*Forestry and Forest Products Research Institute
**Chiba Prefectural Forestry Research Centre

*Norimasa Takayama
**Tamami Kasetani, *Takahide Kagawa

Background

①Forest "bathing" (Taking in the atmosphere of a forest)

Means for physically and emotionally relaxing and restoring vitality by enjoying a forest environment.

②Current status of forest bathing research

Since 2004, rapid progress has been made in clarifying the physiological and psychological effects of forest bathing.

→The therapeutic effects of forest bathing are being confirmed scientifically!
→There is great need for forests as local resources that can vitalize communities!
→Forest bathing is attracting attention as an alternative medical treatment that can help reduce health care costs!

③Changes in forestry and trends in forest management

At the same time, there are many indications that it will become commonplace to allow trees to grow very large before harvesting (forestry which aims for long-term growth to produce large-diameter trees).

→As forests become older with larger diameter trees, there will be a great need for appropriate utilization and management methods!

Assuming future needs, what kinds of effects will arise from bathing in large forests comprised of giant trees?
In addition, it is also necessary to find out what causes the differences in effects!!!

To answer this and other questions, it will be necessary to take research approaches that compare forests composed of large, 200- to 300-year-old trees (old-growth forests) with typical 40-year-old man-made forests (control)!!

Purposes

Against this backdrop, research will be conducted on two old-growth forests and one control forest, with the following purposes:

①To reveal the distinguishing features of the psychological effects of bathing in an old-growth forest
②To examine the relationships among forest bathing effect spatial impressions, and forest environment

Research Methodology

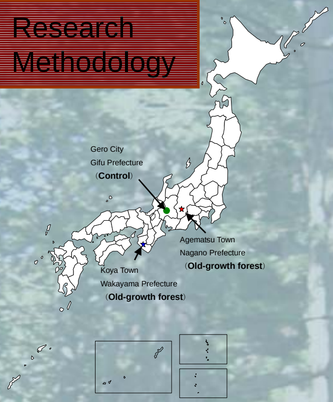

fig. Locations of study areas

Old-growth forests

Koya town, Wakayama Prefecture
Three-Cedar Trolley Trail

Giant sugi (Japanese cedar) forest

Agematsu town, Nagano Prefecture
Akasawa Recreational Trail

Giant hinoki (Japanese cypress) forest

Control

Gero City, Gifu Prefecture
Shimi Hiking Trail

Typical sugi/hinoki (cedar/cypress) forest

Sugi (cedar) and hinoki (cypress) trees are the dominant trees of both the old-growth and control forests.

fig. Scenery of forest bathing courses

Interior forest environments in each study area

Analyses of aerial photographs

・Number of trees per unit area
・Basal area at breast height
・Measurement of relative light intensity

Equipment for measuring thermal environments

・Measurement of climatic conditions

table.Characteristics of forests in the study area and climatic conditions

Study area	Koya Town Wakayama Prefecture	Agematsu Town Nagano Prefecture	Gero City Gifu Prefecture
Category	Old-growth forest	Old-growth forest	Control
Date of environmental measurements	2006/8/3	2005/7/8	2004/11/5
Weather	Fair	Fair	Fair
Temperature (℃)	24.5	19.2	20.1
Humidity (%)	83.1	86.1	44
Radiant heat (℃)	24.7	18.9	20.1
Wind speed (m/s)	0.4	0.62	0.4
Species composition	Coniferous (sugi cedar)	Coniferous (hinoki cypress)	Mixed coniferous (sugi and hinoki)
Forest age	About 40-200 years old	About 300 years old	About 30-60 years old
Relative light intensity (%)	19.1 low	22.6 low	26.4 high
Number of trees per unit area	6.6 low	8.6 low	9.6 high
Breast height basal area (m^2)	26.6 low	34.6 low	38.5 high

Analytical results: The number of trees and basal area at breast height of old-growth forests are both low!
The relative light intensity in old-growth forests (the amount of light entering the forests) is low!

Methodology for the forest bathing (psychological) experiment

■**SDM**(Semantic Differential Method):Understanding impressions of forest interior space
-21 sets of adjectives (SD criteria), 7 levels (1-7 points)

■**POMS**(Profile Of Mood States):Understanding the effects of forest bathing
-Six criteria related to mood (POMS criteria)

Overview and flow of the forest bathing experiment

table.Overview of the forest bathing experiment

Study area	Koya Town Wakayama Prefecture	Agematsu Town Nagano Prefecture	Gero City Gifu Prefecture
Category	Old-growth forest	Old-growth forest	Control
Period of forest bathing experiment	2006/8/1-3	2005/7/6-8	2004/11/3-5
Forest study area	Three-Cedar Trolley Trail	Akasawa Recreational Trail	Shimi Hiking Trail
Number of subjects	12	12	12
Affiliation of subjects	Wakayama University (graduate and undergraduate)	Shinshu University (graduate and undergraduate)	Gifu University (graduate and undergraduate)
Gender of subjects	Male	Male	Male
Average age of subjects	21.5±1.1	21.8±1.3	23.0±0.9

※All subjects in the experiments were male national university students in their 20s (12 subjects per experiment)

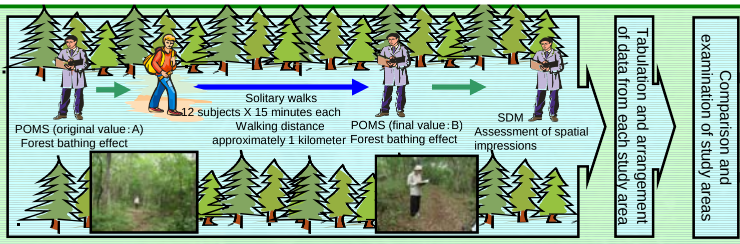

fig. Flow of the forest bathing experiments

Analytical results

②Comparison of physical environments of forest interiors

Compared with the control forest, the old-growth forests…

・had fewer trees and less basal area at breast height, meaning that there were less cluttered views!
・had lower relative light intensity, meaning that their light environments had a soothing effect!!

What is a forest environment?

What is evaluation of impressions？

①Comparison of forest bathing results

table.Comparisons of evaluations between old-growth and control forests

Category	Study area	Tension/ anxiety	Suppression/ melancholy	Anger/ hostility	Vitality	Fatigue	Confusion
Old-growth forest	Koya town Wakayama Prefecture Net value (B-A*)	-1 low	-0.33 low	0 low	6.17 high	-3.67 medium	-0.5 low
	Agematsu town Nagano Prefecture Net value (B-A)	-1.08 low	0.33 low	0.08 low	5.58 high	-1.67 medium	-1.33 low
Control	Gero City Gifu Prefecture Net value (B-A)	-5.75 high	-1.83 medium	-3.17 medium	-0.83 low	-0.83 low	-2.42 medium
Established level of significance		＊＊ ☆☆	☆☆		＊ ☆		

＊: Koya Town – Gero City
☆: Agematsu Town- Gero City
※: Koya Town- Agematsu Town
**:p<0.01,*:p<0.05%,ANOVA-Fisher
B-A* = final value minus original value

・There was no significant difference in forest bathing between the two old-growth forests!
・Compared with the control forest, vitality significantly increased in the old-growth forests! The old-growth forests also showed a significant reduction of tension and anxiety.

③Comparison of evaluations of impressions of forest interiors

table.Comparison of evaluations of impressions of forest interiors
(Five criteria having significant differences were selected from among the 21 SD criteria.)

Category	Study area	Artificial-natural	Ugly-beautiful	Vulgar-spiritual	Unnerving-relaxing	Unhealthy-healthy
Old-growth forest	Koya town Wakayama Prefecture	6.67 high natural	6.33 high beautiful	5 high spiritual	6 high relaxing	5 high healthy
	Agematsu Town Nagano Prefecture	6.67 high natural	6.17 high beautiful	4.33 mideum spiritual	6.33 high relaxing	6.33 high healthy
Control	Gero City Gifu Prefecture	4.83 mideum natural	4.83 mideum beautiful	3.25 mideum spiritual	5.08 mideum relaxing	4.17 mideum healthy
Established level of significance		＊＊ ☆☆	＊＊ ☆☆	＊＊ ☆	＊ ☆☆	＊ ☆☆

＊: Koya Town – Gero City
☆: Agematsu Town- Gero City
※: Koya Town- Agematsu Town
(**:p<0.01,*:p<0.05%,ANOVA-Fisher) 5/21 sets of adjectives 7 levels:1point(low)-2-3-4-5-6-7point(high)

Take a step inside…

・There was no significant difference between old-growth forests!
・Compared to the control forest, SD criteria for the old-growth forests showed highly significant differences in naturalness, beauty, sense of spirituality, soothing ability, and wholesomeness!

④Examination of how differences in impressions of forest spaces influenced the effect of forest bathing

table.Factor analysis of correlation coefficients (between POMS and SD criteria) Factor loadings

Evaluation criteria (7 levels)	Axis-Ⅰ Comfort-aesthetics	Axis-Ⅱ Mystique	Axis-Ⅲ Understan-dability	Axis-Ⅳ Gentle coolness
3-dimensional-2-dimensional	0.911	−0.151	−0.157	0.200
Ugly- beautiful	0.872	0.220	−0.273	0.223
Gloomy- cheerful	0.856	0.181	−0.290	0.134
Friendly-unfriendly	−0.833	−0.417	0.281	−0.039
Comfortable-uncomfortable	−0.758	0.128	0.229	−0.504
Likeable-dislikeable	−0.756	−0.492	0.328	−0.192
Good smelling-bad smelling	−0.717	−0.524	0.355	−0.067
Quiet-noisy	−0.702	−0.056	0.277	−0.516
Artificial-natural	0.701	0.269	−0.530	0.380
Unnerving-relaxing	0.669	0.132	−0.507	0.492
Healthy-unhealthy	−0.663	−0.307	0.560	−0.357
Bright-dark	−0.130	0.864	−0.155	−0.359
At ease-uneasy	−0.374	−0.815	0.100	−0.231
Inactive-lively	−0.178	0.720	0.352	−0.327
Sparse-luxuriant	−0.241	−0.706	0.489	−0.230
Orderly-disordered	−0.392	−0.690	0.161	−0.265
Open-closed	−0.358	−0.314	0.874	−0.074
Generic-individual	0.507	−0.018	−0.777	0.215
Spiritual-vulgar	−0.654	0.056	0.688	−0.296
Stimulating-sedating	0.366	−0.131	−0.038	0.914
Warm-cool	0.101	0.176	−0.489	0.757
Contribution rate	0.376	0.193	0.190	0.150
Total contribution rate	0.376	0.569	0.759	0.909

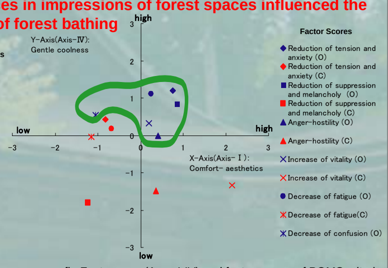

fig.Factor axes (Axes I-IV) and factor scores of POMS criteria (C= control; O= old growth forest)

・Four factor axes were obtained as a result of the factor analysis: Comfort -aesthetics (Axis I), Mystique (Axis II), Understandability (Axis III), and Gentle coolness (Axis IV).
・In the control forest: All factor scores of all criteria occur within the negative range of at least one negative factor axis.
・In the old-growth forests: Numerous criteria were located within the positive ranges of both Comfort-aesthetics (Axis I; x-axis) and Gentle coolness (Axis IV; y-axis).

Discussion

Purpose①: Characterizing the psychological results of bathing in old-growth forests

According to the analytical results in ①, bathing in an old-growth forest significantly increased the vitality criterion compared with the control forest, Furthermore, tension and anxiety were reduced, albeit at a low level of significance. However, because there was no significant difference in the values for tension and anxiety between the control forest and old-growth forest after the walk, it appears that before walking in the old-growth forest, subjects felt neither tense nor uneasy.

Purpose ②-1: Understanding the interrelationship among forest bathing effect, spatial impression, and forest environment①

According to the analytical results ②→③→①, the old-growth forests had a much better viewing environment, and more soothing light conditions, than did the control (analytical result ②), gave better feelings of spirituality, naturalness, and calmness (analytical result ③), and differences in impressions have been especially reflected in the increase in vitality (analytical result ①).

Purpose ②-2:Understanding the interrelationship among forest bathing effect, spatial impression, and forest environment②