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Article

The Japanese and Chinju-no-mori* Tsunami-protecting forest after the Great East Japan Earthquake 2011**

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With 32 photos and 2 figures

Abstract: A great earthquake hit the Tohoku District, eastern Japan, on March 11th 2011. This Great East Japan Earthquake including great tsunami that followed claimed the lives of about 20,000 people, though we made best possible prediction and preparation for natural disasters with full use of the newest science and technologies. Tide prevention forests of pine trees alone did not serve the purpose, but not a tree from the local potential natural vegetation fell in the earthquake and the tsunami. In order to survive in such flat areas, it is essential to build high coastal levees with native forests of indigenous tree species.

Most of the debris from disaster areas is ecologically an earth resource. After removing poisonous materials, debris should be utilized to make well aerated mounds along the 300 km-long coasts of disaster areas. Saplings of native tree species with fully developed root systems are planted mixed and densely on the mounds. They will grow to form tsunami-preventing native forests a "Great Wall of Forests". This afforestation on embankments should spread as a government project and a national movement.

Keywords: tsunami, debris, potential natural vegetation, Great East Japan Earthquake 2011

Civilization, science, technology, and natural disaster

It is said that humans appeared on the earth about five million years ago and survived in forests, accepting abundant blessings from nature over most of that time. Forests were the basis of human existence (Miyawaki 2004).

Humans made tools out of stones, bronze and iron, and because of their extremely developed cerebral cortex they acquired the ability to memorize, to think, to accumulate knowledge, and to judge in a comprehensive and systematic fashion. They developed civilizations that included science and technology. On the other hand, they kept destroying natural forests.

At present, by utilizing such extreme resources as atomic energy, we live a convenient and materially affluent life that our ancestors could never imagine. We live, so to speak, under the best of conditions.

In terms of prediction and preparation for natural disasters, we take the best possible measures by using the newest science and technologies. Kamaishi City, which suffered much damage due to tsunami in the past, completed a concrete breakwater 63 meters deep, 2 km long, 20 meters wide, and 8 meters high above sea level. However, on March 11th, 2011, it could not withstand the power of the great tsunami and was destroyed. The Great East Japan Earthquake claimed the lives of about 20,000 people (Miyawaki 2011).

Otsuchi Town is bordered on the north by Kamaishi and had a population of around 16,000. By the Earthquake and the great tsunami, 1,276 people including the Mayor and executive officials were victimized (803 dead, 473 missing as of Nov. 2011) (Photo 1).

We have realized natural threats are sometimes beyond the capability of humans to resist, and that life is most precious.

Functions of native forests

The course of life on the earth continues from about 4 billion years ago to the present, and we live now as a milestone on the road of life extending far into the future. Native forests of native trees are the green bed for our genetic resources.

Native forests are multi-stratal, each consisting of an overstory tree layer, an understory tree layer, a shrub layer, a herbaceous layer and usually a moss layer. The total green surface area is 30 times greater than that of a single-layer grass lawn. In the earth's ecosystems, green

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vegetation is the only producer, and indigenous forests with multiple layers are the basis of existence for all animals, including humans, which are also consumers.

Forests of evergreen broad-leaved trees with deep taproots (Photo 2) have various functions in environmental protection and disaster mitigation. They also sustain biodiversity and reduce global warming by absorbing carbon dioxide in the atmosphere and fixing carbon in biomass.

Indigenous forests throughout the world, however, have been destroyed through hundreds of years of logging, overgrazing, extensive farming and rapid urbanization. The Japanese have also cut down trees and destroyed forests to make farmland and houses. On the other hand, our ancestors always preserved, protected and built native forests nearby when they constructed villages and towns. These are the *chinju-no-mori* (Photo 3) (Miyawaki 2000) that Japan can be proud to show off to the world. Recently, though, the number of *chinju-no-mori* has dropped rapidly. For instance, only 40 such forests out of 2850 remain in Kanagawa Prefecture, the capital of which is Yokohama, with a population of 3.6 million people (Miyawaki et al. 1979).

Trees in natural disasters

We have been conducting field vegetation surveys in devastated areas since soon after the Great East Japan Earthquake. Monoculture forests of black pine (*Pinus thunbergii*) or red pine (*Pinus densiflora*) trees along the coast of the Sendai Plain and other disaster areas were almost completely destroyed (Photo 4), and some trees were carried inland by the second and third waves, extending the damage by bumping into people, houses and cars.

On the other hand, indigenous tree species of the *chinju-no-mori* in Minamisanriku Town and Otsuchi Town survived the disaster. Trees from the local potential natural vegetation (Tüxen 1956) on steep slopes, including *Persea thunbergii*, *Camellia japonica* and *Euonymus japonicus*, did not fall down, although the soil was washed away and their large roots were exposed (Photo 2, 5).

Forty years ago, at Kamaishi Steel Plant of Nippon Steel Corporation, we planted saplings of indigenous tree species in order to make quasi-natural forests, following an ecological method (Miyawaki 1973). Trees along the sea were cut down when they constructed a new harbor, but they left the forest further inland. After the Great Earthquake, trees of *Quercus myrsinaefolia* higher than 10 meters stood firmly (Photo 6), together with their young trees and other evergreen broad-leaved tree species, including *Camellia japonica* and *Euonymus japonicus*. The "real thing" endures severe conditions and holds out for a long time.

Turn crisis into chance

The Japanese Archipelago is rich in nature and very beautiful. At the same time it is prone to natural disasters, such as big earthquakes, tsunami, fires, typhoons and floods. The most important thing to do right now is to build native forests which survive thousands of years until the next glacial age arrives, in order to protect the life of the Japanese people (Miyawaki 2010, 2012) (Photo 7).

Our ancestors preserved and built *chinju-no-mori* when they constructed villages and towns. It is of great significance to build native *chinju-no-mori* of the 21st century by integrating this traditional Japanese knowledge and the results of the modern science of life and environment, "vegetation science" and "ecology". We propose implementation of this vegetation-ecological reforestation to people in various fields and ask for their cooperation.

Some say that towns affected by the great tsunami should relocate to higher ground. This may be only a desk theory. Looking back at human history, one can see that cities in Mesopotamia, Egypt and Greece, as well as modern large cities such as London, New York, Boston, Tokyo, Yokohama and Osaka, are located on the coast. Areas along the seaside or riverside are ecologically diverse and comfortable to live in. Of course these areas in Japan are small, because Japan is a mountainous country. Even if people move inland, some of them will go down near the sea 10–20 years later, and schools, shops and companies will also return in 30 years. Areas where people have lived over the generations are the most convenient places to live in. It would be best for them to survive there, whatever happens.

Remember, a natural disaster strikes when we lose the memory of the previous one, as Torahiko Terada (1878–1935), a famous Japanese physical scientist, once said. I would like to start to create native forests at once to save the lives of citizens.

Debris as an earth resource

Central and local governments have problems dealing with debris from the Great Earthquake. They are carrying it to many other communities to burn. It contains lots of wood, and CO_2 is emitted when it is burned, which contributes to global warming.

Poisonous materials in the debris should be removed. What can be used should be taken away to use. All that remains is an earth resource. According to our surveys, more than 90 % is woody debris from furniture or building materials plus concrete lumps from house foundations (Photo 8). These hold many memories of family history and victims.

I suggest creating native forests by utilizing the debris filled with memories of local people. We dig deep long

Photo 1

Photo 2

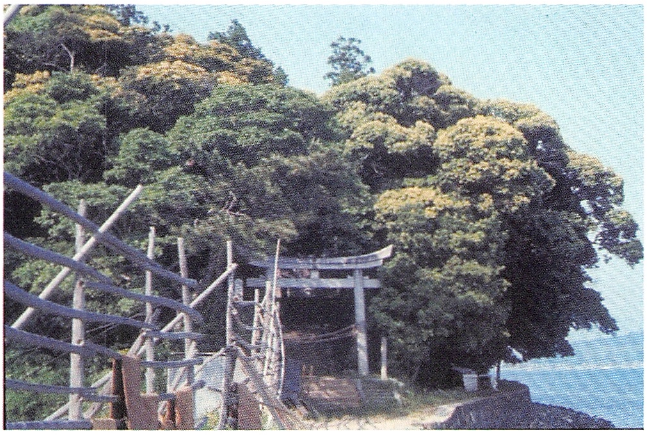

Photo 3

Photo 4

Photo 5

Photo 6

Photo 1–6: 1. Everything was destroyed due to the Great East Japan Earthquake and the tsunami that followed on March 11th, 2011. (Otsuchi Town, Iwate Pref.) (provided by Jiji Press). **2.** Root systems of *Persea thunbergii* which withstood the pressure of the Great Tsunami (Minamisanriku Town, Miyagi Pref.). **3.** Chinju-no-mori facing the Japan Sea. (Wakasa Bay, Fukui Pref.). **4.** Trees of black pine (*Pinus thunbergii*) and red pine (*P. densiflora*) fallen in the Great Tsunami (Sendai Plain). **5.** An old tree of *Persea thunbergii* of a small Chinju-no-mori survived in the Tsunami (Minamisanriku Town, Miyagi Pref.). **6.** Trees of evergreen Oak (*Quercus myrsinaefolia*) survived in the Great Tsunami. (Kamaishi Works, Nippon Steel Corp. (April, 2011).

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 7–12: 7. Environment-protection disaster-mitigation forest at Kimitsu Ironworks, Nippon Steel Corp., located on the shore of the Tokyo Bay. **8.** Disaster debris is an earth resource. After removing poisonous and indecomposable matters, debris should be used to make mounds for reforestation by mixing with soil. **9.** Scrap wood at the site of Eidai Brazil near Belén. This is an earth resource. **10.** Scrap wood was buried to make a plantation mound. **11.** Citizens planted saplings with delight at Belén, Brazil (1996). **12.** 10 years later tress formed a 12 meter high forest.

Photo 13

Photo 14

Photo 15

Photo 16

Photo 17

Photo 18

Photo 13–18: 13. The planting site near the main gate of the new campus of Yokohama National University. We made lattice work, added topsoil and planted saplings of indigenous tree species (1979). **14.** 20 years later, a 15 meter high quasi natural forest was formed in the campus. **15.** Yokohama City Sewage Plant located close to the sea Potted saplings planted on the mound built of construction debris and soil. **16.** Same place 2 years later. (Prof. K. Fujiwara and Prof. E. O. Box following up on the tree growth).**17.** About 10 years later, the trees grow to form a forest with a function of weakening the power of tidal waves and tsunami. **18.** Hirohata Works, Nippon Steel Corp., Hyogo Prefecture. A mound formed in the reforestation site.

Photo 19

Photo 20

Photo 21

Photo 22

Photo 23

Photo 24

Photo 19–24: 19. Same place 10 years later. **20.** Ohgishima Thermal Plant, Tokyo Electric Power Co. Saplings planted on the reclamation site in the Tokyo Bay. **21.** 10 years later an environment-protection disaster-mitigation forest was formed. **22.** Gobo Thermal Plant, Kansai Electric Power Co. (Head Office, Osaka). The site for plantation around the Thermal Plant on a man-made island. (March 1984, Wakayama Pref.). Potted saplings from the local potential natural vegetation, including *Persea thunbergii*, *Castanopsis cuspidata* var. *sieboldii*, and *Quercus glauca*, were planted mixed and densely here. **23.** Same place at present (Dec. 15 2012). A boundary environment protection forest with functions of disaster mitigation and tide prevention is formed. **24.** Inside of the forest of Photo 23.

Photo 25

Photo 26

Photo 27

Photo 28

Photo 29

Photo 30

Photo 25–30: 25. Teachers and students of Kitakami Junior High School in a disaster area planted saplings together in order to make a disaster-mitigation forest around the school ground. (May 2011). **26.** Trees are growing well (Oct. 2012). **27.** Planting event in Otsuchi Town, Iwate Pref. (April 2012). People of the town suffered devastating damages from the Great Tsunami. **28.** Right after planting (Otsuchi Town). **29.** Planting event in Iwanuma City, Miyagi Pref. (May 2012) Mr. Hosokawa (right), former Prime Minister, joined in planting. **30.** Saplings after mulch treatment (Iwanuma City).

Photo 31

Photo 32

Photo 31–32: 31. After 20–30 years planted saplings will grow to form a disaster-mitigation environment-protection forest like this. (A forest built up around Gobo Thermal Plant on a man-made island). **32.** Inside of a forest regenerated by the Miyawaki Method. (Kimitsu Ironworks, Nippon Steel Corp. refer photo 7).

trenches along the coast in disaster areas, put the debris and soil into these holes to make mounds (the higher, the better), and plant saplings of many main and companion tree species from the local potential natural vegetation. Mounds consisting of mixed soil and debris are well aerated, and trees grow well, because their roots also breathe under the ground (Miyawaki 2011, 2012).

The forests grown on the mounds will function as green embankments protecting life and property of local people from great tsunami. If all the debris is used up in building 100 m-wide 22 m-high mounds on the 300 km of affected coastline, then the debris accounts for no more than 4.8 % of the total amount of soil in the mounds (Fig. 1), according to calculations by a retired senior official from the Construction and Transport Ministry and others.

Poisonous materials must be removed from the debris. The law that requires incineration disposal of general waste, including household garbage, was enacted at the beginning of 1970s. However, burning is the easiest way ecologically.

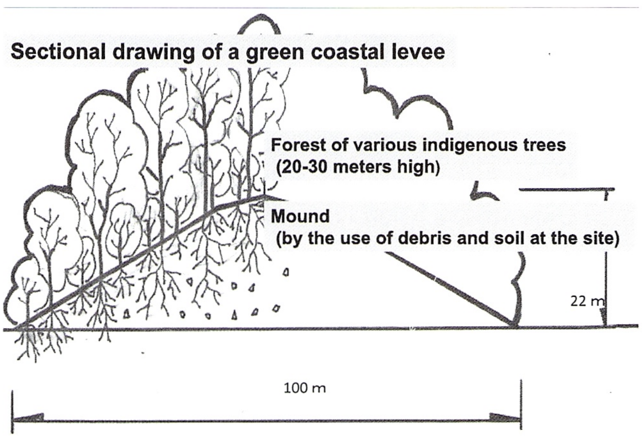

Fig. 1. Sectional drawing of a green coastal levee.

About 20 years ago, we already made plantation mounds by mixing wood refuse and soil as an experimental project at Belém, Brazilian Amazon. Trees planted on the mounds grew steadily, and now multi-stratal quasi-natural forests are formed (Miyawaki & Abe 2004) (Photo 9, 10, 11, 12).

Reforestation as national movement

Fortunately, former Prime Minister Morihiro Hosokawa (Photo 29, right person), who once joined in our reforestation project as the governor of Kumamoto Prefecture, Kyushu, cooperates actively in the implementation plan to build green embankments by utilizing the debris from the disaster areas.

We talked to the then Prime Minister Noda, as well as to former Minister Hirano of the Reconstruction Agency, and to former Minister Hosono for the Environment, about our proposal for making green embankments. They listened attentively but things have not gone forward, probably because the administrative system is too big and complex. In the meantime, debris, the useful earth resource, is being burned. It is quite effective to mix debris in order to aerate soil.

In our reforestation we do not use high-cost adult trees. We plant 30 cm tall saplings of the main and companion tree species from the local potential natural vegetation, which you can see surviving in *chinju-no-mori*. Saplings grow rapidly in mixed dense plantations based on the rule of natural forests.

The choice of native tree species to plant is most important. Monocultures of pine trees are weak in disaster prevention. As plants evolved, 300 million years ago was the age of the Pteridophytes (ferns and similar), which were buried in the earth during the next glacial age and became our present-day fossil fuels. Next was the time of the Gymnosperms, including cycads, ginkgos, and needle-leaved coniferous trees like *Cryptomeria japonica* and *Pinus* spp. Today is the age of the angiosperms (flowering plants) since about 150 million years ago.

Woody vegetation of angiosperms includes evergreen broad-leaved trees (laurel trees) with deep taproots, which grow in areas southwest of the Kanto District with the Tokyo metropolitan district up to 800 meters above sea level, and northward along the Pacific coast to around Kamaishi and Otshuchi of Iwate Prefecture, and even to southern Akita Prefecture on the Japan Sea coast. The main tree species in these areas are *Persea thunbergii, Quercus acuta, Q. salicina, Q. myrsinaefolia, Q. glauca,* and *Camellia japonica*, plus *Castanopsis cuspidata* var. *sieboldii* in southern areas i.e. phytosociologically Camellietea japonicae (Miyawaiki & Ohba 1963) region.

We choose these main tree species for ecological reforestation. To support the main tall trees, we also choose shorter trees and arborescent species, such as *Neolitsea sericea, Ilex integra, Myrica rubra, Dendropanax trifidus, Aucuba japonica, Fatsia japonica* and *Eurya japonica*. Along the coasts we plant tree species strong against salty winds such as *Pittosporum tobira, Rhaphiolepis umbellata* , *Eurya emarginata* and *Euonymus japonica*.

We spend six months to one year nursing potted seedlings of these tree species until their root systems are fully developed, and then plant the resulting saplings in dense mixes according to the rule of natural forests. After three years, weeding is unnecessary. By natural selection, the trees grow about 10 meters tall in 10 years, and 20 meters tall in 20 years, to form a disaster-preventing and environment-protection forest of native trees (Miyawaki 2012, Photo 7 and others).

Some actual cases are shown in Photos: I. Yokohama National University (Photo 13, 14). II. Yokohama City Sewage Plant close to seashore (Photo 15, 16, 179. III. Hirohata Works, Nippon Steel Corporation (Photo 18, 19). IV. Ohgishima Thermal Plant, Tokyo Electric Power Company (Photo 20, 21). V. Gobo Thermal Plant, Kansai Electric Power Company (Photo 22, 23, 24).

We plant three saplings per square meter. This means that 90 million potted saplings will be needed to build forests on the 300 km-long 100 m-wide mounds along the coasts of the disaster areas. Of course we cannot plant all at one time. We start where we can.

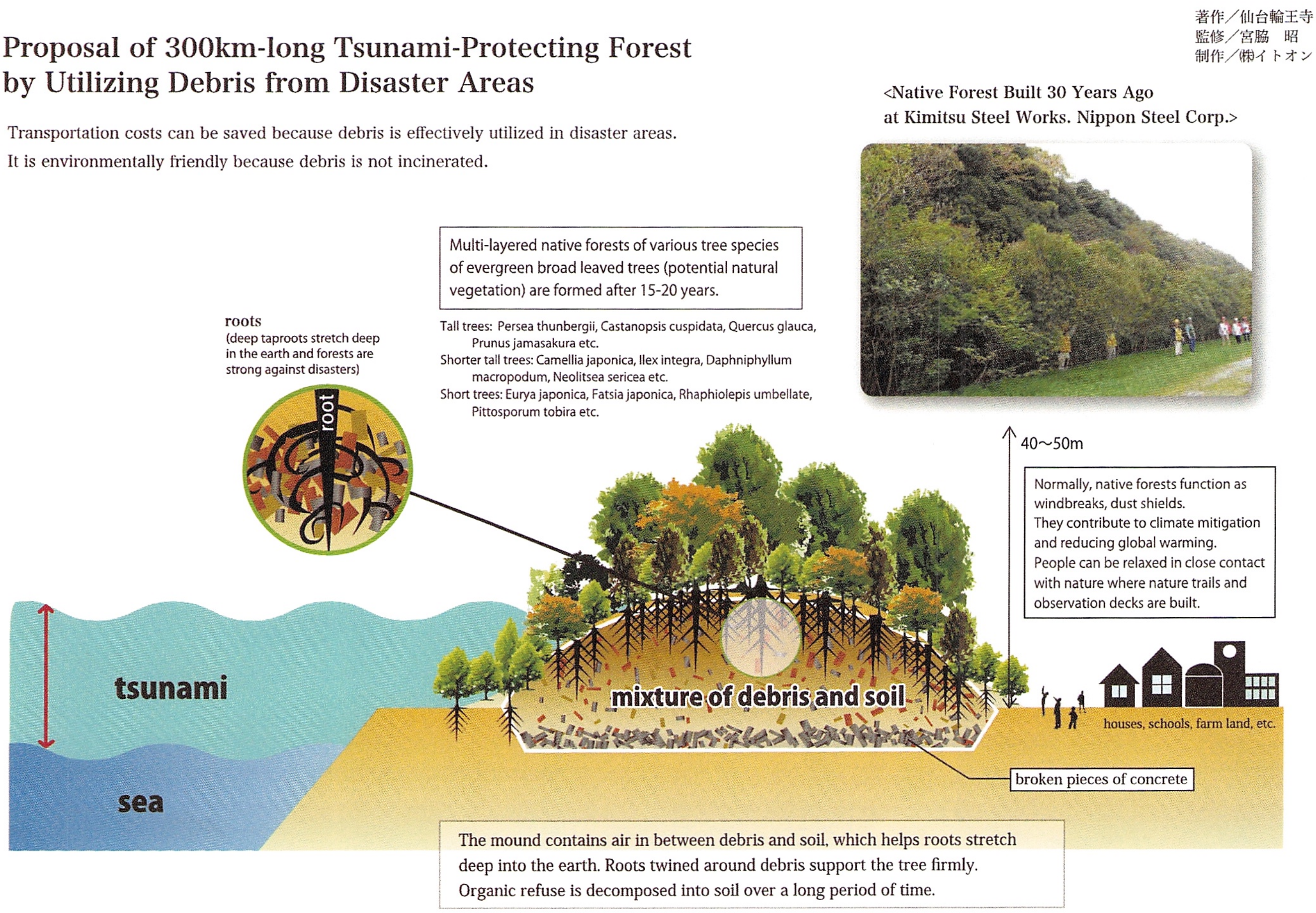

Fig. 2. Proposal of 300 km long tsunami-preventing forest levee (contributed by Rin-no-ji Temple, Sendai).

The first ecological planting in disaster areas, mixing debris with soil in a mound, was carried out at Kitakami Junior High School in Ishinomaki City, Miyagi Prefecture in May, 2011 (Photo 25, 26). Two months later, we also planted saplings of native tree species in Sendai, but in this project debris was not utilized. If the growth conditions compared, are compared the former is much better.

In 2012, planting festivals were held in Otsuchi Town (Photo 27, 28) and Iwanuma City (Photo 29, 30), governed by farsighted, decisive mayors. Volunteers from all over Japan planted saplings with the former Prime Minister, Mr. Hosokawa (Photo 29, right person). These saplings are now growing steadily, and 20-30 years later quasi-natural forests will be formed just like forests at Gobo Thermal Plant of Kansai Electric Co. and at Kimitsu Ironworks of Nippon Steel Corp. regenerated by using the Miyawaki Method (Photo 31, 32). Our hope is that the afforestation on embankments in disaster areas will spread as a government project and a national movement.

"Forests of Heisei" to the world

In the midst of Tokyo, there is a splendid dense laurel forest. This forest is located at Meiji Shrine which was built in 1920 to honor the Meiji Emperor who led Japan to become a modern nation after the long national isolation. The forest was built from around 1915 based on a grand design of people involved at that time to make an eternal forest on the premises. They chose native broadleaved tree species and planted 100,000 trees given from all over Japan. In 50 years a quasi-natural forest was formed. At present 170,000 trees of 245 species are growing in 700,000 m^2 (Miyawaki et al. 1980).

The Great Wall of Forests on the 300 km-long embankment in the disaster areas of Tohoku district protects the lives of local people (Fig. 2), gives learning opportunities and relaxation time to visitors from home and abroad, and provides a feature of the regional landscape. These forests coexist with the local economy through selective cutting and selling after 80–120 years, and will survive thousands of years through the replacement of individuals until the next glacial age comes. We would like to build Forests of 'Heisei', the Great Wall of Forests. Heisei represents the era of the present Emperor.

For 40 years I have been planting saplings of indigenous tree species at more than 1700 sites in Japan and overseas, with local people in cooperation with farsighted companies, governments and various other groups. At each site the saplings grew to form forests that save the lives of people.

I hope all of the Japanese people plant small saplings with their own hands in order to protect their own lives and those of their loved ones, and to preserve the lush verdure of Japan. I wish to spread the know-how and the results of this ecological reforestation to the whole world.

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