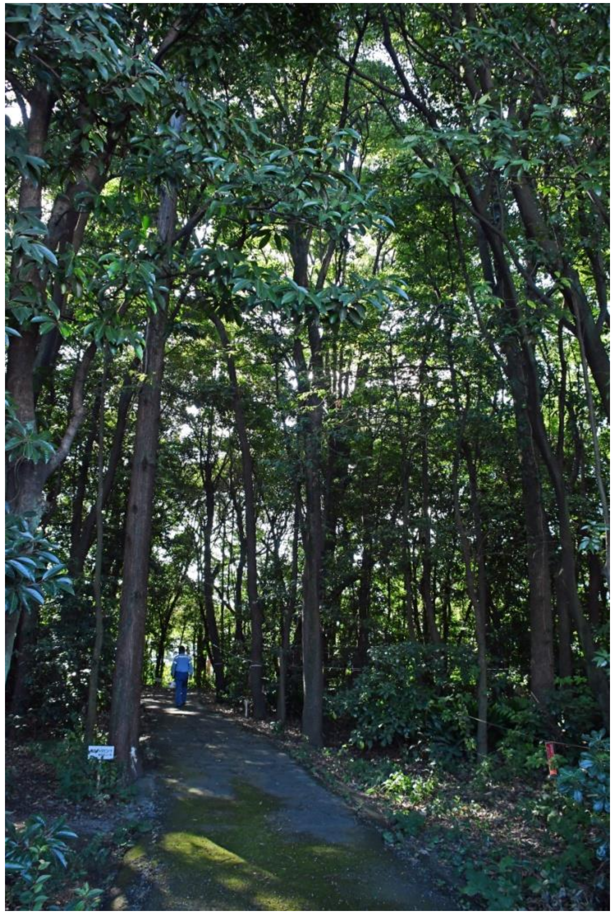



The Miyawaki Method was developed in warm-humid southern Japan, where the potential vegetation is **evergreen** broad-leaved “laurel” forest, dominated by trees with dark-green, shade-tolerant leaves

Many such Miyawaki forests have been created in this part of Japan, and all are surviving well, providing stable forests

Left: natural “laurel” forest in Kyūshū

Right: roughly 50-year-old Miyawaki plantation, also in Kyūshū



# **Shade** is one main key to Miyawaki success

Shade keeps out **fast-growing**, disruptive other plants
(e.g. early-successional trees, shrubs, and weeds)

Shade makes a **humid microenvironment** that promotes tree growth

Shade permits only the potential **last-stage** (“climax”) trees to grow, because these are the most shade-tolerant

→It’s these most shade-tolerant trees that you want
because they provide long-term stability –
they cannot be pushed out by other tree species

# The “Miyawaki Method”

**Purpose**: create a stable forest canopy using long-living, dominant tree species from the local mature forest

**Strategy**: circumvent succession by planting the “climax” canopy tree species in an environment that creates a self-maintaining forest as quickly as possible

- well-prepared soil on the plantation site
- saplings with well-developed root systems
- dense plantation promotes rapid growth and canopy development

The Miyawaki Method requires **6 basic steps**:

1) **Understanding** the local potential natural forest vegetation and its long-term canopy dominant species
2) Planting well-prepared **pot-grown saplings** of these species, with root systems already well developed
3) Planting on a slightly raised, **prepared site**, with imported better soil
4) Planting **mixtures** of 6-15 “climax” tree species, plus a few others
5) Planting at a **high density**, which promotes rapid, light-seeking upward growth, creates a shady, humid forest microclimate, and minimizes invasion by light-demanding weeds
6) **Mulching** immediately after planting, to hold water and deter weeds.

# 1) **Understanding** the local potential natural forest vegetation and its long-term, canopy dominant “climax” species

This requires detailed **fieldwork** in order to identify the local climax species, i.e. the

**long-term dominant canopy trees**
of mature forests

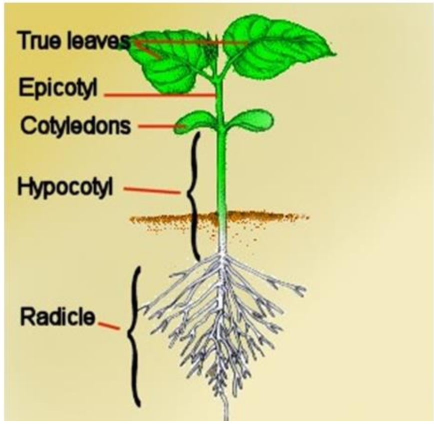
Climax species are usually well known in the temperate zone but may be more difficult to determine in the tropics

## 2) Planting well-prepared **pot-grown saplings** of these species, with root systems already well developed

Saplings no longer have cotyledons and must rely on their roots for water and on their own leaves for photosynthesis.

Pot-grown saplings must thus be prepared in order to have good, well developed root systems, ready to grow quickly after planting.

The roots should grow quickly to equal the plant's height above ground.




## 3) Planting on a slightly raised, **prepared site**, with imported better soil if necessary

Prepared sites may even be hillsides, where forests can stabilize steep terrain

## 4) Planting involves **mixtures** of 6-15 local climax tree species, plus a few others

5) Planting should be at **high density**, which

- promotes rapid, upward, light-seeking growth
- creates a shady, humid microclimate, and
- minimizes invasion by light-demanding weeds

Here (1984): a Miyawaki forest in Japan, planted by visiting botanists

## 6) **Mulching** immediately after planting, with rice straw or other (but wood chips do not hold water as well)

- Management in the first years: weeding, mulch maintenance

A well executed plantation should be self-maintaining after about 3 years

It should not need weeding after that because the shade created by the canopy will prevent weeds from coming in

Each of these 6 steps is important, but each also becomes meaningless if the previous steps were not done right.

This means that step #1 is the most important

So let’s go back to that 1st, most important requirement:
**Understanding** the site potential correctly

a) First, do you have a **forest climate**?

That means, a climate that has enough water to support the large, water-losing leaf area of a closed forest?

Water must be available **permanently** (climate) –
a Miyawaki forest is not a groundwater-mining operation

This is no problem in Japan, where the Miyawaki method was developed – but it may be a critical **limit elsewhere**

b) Then the **potential natural vegetation,** i.e. the "climax" (canopy-dominant) tree species of mature forests:

- canopy stature (usually > 20 meters, more in tropics/subtropics)

- relatively long lifespans (usually > 100 years, ca 100y in tropics)

- darker green leaves (more chlorophyll), which permit growing in shade as well as the canopy

These shade-tolerant "climax" species are the ones to plant. If you don't know what they are, don't guess, just **ask the local ecologists!**

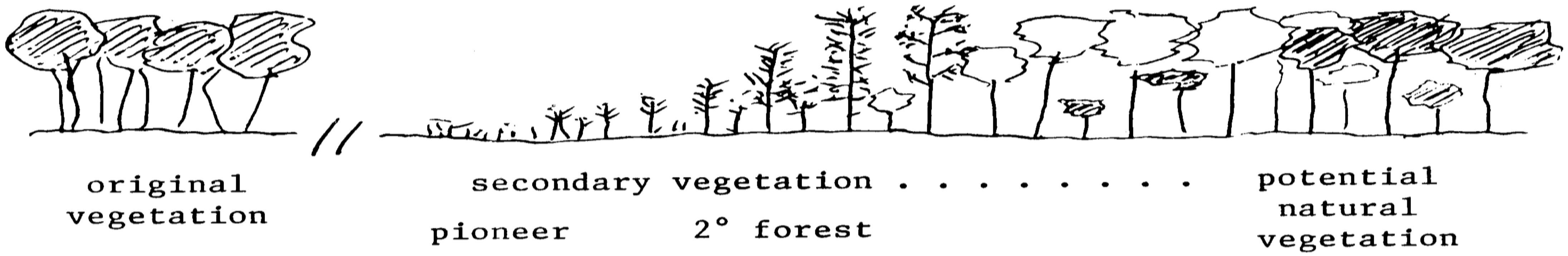
# Biodiversity over the course of Forest Development

Each stage represents plants that can colonize and persist under current conditions

Each stage **modifies** conditions so that the next species group can enter:
- more shade, greater humidity, more soil water, more dead organic matter

Each stage is followed by taller/equally tall but more shade-tolerant trees (able to grow up in the understorey)

The terminal stage is composed of the **most shade-tolerant** tree species, which can persist and **cannot be replaced** by other species




**Potential natural vegetation** (PNV) – the vegetation that would arise on a site if all outside influences were removed, i.e. the “climax” vegetation

# Plant Types over the course of forest development

| Early | Late |
| --- | --- |
| Smaller plants | Larger plants, e.g. trees |
| Fast-growing plants | Slower-growing plants |
| Short lifespans | Longer lifespans |
| Weeds, grasses, fast-growing trees (esp. deciduous), etc. | Evergreen, deciduous trees; **most shade-tolerant spp.** |

→ Miyawaki approach: go directly to the terminal-stage species

# When is species richness highest?

Generally toward the end of succession, as a stable forest develops – but it varies . . .

a) Some forests lose a few species at maturity, partly due to strong dominance by overstorey species, partly due perhaps to the strong shade created

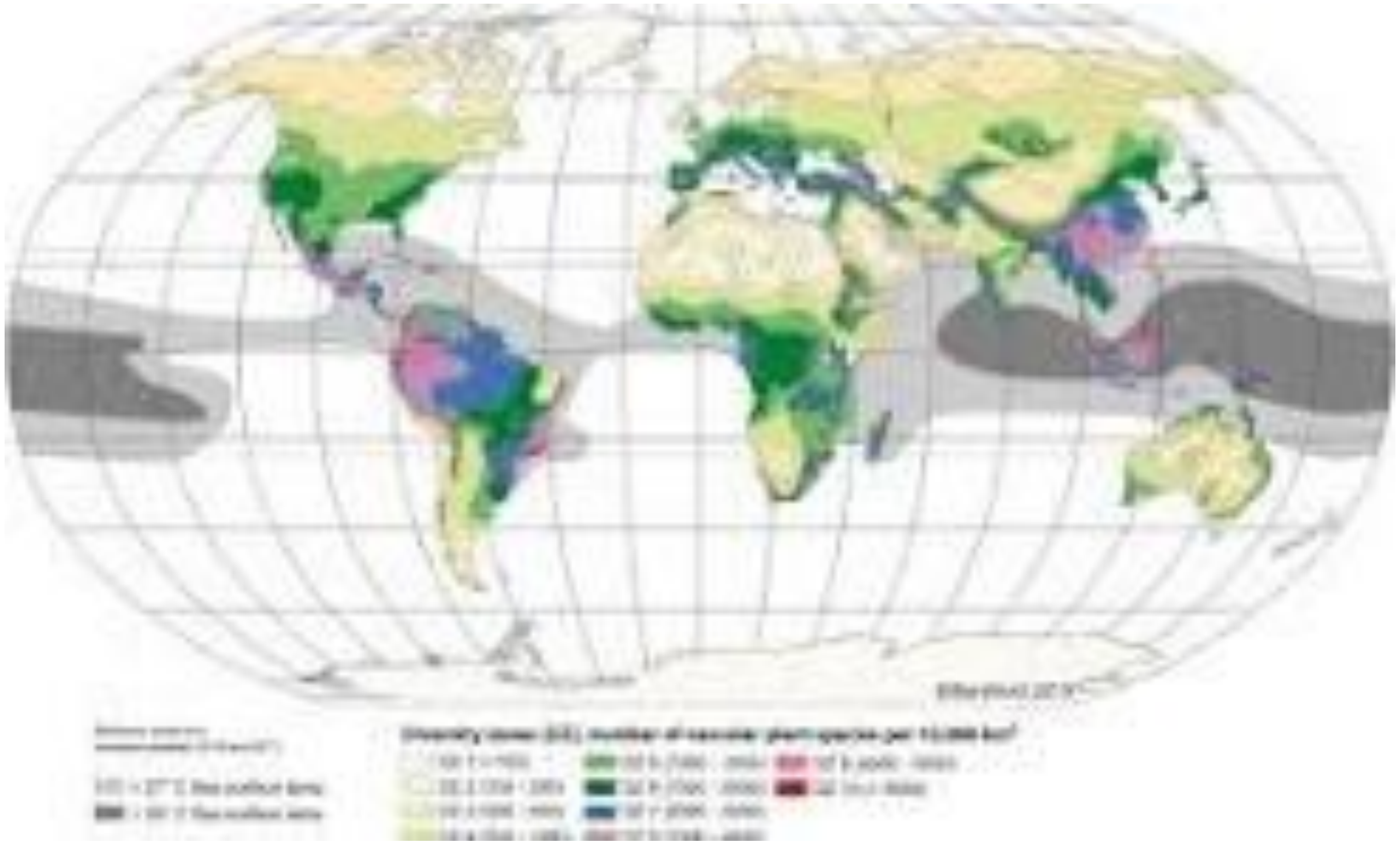
b) Other forests, though, continue to accumulate new species indefinitely

Tropical forests generally seem to follow this second pattern

# Summergreen deciduous forest in the southern Appalachian Mountains, southeastern USA

After logging, forest structure may be reestablished within a century – faster in a Miyawaki plantation – but the great diversity of understorey herbs does not come back quickly, even after > 100 years

# Where is biodiversity highest?



Generally in forests, especially old forests

- tropical humid forests
- rich temperate forests

But also in other vegetation

with long history,
e.g. fynbos, kwongan

of S Hemisphere

“Miyawaki mini-forests” have now become quite popular

Many (most?) are done, though
 - in areas other than potential evergreen broad-leaved forest
 - without understanding the real basis for long-term stability

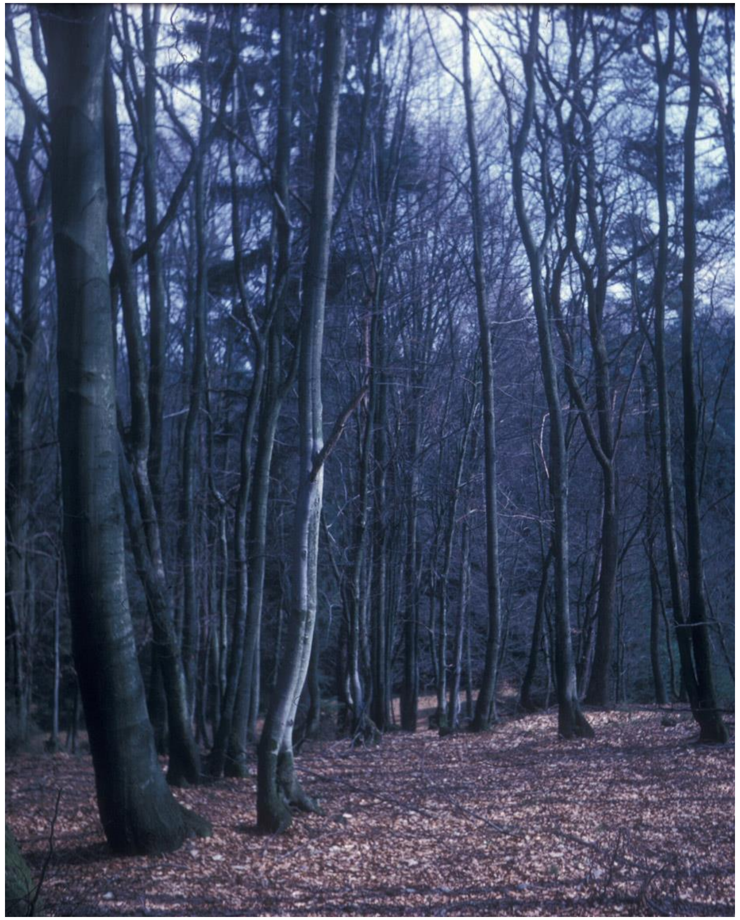
What happens, for example, if

- the **canopy disappears** every year in a  cold or dry season?

- the climate is **too dry** for a densely closed forest canopy?

- the **soil** is bad?

# In temperate **deciduous forests** (“summergreen”) the canopy collapses every winter and must be recaptured every spring, in mature forests, by the climax species



Main forest type in N Japan, Europe, N America

This limitation is compounded in Europe by the small number of native, canopy-dominant tree species of mature forests, sometimes only **beech** (*Fagus*) and 1-3 **oak** (*Quercus*) species.

Faster-growing species such as birch, willow and alder are more common but are **unsuitable**, due to short lifespans and rapid early growth that creates unstable canopies

In **tropical evergreen forests**, regeneration occurs in canopy gaps:
- by forest species in smaller gaps, or
- by colonizers (non-forest species) from outside if gaps are large

Life spans only 100 years

Species rarely replace themselves, since seeds germinate away from parent trees

Initially more mixed but becomes dominated by shade-tolerant canopy trees plus emergents

Miyawaki forests have been established in Kenya, Malaysia, Brazil, etc.

# Tropical Soils are inherently nutrient-poor

**Latosols** (left) are
- many meters deep
- extremely leached, acidic clay
- extremely poor in nutrients

**Lateritic** soils (right) are similar but had their surfaces dried out and hardened; broken pieces are mixed into the soil

Miyawaki forests have been established in these “other” situations (deciduous, tropics), but there are **complications**, and many questions still need to be answered, for example:

- Are the canopy trees maintaining the forest structure? Are they regenerating?
- What kinds of other species are coming in naturally?
- Is undergrowth while canopy leafless a problem?
- How much mortality can be tolerated and still have stability?
- What is the timeframe for development of stable forest?

Feedback (data) is needed early and often in such forests.

On the other hand, some questions may become apparent (or get answered?) only **later**, after 50 years or more.

We are just now approaching the natural lifespan of some trees in the earliest plantations in Japan.

So, we are still studying how well Miyawaki's oldest forests are holding up: growth rates, canopy maintenance, etc.


(at right: Ōita Steel Works, planted in 1970s)

# Why does the Miyawaki Method work?

The local climax species are those **best adapted** to local conditions

Dense plantation creates, more quickly, **good conditions** for tree growth (humid understorey microclimate)

Climax species are the most **shade-tolerant** species and thus produce a stable forest structure (they cannot be replaced by other species)

→ **Key**: choice of the right species, i.e. the shade-tolerant, long-living potential **climax species**

# Main reasons why plantations fail . . .

- Site could not be prepared adequately (too dry, bad soil, etc.)

- Poor planting procedures

- Off-season mortality – a greater problem in deciduous stands

- But mainly, **wrong species** chosen: not long-living climax species

Faster-growing species, albeit native and more common, do not permit the canopy species to grow up together and produce a stable canopy.

Hint: if you still have weeds after 3 years, too much light is getting in (area too small, wrong species, etc.)

In conclusion, plantation success depends mainly on 3 things:

- Correct **identification** of the potential canopy-dominant "climax" tree species (usually the most shade-tolerant)

- Upward growth of these "climax" tree species **together**, creating and maintaining a forest canopy over many years

- **Shade tolerance** of the climax species, which maintains long-term forest stability by keeping out fast-growing sun-loving weedy species

Some, mainly temperate-zone forests may have slightly fewer total plant species at maturity, but they generally have **more other species**: birds, small mammals, soil organisms, etc.

So the total species richness is high – and the number of functional patterns and biotic relationships among species is also high

Stable mature forests have **high total biodiversity**