Chapter 5 Reconstruction of Homes and Cities

Section 12 Afforestation and forestry facilities

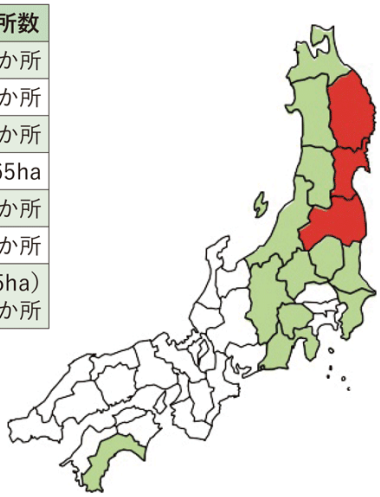
1. Overview of damage

Damage occurred in 15 prefectures from Aomori to Kochi, including forest land devastation such as hillside collapses and landslides (458 locations), damage to afforestation facilities such as seawalls by the tsunami (275 locations), damage to forest road facilities such as the collapse of road slopes and shoulders (2,632 locations), and forest damage such as burning out due to fire (1,065 ha).

In the six prefectures of Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba in particular, coastal disaster prevention forests of approximately 1,718 ha in 253 locations were damaged by the tsunami, and many trees were flattened and swept away. Even in inland areas that escaped damage from the tsunami, many hillside collapses and landslides occurred due to the earthquake. Earthquakes and aftershocks continued to occur after March 11, 2011, and the scale of the disaster increased.

Figure 5-12-1 Forest land-related damage caused by the Great East Japan Earthquake

被害の内容	被害箇所数
林地荒廃	458か所
治山施設	275か所
林道施設等	2,632か所
森林被害	1,065ha
木材加工流通施設	115か所
特用林産施設等	476か所
合　　計	(1,065ha) 3,956か所



注１：着色部は震災による林野関係の被害が確認された県(15県)。
■は特に被害が甚大であった３県。
２：被害箇所数は平成23(2011)年に報告された数値。
資料：林野庁調べ(平成23(2011)年時点)。

Source) Annual Report on Forest and Forestry in Japan Fiscal Year 2020, Chapter V, 1. (3) Damage to Forests and Restoration and Reconstruction
https://www.rinya.maff.go.jp/j/kikaku/hakusyo/R2hakusyo/attach/pdf/zenbun-67.pdf (browsed July 31, 2023)

In the Great East Japan Earthquake, high tsunamis were observed along the Pacific coast from Aomori Prefecture to Chiba Prefecture, including a tsunami of 8.5 m or more at a tide gauge station in Miyako City, Iwate Prefecture. The tsunami run-up height was over 20 m in small valleys on the Sanriku coast and reached about 10 m in inland bays such as Matsushima Bay and plains such as Sendai Plain.

Flood damage due to these tsunamis in coastal forests in the prefectures of Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba extended over 3,660 hectares, and as a result of analyzing the state of outflow, submergence and lodging using aerial photographs, etc., it was found that about 30% of coastal forest was in the damage ratio category of “75% or more” and little more than 20% of coastal forest was in the damage ratio category of “25 to 75%,” indicating that these tsunamis caused unprecedented damage.

The “Future Regeneration of Coastal Disaster Prevention Forests” compiled by the “Study Group on the Regeneration of Coastal Disaster Prevention Forests Relating to the Great East Japan Earthquake” in February 2012 reports on the state of damage to coastal disaster prevention forests, their disaster prevention effects, the policy on their regeneration, etc. This report states that it was confirmed by a survey of damaged coastal disaster prevention

forests that in locations with low ground height and high groundwater levels, many trees had turned into driftwood because their roots did not extend deep into the ground and their binding strength was weak so they were uprooted. It was also reported that, depending on the location, although trees were not uprooted due to the strong binding force of their roots, the trunks could not withstand the flowing force of the tsunami and were broken off and washed away.

2. Emergency recovery

In Mishima National Forest in Kesennuma City, Miyagi Prefecture, afforestation facilities such as seawalls were washed away and the ground subsided due to the Great East Japan Earthquake, and the danger of flood damage due to high tides and waves occurred. Because of this, the Tohoku Regional Forest Office carried out emergency construction in June 2011, installing large sandbags across a distance of 917 m.

Furthermore, in response to a request from Miyagi Prefecture, the Tohoku Regional Forest Office carried out emergency construction in August 2011, installing large sandbags across a total distance of 539 m in privately-owned forests at places such as Oisehama Beach in Kesennuma City.

Figure 5-12-2 Emergency construction using large sandbags

Source) Annual Report on Forest and Forestry in Japan Fiscal Year 2011, Chapter VI, 2. (1) Management Aimed at Maintaining and Enhancing Public Interest Functions, Case VI-2
https://www.rinya.maff.go.jp/j/kikaku/hakusyo/23hakusyo/pdf/honbun6-2.pdf (browsed July 31, 2023)

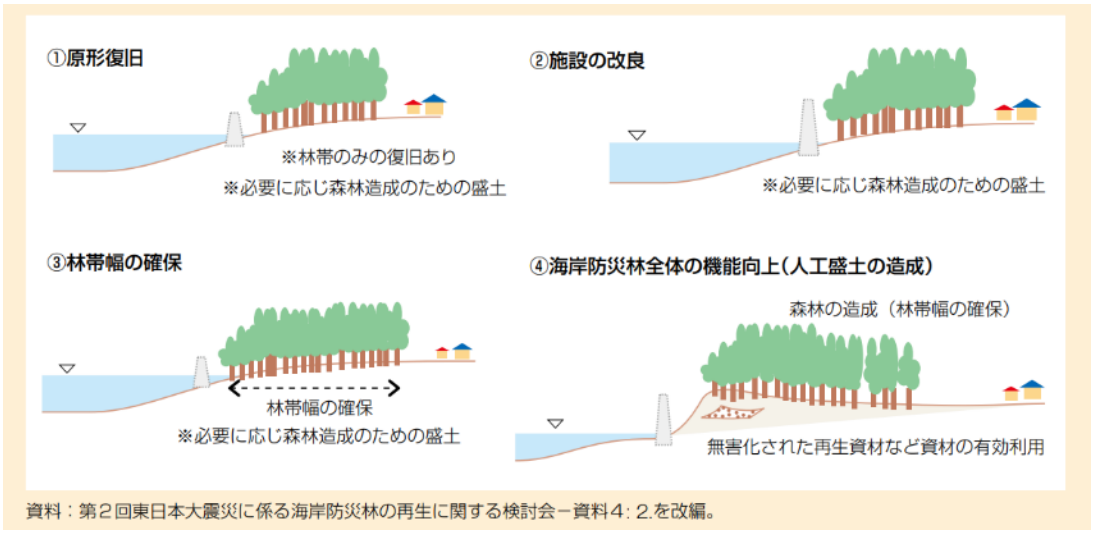
3. Recovering and reconstructing

(1) Development policy based on the Great East Japan Earthquake

The Forestry Agency has held meetings of the "Study Group on the Regeneration of Coastal Disaster Prevention Forests Relating to the Great East Japan Earthquake" consisting of academic experts and others since May 2011, aimed at grasping the state of damage of coastal disaster prevention forests, verifying their effects and examining restoration methods. In February 2012, the Study Group compiled the "Future Regeneration of Coastal Disaster Prevention Forests" and presented a policy for the future regeneration of coastal disaster prevention forests.

After organizing the state of damage of coastal disaster prevention forests and their effects against tsunamis, the policy states that although coastal disaster prevention forests cannot stave off tsunamis completely themselves, they can be positioned as one of multiple defenses from the perspective of community development because damage reduction effects can be seen, such as the attenuation of tsunami energy and a floating debris capture effect. As for the direction of restoration of coastal disaster prevention forests, the Study Group presented four patterns: "restoration to original form" or "improvement of facilities," mainly in places where forest belts were narrow or where only facilities were damaged, and "securing the width of forest belts" or "functional improvement of the coastal disaster prevention forest overall," mainly in places where the width of forest belts could be secured. Based on the above, it was decided to improve the functions of coastal disaster prevention forests by securing the width of forest belts and creating growth base embankments in accordance with the state of damage and actual conditions of the area, and to work on the restoration and regeneration of coastal disaster prevention forests that demonstrate functions such as protection against tsunamis, tide damage, flying sand and wind damage, while considering regeneration methods in accordance with the need for conservation of the area's ecosystem.

Figure 5-12-3 Direction of regeneration of coastal disaster prevention forests



Source) Annual Report on Forest and Forestry in Japan Fiscal Year 2011, Chapter I, 3.(2) Contributions of Forest, and the Forestry and Wood Industries to Reconstruction
https://www.rinya.maff.go.jp/j/kikaku/hakusyo/23hakusyo/pdf/honbun1-3.pdf (browsed July 31, 2023)

(2) A coastal disaster prevention forest project (the example of the Sendai Bay coast)

The Sendai Bay coastal disaster prevention forest is one where adjacent private and national forests worked together to exhibit disaster prevention functions. Many coastal disaster prevention forests suffered catastrophic damage due to the tsunami caused by the Great East Japan Earthquake, but the effects of attenuation of tsunami energy, the capture of floating debris, and the delay of arrival time have been confirmed. In the restoration of fallen coastal disaster prevention forests, in addition to the restoration of the disaster prevention functions that were lost, the restoration of forest belts with stronger tsunami damage reduction functions than before was required, and it was necessary to secure sufficient forest belt width and establish growth base to enable the growth of healthy root systems that are difficult to uproot.

On the other hand, the Sendai Bay coastal disaster prevention forest is a vast one of about 1,100 ha, and the restoration project, from the development of growth base to planting, was expected to be of unprecedented scale. Because of that, the governor of Miyagi Prefecture requested strongly that the restoration of privately-owned forests be carried out as a directly-controlled project of the national government. Having received this request while early recovery from the large disaster was required, the Tohoku Regional Forest Office decided to aim for early completion of the project by restoring private and national forests in an integrated manner. In addition, it was decided to establish the new Coastal Disaster Prevention Forest Restoration Office in Sendai District Forest Office as a dedicated organization to execute this restoration project and aim for its smooth promotion.

In the implementation of the project, a basic policy for restoration was compiled together with the formulation of the overall plan, with the basic policy being to restore the width of both private and national forest belts to what it was before the disaster, to restore their previous functions and to construct growth base embankments for improvement of the tsunami damage reduction function.

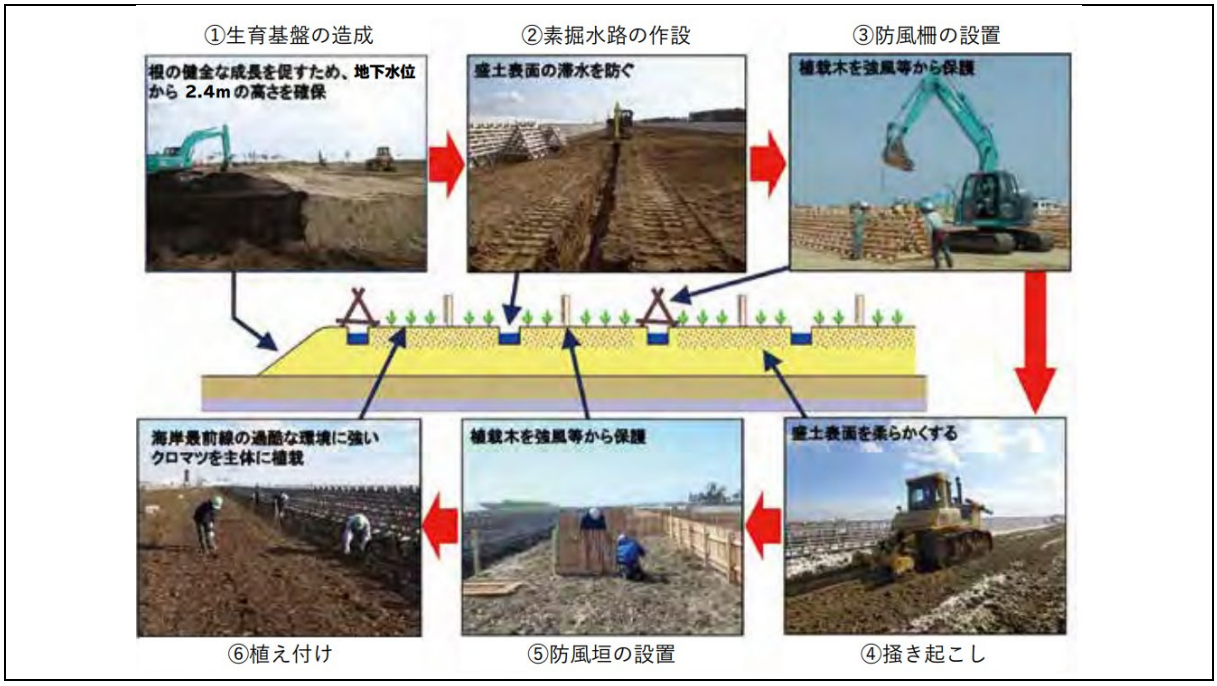
On the other hand, biodiversity conservation measures were also carried out together, such as avoiding embankments, to protect the habitats of flora and fauna confirmed during the project execution phase as much as possible. Meetings of a Review Committee were held to work on conservation while making adjustments to the project, including incorporating the opinions of academic experts and related institutions. In addition, monitoring surveys were carried out throughout the project implementation period after carrying out conservation measures.

During the restoration of the coastal disaster prevention forest, it was decided to plant trees after constructing growth base embankments based on the restoration basic policy, but various issues became clear at the construction

stage, and the construction of growth base embankments with little prior technical accumulation, in particular, was a repetition of trial and error.

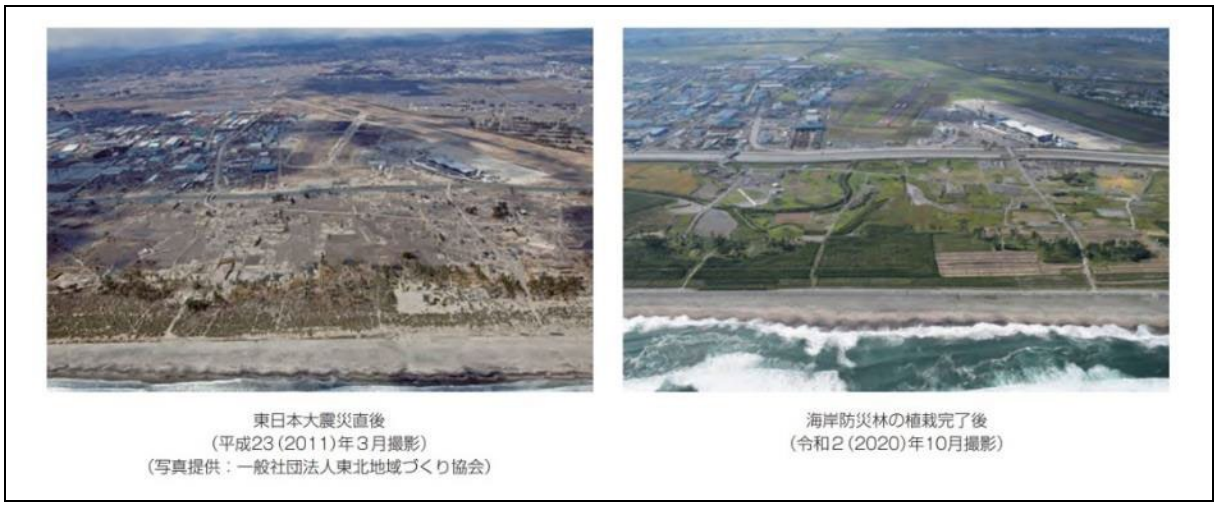
The infrastructure development on this project, such as the construction of growth base embankments was carried out by the directly-controlled project for the recovery from damage of afforestation facilities, and was completed in all locations from FY2012 to FY2018. In addition, work such as planting and the installation of windbreak facilities was implemented by the directly controlled afforestation project, and was started successively in locations where the development of infrastructure was completed, with planting completed in all locations by FY2019. In FY2020, nurturing management including supplementary planting and the renovation of windbreak facilities was carried out, all projects were completed, and the management of private forest was transferred to Miyagi Prefecture.

Figure 5-12-4 Standard construction procedure for growth base embankments on the Sendai Bay coast



Source) Tohoku Regional Forest Office, Forestry Agency "Restoration of Coastal Disaster Prevention Forests on the Sendai Bay Coast"
https://www.rinya.maff.go.jp/tohoku/koho/saigaijoho/attach/pdf/kinennsi-4.pdf (browsed July 31, 2023)

Figure 5-12-5 Sendai Bay coastal disaster prevention forest immediately after the disaster and after planting



Source) Annual Report on Forest and Forestry in Japan Fiscal Year 2020, Topics 6. Restoration of Coastal Disaster Prevention Forests Damaged by the Great East Japan Earthquake
https://www.rinya.maff.go.jp/j/kikaku/hakusyo/R2hakusyo/attach/pdf/zenbun-51.pdf (browsed July 31, 2023)

(3) State of recovery

With regard to areas with damage to afforestation facilities, forest road facilities, etc., 591 locations of restoration projects for damage to mountain and forest facilities adopted by the national government, the national government, prefectures and municipalities advanced the projects and they were completed by FY2021.

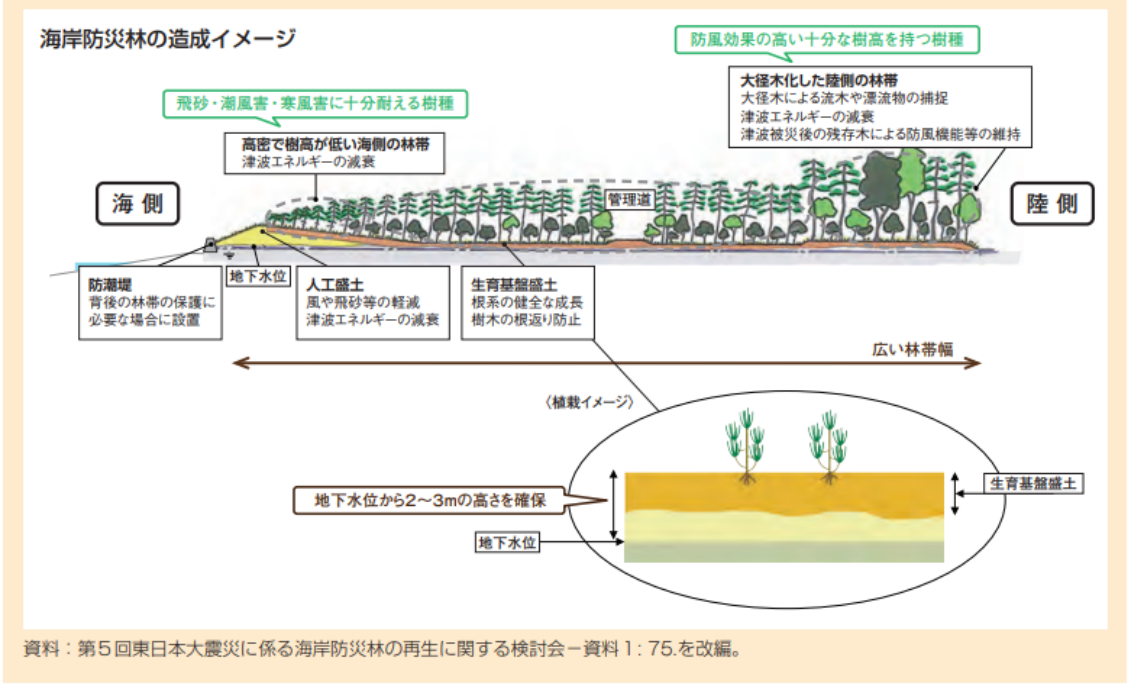
Of the roughly 164 km of locations of damage to coastal disaster prevention forests that required restoration, restoration projects such as planting were completed for about 153 km in FY2021.

4. Issues that arose in project implementation and responses, etc.

(1) Issues that arose in project implementation and responses

1) Uprooting trees and creating growth base

Figure 5-12-6 Image of the creation of coastal disaster prevention forests



Source) Annual Report on Forest and Forestry in Japan Fiscal Year 2020, Chapter V, 1. (3) Damage to Forests and Restoration and Reconstruction
https://www.rinya.maff.go.jp/j/kikaku/hakusyo/R2hakusyo/attach/pdf/zenbun-67.pdf (browsed July 31, 2023)

The “Future Regeneration of Coastal Disaster Prevention Forests” compiled in February 2012 indicated the following points to be noted with regard to the creation of a growth base.

ア. Microtopography is thought to affect the attenuation of tsunami energy and the growth of trees so it is necessary to examine plans while also paying attention to microtopography.

It was confirmed that particularly in locations with low ground height and high groundwater levels, trees had uprooted and turned into driftwood because their roots did not extend deep into the ground and their binding strength was weak.

In addition, as a result of field surveys, it was confirmed that trees that had sufficient height and remained undamaged grew in places where the depth of the soil layer above the groundwater level was about 3 m; and that trees whose trunks broke but were not uprooted were growing in places where the depth of the soil layer above the groundwater level was about 2 m.

イ. Because of this, from the perspective of ensuring the sound growth of the root systems of trees of the height required for protection against flying sand, wind damage, etc., and from the perspective of creating forest belts that are not easily uprooted by tsunamis, it is desirable to implement embankments securing a ground height of about 2 to 3 m above groundwater level, etc., in the creation of growth bases for planted trees.

When doing so, it is desirable to examine setting a gentle upward slope or undulation from the sea side to the land side from the perspective of the tsunami energy attenuation effect due to the embankment.

ウ. Also, it is desirable to secure sufficient embankment height at least at the edge of the forest on the landside from the perspectives of demonstrating the effect of capturing drifting debris, securing the disaster prevention function of coastal disaster prevention forests after tsunami damage such as protection against flying sand and wind damage, and catching trees that became driftwood in the forest belt.

エ. In addition, it is considered effective from the perspective of forest belt conservation to secure sufficient embankment height on the seaside and middle parts of a forest belt, because cases have been confirmed where the forest belt behind them is preserved if part of the forest belt escapes destruction by a tsunami.

Therefore, in the restoration of forest belt ground, in places where ground height is low and the groundwater level is high, the growth base of planted trees was secured by an embankment from the perspective of raising the binding force of the tree roots and creating a forest belt that is difficult to uproot.

2) Establishing a seedling supply system

In FY2011, it was expected that about 10 million seedlings would be required to restore damaged coastal disaster prevention forests. Because a period of two to three years is required to produce saplings, it was necessary to secure systematically the required number of saplings matched to the progress of restoration projects in coastal disaster prevention forests in each region.

In addition, the "Future Regeneration of Coastal Disaster Prevention Forests" compiled in February 2012 indicated the following points to be noted with regard to the development of a greening system.

ア. It is necessary to establish a seedling supply system to restore coastal disaster prevention forests damaged by the tsunami steadily.

The production volume of pine saplings nationwide is currently 900,000 for Japanese black pine and 700,000 for Japanese red pine, but the maximum possible production volume is estimated to be 4 million for Japanese black pine and 7.2 million for Japanese red pine, and because it takes two to three years to produce saplings, it is necessary to grasp the progress of regeneration of coastal disaster prevention forests and the demand for saplings suitable for the environment of planting sites, and then work to secure the production volume of saplings matched to that and the production of resistant pine saplings.

Moreover, from the perspective of controlling pine weevil damage, it is desirable to select seedlings in consideration of the geographical and topographical conditions of the planting site.

イ. In addition, the production volume of broad-leaved saplings in the three prefectures of Iwate, Miyagi and Fukushima is only about 700,000 saplings including garden trees, so when examining provision of broad-leaved saplings, it is desirable to grasp the demand for saplings, and establish a system that can produce the saplings from seeds collected in areas as close to the growing environment of the planting site as possible and of tree species that grow naturally in planned planting sites.

ウ. Moreover, apart from planting and subsequent nurturing, etc., carried out by the afforestation projects, it is necessary to examine actively of planting, nurturing, etc., through the participation of local residents, local greening organizations and others from the perspectives of raising awareness of disaster prevention and being able to become a symbolic activity of the area's reconstruction.

In addition, considering the interest shown by NPOs and companies in the restoration of coastal disaster prevention forests, it is necessary to examine actively the ongoing cooperation with such private organizations.

Based on such circumstances, the Forestry Agency supported the development of seedling raising machines, seedling production facilities, etc., for project cooperating associations from FY2012 to FY2015, and supported the development of facilities for mass producing container seedlings at low cost from FY2016 to establish a stable supply system for superior seeds and seedlings.

During the three-year period from FY2013 to FY2015, the Tohoku Regional Breeding Office of the Forest Tree Breeding Center run by the Forestry and Forest Products Research Institute, a national research organization, and others implemented joint industry-government efforts towards the establishment of a supply system for Japanese black pine seedlings resistant to the pinewood nematode, such as the development of technology to increase the seed production of Japanese black pine trees.

3) Nurturing management

Planting and nurturing for the restoration and regeneration of coastal disaster prevention forests have been promoted with the participation and cooperation of local residents, NPOs and companies. Coastal disaster prevention forests have been maintained with the involvement of local residents for a long time, and such efforts have important significance as activities that local communities cooperate with for reconstruction, while they are also important from the perspective of raising awareness of disaster prevention against large-scale disasters.

It is necessary to continue nurturing operations such as weeding, clearing and thinning after planting for the coastal disaster prevention forests to demonstrate the disaster prevention functions expected of them such as protection against tide damage, flying sand and wind damage. For this reason, the nurturing required on the coastal disaster prevention forests where trees are planted will be implemented while continuing to obtain the participation and cooperation of local residents, NPOs, companies and others.

(2) Lessons learned and know-how gained

The total length of Japan's coastline is about 35,000 km and our predecessors created coastal disaster prevention forests consisting mainly of pine trees, which are resistant to sea winds, have strong roots and grow tall, to prevent tidal damage and flying sand and wind damage due to seasonal winds. Apart from playing an important role in the preservation of local life and industry, these coastal disaster prevention forests are also places for people to relax, providing beautiful scenery of white sand and green pines, etc.

It was confirmed that during the Great East Japan Earthquake, coastal disaster prevention forests demonstrated damage reduction effects such as the attenuation of tsunami energy, the capture of floating debris and the delay of arrival time. As a result, moves are apparent to position coastal disaster prevention forests as one of our future tsunami countermeasures.

The "Central Disaster Management Council" of the Cabinet Office established the "Committee for Policy Planning on Disaster Management" in October 2011 to verify the national government's handling of the Great East Japan Earthquake and to enhance and strengthen disaster prevention countermeasures. The committee determined and published its final report, "Committee for Policy Planning on Disaster Management Final Report - Toward the reconstruction for sound and unwavering Japan" in July 2012. In this report, it was suggested with regard to tsunami countermeasures that regional development based on "multiple defenses" should be promoted, including the development of coastal disaster prevention forests.

The reports by the "Working Group for Reviewing Measures to Cope with a Major Nankai Trough Earthquake" and the "Working Group for Reviewing Measures to Cope with Tokyo Inland Earthquakes" of the committee also suggested that coastal disaster prevention forests should be developed as required because damage reduction effects can be seen such as reduction of the external force of tsunamis in the hinterland and the capture of floating debris.

In addition, the "Future Regeneration of Coastal Disaster Prevention Forests" compiled in February 2012 focused on the points that coastal disaster prevention forests have disaster prevention functions such as protection against flying sand and wind damage, have played an important role in preserving the local living environment, and are effective in reducing tsunami damage, and stated with regard to the restoration of damaged coastal disaster prevention forests that the following should be examined from the perspective of ensuring local disaster prevention functions.

① Regeneration method should be decided for each damaged location in accordance with the state of the disaster, the actual conditions of the area and the need for conservation of the area's ecosystem, and the regeneration of coastal disaster prevention forests should be examined also taking into account the disaster mitigation function that coastal disaster prevention forests possess in regard to tsunamis.

② In the regeneration of coastal disaster prevention forests, consideration should be given so that it harmonizes with the content of local reconstruction plans, such as the perspective of land use and community development in the hinterland.

③ The width of coastal disaster prevention forest belts should be examined based fully on the actual conditions of the area, such as the state of land use in the hinterland, keeping in mind technical knowledge based on research results to the present, etc., from the perspective that disaster prevention functions are expected.

④ In places where ground height is low and the groundwater level is high, securing the growth base of planted trees with embankments should be considered from the perspective of raising the binding force of the tree roots and creating a forest belt that is difficult to uproot.

⑤ The structure and arrangement of artificial embankments in multifunctional coastal disaster prevention forests should be examined, taking fully into account factors such as the necessity and cost in each location, including cases where recycled materials, etc., are used as embankment materials and while bearing in

mind the various conditions in their creation. In particular, arranging artificial embankments effectively not only in continuous lines, but also independently or in a staggered grid pattern should be examined.

⑥ If recycled materials, etc., are used as embankment materials, consideration should be given so there are no impacts on the surrounding environment such as impacts on coastal fisheries.

⑦ The composition of forests, such as the number of planted trees, tree species and stand structure, as well as their subsequent maintenance and management should be examined from the perspective that disaster prevention functions are expected.

⑧ In addition to a seedling supply system, planting, nurturing, etc., by the participation of local residents should also be examined.

Based on these reports, the Forestry Agency has promoted the restoration and regeneration of coastal disaster prevention forests damaged by the Great East Japan Earthquake in cooperation with the prefectures, etc., taking into account factors such as the actual situation of the region and the need for the conservation of ecosystems. We are using the knowledge, etc., gained through the creation of growth base embankments in these projects, and advancing the nationwide development and conservation of coastal disaster prevention forests aimed at the creation of coastal disaster prevention forests that are not easily uprooted by tsunamis and protection against damage from flying sand, wind and tides.

Furthermore, we compiled the “Guidelines for the Creation of Growth Base Embankments in Coastal Disaster Prevention Forests (draft)” in March 2018 based on the actual conditions of construction carried out in disaster-affected areas following the Great East Japan Earthquake, to promote the nationwide creation of coastal disaster prevention forests that are highly effective at reducing tsunami damage. In addition, we compiled the “Guidelines for Nurturing Management of Coastal Disaster Prevention Forests (draft)” in March 2020 to enhance tsunami damage reduction effects further through the appropriate nurturing management of created coastal disaster prevention forests.