# Damage Cost on Heat-stroke, Beech-forest and Tidal-flat by Global Warming

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# Background of Heat-stroke

- Mortality rate of heat-stroke in Japan:
  0.3 per 100,000 population annually

  >>> The mortality rate will increase
  by global warming.

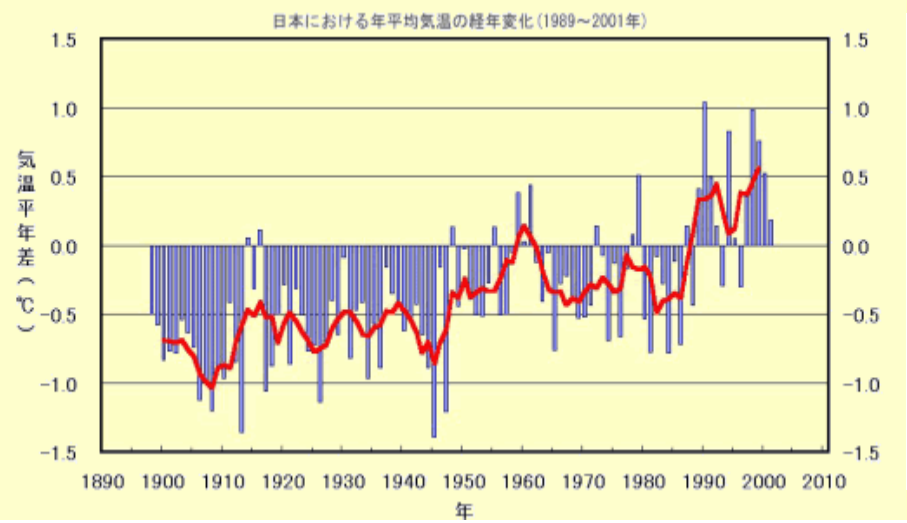
# Mortality Rate

| Death | Mortality rate |
|---|---|
| Cancer | 250 |
| Overweight | 140 |
| Heart disease | 127 |
| Suicide | 24 |
| Traffic accident | 9 |
| Fire | 1.7 |
| Murder | 0.52 |
| Heat-stroke | 0.3 |
| Hazardous chemical substance | 0.3 |
| Natural disaster | 0.1 |
| HIV / AIDS | 0.04 |
| Plane crash | 0.013 |

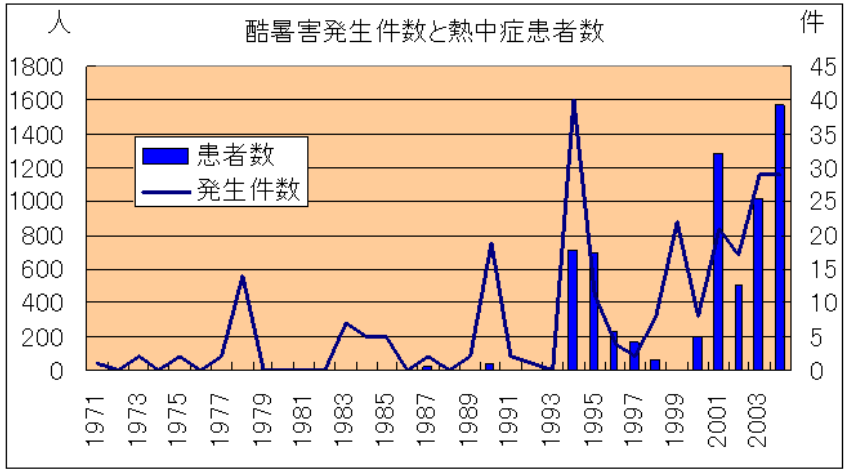
Mortality rate
= number of mortality per 100,000 population annually

# People with Heat-stroke in Japan

- If temperature will continue to remain high by global warming, it is predicted that the number of people with heat-stroke and the death rate of aged people with heat-stroke will increase.



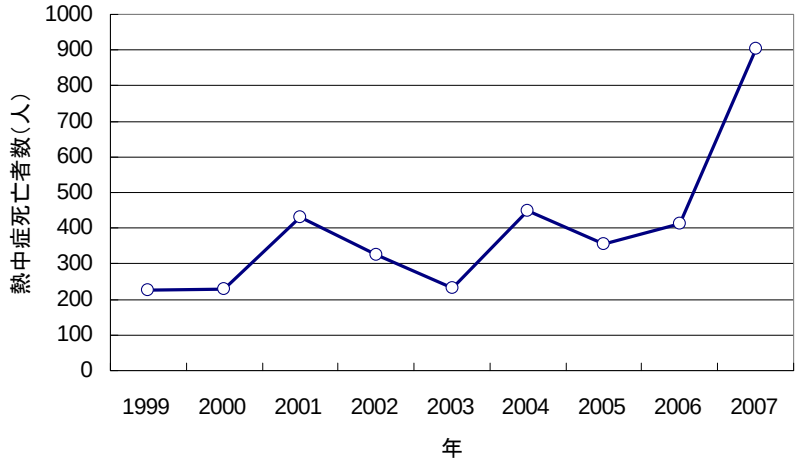

Annual average temperature



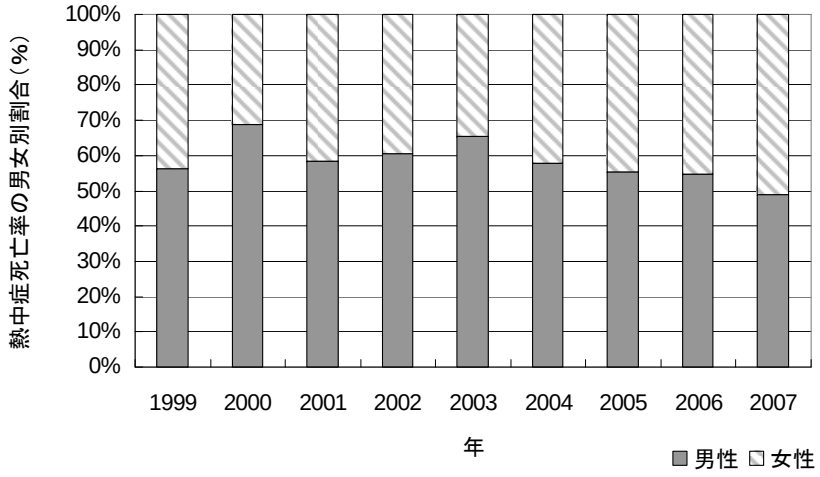

Number of people with heat-stroke

# Mortality of Heat-stroke in Japan

- The number of mortality of heat-stroke increased year after year, and it has reached 904 people in 2007.
- Man is weaker against heat-stroke than woman.




Number of mortality of heat-stroke




Ratio of male mortality to female mortality

# Background of Beech-forest

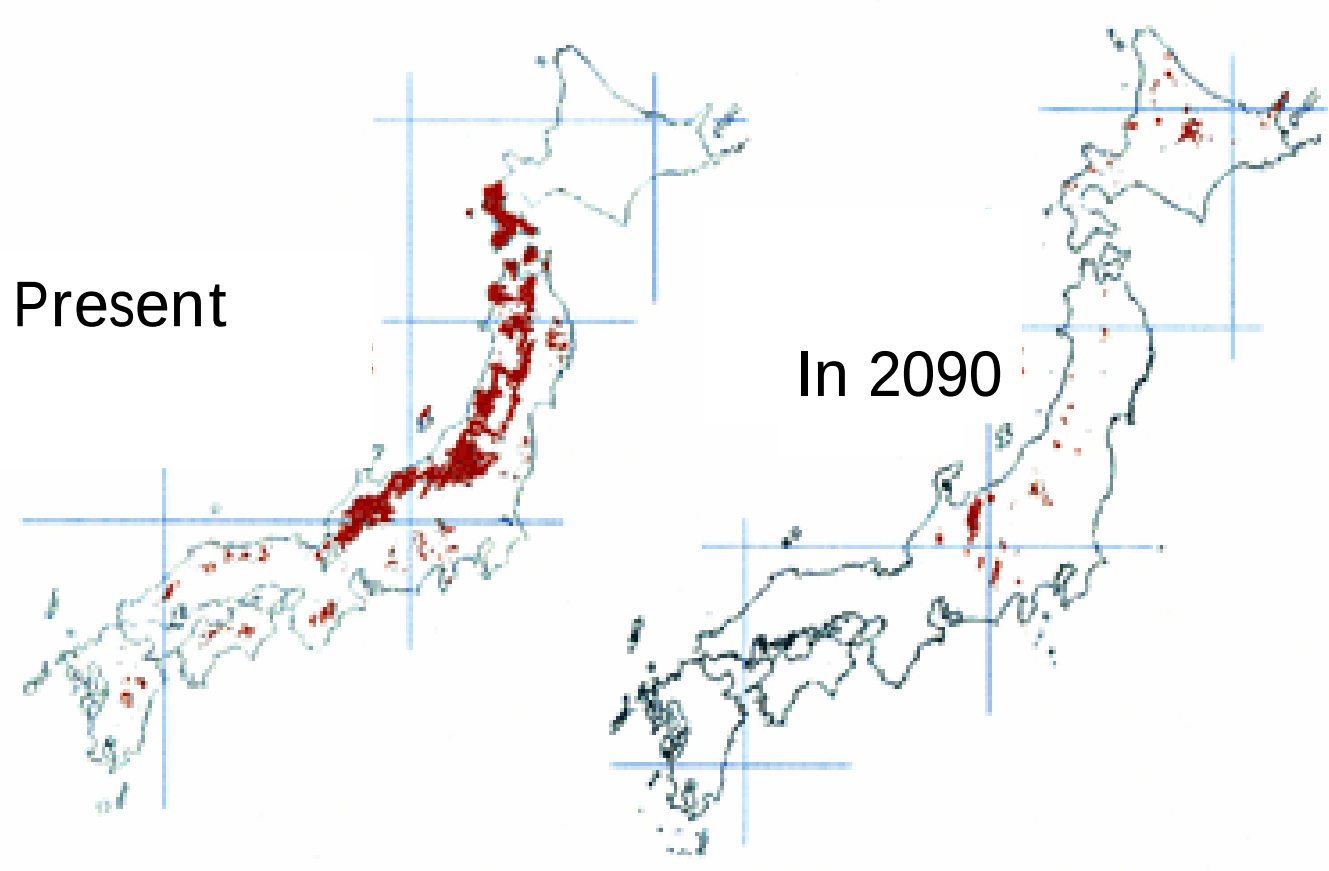
- Total area of beech-forest in Japan:
  23,000km$^2$

  >>> The beech-forest will disappear
  by global warming.

# Fine Beech-forest

http://www.flickr.com/photos/jetalone/1512741981/in/photostream/

# Distribution map of Predicted Beech-forest Belt in Japan




http://www.shinrin-ringyou.com/ondanka_boushi/buna_bunpu.php

# Background of Tidal-flat

- Total area of tidal-flat in Japan:
  514km$^2$

  >>> The tidal-flat will disappear
  by global warming.

# Fine Tidal-flat

http://www.fujimae.org/modules/tinyd0/index.php?id=22

# Tidal-flat exposed to crises in Japan


http://www.fujimae.org/modules/tinyd0/content/index.php?id=34

# Value of Statistical Life - Economic Evaluation of Heat-stroke Mortality Risk -

# Methodology

- Evaluating WTP (willingness to pay)
  in order to avoid death due to heat-stroke
  by using CVM (contingent valuation method)

- Measuring VSL (value of statistical life)
  concerning mortality risk of heat-stroke

# Definition of VSL

- VSL is WTP in order to avoid one death from some phenomenon (e.g. heat-stroke) statistically.

$$VSL = \frac{WTP(\Delta Risk)}{\Delta Risk}$$

$\Delta$ Risk: change of mortality risk

# Contingent Valuation Survey

- Date: May, 2008
- Object: Adult men and women in Japan
- Means: Internet
- Collections: 1,193
- Contents:

  1) Interests in problems concerning global warming
  2) Interests in increase of people with heat-stroke
  3) WTP in order to avoid increase of people with heat-stroke
  4) WTP in order to avoid increase of death from heat-stroke

# Main Question

(WTP in order to avoid increase of death from heat-stroke)

- If you have the policy, the mortality rate of heat-stroke becomes 0.3, maintaining present condition.
- If you do not have the policy, the mortality rate of heat-stroke becomes Y.

(1) If the policy cost is 100 yen per year, do you accept the policy?

1. Yes 2. No

(2) If the policy cost is 300 yen per year, do you accept the policy?

1. Yes 2. No

:

:

Mortality rate
= number of mortality per 100,000 population annually

- with policy:
  Mortality rate = 0.3
  (present condition)

- without policy:
  Mortality rate = Y
  Case-1) Y = 0.6
  Case-2) Y = 0.9
  Case-3) Y = 1.5
  Case-4) Y = 3.0

# Utility Function

- Model - 1: $\Delta V = a \cdot x + \sum_{k=2}^{4} b_k d_k + c \cdot \ln(p)$
- Model - 2: $\Delta V = a \cdot x + b \cdot \ln(\Delta r) + c \cdot \ln(p)$

$\Delta V$ : difference between utilities in Yes and No for policy
$x$ : degree of interest in increase of people with heat-stroke
$d_k$ : dummy variables of case k
$\Delta r$ : change of mortality risk
$p$ : policy cost
$a, b, c$ : unknown parameters

# Choice Probability

- Probability of Yes: $P_{yes} = \frac{1}{1 + \exp(-w \cdot \Delta V)}$
- Probability of No: $P_{no} = 1 - P_{yes}$

# WTP (willingness to pay)

- WTP of specific people:
- Model-1: $$WTP = \exp\left( -\frac{a \cdot x + \sum_{k=2}^{4} b_k d_k}{c} \right)$$
- Model-2: $$WTP = \exp\left( -\frac{a \cdot x + b \cdot \ln(\Delta r)}{c} \right)$$

# WTP (willingness to pay)

- Mean value of WTP:

$$WTP_{mean} = \sum_{i=1}^{5} f(x_i) \cdot WTP(x_i)$$

$f(x_i)$ : ratio of people who has degree $x_i$ of interest in increase of people with heat-stroke

$WTP(x_i)$ : WTP of people who has degree $x_i$ of interest in increase of people with heat-stroke

# Results of WTP

| Case | WTP of people who has degree 1.00 (13.8%) | WTP of people who has degree 0.75 (34.7%) | WTP of people who has degree 0.50 (35.8%) | WTP of people who has degree 0.25 (12.3%) | WTP of people who has degree 0.00 ( 3.4%) | Mean value of WTP |
|---|---|---|---|---|---|---|
| 1 | 658 | 323 | 159 | 78 | 38 | 271 |
| 2 | 1,382 | 679 | 333 | 164 | 80 | 569 |
| 3 | 2,904 | 1,426 | 700 | 344 | 169 | 1,195 |
| 4 | 6,923 | 3,399 | 1,668 | 819 | 402 | 2,849 |

# Results of VSL

| Case | Change of mortality risk | WTP [yen/year] | 95% confidence interval of WTP [yen/year] | VSL [mil. yen] |
|---|---|---|---|---|
| 1 | 0.6 → 0.3 | 271 | 260 - 281 | 90.23 |
| 2 | 0.9 → 0.3 | 569 | 547 - 590 | 94.80 |
| 3 | 1.5 → 0.3 | 1,195 | 1,150 - 1,240 | 99.59 |
| 4 | 3.0 → 0.3 | 2,849 | 2,741 - 2,956 | 105.50 |

# Comparison to Previous Studies

| Researchers（Year） | Evaluation Object | Estimated VSL |
|---|---|---|
| Yamamoto et al.(1994) | Mortality Risk of Water Quality | ¥ 2,240～3,550mil. |
| Imanaga(2001) | Mortality Risk of Traffic Accident | ¥460mil |
| Takeuchi et al.(2001) | same as above | ¥ 20～240mil |
| Matsuoka et al.(2002) | Mortality Risk of Air Pollutions | $3.14～4.32 mil. |
| Koyama et al.(2003) | Mortality Risk of Traffic Accident | ¥ 150mil |
| Furukawa et al.(2004) | same as above | ¥ 790～990mil |
| Kei et al.(2004) | same as above | ¥ 266mil |
| Koshi(2004) | same as above | ¥ 1400mil |
| Ministry of Land, Infrastructure, Transport and Tourism(2005) | same as above | ¥ 160mil |
| Tsuge et al.(2005) | same as above | ¥ 350mil |
| Itaoka et al.(2005) | same as above | ¥ 103～344mil |
| Kashima(2006) | same as above | ¥ 960mil |
| Cabinet Office(2007) | same as above | ¥ 226mil |
| This study(2009) | Mortality Risk of Heat-Stroke | ¥ 90.2～105.5mil. |

# Economic Value of Beech-forest

# Methodology

- Measuring value of natural environment preservation function of beech-forest by CVM (contingent valuation method)

# Contingent Valuation Survey

- Date: May, 2008
- Object: Adult men and women in Japan
- Means: Internet
- Collections: 1,193
- Contents:

  1) Interest in problems concerning global warming
  2) Interest in decrease of areas of beech-forest
  3) WTP in order to avoid decrease of beech-forest

# Main Question

(WTP in order to avoid increase of death from heat-stroke)

- If you have the policy, total area of beech-forest in Japan (23,000km$^2$) is preserved.
- If you do not have the policy, X% of total area of beech-forest in Japan (23,000km$^2$) is decreased.

(1) If the policy cost is 100 yen per year, do you accept the policy?

1. Yes 2. No

(2) If the policy cost is 300 yen per year, do you accept the policy?

1. Yes 2. No

:

:

Total area of beech-forest

• with policy:
23,000km$^2$
(present condition)

•without policy:
X% of 23,000km$^2$
is decreased.
Case-1) X = 20
Case-2) X = 40
Case-3) X = 60
Case-4) X = 100

# Results

| Case | Rate of area preserved [%] | WTP [yen/year] | Unit value [yen/$m^2$] |
|---|---|---|---|
| 1 | 20 | 307 | 213.0 |
| 2 | 40 | 750 | 260.4 |
| 3 | 60 | 1,266 | 292.9 |
| 4 | 100 | 2,446 | 339.6 |

Total area of beech-forest in Japan: 23,000$km^2$

# Comparison to Pine-forest

| Case | Rate of area preserved [%] | WTP [yen/year] | Unit value [yen/$m^2$] |
|---|---|---|---|
| 1 | 20 | 269 | 171.0 |
| 2 | 40 | 699 | 222.4 |
| 3 | 60 | 1,223 | 259.4 |
| 4 | 100 | 2,475 | 314.9 |

Total area of pine-forest in Japan: 25,100$km^2$

# Economic Value of Tidal-flat

# Methodology

- Measuring value of biodiversity preservation function of tidal-flat by CVM (contingent valuation method)
- Measuring value of recreation function of tidal-flat by TCM (travel cost method)

# Contingent Valuation Survey

- Date: March, 2007
- Object: Adult men and women in Japan
- Means: Internet
- Collections: 1,196
- Contents:

  1) Interest in problems concerning global warming
  2) Interest in decrease of biodiversity
  3) WTP in order to avoid decrease of biodiversity

# Travel Demand Function for TCM

- Demand Function:

$$\ln(x_{ij}) = \alpha + \beta \cdot p_{ij}$$

$x_{ij}$ : travels to go shellfish gathering between zones $i - j$

$p_{ij}$ : generalized travel cost between zones $i - j$

$i - j$ : origin and destination (prefectures)

$\alpha, \beta$ : unknown parameters

# Results

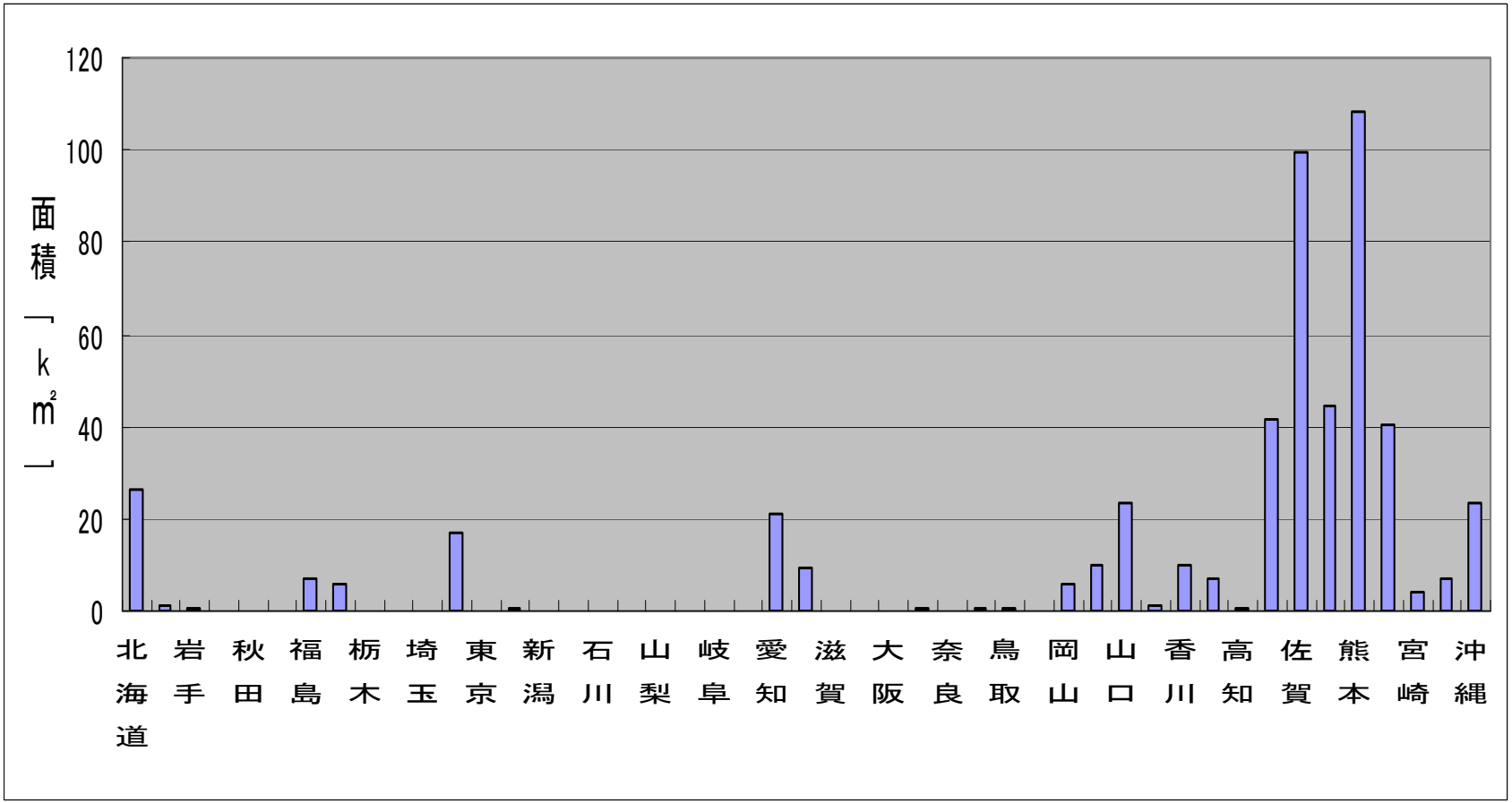
- Value of biodiversity preservation function (by CVM)
  Value per year per people: 1,599[yen/year/people]
  Total value in Japan: 5,106.6[billion yen]
  Average value in Japan: 9,935[yen/㎡]

- Value of recreation function (by TCM)
  Value per trip: 2,099[yen/trip]
  Total value in Japan: 117.5[billion yen]
  Average value in Japan: 228[yen/㎡]

- Unit value of tidal-flat
  Average value in Japan: 10,163[yen/㎡]

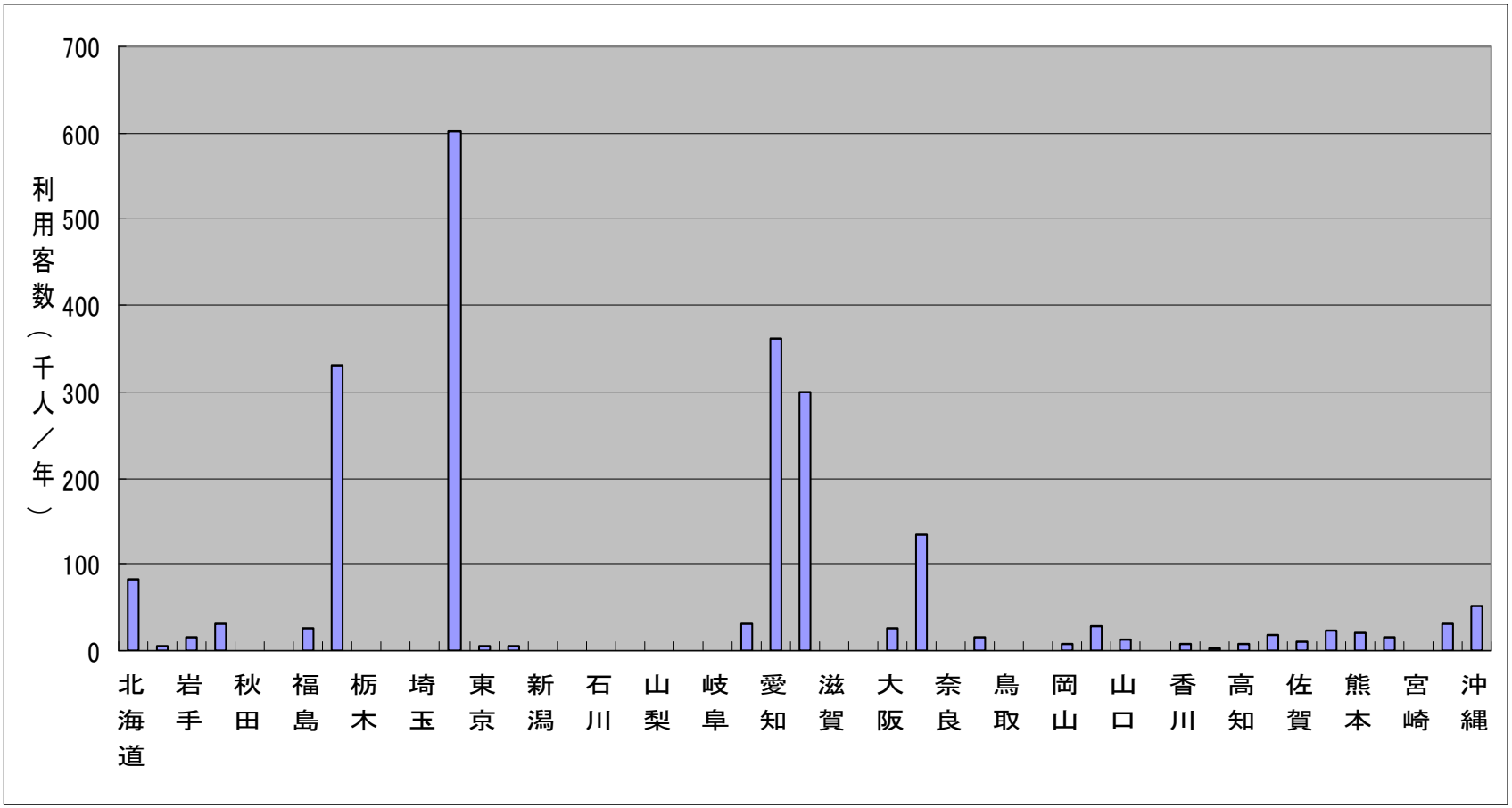
# Areas of Tidal-flat

(×9,935[yen/㎡]=Value of Biodiversity Preservation Function)

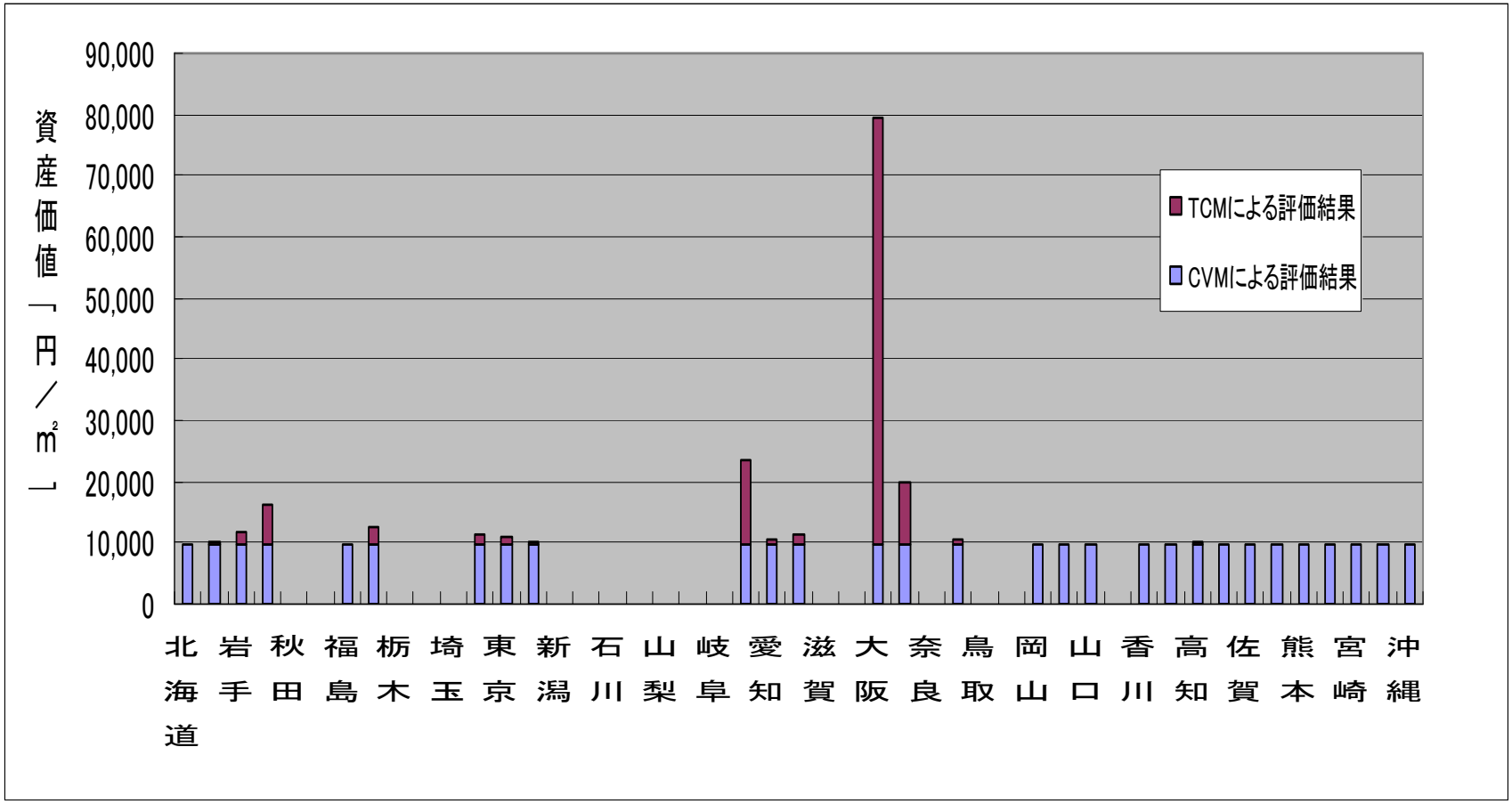


# Users of Tidal-flat

(×2,099[yen/people]=Value of Recreation Function)



# Unit Value of Tidal-flat



# Damage Cost by Global Warming

# Damage Cost on Heat-stroke

## ■ Outline of impact assessment index

- In the present study, focusing on the mortality risk due to heatstroke, which is the main factor in heat stress, the cost of damage is measured by the contingent valuation method (CVM).
- Changes in heatstroke mortality are estimated by multiplying the current average mortality due to heatstroke by the future changes in risk estimated using a model for estimating excess mortality due to heat stress, and the results are multiplied by the value of a statistical life (VSL) to estimate the cost of damage from mortality due to future heat stress (heatstroke).

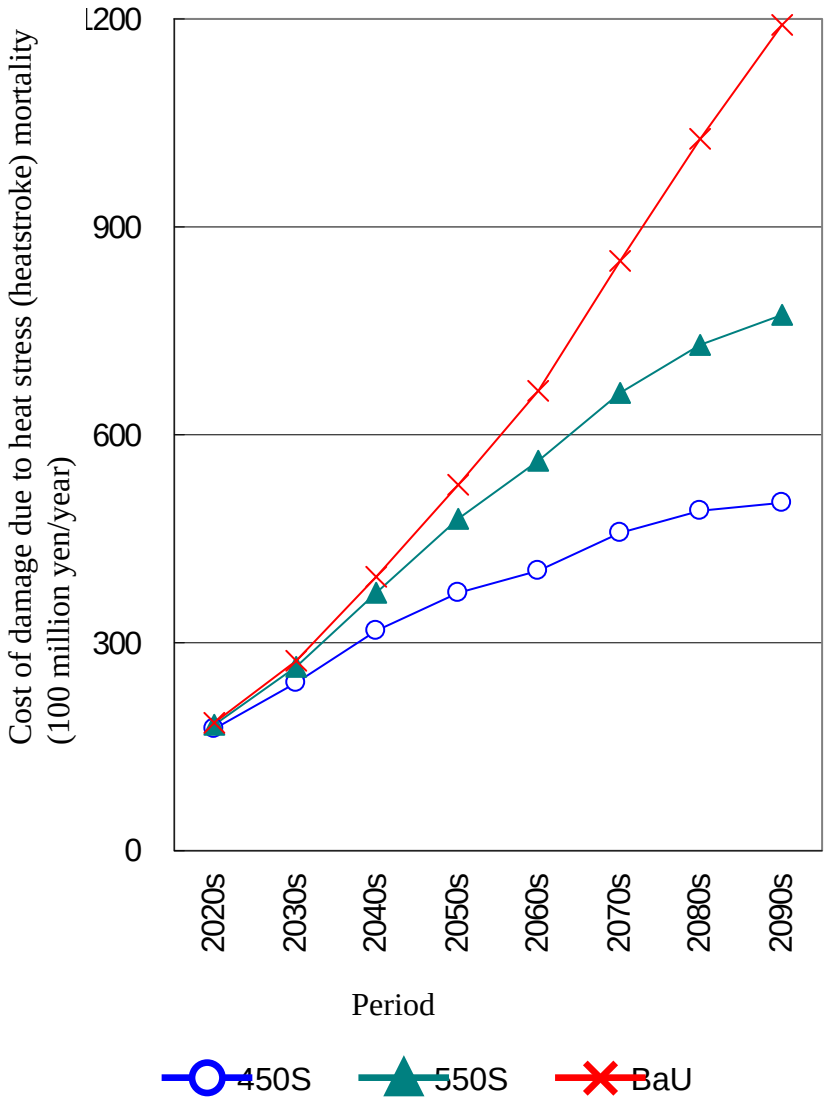
### □ Future impacts

● Nationwide trends

- The lower the level at which GHG concentration is stabilized, the lower the cost of damage due to heat stress (heatstroke) mortality becomes. Particularly in the case of the strictest stabilization level (450s), the cost of such damage is expected to roughly reach a ceiling at approx. 50 billion yen/year.
- Differences in the cost of such damage remain comparatively small around mid-century (2050s), at approx. 37.3 billion yen/year (450s), 48.0 billion yen/year (550s), and 52.9 billion yen/year (BaU). However, at the end of the century (2090s), large differences are expected according to the stabilization level, reaching approx. 50.1 billion yen/year (450s), 77.5 billion yen/year (550s), and 119.2 billion yen/year (BaU), respectively.

● Regional trends

- The costs of damage are large in the Kanto/Koshinetsu/Hokuriku and Tokai/Chubu/Kinki regions, which have high estimated values of heat stress mortality risk during the base and future periods as well as large populations. The rate of increase in the cost of damage is expected to become larger in the Chugoku/Shikoku/Kyushu region, where a high increase in risk is expected.



# Damage Cost on Beech-forest

## Outline of impact assessment index

- Focusing on the biodiversity maintenance function of *F. crenata* forests, their environmental economic value is estimated by the contingent valuation method (CVM).
- The environmental economic value estimated in the present research is the nonmarket value (the value of items not traded on the market). For accurate cost-benefit analysis, it is necessary to also estimate the market value.

## Future impacts

### Nationwide trends

- Under the 450s and 550s GHG concentration stabilization scenarios, the rate of increase in the cost of damage is expected to be reduced.
- Slight differences are seen in the cost of damage under the 450s, 550s, and BaU scenarios by around mid-century (up to the 2050s), at approx. 103.4 billion, 127.3 billion, and 138.1 billion yen/year, respectively. However, significant differences appear among the scenarios by around the end of the century (up to the 2090s), with the cost of damage expected to reach approx. 132.5 billion, 181.1 billion, and 232.4 billion yen/year, respectively (present value: approx. 7.8 trillion yen).

### Regional trends

- In the Hokkaido/Tohoku region where the present area of suitable habitats for *F. crenata* forests is large, the cost of damage by around the end of the century (up to the 2090s) is expected to reach approx. 83.2 billion yen/year (450s), 114.6 billion yen/year (550s), and 147.9 billion yen/year (BaU).