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Finding stress relief in a forest

Matilda Annerstedt, Johan Norman, Mattias Boman, Leif Mattsson, Patrik Grahn and Peter Währborg

This study investigates the purpose of visiting forests in southern Sweden in addition to examining a hypothesis of broad leaved forests as particularly efficient in reducing stress. A questionnaire was sent to a random sample (n=1476) of inhabitants in the counties of Skåne and Blekinge. The respondents assessed their symptoms of stress and general health as well as the frequency of visits and duration of stay in the forest. They were also asked about their distance to the forest and what kind of forest they usually visited. The material was subdivided by gender as well as in accordance with the kind of forest the respondents visited – broadleaved or coniferous. Three symptoms of stress were factor analyzed and a single estimate, level of stress (LS), was calculated. The purposes of forest visits differed between the forest groups. In comparison with the coniferous forest visitors, it was of relatively higher importance to the broad leaved forest visitors to merely experience nature without any concrete activity in mind. Regression analyses revealed several significant determinants of variation in LS, namely age, perceived health state, education level, sick leave, household size, length of stay in the forest and distance to the forest. Concerning the explanatory variables of interest length of stay had a significant negative association to LS among men in the group of broadleaf visitors, and in the same forest group distance to forest was positively related to LS among women. These findings indicate that broad leaved forests may have specific important experience values to human beings as well as a beneficial relation to human health in aspects of stress relief. This can have implications when considering the establishment and preservation of forests as well as in questions and priorities of public health.

M. Annerstedt (matilda.annerstedt@ltj.slu.se), P. Grahn and P. Währborg, Swedish Univ. of Agricultural Sciences, Dept of Work Science, Business Economics and Environmental Psychology, P.O. Box 88, SE-230 53 Alnarp, Sweden. – J. Norman, M. Boman and L. Mattsson, Swedish Univ. of Agricultural Sciences, Southern Swedish Forest Research Centre, P.O. Box 49, SE-23053 Alnarp, Sweden.

Stress related states like mental fatigue (e.g. burnout syndrome), sleep disturbance, and depression, are together with musculoskeletal disorders today the most widespread diseases causing long term sick leaves in Sweden among patients between 20 and 60 yr of age (The Swedish Social Insurance Agency 2007). This is in line with the World Health Organization (WHO) global scenario, which suggests that mental health disorders and cardiovascular diseases are expected to be the two major contributors to illnesses in almost all parts of the world, by the year of 2020 (Murray and Lopez 1996).

Compared to ancient days, the contemporary human being has to deal with a rapid pace of life, high continuous demands, and competitiveness resulting in an overload of uncontrollable stressors (factors triggering stress) (Maller et al. 2006). During stress different body organs react in many varied ways, and if sustained for a prolonged time without the possibility for recovery these reactions become dysfunctional and harmful with the risk of causing deleterious changes to, for instance, the cardiovascular system and neuro-hormonal systems of the body (McEwen 2000, Währborg 2002). This may cause psychiatric illnesses, metabolic disturbances, impaired immunological function, as well as a higher incidence of tumours (Lundberg 2005, Öhman et al. 2007). In combination with the current sedentary lifestyle, with a substantial lack of daily physical activity to many persons (30–40% of the Swedish population is insufficiently physically active according to Elinder and Faskunger 2006), this is a significant threat to public health.

In aspects of mental health disorders and in matters of stress, gender is an important predictive factor or determinant. It has been found that reactions and responses to stress differ between men and women, both on a somatic, neurological level, and in psychosocial aspects (Frankenhauser 1983, Kudielka and Kirschbaum 2005). Due to

these observations it seems important to reveal any gender specific qualities in recreational activities and whether one can find differences in the factors related to restoration and stress relief between men and women.

Since the beginning of the 1980s an increasing number of research findings have indicated that nature can bring about quick and strong recovery for stressed individuals (Kaplan and Talbot 1983, Ulrich 1984, Ulrich et al. 1991, Herzog et al. 1997) and the links between natural landscape and health are continuously recognized, as is shown by the emergence of recent studies on the ameliorating effects of exposure to green spaces on stress levels (Hartig et al. 2003, Hansmann et al. 2007). One aspect of this is concerned with the accessibility to nature and recreational surroundings as a means of providing opportunities for physical activity and mental restoration, in order to reduce stress and maintain a balanced lifestyle (Grahn and Stigsdotter 2003). It has also been investigated if the amount of "nature exposure" in terms of the length of stay and the frequency of visits to nature have any influence on the potential stress relief, and particularly the length of stay has in previous research revealed some importance (Grahn and Stigsdotter 2003, Korpela et al. 2008). There is a lack of empirical evidence though, and only few epidemiological studies have been performed on the subject (Björk et al. 2008, Mitchell and Popham 2008).

What is also sparsely investigated is if any particular kind of nature might be more efficient for stress recovery compared to another. This is a complex question, considering that landscapes are dynamic and perceived individually. Given that theories of environmental psychology and studies of association between nature and health are mainly dealing with nature as such as a means for providing health benefits, we formulated hypotheses based on the special qualities of broad leaved forests to investigate these qualities in relation to existing theories and paradigms.

The character of a broadleaved forest could be considered as quite similar to the kind of environment that is thought to be our evolutionary origin, the savannah – moderate to high depth or openness, relatively smooth or uniform-length grassy vegetation or ground surfaces, scattered trees or small grouping of trees, and water. It has in earlier research been shown that people's actual landscape preferences conform to this scenario (Purcell et al. 1994). This is also in accordance with the evolutionary perspective of the biophilic hypothesis (which suggests that there is an instinctive bond between human beings and other living systems, Wilson 1984), as well as with the Aesthetic-Affective theory (Ulrich 1983), both part of the environmental psychology framework. The Aesthetic-Affective theory considers the stress-reducing effects of nature as a matter of unconscious processes located in the evolutionary oldest, emotion-driven, parts of the brain (Ulrich 1993, Demos 1995). According to this theory nature has an ability to rapidly reduce, or induce, stress – aesthetically. The theory concerns special information in nature that advises us when it is possible to rest, which results in decreased stress. This is an unconscious feeling of security that occurs in environments like those wherein humans developed originally. These processes, or reflexes, inform us when we can rest or when we should be active, including being prepared to flee or fight. Thus, in fractions of a second we get basic information about the whole context in the surrounding environment. According to this evolutionary theory, our original environments were open pastoral landscapes dominated by broad leaved vegetation, wooded meadows, and a few larger trees.

The nature of a broadleaved forest can also, hypothetically, conform to the Attention Restoration Theory (Kaplan and Kaplan 1989). In short this theory is based on a cognitive view, founded on the idea that people's power of attention consists of two fundamentally different parts: directed attention and fascination. The capacity of directed attention is restricted and is linked to executive functions, hence important for decision making. The involuntary attention, fascination, is on the other hand of a passive character and usually not constrained. Due to overload of input and a continuous demand of directed attention (concentrated focusing) the connections between information retrieving and information processing in higher cognitive parts of the brain are worn out and the system becomes "exhausted" resulting in mental fatigue, which ultimately diminishes our normal brain functions. By dwelling in a setting where there is a restricted amount of input, and where the input is also of another character than in modern civilization – stimulating the non-demanding involuntary attention, fascination – the systems in our brains get a chance to rest and recover from mental fatigue. To a relatively high extent, broad leaved forests provide the features of being away, extent, fascination and compatibility, the four qualities outlined by Kaplan and Kaplan to be essential for the directed attention to rest, in favour of spontaneous and non-demanding fascination. This enables a cognitive restorative experience to occur.

With the theories of environmental psychology as basis (Wilson 1984, Ulrich 1993, Kaplan and Kaplan 1989) we formulated a hypothesis that access to and visits to forest nature would provide stress relief. In addition we wanted to explore whether broadleaved forests might, to a greater extent than some other natural settings (in this case compared to coniferous forests), provide the characteristic qualities necessary for a restorative and recreational experience to occur. Our intention was to test these hypotheses by investigating the purposes for visiting two kinds of forests (broadleaved or coniferous) in southern Sweden. We also aimed at testing the hypothesis by exploring the association between the number of, and the duration of, visits in forests, and stress experience as well as any importance of accessibility (as measured by distance to the forest), something that would be in accordance with previous studies of the impact of nature on health.

Definitions

Stress and health

There is no consent universal definition of the term stress. In early studies and writings by Hans Selye (1936), who introduced the concept in the way it is used today, he defined stress as "the non-specific response of the body to any demand for change". In our view mental stress results from interactions between persons and their environment that are perceived as straining or exceeding their adaptive capacities, and threatening their wellbeing.

The term allostatic load was coined by McEwen (2000). This model focuses on how the individual experiences challenging events and how the body reacts physiologically by trying to adapt hormonal systems to reach stability – "maintaining stability through change" (allostasis). The model also distinguishes between acute and chronic stress responses. The acute responses are necessary in order to adapt effectively to current demands in the environment, but they need to be followed by periods of rest and recovery. A prolonged activation leads to wear and tear on bodily resources (allostatic load), increasing the risk for future health problems. Allostatic load can be measured in diverse physiological systems of the body as chemical imbalances, and in some cases as plasticity changes in brain structures (McEwen 1999, Kim et al. 2001).

Definitions of health have evolved from varied perspectives. From a clinical point of view focus has been on the bio-medical concept, where health is principally defined as absence of disease. This is in discrepancy with the broader humanistic definition, comprising holistic, socioecological, and salutogenic (stressing the individual's capacity for achieving and maintaining health) perspectives as well. In this paper we will consider health as mainly a multidimensional resource, including aspects of stress and possibilities for recovery. This is in accordance with the declaration of health by WHO (1948) – "a state of complete physical, mental and social wellbeing, not merely the absence of disease or infirmity". WHO has also put an emphasis on our everyday occupation as a means of developing health or disorder – "Health is created and lived by people within the setting of their everyday life: where they learn, work, play and love" (WHO 1986).

Definitions of forest types

The area in Sweden covered by forests is ca 60% (ca 22 million ha). A great majority (83%) of these forests is dominated by coniferous (Norway spruce and Scots pine) tree species, 6% are dominated by broadleaved tree species and 8% are mixed forests with both conifers and broadleaves. The broadleaved forests are in turn composed of "trivial" broadleaved tree species (e.g. birch, aspen and alder, 5%) and "noble" broadleaved tree species (1%). The forest conditions in the southernmost counties of Skåne and Blekinge, where this study was performed, differ from the national level. The corresponding percentages of "noble" broadleaved tree species in these two counties are 21 and 14%, respectively.

Making a division into broadleaved forests (noble broadleaves + trivial broadleaves), mixed forests, and coniferous forests, 38% of Skåne's forests would be classified as broadleaved and the corresponding percentage for Blekinge is 23%. Coniferous forests (spruce + pine) are dominating the forest area in the two counties, 54% in Skåne and 67% in Blekinge.

Materials

From The Swedish Population Address Register a randomized sample of 3000 persons aged between 18 and 75 yr (mean 47 yr), dwelling in the southernmost parts of Sweden (the counties of Skåne and Blekinge), was obtained. The survey was distributed in June 2006 and 1476 respondents returned our mailed questionnaire (response rate 49%).

The questionnaire ("An investigation of the importance of forest nature in Skåne and Blekinge") had a broad perspective in order to examine different dimensions of the value of forest nature and outdoor recreational habits, in particular broad leaved forests in southern Sweden. The questions were grouped in themes regarding visits to forest and nature, preferences regarding different kinds of forests, how the forest nature was explored and experienced, what the purposes and expenses of the visits were, as well as questions on varied dimensions of health, and background data. Altogether the survey included 50 questions, some of them including several items. To address the aims of this particular study, we focused on the questions concerning self perceived health and level of stress as well as those examining distance to forest, time spent in forest, purpose of the visits, and number of visits. Background data was also obtained as is shown in Table 1.

The geographical area was chosen partly because of its relatively high prevalence of broadleaved forests (23–38%, see above).

Methods

Measuring health and calculating the level of stress (LS)

In order to investigate perceived health state of the respondents we used a self assessment instrument. There are several different validated instruments used worldwide for the purpose of measuring self perceived health, and these may contribute to a slightly different perspective on the ques-

Table 1. Descriptive statistics for the sample.

Variable	Scale/ranking	Means	Median	SD	n
Age	Continuous, 18–75 yr	47.7	48	15.7	1413
Gender	Dummy, 0=woman, 1=man	52% women	–	–	1423
Income, SEK yr^{-1}	Ordinal, (16 alt.), 25 000–775 000	312 693	275 000	171 845	1292
Unemployment	Dummy, 1=unemployed, 0 otherwise	4% unemployed	–	–	1419
Sick leave	Dummy, 1=on sick leave, 0 otherwise	3% on sick leave	–	–	1419
Household size	Ordinal, 1=1 person, 5=5 or more	2.6	2	1.2	1424
Body mass index, BMI	Continuous, 16.5–57.1	25.1	24.6	41.0	1377
Education level	Dummy, 1=university or higher, 0 otherwise	32% high	–	–	1379
General health state, VAS	Continuous, 0–100	77.7	80	19.0	1406
Level of stress, LS	Continuous, 2.67–18.69	10.0	10.65	15.6	1265
Forest visitor group	Dummy, 1=broadleaf, 2=coniferous	37% coniferous	–	–	1476
Born in Sweden	Dummy, 1=born in Sweden, 0 otherwise	89% born in Sweden	–	–	1419

Note: data from the whole sample was used to produce the results in this table. SD=standard deviation, n=number of observations. The numbers of observations vary due to different response rate to different questions. The lowest values (1265 resp. 1292) come from the questions of income and level of stress respectively. This might be indicative of a general reluctance among respondents to share information of their income. In the case of level of stress it may be that in order to generate one observation on this variable the respondent had to answer three questions (about stress, irritation and fatigue).

tion of health compared to clinical medical instruments like x-ray or laboratory examinations, since they demand for the individual's personal and subjective experience.

Among the most common and validated formats is EuroQol (EQ-5D), which was used in this survey as well as the attached EuroQol Visual Analogue Scale (EQ VAS) (Brooks 1996, Brooks et al. 2003) (Fig. 1). We used the respondents' estimate on EQ VAS in order to achieve a single measure of perceived health state, and we denoted the variable "general health" (referred to as VAS in tables and figure).

To estimate a population's stress level a frequently used test in Sweden is SCI-93, developed by Nyström and Nyström (1995). This test contains 35 questions concerning stress symptoms in terms of mental complaints, muscular complaints, and autonomic complaints (problems with eating, sleeping etc.). In a study by Grahn and Stigsdotter (2003) the, from their interpretation, most prominent and clearest questions from SCI-93, as well as from a couple of other sources (Uvnäs-Moberg 1997, Maslach 2001), were chosen to achieve a simplified, but relevant subset of questions to examine perceived stress. The chosen questions were concerned with headache, ache in the back of the head, irritation, fatigue, backache, and stress. By using factor analysis (Varimax, orthogonal rotation) the association between those six complaints was examined and the three variables stress, fatigue, and irritation together pointed to one strong factor that was interpreted as level of stress. A new variable, level of stress (LS), could hereby be calculated. In our survey the respondents answered how often during a year they experienced the same three feelings – stress, fatigue, and irritation. There were seven response alternatives ranked from never to every day, and we recoded the answers to numbers estimating how often they suffered from each complaint per year (0, 2, 4, 12, 26, 52, 365) (Table 2). We performed, in accordance with the procedure by Grahn and Stigsdotter (2003), a princi-

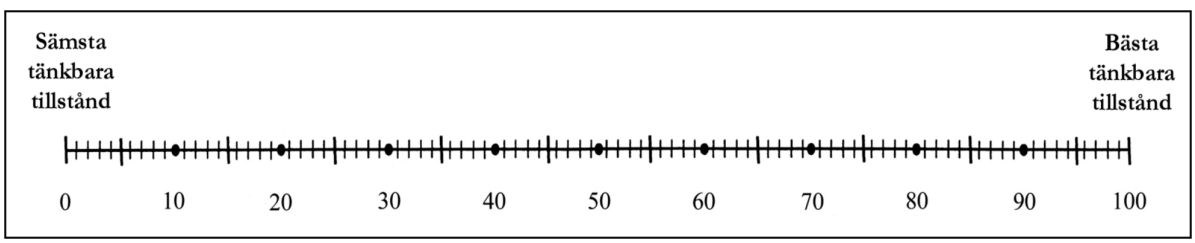

Figure 1. The Visual Analogue Scale (EQ VAS) used in the survey (the text at both ends of the scale is in Swedish). Translated to English, "0" says "worst imaginable state" and "100" says "best imaginable state". The word "state" is in this case understood as health state.

pal component analysis, based on the correlation matrix, to examine the relative contribution of the variance in LS by those three complaints. The first principal component explained 65% of the variation and the values (PC1) were 0.582, 0.594 and 0.555 for irritation, stress and fatigue respectively. By the aid of those values, we were able to make a fairly weighed calculation of LS, according to this formula (Manly 1994, Morrison 1976):

$(PC_{stress} \times stress) + (PC_{irritation} \times irritation) + (PC_{fatigue} \times fatigue) = Level\ of\ Stress\ (LS)$

that is:

$(0.594 \times stress) + (0.582 \times irritation) + (0.555 \times fatigue) = Level\ of\ Stress\ (LS)$

The same formula was used for all calculations of LS, in different groups of the material. We used non standardized values of stress, irritation, and fatigue since the standard deviation of the three variables were rather similar (Table 2). In this article we will examine how LS might be predicted by different parameters of forest use.

Statistical methods and principles for analysis

We wanted to examine if there was any discrepancy between the purposes of the visits to different forest types. We also wanted to investigate the hypothesized restorative experience derived from visiting forests and if any difference could be found between visits to broadleaf forests and visits to coniferous forests. For that reason the data was split into "broadleaf forest visitors" and "coniferous forest visitors". This was accomplished in accordance with one of the questions in the survey, where the respondents answered to what kind of forest they usually visit. There were four different response options – spruce, pine, "noble" broadleaved, and other broadleaved – but in this study we found it most relevant to use the definitions of just broadleaved forest (noble broadleaves together with other broadleaves) or coniferous (spruce and pine) forest. Due to previously discussed differences in experiences and reactions of stress we also subdivided the sample by gender, performing the analyses to men and women separately.

Because of different units among the variables we used the non parametric Mann-Whitney's test for investigating differences between the gender groups and the two forest groups. Our aim was to reveal any significant differences between the purposes of the forest visits to the two groups of forest types ("broadleaved forest visitors" and "coniferous forest visitors"). The respondents were asked to rank (from 1 to 100) the relative importance of six purpose dimensions of forest visits (to merely experience the forest by all senses, to exploit the forest by picking berries and mushrooms, to visit ancient remains, to perform physical activities, to walk with the dog, or finally any other purpose).

We also wanted to relate LS (dependent variable) to theoretically interesting variables derived from the data. We compared the mean ranks (Mann Whitney's test) of the variables that we intended to use in the advanced analyses, between the groups. We hypothesized the interesting explanatory variables to LS, from our point of view, to be length of stay in forest, number of visits, and distance to forest (Table 3). Several varied factors (e.g. lifestyle related, relationally related, socially related, economically related) are known to influence stress (Währborg 2002). With this background we theorised other possible explanatory variables to the variance in LS to be country of birth (Sweden or not), household size, income, status of employment (employed or not), level of education (high or low), whether the person was on sick leave or in duty, age, general health (VAS), and body mass index (a function of an individual's length and weight, BMI). For all these variables any significant differences between the groups were examined.

The further statistical analysis consisted of multiple linear regression analysis (stepwise) with LS as dependent variable and 13 main variables as independent variables.

The statistical software used in this study was SPSS 16.0, Minitab 15.0, Microsoft Excel, and LIMDEP 3.0. Origin 8 was used for analyses.

Results

The results from Mann-Whitney testing between the two groups of forest types revealed the groups to be different in some aspects (Table 4) and alike in others. Regarding pur-

Table 2. Variables included in the principal component analysis (PC), to achieve LS source: all material.

Measure	Scale/ranking	Mean	Median	SD
Annoyance yr^{-1}	Ordinal, 0=never, 365=everyday (7 alternatives)	46	12	99
Stress yr^{-1}	Ordinal, 0–365	72	12	128
Fatigue yr^{-1}	Ordinal, 0–365	59	12	117

Note: data from the whole sample was used to produce the results in this table. SD=standard deviation, number of observations= 1271, 1264 and 1260 respectively.

Table 3. Descriptive statistics for variables related to forest use.

Variable	Scale/ranking	Mean	Median	SD	n
Experience nature	Continuous 0–100 points	40.4	40	28.5	1417
Pick berries and mushrooms	Continuous 0–100 points	11.7	2	18.1	1417
Visit ancient remains	Continuous 0–100 points	7.0	0	12.6	1417
Perform physical activities	Continuous 0–100 points	26.4	20	26.1	1417
Walk the dog	Continuous 0–100 points	8.8	0	20.0	1417
Other purposes	Continuous 0–100 points	6.0	0	18.7	1417
Length of visit	Ordinal 1=30 min – 10≥8 h	2.9	3	1.5	1401
Number of visits to forest	Ordinal scale 0=never – >156 visits yr^{-1}	39.0	15	47.4	1446
Distance to forest	Continuous 0–640 km	17.2	7	41.2	1385

Note: data from the whole sample was used to produce the results in this table. SD=standard deviation, n=number of observations.

pose of the visit there was a significant difference, whereas it seemed to be more important for the broad leaved forest visitors to merely experience the nature in the forest ($p = 0.001$). Between other purposes there were no significant differences. There were significant differences between the groups with relation to the background variables household size (highest mean rank among coniferous forest visitors, $p = 0.045$), and education level (highest mean rank among broad leaved forest visitors, $p = 0.003$). No significant differences in the variables LS, general health, unemployment, percentage on sick leave, percentage born in Sweden, BMI, age, gender, income, frequency of visits, distance to or length of stay in forest were found between the groups.

For the gender groups (Table 4) significant differences were found between the purposes of performing physical activities (higher mean ranking for females, $p = 0.011$) or other purpose (highest mean ranking for men, $p = 0.03$). None of the remaining purposes revealed any significant differences between the groups. There was a significant difference in duration, with lower mean ranking for women ($p = 0.001$). Among other variables women scored higher mean rankings for percentage on sick leave ($p = 0.048$), high education level ($p = 0.001$), and LS ($p < 0.001$). Significantly lower mean rankings were found for women on the variables income ($p = 0.006$) and BMI ($p < 0.001$). The variables general health, unemployment, age, born in Sweden, household size, frequency of visits, and distance to forest were not significantly different between the groups.

Results from the statistical regression analyses are shown in Table 5. The analyses contributed to four regression equations/models:

Table 4. Results from Mann-Whitney testing between the groups of broadleaf and coniferous visitors, listing the variables revealing significant differences.

	Highest mean rank	
Variable	Broadleaf/coniferous	Men/women
Experience nature	Broadleaf**(786/689)	–
On sick leave	–	Women*(746/764)
Household size	Coniferous*(736/793)	–
Body mass index (BMI)		Men**(25.9/24.4)
Education level	Broadleaf**(766/692)	Women**(716/760)
Level of stress (LS)	–	Women**(641/739)
Income	–	Men**(723/672)
Perform physical activities	–	Women*(717/775)
Length of visit	–	Men**(784/705)
Other purposes	–	Men*(758/735)

Note: * indicates significance at the 5% level, ** indicates significance at the 1% level. Values in parentheses are mean rank values from the non-parametric testing.

Coniferous forest visitors
Female: LS=21.716 – 0.113 × age – 0.077 × VAS
(t=–3.608, p<0.001; F=15.608, p<0.0001).
Male: LS=24.140 – 0.137 × age – 0.101 × VAS
(t=–4.137, p<0.001; F=19.715, p<0.0001).
Broadleaved forest visitors
Female: LS=20.708 – 0.103 × age – 0.077 × VAS + 2.350 × sickleave + 0.736 × educationlevel + 0.008 × dist.
dist.=distance
(t=2.076, p=0.038; F=36.218, p<0.0001).
Male: LS=21.289 – 0.100 × age – 0.094 × VAS + 2.097 × unemployed – 0.235 × duration + 0.299 × household
(t=1.996, p= 0.046; F=33.010, p<0.0001).

The equations are based on the unstandardized regression coefficients (b). Since the variables differ substantially in units of measurement neither their standardized coefficients (ß) are directly comparable (Norusis 1993). However, the absolute values of the coefficients are applicable and it is also important to notice the values of the signs before the coefficients. We can tell that in the group of coniferous visitors both age and general health have a significant negative relation to LS, irrespectively of gender, but none of the other variables contribute significantly to any explanation of the variation in LS. In the group of broadleaved forest visitors there are slight differences between the sexes. Among females we found a positive relation between distance to forest and LS, as well as with sick leave and education level, and a negative relation between age and general health and LS. For the male part of the sample we found a negative relation between length of stay in the forest and LS. There were also negative relations to LS for the general variables age and general health. Unemployment and household size were positively related to LS. In conclusion this reveals that, for the broad leaved forest visitors, a longer stay in the forest and shorter distance to the forest were associated with lower LS. In the sample of coniferous forest visitors age and VAS contribute to explain the variation in LS.

Table 5 shows the different variables significantly related to LS for each sample. The models explain 21.3–24.5% of the variance in LS and for all the models the F-test proves significant regression coefficients ($p < 0.0001$), with F ranging from 15.608 to 36.218. Collinearity diagnostics did not show problems of multicollinearity.

Discussion

In this study we found that the purpose of experiencing the forest nature was relatively more important to broad leaved forest visitors compared to coniferous forest visitors. Further on we observed an association between lower levels of stress and visits to nature. A pattern of five significant determinants with predictive value for LS was found in the group of broad leaved forest visitors and two significant determinants in the group of coniferous forest visitors. Among females in the broad leaved group a longer distance to forest predicted higher LS, apart from the determinants of background data (age, general health, sick leave, and level of education). A longer stay in the forest predicted lower LS among men in the broad leaved group, and the background data determinants were age, general health, unemployment, and household size. For coniferous forest visitors the explanatory variables to LS were both of background character – age and general health for both genders. These findings suggest that there may be an association between LS and the time spent in a broadleaved forest as well as the distance to the forest, though such

Table 5. Results from the stepwise regression analysis showing predictors of LS in the groups of coniferous forest visitors and broadleaved forest visitors, men and women respectively.

	Coniferous						Broadleaved					
	Men (n=113)			Women (n=105)			Men (n=492)			Women (n=490)		
	B	β	adj. R^2	B	β	adj. R^2	B	β	adj. R^2	B	β	adj. R^2
Age	–0.137	–0.391**	0.135	–0.113	–0.367**	0.124	–0.100	–0.310**	0.200	–0.103	–0.337**	0.112
VAS	–0.101	–0.340**	0.245	–0.077	–0.319**	0.219	–0.094	–0.326**	0.105	–0.077	–0.314**	0.209
Sick leave	–	–	–	–	–	–	–	–	–	2.350	0.111**	0.220
Distance	–	–	–	–	–	–	–	–	–	0.008	0.076*	0.230
Unemployed	–	–	–	–	–	–	2.097	0.075*	0.204	–	–	–
Length of stay	–	–	–	–	–	–	–0.235	–0.081*	0.209	–	–	–
Household size	–	–	–	–	–	–	0.299	0.075*	0.213	–	–	–
Education level	–	–	–	–	–	–	–	–	–	0.736	0.079*	0.226

Note: * indicates significance at the 5% level, ** indicates significance at the 1% level, B= unstandardized coefficient, β= standardized coefficient.

relations were not statistically significant in the group of coniferous forest visitors. Contrary to our hypothesis of a beneficial outcome of number of visits to forest per year, the frequency of visits to any kind of forest had no significant explanatory relation to LS.

As with many empirical studies in social and medical sciences (Jeffs et al. 2006), only a limited share of the variance in the dependent variable (LS) could be explained with the models (21–25% in different settings for men and women). What one has to keep in mind is that the magnitude of R^2 is dependent on the characteristics of the data being studied. It is a typical finding with a relatively low R^2 in cross-section studies where differences in behaviour are explained, since individual differences are likely to be caused by many factors that cannot easily be measured. This is a methodological limitation though, and in the future other important determinants might be found, even though we have tried to focus on what one theoretically may believe is relevant. Further research with more detailed questionnaires, concerned with e.g. aspects of nature orientedness and childhood forest experiences, as well as a more experimental methodological approach might be helpful.

We must also acknowledge that the determinants of LS with the lowest coefficients in our models (distance for women; length of stay and household size for men) may change in significance in other models. However, the results are consistent with previous research on the subject (see below), something that may indicate that there actually is a significant association between those variables and LS.

An important restriction concerned with the comparison of the forest types is the different sizes of the groups. The group of broad leaved forest visitors was considerably larger (n= 982) than the group of coniferous forest visitors (n= 218). This may contribute to the statistical differences between the groups, and further studies with comparable sample sizes are necessary to draw any firm conclusions.

The strength of this study is the overall large randomly provided empirical material. However the response frequency was only 49% and even though this is a rather ordinary outcome in population studies we must be aware of the risk for bias among our results. It has been found that urban residence lowers retrieval rate (Eaker et al. 1998), and since the region in question is to a relatively high extent urbanized this may be part of the explanation.

It is advantageous that the questions in the survey were concerned with ordinary activities in ordinary settings, with no experimental character, making the results more appropriate for generalizing.

The legitimacy of the new variable, LS, was supported by its close relation to the general health state of the respondents, measured by a common, validated instrument, VAS. However, any method of measuring perceived stress among a population has its weaknesses and one may discuss whether a more precise instrument would have contributed to more precise data in this case.

The fact that distance to broad leaved forests was a significant determinant among women might be a matter of self-selection (people with a physically active lifestyle, presumed to be correlated to good health, choose to live close to natural settings providing recreational opportunities), but another way of explaining it could be that living close to nature may as such provide health benefits. Another possible explanation is that a further distance to the forest is connected with expenditures for transport, exhausting traffic situations and other inconvenient circumstances that may override the positive experience. It is also interesting to notice that women had a significantly higher LS on baseline, and one may hypothesize that to a more stressed person easy access (like short distance) may have a greater importance to the restorative experience. For the male group the time spent in forest was a significant determinant of LS, which is in accordance with the postulates of the attention restoration theory (Kaplan and Kaplan 1989). One may speculate about the reasons for this effect to occur only among men, and we have no definite answer, but it is noteworthy that on baseline women spent significantly less time in the forest.

Concerning the gender aspects several studies have shown different biological responses to stress between men and women (Holden 2005, Kudielka and Kirschbaum 2005). In addition the behavioural responses to physiological stress reactions seem to differ (Taylor et al. 2000). From a sociological point of view one may claim that the life situation often vary between the sexes (Frankenhaeuser 1993), and altogether it is possible to speculate about these aspects as being part of the explanation for the different results between men and women in our study.

Mainly within the field of environmental psychology several studies have shown a general positive relationship between nature and health (Kaplan and Talbot 1983, Ulrich 1984, Ulrich et al. 1991, Herzog et al. 1997, Grahn and Stigsdotter 2003). Also more recent research has shown an association with less stress and access to green areas (Nielsen and Hansen 2007). But why should one hypothesize that broadleaved forest might have a higher therapeutic value than a coniferous one? This is an intriguing question and we have focused on five possible explanations.

1. The cognitive theories by Kaplan and Kaplan base nature's restorative power and stress relieving capacity on concepts of specific qualities in nature, like extent and fascination (Kaplan et al. 1998, Kaplan 2001). Extent is described as coherence in the experience of the environment and a scope for continued exploration and fascination as an effortless kind of attention, like for the richness of species in nature. These qualities are likely to be found in a broadleaved forest, which contains extent in the sense that it is often relatively easy to find one's way in, at the same time as it provides space and complexity. Additionally it is often light and rich in biodiversity, providing the necessary attributes for fascination. Finally, as the various parts of

the broad leaved forest can be perceived as belonging to a larger whole, one must not expend any effort to find the model that is appropriate to the current situation.

2. The more genetic, biological theories of Ulrich are associated with qualities of nature that attract our unconscious, innate preference for certain natural settings. By giving us a sense of connection to our past we feel safe, resulting in stress recovery (Ulrich 1993). The trees in broadleaved forests are often scattered and with spread crowns, reminding of the trees of a savannah, our evolutionary origin.

3. A few Swedish research groups have studied the perception of nature and found eight dimensions or characters of importance to restorative environments – serene, wild, lush, spacious, culture, the common, the pleasure garden and festive/centre (Grahn et al. 2005a, b). Several of these qualities are likely to be found in a broadleaved forest, but not as much in a coniferous stand.

4. It has been found that broadleaved woodland is particularly effective in reducing the perception of crowding (Chambers and Price 1986), and crowding may be a phenomenon restricting the possibilities for stress recovery.

5. The finding that to broad leaved forest visitors the purpose of merely experiencing the element of nature, to use all senses, was relatively more important than to coniferous forest visitors may also indicate why a broad leaved setting might be more stress relieving. Since this aspect of nature experiencing could be connected to emotion regulation and the individual's call for coherence with her surrounding it may contribute to relieving negative emotions and decreasing LS.

About the aspect of length of stay in the forest it is a common determinant in previous research on nature's impact on health. In for example a meta-analysis concerned with wilderness therapy research (Cason and Gillis 1994) one important variable was program duration, where a strong positive correlation was found between the length of the program and the effect size. The same pattern was found in Grahn and Stigsdotter (2003), where a significant relationship was found between LS and the amount of time spent in open green spaces. The length of stay was also found to be one of the major determinants of restorative experiences in Korpela et al. (2008). We can only speculate about the reasons for these findings, it might be that the biological systems and processes dealing with stress are complex, and the effects may not be redirected immediately.

In conclusion our results may contribute to the hypothesis that forest nature might be valuable to human health and that broadleaved forests might be particularly beneficial in a stress-relieving aspect. This research can support a necessary new approach to health and health care in modern society, where stress-related diseases are continuously escalating (Murray and Lopez 1996). Health promoting actions are becoming more important in health policies, and the concept of public health has to move towards more inclusive ecological models that recognize the importance of physical as well as social determinants of health and their relation to surroundings. In this perspective it is important to define potential health promoters in our natural environment. The recreational value of broadleaved forests needs to be further evaluated and this study may be one step on the way of connecting economical, medical and ecological issues when it comes to forestry and non-timber forest values, something that can have great consequences for public health.

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