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Land use proposals to promote decarbonization under depopulation in Japan

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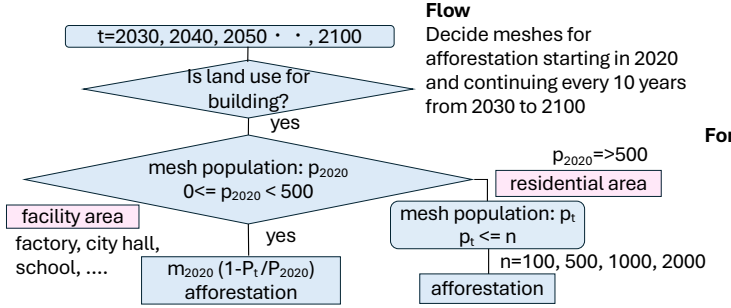
Introduction

- A lot of actions for a decarbonized society in 2050, such as energy conservation, introduction of renewable energy, changes in industrial structure, and so on, has been promoted in Japan. CO_2 emission has been reduced by them and the forests has been expected to be important to absorb the residual CO_2 in near future. However, forest CO_2 sink peaked in 2003 and have been declining .
- On the other hand, the population began to decline in 2008 and has been expected to continue to decline in the future. Increment of vacant building area has been social issue. Converting such unused area to forest would be one of decarbonization option.
- Therefore, we attempted to assess the contribution of new sink forest to decarbonation and effect of building area through land use change with planting vacant area.

Methods

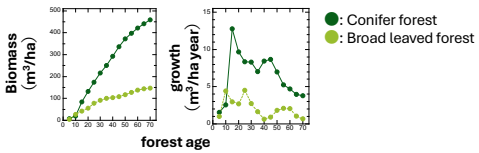


Flow
Decide meshes for afforestation starting in 2020 and continuing every 10 years from 2030 to 2100

m_{2020}: No. of mesh for facility area in 2020
P_t=Σp_t (population in t)

- 1) Number of meshes of less or n populations
- 2) Conifer is plantation trees and grow fast, broad-leaved trees consist natural forest grow slow.
- 3) Population in meshes determine to be afforested move to the other residential area or not

Forest biomass and CO_2
The trees in the planting mesh were assumed to grow according to the following graphs



$$CO_{2\ absorption}(t) = \sum_t Growth(t) \cdot NO_{mesh} \cdot BEF \cdot (1+R) \cdot D \cdot CF \cdot 44/12$$

BEF: biomass expansion factor *2
R: ratio of belowground biomass to aboveground biomass *2
D: density *2
CF: carbon fraction *2

Solar power generation

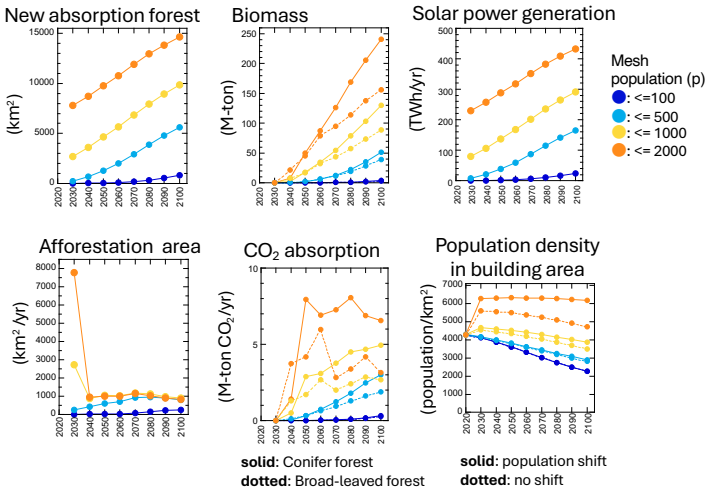
$$\text{Capacity(kW)} = area(m^2) \cdot land\ use\ rate \cdot \text{system efficiency} \cdot \text{install density}$$

$$\text{Power generation(kWh/year)} = \text{Capacity(kW)} \cdot 24\text{hour} \cdot 365\text{day} \cdot device\ use\ rate$$

land use rate: 0.25, system efficiency: 0.88, install density: 1/12*3
device use rate: 0.184*4

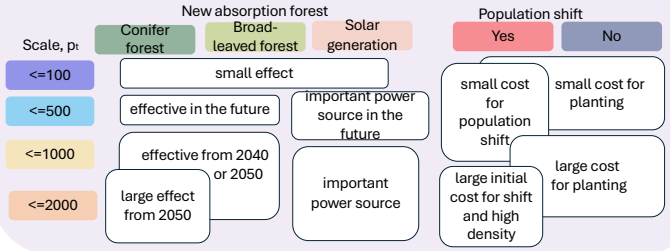
Scenario

1) Afforestation scale, p_t: <= 100, <= 500, <= 1000, <= 2000 ×
2) Forest type: Conifer forest, Broad-leaved forest, Solar power generation ×
3) Population shift: Yes, No



- The new absorption forest will occupy up to 65% of the building area in 2020 (in 2100 at <=2000 scale)
- The forests absorbed 5020Mton-CO_2 in 2022, and the new absorption forests will absorb up to 16% of that amount, or 8.1Mton-CO_2 (conifer forests in 2080 at <=2000 scale)
- Solar power generation will be up to 433 TWh/yr. This is 44% of the 988 TWh/yr generated in Japan today.
- The population density of the building site remains high, exceeding 6,000 in one case at <=2000 scale

Land use change from building area into forest contributes to decarbonization. On the other hand, population shift will need cost depending on scale as shown below. The relationship between scale, cost, and decarbonization benefits needs further scrutiny.



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