# Biomass transportation cost
## by activating upgraded forest roads and intermediate landings

*50th Anniversary of the International Symposium on Forestry Mechanization*
*Brasov, Romania, 25th-29th September 2017*

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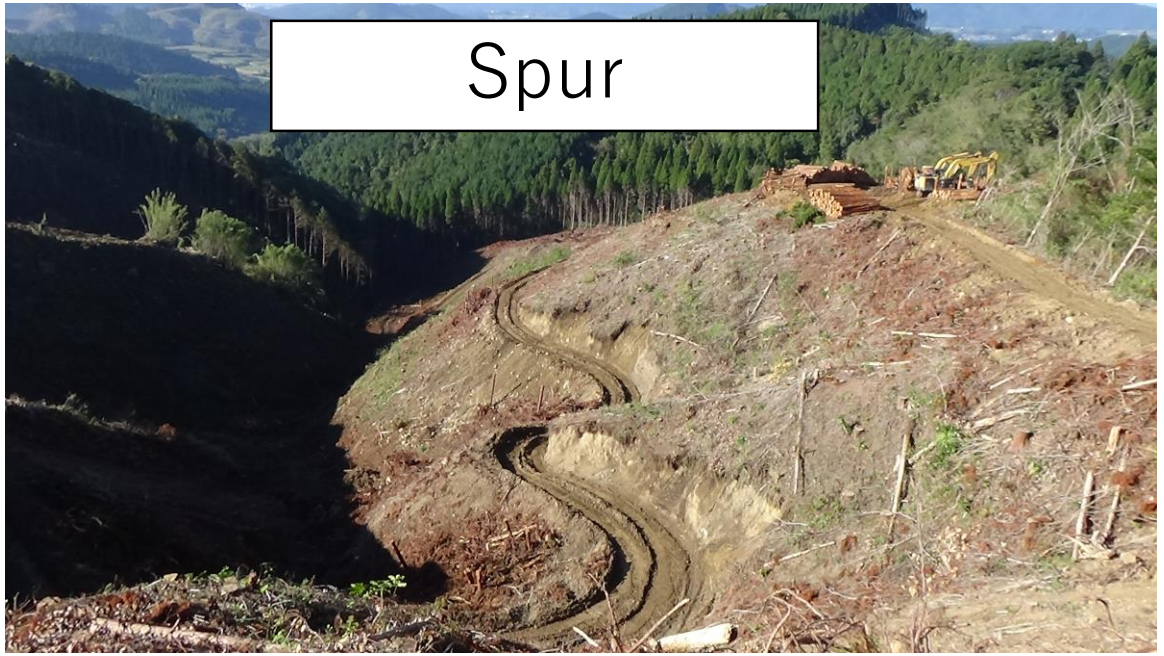
# Existing primary forest roads

- 50-years period national project: 1956 - 2008
  - 3,300 km all over Japan
  - Inter-regional infrastructure
  - Enable to introduce the largest trucks to forest

# Secondary and spur forest roads

- Promoted standard: Secondary road
  - Designed for 10t-payload truck




About operations on spur roads: Berg et al. (2017) Int. J. For. Eng. DOI: 10.1080/14942119.2017.1358550

# Forest roads in Japan

- The effective use of exiting primary road is necessary by combining secondary and spur roads
- Different capacity for transportation
  - We can improve truck capacity on primary roads
  - But it needs an extra operation at intermediate landings

| | **Standard** | **Primary** | **Secondary** | **Spur** |
|---|---|---|---|---|
| | Width (m) | 4-5 | 3.5 | 2.5-3 |
| Design speed (km/h) | | 20-40 | 15 | - |
| | Period | Permanent | Permanent | Temporary |
| | Openness | For everyone | Forestry only | Forestry only |

# Trucks

- On primary roads

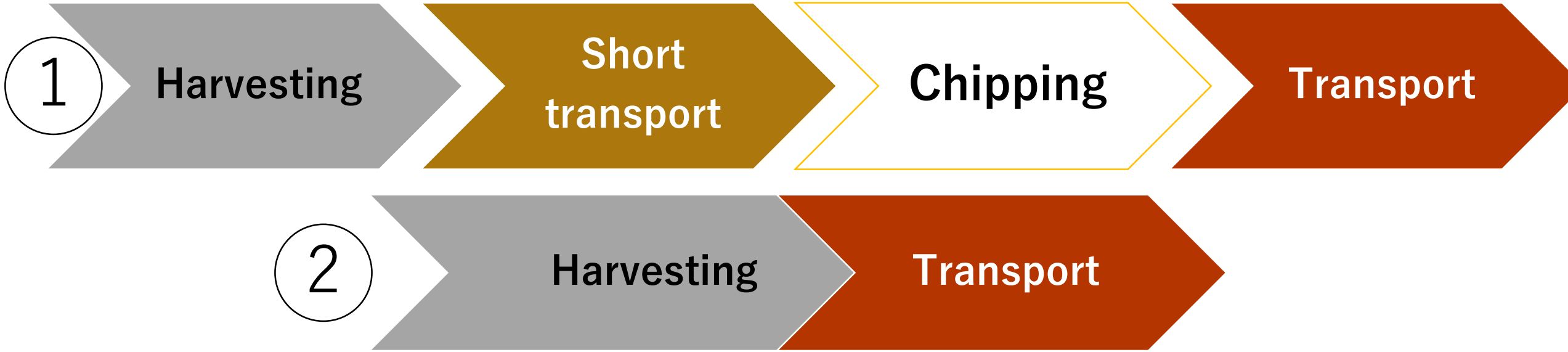
- On secondary roads

# Demand of biomass energy: chipping

- Logging residue utilization: mobile chipping

① Mobile chipping at intermediate landings

② Direct transportation of resources



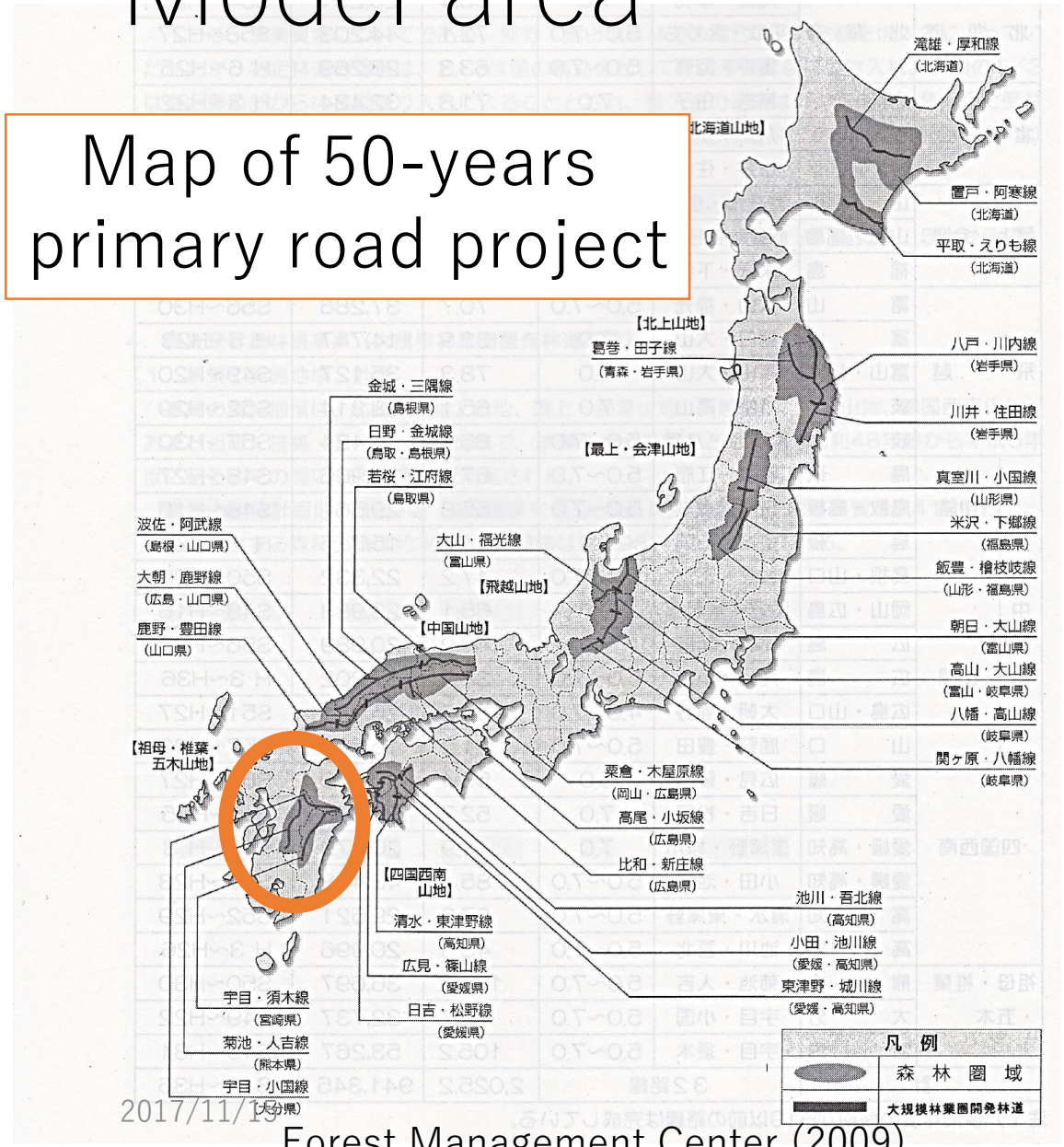
# Purpose of this study

- Evaluate biomass transportation cost on the road network with several standards

| Scenario | Biomass type | Road from forest to primary road | Operation at intermediate landing |
|---|---|---|---|
| 1 | Logging residue | Spur | Chipping |
| 2 | Logging residue | Secondary | Chipping |
| 3 | Timber | Spur | Chipping |
| 4 | Timber | Secondary | Chipping |
| 5 | Timber | Spur | Reloading |
| 6 | Timber | Secondary | Reloading |

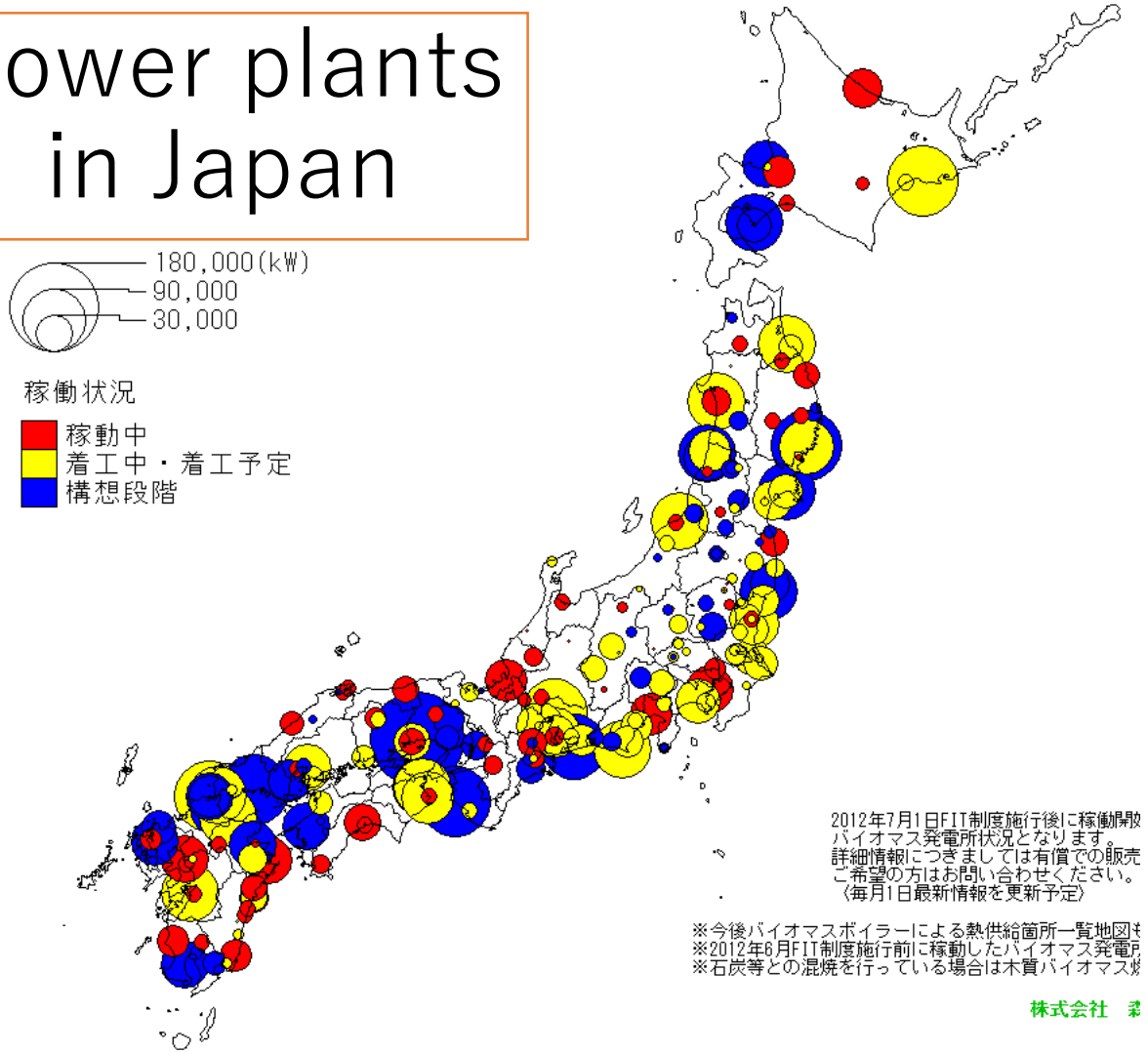
# Model area

## Map of 50-years primary road project




Forest Management Center (2009)

## Power plants in Japan



# Model area

- Material: Sugi (*Cryptmeria japonica*)
- 120 harvesting sites (1ha each)
- 20 intermediate landings at roadside
- 3 destinations (ave. 2.5 h/one-way)

# LP model

- x: transported amount (solid $m^3$)
- C: transportation cost (EUR/solid $m^3$)

$$Minimize\ C = \sum_{i,j,k}^{n,m,l} (x_{ik}C_{ik} + x_{kj}C_{kj} + x_{ij}C_{ij})$$

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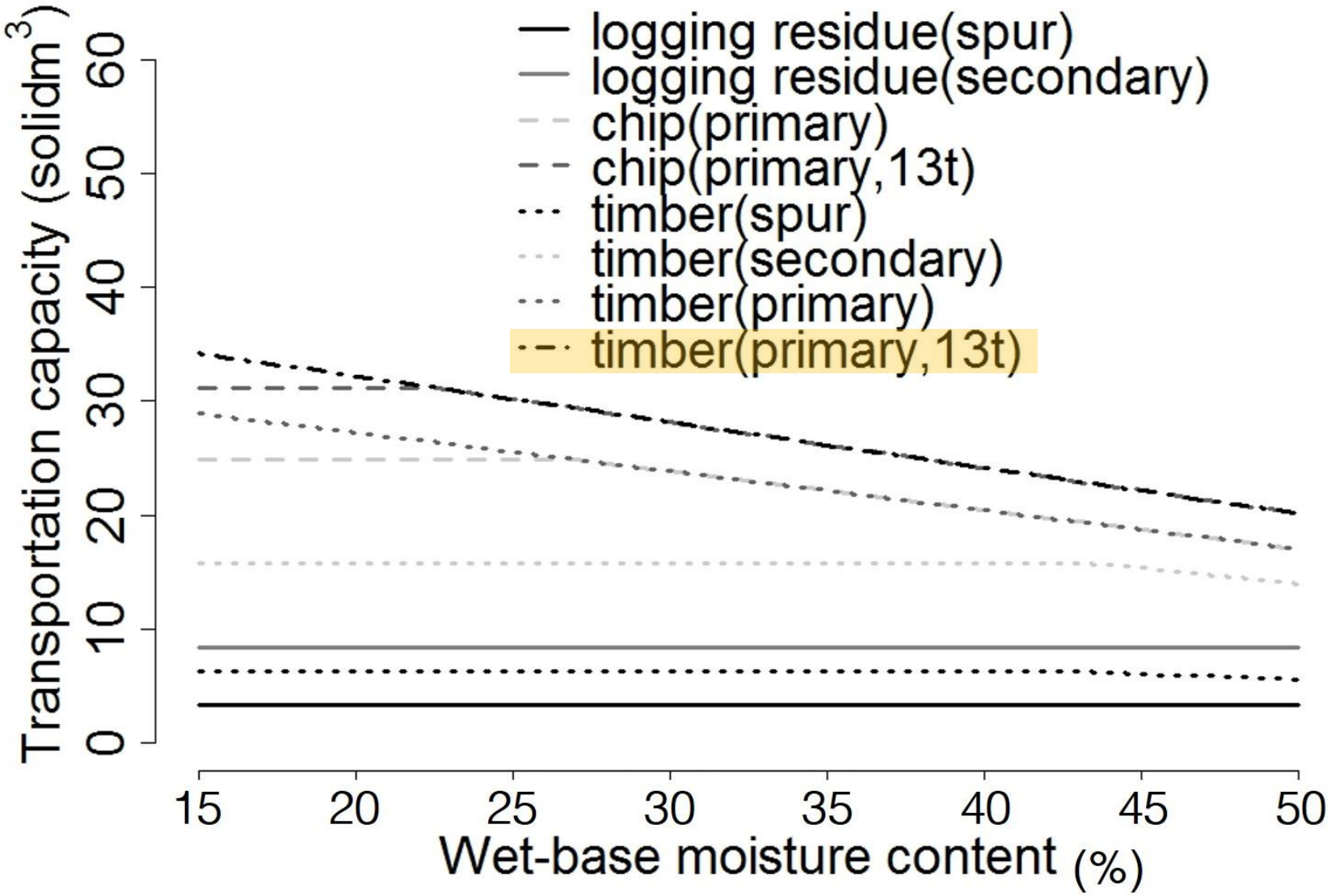
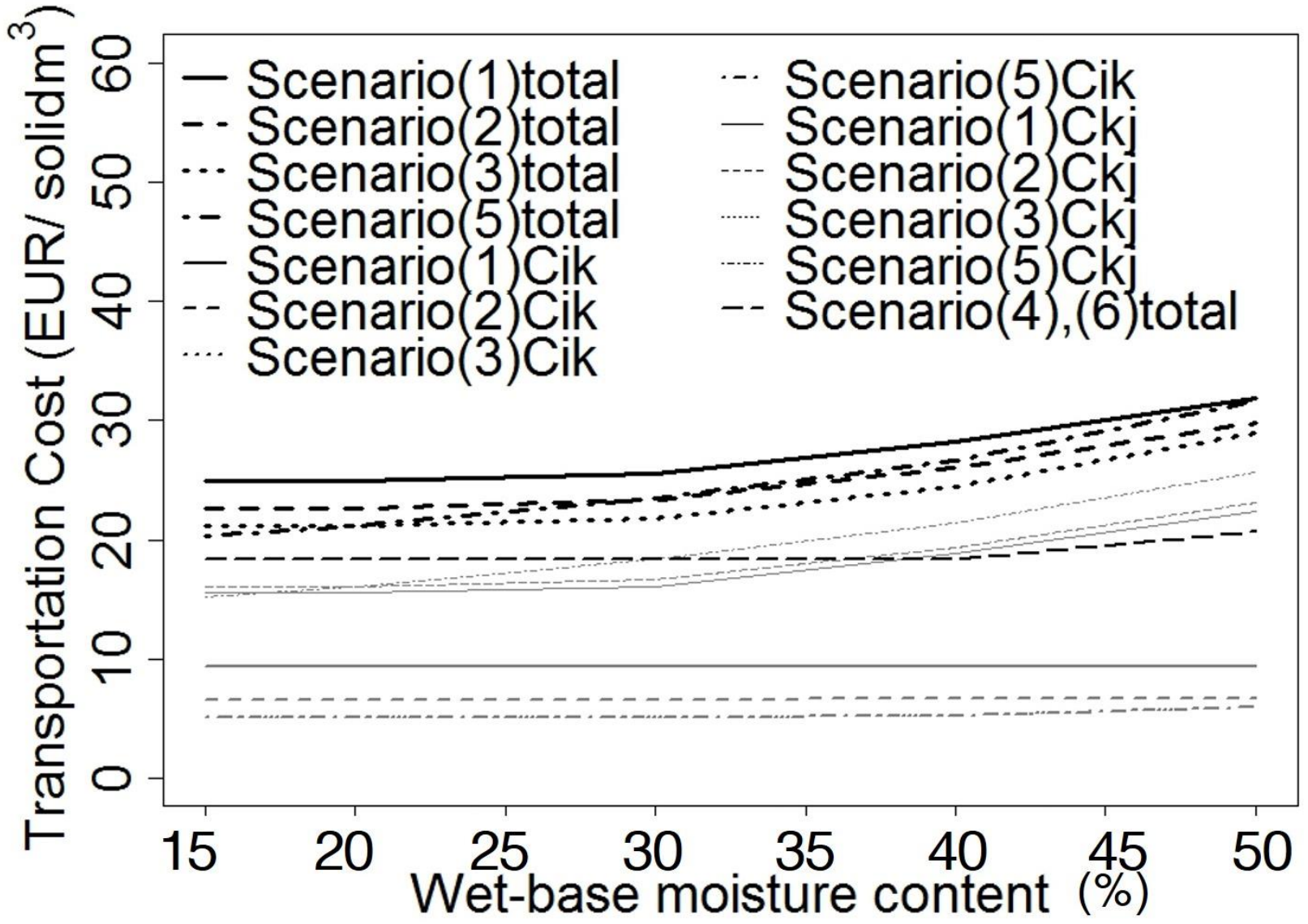
In-direct transportation (via intermediate landings)

Direct transportation

# Moisture content vs transportation capacity



# Average cost of each scenario



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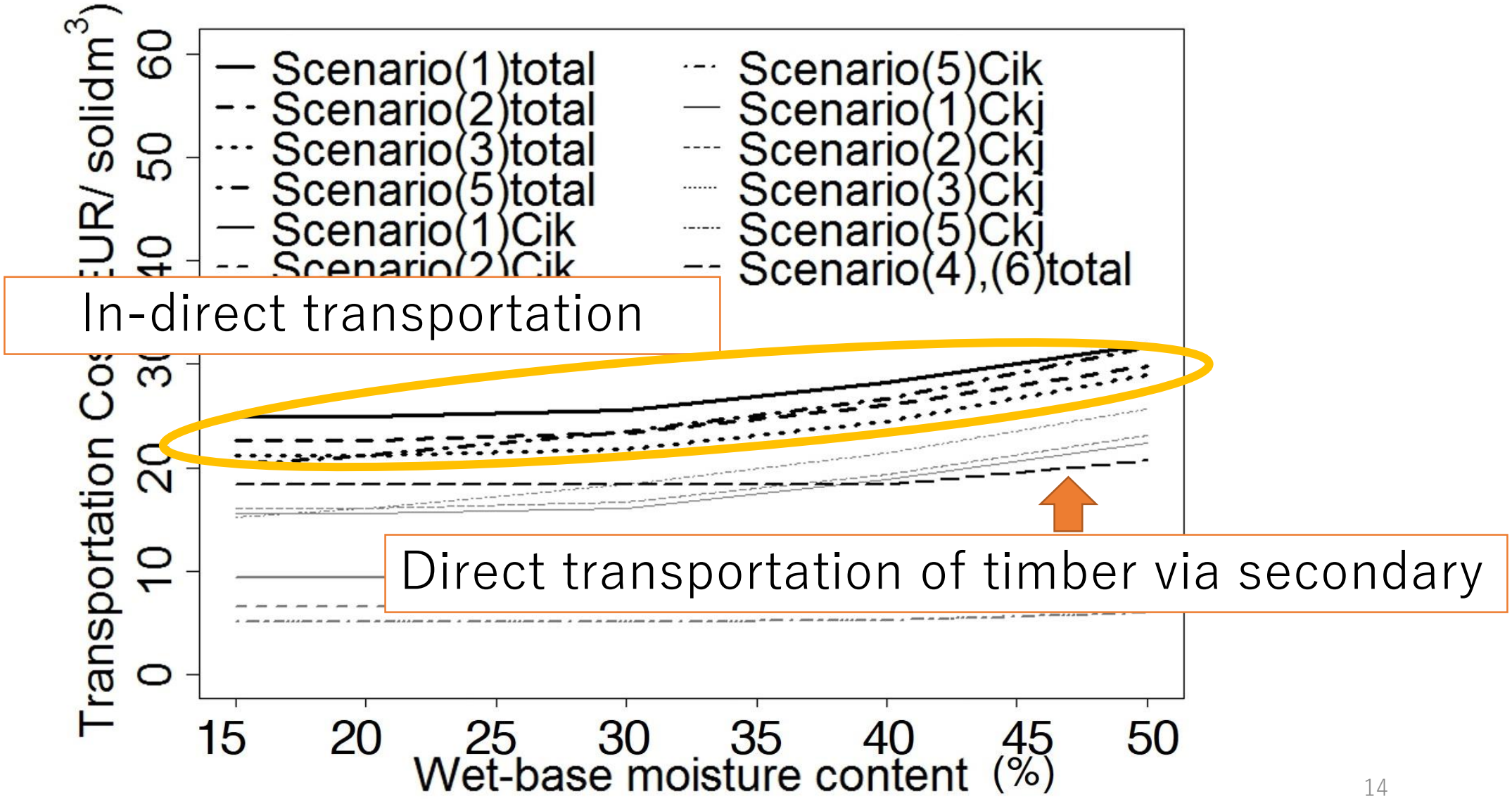

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# Conclusion: Transportation of biomass

- Intermediate landing is proved to be necessary on spur roads/when using logging residue
  Because of small truck payload/low density

- Upgrading to secondary road is effective
  Average 4.7 EUR/solid $m^3$ cost reduction

- Moisture content
  Logging residue: 30%
  Timber (secondary roads): 40%

# Acknowledgment


- This research was supported by JSPS Research Fellow JP16J00623.

- Thank you for your attention.

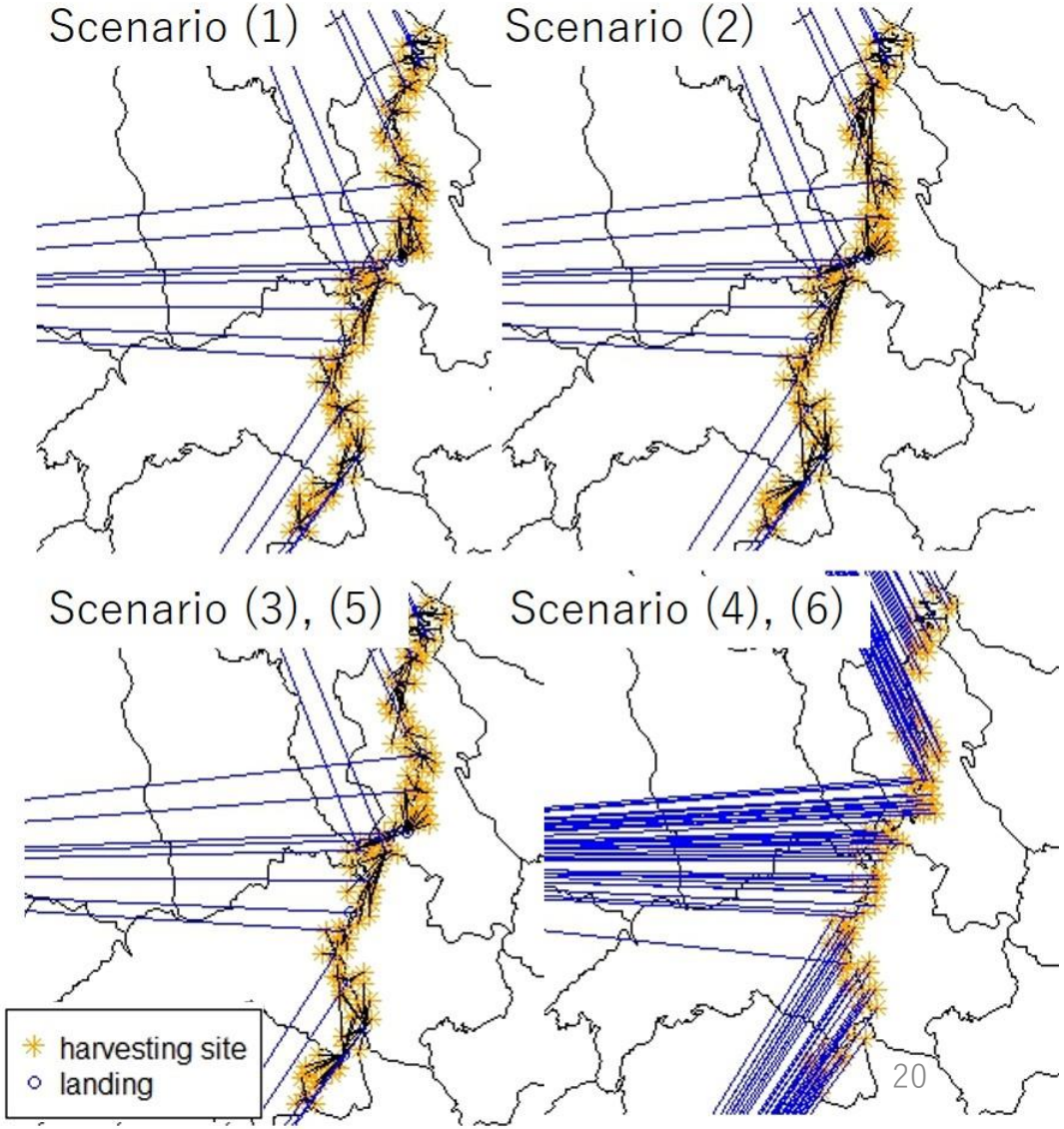
# Conclusion

- Intermediate landings
  - always necessary to reduce the transportation cost when using spur roads or logging residue

- Upgrading forest roads
  - worth to consider (not only to primary, but also to secondary)

# Result: Biomass distribution

- Scenarios (1)~(3), (5)
  - Via intermediate landings
  - Spur road
  - Logging residue on secondary road
- Scenarios (4), (6)
  - Direct transport from forest
  - Timbers on secondary road

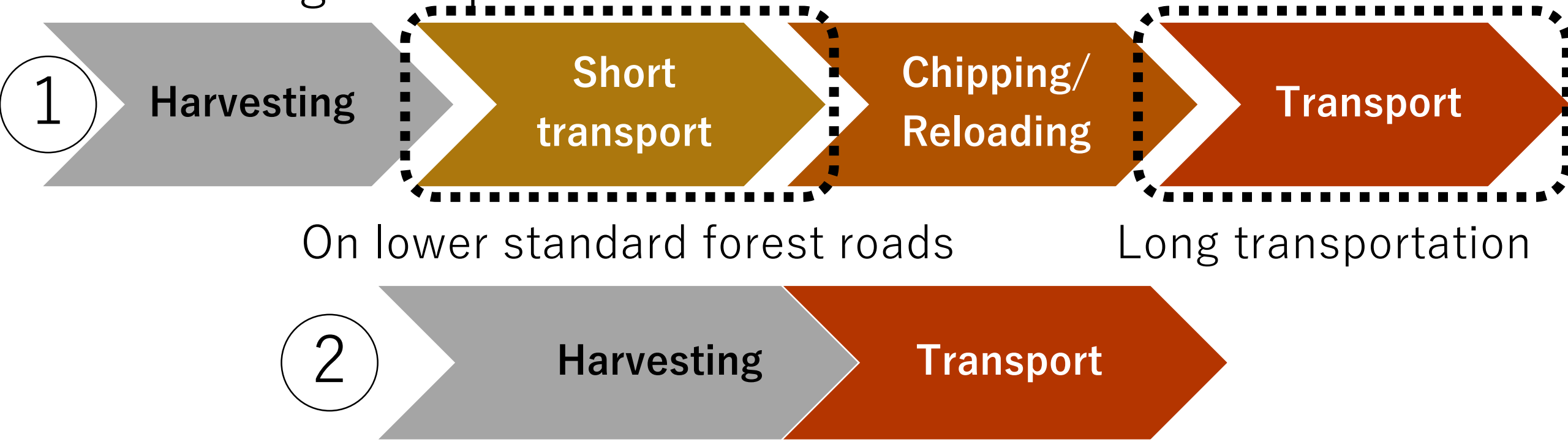


# Transportation is an issue

- Density of roads in forest : 21m/ha
- Multi-standards forest road network
  - Different availability of trucks

# Rising demand for biomass energy

- Expansion of procurement area
  - Logging residue utilization: mobile chipping
  - Long transportation



# Rising demand for biomass energy

- Expansion of procurement area
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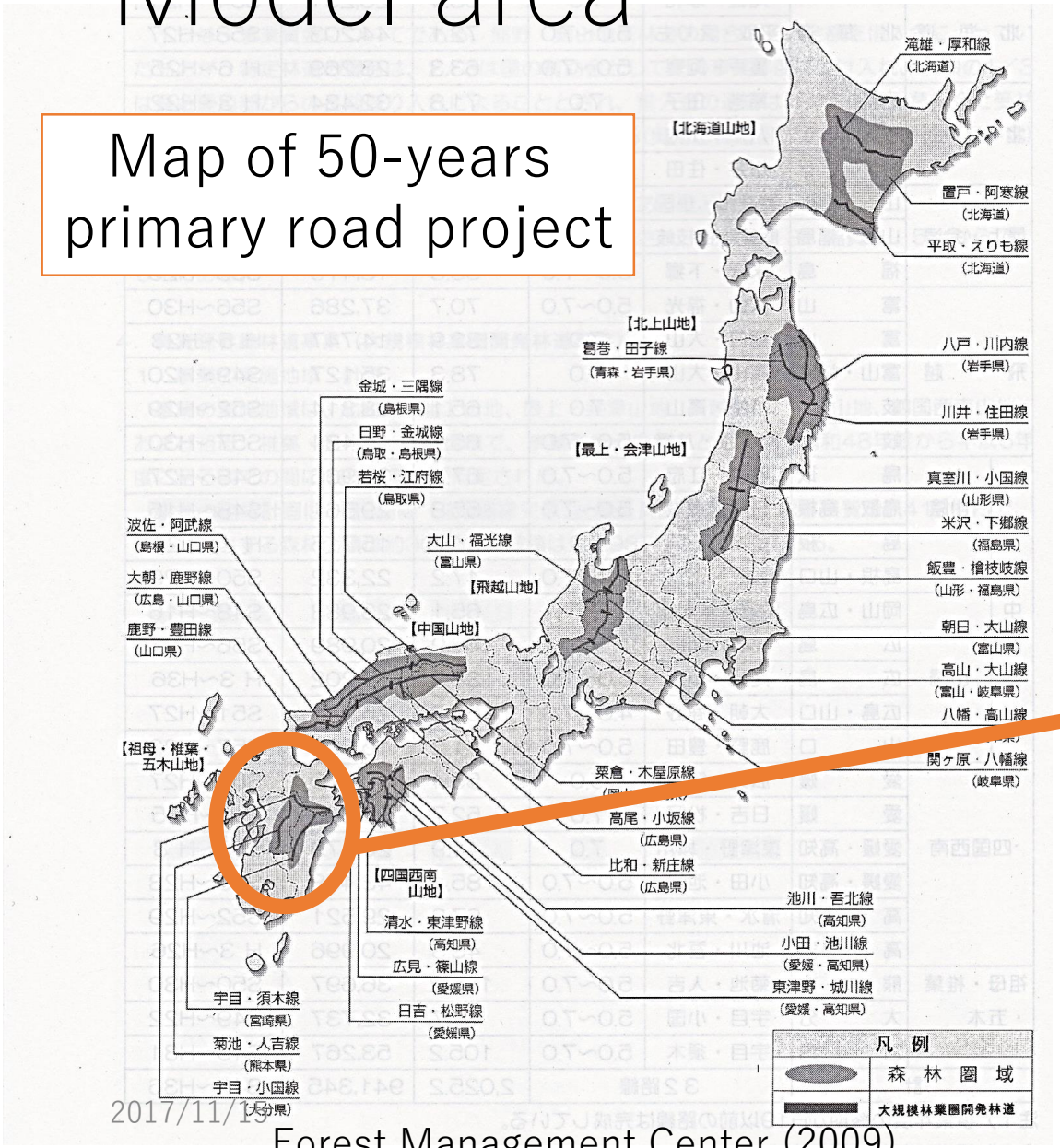
From lower standard forest roads for long distance

# Model area

Map of 50-years primary road project




2017/11/13

Forest Management Center (2009)

# Rising demand for biomass energy

- Closer areas

- Further areas

Power plants in Japan

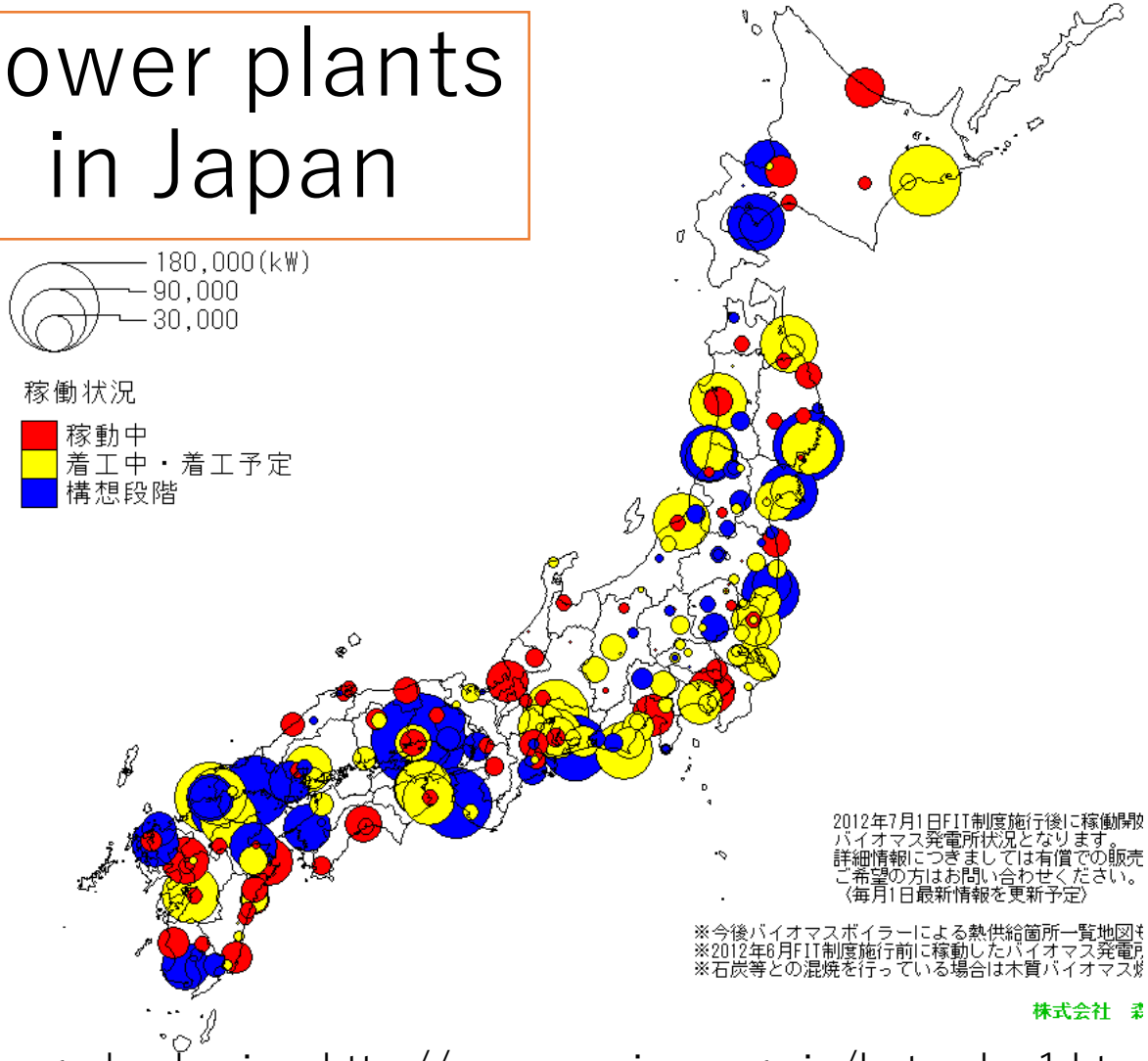



Image: Morino-energy-kenkyujyo, http://www.mori-energy.jp/hatsuden1.html (last update: 8/31/2017)