

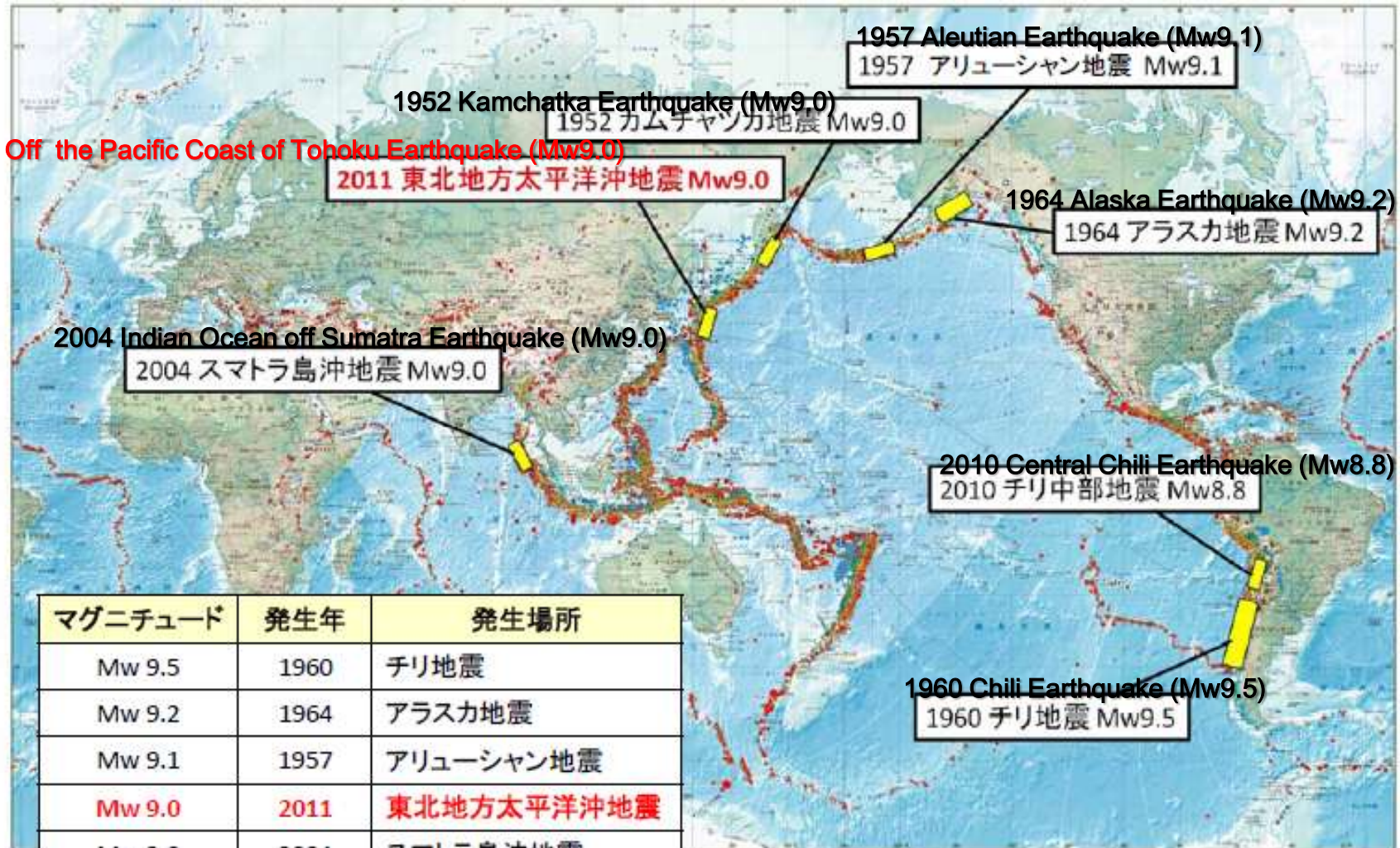
# **Recovery Efforts for Coastal Disaster-Prevention Forest from the Great East Japan Earthquake**

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## Mega-Earthquake of the world

2011 Off the Pacific Coast of Tohoku Earthquake (Mw9.0)



マグニチュード	発生年	発生場所
Mw 9.5	1960	チリ地震
Mw 9.2	1964	アラスカ地震
Mw 9.1	1957	アリューシャン地震
<b>Mw 9.0</b>	<b>2011</b>	<b>東北地方太平洋沖地震</b>
Mw 9.0	2004	スマトラ島沖地震
Mw 9.0	1952	カムチャッカ地震

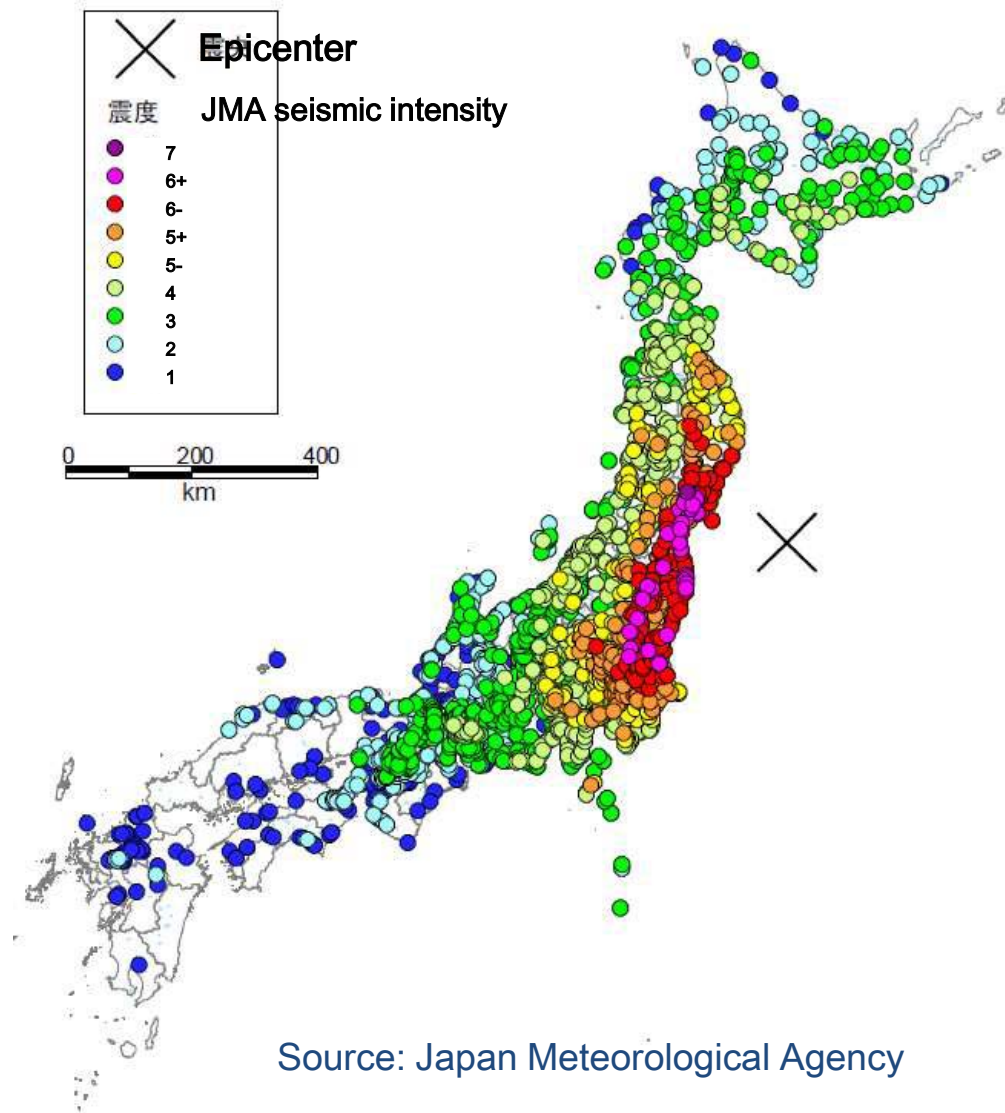
出典: 東京大学地震研究所 2011年3月東北地方太平洋沖地震 特集サイトをもとに作成  
 (http://outreach.erl.u-tokyo.ac.jp/wordpress/wp-content/uploads/2011/03/WorldLargestEQ\_v4.jpg)

# The Great East Japan Earthquake & Tsunami : Outline ②

## Distribution of Seismic Intensity

- Date and Time:  
March 11, 2011 (14:46 JST)
- Epicenter:  
Off the Sanriku Coast  
N 38.0  
E 142.9  
Depth: 24 km
- Magnitude:  
Mw: 9.0
- JMA seismic intensity at major locations:

Aomori,	Hachinohe:	5-
Iwate,	Miyako:	5-
	Kamaishi	6-
	Kesennuma:	6-
Miyagi,	Kurihara:	7
	Shiogama:	6+
	Higashimatsushima:	6+
	Sendai:	6-
Fukushima,	Minamisoma:	6-
	Tomioka:	6+

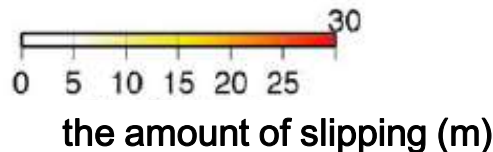


Source: Japan Meteorological Agency

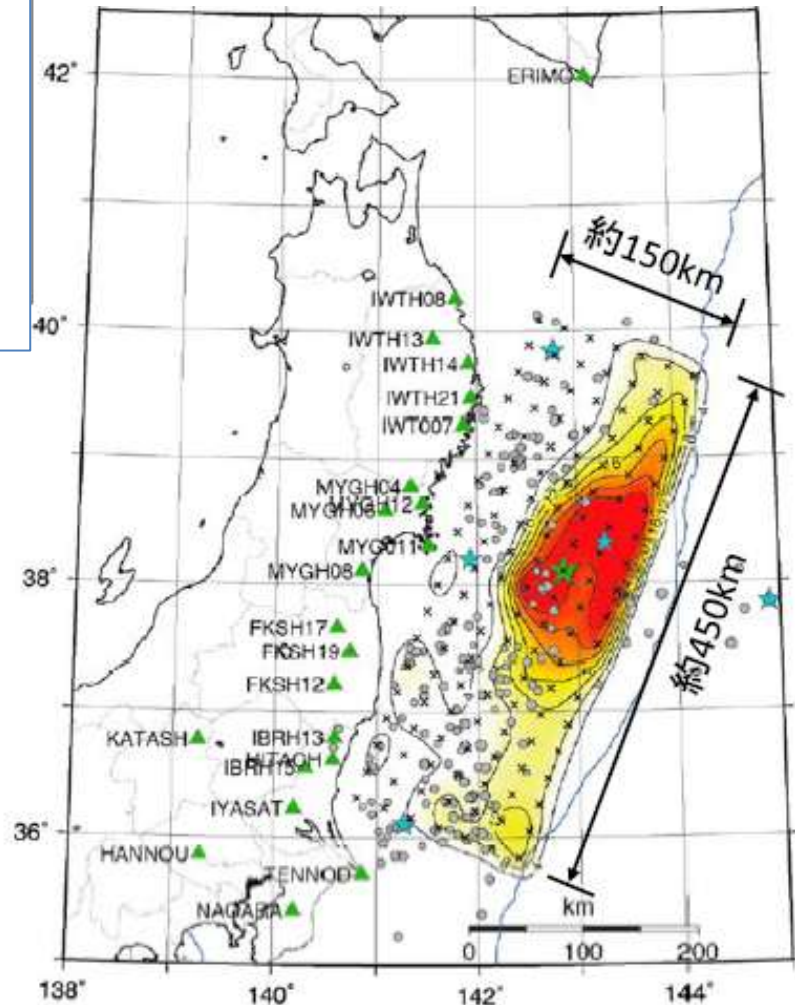
## Slipping Distribution of Faults

- ◆ Maximum amount of slipping; approximately 30m
- ◆ Length × Width of major faults; 450km × 150km
- ◆ Fault rapture duration; approximately 170 seconds
- ◆ Intermittent aftershocks occurred the range of wide slipping point

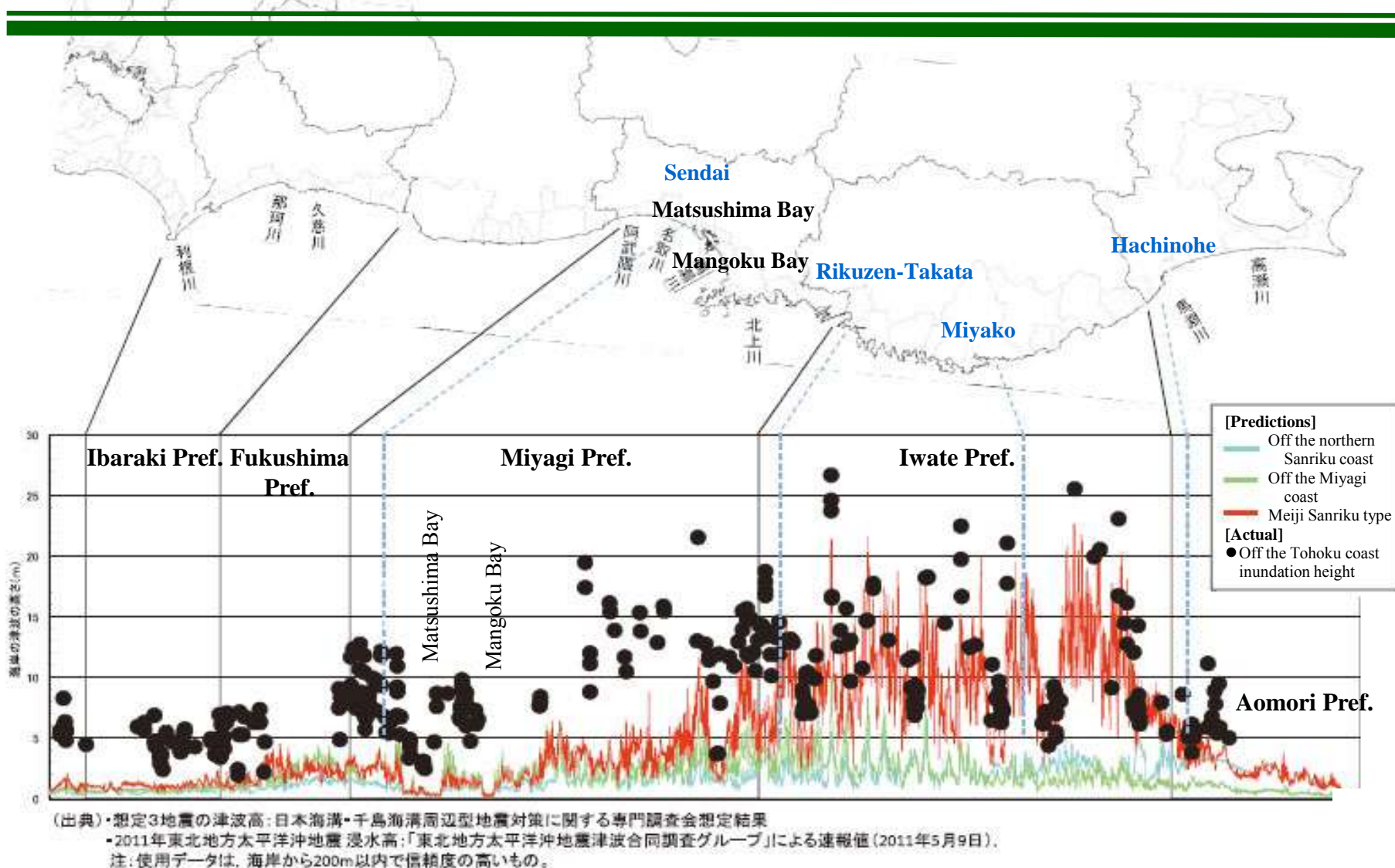
- ★ Starting point of main shock
- ★ Epicenter (Mw7.0+) occurred after March 9th
- Epicenter (Mw>5) within a day from main shock
- × Center of small faults
- ▲ Observation point



### Slipping Distribution of Faults



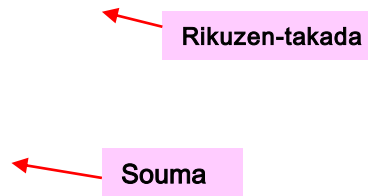
## Height of Tsunami



# The Great East Japan Earthquake & Tsunami : Outline ⑤

## Situation of Earthquake Tectonic Deformation

Deformation caused by the main earthquake (M=9.0)  
Variation diagram (vertical variation)



- Extraordinary deformation of maximum ; 5.3 m (horizontally) and 1.2 m (vertically)
- Southern part of Sanriku Coast (ex. Rikuzen-takada) shows extensive vertical variation, though, not so extensive around Sendai bay area (ex. Souma)

## Situation of Damage

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### ➤ human suffering

(a) dead	15,882 people
(b) missing	2,668 people
(c) injured	6,142 people

### ➤ Building damage

(a) complete collapse	128,803 building/house
(b) half collapse	269,821 building/ house
(c) partial collapse	739,816 building/house

( As of March 26<sup>th</sup>, 2013)

# Situation of damage of coastal disaster-prevention forest ①

Pre-disaster (2005@ Iwanuma-city)



Post-disaster (2011)





# Situation of damage of coastal disaster-prevention forest ②

- ✓ Damage to the coastal disaster-prevention forest by tsunami found to be depend on condition of its location
- ✓ Damage to forest could be mainly categorized into “Trunk broken”, “toppling”, “tilting”



“Damaged coastal disaster-prevention forest and wreckage”, Hachinohe city, Aomori



“Trunk Broken” , Noda village, Iwate



“Toppling” , Sendai city, Miyagi



“Tilting” , Natori city, Miyagi

# Coastal disaster-prevention forest for the livelihood of local people

- ✓ Since old time, coastal disaster- prevention forest has been developed and conserved for its salt, wind, blown sand damage prevention as well as Tsunami disaster prevention effects and has played an important role for community's daily life.
- ✓ In addition, coastal disaster-Prevention forest has provided us precious space for relaxation, and beautiful scenery such as, so called, "Coastline with White Sand and Green Pine".

## *the Three Major Coastal Disaster-Prevention Forest*



**Miho-no-Matsubara**  
(Shizuoka-city, Shizuoka)



**Kehi-no-Matsubara**  
(Tsuruga-city, Fukui)



**Niji-no-Matsubara**  
(Karatsu-city, Saga)

## *Example of recovering coastal disaster-prevention forest*

- From early Meiji-period to early Showa-period, natural forest, mainly consist of Kashiwa-oak (*Quercus dentata*) around Erimo-cape were completely cut down as fuel for fisheries etc. and area were called "Erimo Desert" since then.
- For this reason, a large amount of red soil was run off to the sea, which had become serious problems for fisheries industry, especially kelp fishing.
- To retrieve rich and varied sea, the project for greening devastated area were launched on 1953 collaborating with National forestry office and residence.
- Approximately 15 years after the launch of project, around on 1967, more than 150 ha of forest has been recovered.



# Situation of damage of coastal disaster-prevention forest / Effect of coastal disaster-prevention forest on the tsunami by the Great East Japan Earthquake

## Effect on tsunami energy attenuation, capture of floating objects, retardation.

- ✓ Coastal disaster-prevention forest belt which were not destroyed and blocked flowing of boats and ships, concrete debris, or drifting objects etc. thus the damage to buildings or houses were mitigated.
- ✓ According to the result of simulation survey and analysis, the degree of effect of tsunami energy attenuation is depend on the width of coastal disaster-prevention forest belt - 200m width costal forest can reduce 30% of fluid force.

## Significant damage; Approximately 140km of coastal disaster- prevention forest (Aomori ~ Chiba)

- ✓ Where the soil depth was limited and/or the groundwater level was high, the tree root system had not developed enough to keep tree root bearing capacity, thus there shows many cases that trees tipped over from the roots.
- ✓ The result of field investigation shows that the coastal tree which could survive from tsunami ware growing on the ground whose soil layer depth above groundwater level was 3m or above.

### Effect of coastal disaster-prevention forest on Tsunami



Hachinohe-city, Aomori



Iwaki-city, Fukushima

### Situation of damage of coastal disaster-prevention forest



Pre-disaster (2005)

Post-disaster (2011)

Coast along Iwanuma city, Miyagi



Noda-village, Iwate



Sendai-city, Miyagi



Natori-city, Miyagi

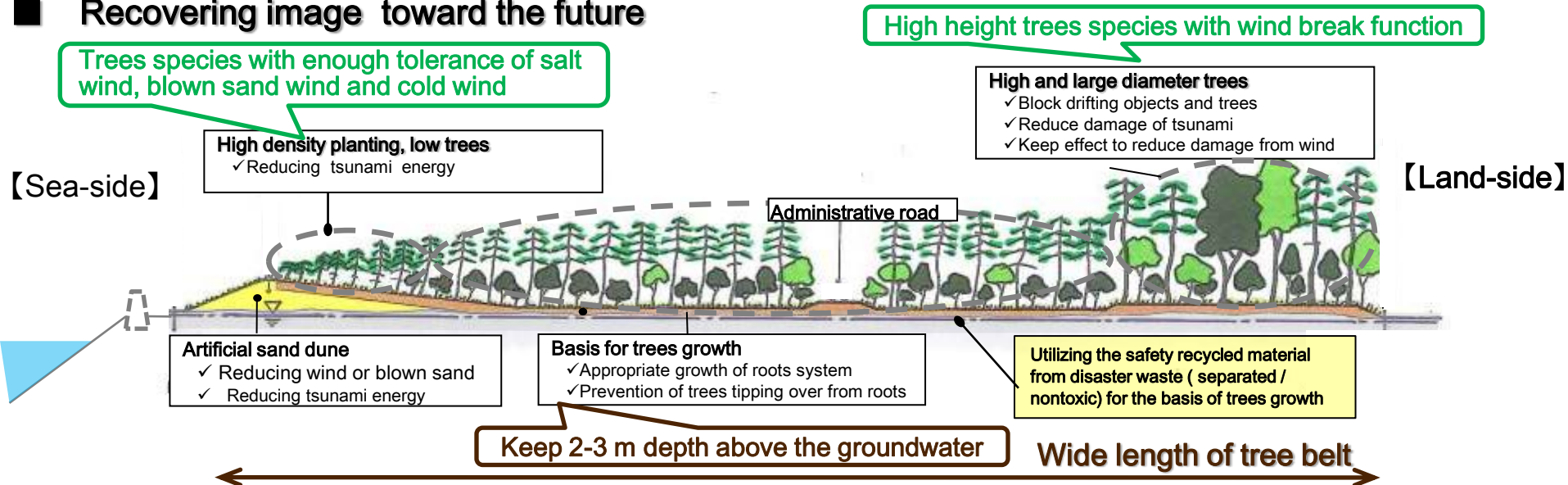
# Recovering for coastal disaster-prevention forest for the Future

- ❑ Experts meeting - Committee on early recovery for the coastal disaster-prevention forest related to "the Great East Japan Earthquake" (Chairman; Dr. Takehiko, Ohta (professor emeritus at University of Tokyo))- toward early recovering for the coastal disaster-prevention forest was established by Forest agency, Japan.
- ❑ Experts' meeting was held for 5 times from May, 2011 to January 2012.
- ❑ From technical point of views, the final report regarding to recovery for the coastal disaster-prevention forest was completed.
- ❑ Following technical points such as ---
  - necessity to ensure enough width of forest belt,
  - importance of constriction of basis for trees growth ground to keep healthy planting tree growth,
  - effectiveness for tree planting with a wide variety of species etc...are recommended on the final report.

## Basic principles for recovering the coastal disaster-prevention forest

- To ensure the disaster prevention capacity for local districts, not only disaster prevention function such as blown sand damage or wind related disaster prevention but also disaster mitigation function against tsunami as "multi-layer protection" should be considered for recovering the coastal disaster-prevention forest.
- Specifically, the process for recovering should be decided for each disaster affected area on the basis for the degree of disaster damage, various situation of local district, and furthermore, necessity of protection for local biodiversity and so on.

## Recovering image toward the future

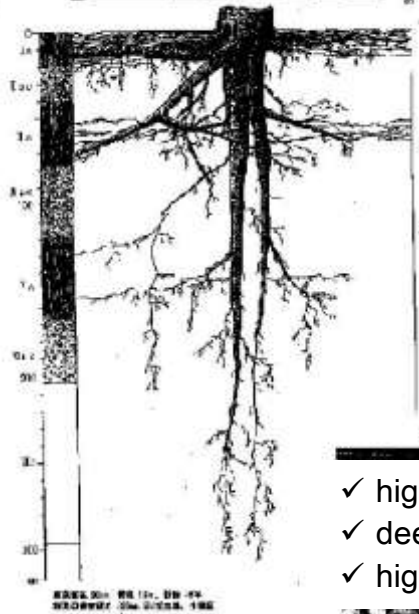


# Root system of Typical Tree Species

According to Dr. Noboru KARIZUMI who surveyed 473 kinds of forest root system, the typical root system of Japanese tree species are as illustrated below.

## Root system of typical softwood

### ● Japanese black pine

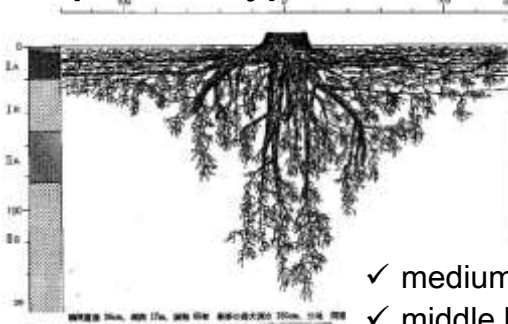


\*.H.D; breast-height diameter  
\*M.D.R.S; Maximum depth of root system

B.H.D : 30cm  
H : 16m  
AoT : 45  
M.D.R.S : 330cm

- ✓ high- salt - resistance
- ✓ deep length rooted tree
- ✓ high bearing resistance

### ● Japanese cypress

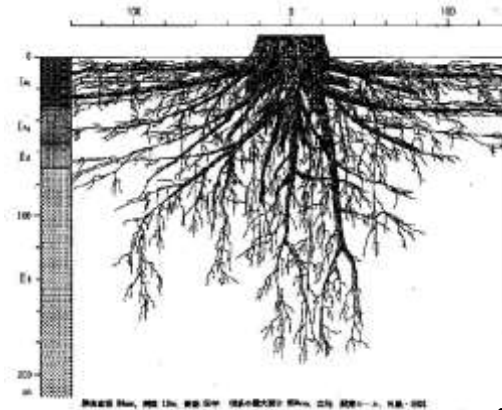


B.H.D : 36cm  
H : 17m  
AoT : 65  
M.D.R.S : 150cm

- ✓ medium- salt - resistance
- ✓ middle length rooted tree
- ✓ medium bearing resistance

## Root system of typical hardwood

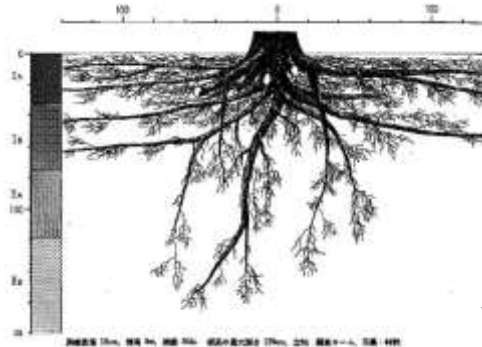
### ● Persea thunbergii



B.H.D : 26cm  
H : 12m  
AoT : 50  
M.D.R.S : 210cm

- ✓ high- salt - resistance
- ✓ middle length rooted tree
- ✓ high bearing resistance

### ● Neolitsea sericea



B.H.D : 16cm  
H : 8m  
AoT : 35  
M.D.R.S : 170cm

- ✓ high- salt - resistance
- ✓ middle length rooted tree
- ✓ low bearing resistance

# Major tree species for reconstruction work for coastal disaster-prevention forest

- Coastal disaster-prevention forest has an important role such as salt, wind, blown sand damage prevention.
- In general, the location of environment of coastal disaster-prevention forest developing area is strictly severe, selecting the planting tree species with enough tolerance of salt wind, blown sand wind and cold wind are indispensable condition.

## Typical tree species for the coastal disaster-prevention forest

- ◇ Typical tree species for the coastal disaster-prevention forest are as follows....
  - Softwood : Japanese black pine, Japanese red pine, etc
  - Hardwood : Quercus dentata, cheesewood, Machilus thunbergii, Quercus serrata, Acer mono etc.



## Tree planting condition on sea/land side of recovering the coastal disaster-prevention forest

- ◇ Tree planting condition on sea/land side of recovering the coastal disaster-prevention forest are as follows....
  - Sea-Side; tree species with high tolerance of blown sand, salt wind, and cold wind
  - Land-side; enough tree height to keep/strength the function of windbreak for local area or facilities etc

## Example for planting tree for each area (sea-side / land-side)

		Sea-side		Center		Land-side	
		Upper-layer of forest	Lowe-layer of forest	Upper-layer of forest	Lowe-layer of forest	Upper-layer of forest	Lowe-layer of forest
Softwood		Japanese black pine Japanese red pine		Japanese black pine Japanese red pine		Japanese black pine Japanese red pine	
Hardwood				Machilus thunbergii Celtis sinensis Neolitsea sericea Alnus japonica	Elaeagnus umbellata cheesewood Quercus dentata Rosa rugosa Rhaphiolepis umbellata Camellia japonica Ligustrum japonicum	Machilus thunbergii Celtis sinensis Neolitsea sericea Zelkova serrata Quercus serrata Acer mono	Elaeagnus umbellata cheesewood Quercus dentata Rosa rugosa Rhaphiolepis umbellata Camellia japonica Ligustrum japonicum

# Toward recovering for coastal disaster-prevention forest

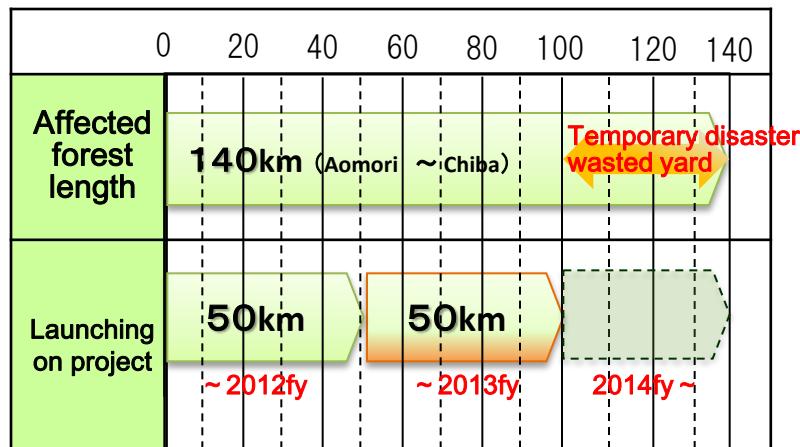
- To promote the project of recovering the Coastal Disaster-Prevention Forest utilizing disaster waste which is the basis for reconstruction for disaster affected area was named "Greenery relating Bond Renaissance Projects -Midori no Kizuna Saisei Project-".
- It means bond between disaster affected area and supporters, among disaster affected people, the present generation and the future generation, human beings and nature, etc. through recovering disaster-prevention of forest along the coast.
- It is scheduled to advance the procedure from the part where the preparation is completed one by one, and to start the restoration of the coastal disaster-prevention forest of approximately 100km length by the end of current fiscal year among the disaster affected costal forest extension approximately 140km length.
- Forest Agency of Japan set a roadmap for reconstruction for costal disaster- prevention forest, that is, constriction of basis ground for planting trees growth is completed within 5 years after the Great East Japan Earthquake of March 11, 2011, then, total project including tree planting is completed within 10 years.
- The basis of trees growth is constructed utilizing the safety recycled material from disaster waste ( separated / nontoxic).
- Trees in some sites are planted by the cooperation of NPOs or private organizations taking into consideration a natural condition in the region etc.



# Current state of recovering for coastal disaster-prevention forest

- Approximately 140km length (from Aomori to Chiba) of coastal disaster-prevention forest was affected.
- Coastal levee, the basis of trees growth, and tree-itself were affected serious damage.
- Recovering target; launch the recovering project approximately 100km lengths till 2013 of fiscal year
- Utilize the safety recycled material from disaster waste ( separated / nontoxic) for the basis of trees growth
- Tree planting from the cooperation of NPO or private organizations taking into consideration a natural condition in the region etc.

## ■ Current state of recovering



※Above schedule may be changed depend on circumstance.

It is scheduled to advance the procedure from the part where the preparation is completed one by one, and to start the restoration of the coastal disaster-prevention forest on all disaster affected area except for the area utilizing for temporary disaster wasted yard approximately 100km length by the end of current fiscal year among the disaster affected costal forest extension approximately 140km length.

### 【Roadmap for recovering for coastal disaster-prevention forest】

- ✓ Constriction of basis ground for planting trees growth is completed within 5 years after the Great East Japan Earthquake.
- ✓ Total project including tree planting is completed within 10 years.

## ■ Example of recovering project

### Miyako-city, Iwate

Recovering of basis for trees growth had completed utilizing the recycled material from disaster waste (tsunami deposit) which were verified safety.



Tsunami deposit introduced into project-site

### Sendai-city, Miyagi

As for the affected costal disaster-prevention forest from Sendai-city to Yamamoto-chou, the recovering project has been proceeding under Forest Agency's project.



Recovering of basis for tree growth

### Iwaki-city, Fukushima

Costal levee and costal disaster-prevention forest were damaged in this area. Tree-planting was done by local residents and citizen volunteer



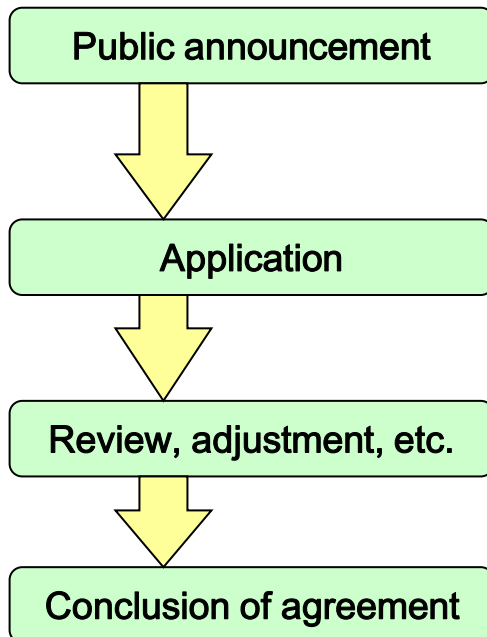
Japanese black pine tree planting by local residence



# Collaboration with NPOs and Private Sector Corporations

- In National forest area, trees planting by NGOs or private corporations / organizations who want to do tree planting and maintenance activities will be planned at a part of area where basis for tree growth construction is completed.
- Standard procedure for participation is “public offering” and “conclusion of agreement with participants”.
- Procedures for public offering are as follows...
  - public announcement including area, requirement for applicants for public offering
  - considering the activities plan and implementation system into account, NGOs or private organizations are chosen from a standpoint of equality and technicality
- As for cooperation procedure for private or local government forest should be decided on the basis of land owner’s intents or requests

## ■ Flow chart for conclusion of agreement with NGOs’ etc.



### ■ Items and content of agreement

- ✓ Area
- ✓ Content of activities
- ✓ Duration of agreement
- ✓ Burden of expense
- ✓ Requirement etc.

※Above flow chart is procedure of “National forest”. As for cooperation procedure for private or local government forest, it should be decided on the basis of land owner’s intents or requests .

# Conclusion of agreement for tree-planting activities at Arahama District national forests with NGOs/Private-sector corporations

- On November, 2012, Tohoku Regional Forest Office invited the NPOs or private organizations to offer participants for planting tree on the national forest area at Arahama, Sendai-city for planting on next coming spring.
- Total 14 NGOs or private organizations whose plan documents were passed have concluded agreements with Tohoku Regional Forest Office, then stated tree-planting from the beginning of last April to the beginning of June in 2013.
- Offering participants for planting trees at recovering the costal disaster-prevention forest area is planning for next year or beyond in consideration of the progress state of the recovering constriction of basis ground for planting tree growth or requests from private organizations etc.

## Location



## Plan map



## NGOs/private organizations

- ① Yuurin -aigo-kai (0.2ha)
- ② Midori-Jyujigun (0.11ha)
- ③ Banri-no- matsubara-ni-Hitashimu-kai (0.11ha)
- ④ Sendaishi- shinrin-adviser-no-kai (0.1ha)
- ⑤ Moritono-kyousei-wo-kangaeru-kai (0.13ha)
- ⑥ Nihon-no-moriwo-mamoru-kai (0.15ha)
- ⑦ Sanriku-morino-kai (0.12ha)
- ⑧ Meiji consaltant L.T.D (0.1ha)
- ⑨ Midorino-moriwo-sodateru-Miyagiken-rengou-kaigi (0.12ha)
- ⑩ Moribito-Project-iinkai-michinoku-jimusyo (0.02ha)
- ⑪ Garekiwo-ikasu-morino-Cyoujyou-project (0.1ha)
- ⑫ Daiichi-hukkou-kyouryoku-kai (0.1ha)
- ⑬ Homac L.T.D (0.18ha)
- ⑭ Nihon-yuugikannrenn-jigyou-kyoukai (0.17ha)

# Tree planting activities in collaboration with NPOs and private sector corporations -Arahama district National Forests, Sendai, Miyagi -

## ①Yuririn-Aigokai



100 members or participants planted Japanese black pine

Japanese black pine, quercus serrata, Japanese Cherry Prunus serrulata were planted

## ②Nihon no mori wo mamoru chihouginkou yuushi no kai



H25.5.18撮影

50 members planted Japanese black pine, apanese Cherry Prunus serrulata



400 volunteeer participants planted Persea thunbergii, oak etc under the guidance of Dr.Miyawaki



## ③Gareki wo ikasu mori no choujyou project

## ④Banri no matubara ni hitashimu kai