State of the Science
public health benefits of urban forests/trees

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University of Washington
School of Environmental & Forest Sciences

Chesapeake Tree Canopy Summit
14 January 2020
How are urban trees associated with human health?
Health is...

A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity

(World Health Organization, 1946)
Green Cities: Good Health
www.greenhealth.washington.edu

Sponsors:
USDA Forest Service,
(U&CF Program + Pacific NW Research)
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Thanks!
to U of WA students:
Katrina Flora
Mary Ann Rozance
Sarah Krueger

Research Reviews & Summaries
Local Economics

Trees in cities are not grown and managed for products that can be bought and sold on markets, but they do provide many intangible services and functions! This article serves two purposes. First, it introduces valuation methods that are used to convert intangible benefits to dollar sums. Then, it shows how nonmarket valuations can support local decision-making.

Fast Facts

- The presence of larger trees in yards and as street trees can add from 3% to 15% to home values throughout neighborhoods.
- Averaging the market effect of street trees on all house values across Portland, Oregon yields a total value of $1.35 billion, potentially increasing annual property tax revenues $15.3 million.
- A study found 7% higher rental rates for commercial offices having high quality landscapes.
- Shoppers claim that they will spend 9% to 12% more for goods and services in central business districts having high quality tree canopy.
- Shoppers indicate that they will travel greater distance and a longer time to visit a district having high quality trees, and spend more time there once they arrive.
Introduction

Writers, philosophers, and naturalists have praised the benefits of nature for human health, happiness, and well-being for centuries, but only relatively recently have researchers begun studying and quantifying the complex relationship between human health and nature.

In 1953, Roger Ulrich, professor and director of the Center for Health Systems and Design at Texas A&M University, published the results of a pioneering study that looked at the recovery rates of gall bladder surgery patients in relation to the views from their rooms in a Texas hospital. Some of the patients looked out over a garden and grove of trees, while others had a view of a brick wall. Ulrich found that patients with a natural view spent fewer days in the hospital and used fewer pain medications (Ulrich 1984).

Ulrich’s study helped open the door to a new field of inquiry focused on illuminating the ways that nature influences our physical, mental, and social lives. More than three decades later, a broad and diverse body of scientific literature describes the human health value of nature, confirming that trees, parks, gardens, and other natural settings are as essential to livable and sustainable cities as the other critical systems that keep their residents moving and working.

Findings from the current literature indicate the wide range of effects.

USDA
Forest Service
2018

Literature review of research about nearby nature & human health
Urban Trees & Human Health

- Literature Review
- Economic Implications
- Urban Forest Planning & Planting
Urban Trees & Human Health: A Scoping Review

Purpose:
To carefully collect and synthesize the peer-reviewed evidence concerning urban trees and human health.
Project Team

- Kathleen Wolf, Ph.D., University of Washington
- Sharon Lam, MSc, Ontario Climate Consortium
- Jennifer McKeen, MPH, Simon Fraser University
- Gregory Richardson, MUP, Health Canada
- Matilda Van Den Bosch, M.D, University of British Columbia
- Adrina Bardekjian, Ph.D., Tree Canada
Method

Keyword search (n = 2563)

Abstract review (n = 436)

Quality assessment (n = 215)

Final article set (n = 199) (201 studies)

Synthesize and present findings
What did we learn?

Publication Dates by Decade

What did we learn?

- Single & park trees
- Pollen
- Immersion

Credit: Univ of Utah

Image/simulation

Tree canopy/NDVI
What did we learn?

Health Outcomes Themes:

- Tree Pollen and VOCs
- Active Living/Weight Status
- Psychophysiological Stress
- Excess Heat and Thermal Comfort
- Cardiovascular Function
- Mental Health, Anxiety and Mood
- Air Pollutants and Respiratory Condition
- Other Restoring Capacities (e.g., Birth...)
- Cognition and Attention Restoration
- Other Reducing Harm (Crime, UVR)
- Clinical Outcomes
Green High School Campuses

- cafeteria & classroom window views with greater quantities of trees and shrubs
- positively associated with:
  - standardized test scores,
  - graduation rates
  - %s of students planning to attend a four-year college
  - fewer occurrences of criminal behavior
Encouraging Physical Activity

Review of studies of adults, natural environments vs indoors

Results of activity in natural environments:

- greater feelings of revitalization and positive engagement, increased energy
- decreases in tension, confusion, anger, and depression
- greater enjoyment and satisfaction, declared a greater intent to repeat the activity at a later date

Coon et al. 2011. *Environmental Science & Technology*
Improving Depression

20 adults with major depression walk in park setting or built setting

• 50-minute walks one week apart

• before-after testing:
  • Mood: Positive and Negative Affect
  • Cognition: Backward Digit Span

Berman et al. 2012. *Journal of Affective Disorders*

cognitive and affective improvements after walking in a nature setting
How Walking in Nature Changes the Brain

**rumination:** Maladaptive self-referential thoughts, heightened risk for depression and other mental illnesses

**90-min walk in a natural setting decreased**
- self-reported rumination
- neural activity in the subgenual prefrontal cortex
- no reduced effects from built environment walks

Bratman et al. 2015. *Proceedings of the National Academy of Sciences of the USA*
Group Walks Improve Mental Health

England, Walking for Health national program test Nature Group Walkers vs Non Group Walkers

results:
- lower depression, perceived stress, negative affect
- enhanced positive affect and mental well-being
- group walks synergize with physical activity to improve positive affect and mental well-being

Marselle et al. 2014. *Ecopsychology*
Urban Trees & Human Health

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Health Care Spending in U.S.

- $10,348 annual per capita (2016)
- $3.5 trillion total
- 17.9% of Gross Domestic Product

Maryland (2009): $7,492 per capita, 15% of GSP, (generally higher % than U.S.)
15 Leading Causes of Death in U.S., 2017

- Diseases of heart
- Cancer
- Accidents (unintentional injuries)
- Chronic lower respiratory diseases
- Cerebrovascular diseases
- Alzheimer's disease
- Diabetes mellitus
- Influenza and pneumonia
- Nephritis, nephrotic syndrome and nephrosis
- Intentional self-harm (suicide)
- Chronic liver disease and cirrhosis
- Septicemia
- Essential hypertension & renal hypertension
- Parkinson's disease
- Pneumonitis due to solids and liquids

Total deaths (2017)

Source: U.S. Centers for Disease Control and Prevention
Costly chronic diseases

(Disability Adjusted Life Year)
Nature & Health Economics Analysis Process

- human scale: individual to community
- screen for benefits
- urban forestry
- parks
- gardens, etc.
- green condition
- market
- non-market
- valuation strategy
## Nature & Health Annual Savings

Millions of U.S. Dollars (2012)

<table>
<thead>
<tr>
<th>Benefit (geographic scope)</th>
<th>Minimum ($)</th>
<th>Maximum ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn Health (U.S.)</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Attention Deficit Hyperactivity Disorder (U.S.)</td>
<td>383.5</td>
<td>1,917.7</td>
</tr>
<tr>
<td>Schools (U.S.)</td>
<td>20.4</td>
<td>1,262.9</td>
</tr>
<tr>
<td>Crime (U.S.)</td>
<td>340.6</td>
<td>899.4</td>
</tr>
<tr>
<td>Cardiovascular Disease (U.K., U.S.)</td>
<td>1,220.0</td>
<td>1,220.0</td>
</tr>
<tr>
<td>Alzheimer’s Disease (U.S.)</td>
<td>724.6</td>
<td>1,449.2</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>2,694.4</strong></td>
<td><strong>6,754.5</strong></td>
</tr>
</tbody>
</table>


KATHLEEN L. WOLF, PH.D.

design: milepost

author: UAS

printing: The Nature Conservancy
Nearby nature experiences are important across the entire life cycle, from cradle to grave.

Research about nature benefits and economic value is fairly new. Some of the quantified health benefits of nature in cities are easier to convert to economic value than others. Here are some preliminary valuations—estimated for the entire U.S. on an annual basis.

INFANTS

BIRTH WEIGHT

ECONOMIC IMPACT

$5.9 million savings on annual healthcare costs.

Birth weight influences long-term childhood health and development, and has been linked to some adult diseases. Low birth weight is associated with higher hospital stays and increased illness. Pregnant women who have more tree canopy and green space near their homes generally have babies with healthier birth weights.

IMMUNE FUNCTION

ECONOMIC IMPACT

Stronger immune system leads to reduced illness and chronic disease across a lifetime.

We are most vulnerable in the early months of our lives, when the body and mind are growing and developing at an astonishing rate. The 'hygiene hypothesis' suggests that early contact with outdoor microorganisms stimulates the development of a healthy immune response.

FAMILY DYNAMICS

ECONOMIC IMPACT

Improved family dynamics, perhaps reducing mental health treatment and counseling services.

An infant's parents and siblings adjust their lives after a baby arrives, and the changes can bring on stress and anxiety. Nature views and walks help reduce these conditions and improve interactions between people within the household.

Note: All economic values are in 2018 U.S. dollars, and are potential annual savings across the entire U.S.

CHILDREN & TEENS

OVERALL HEALTH AND WELL-BEING

ECONOMIC IMPACT

$10.5 million savings on annual healthcare costs.

Increased physical activity, reduced anxiety, and reduced risk of asthma. Positive outdoor activity can improve children's attention span and reduce behavior problems. Children who have access to parks and nature-based outdoor play are more likely to be physically active.

ADHD

ECONOMIC IMPACT

$31.4 million savings on annual medication costs.

Millions of children ages 3-17 are treated for Attention Deficit Hyperactivity Disorder (ADHD) in the U.S. Nature exposure is a potential alternative treatment, especially for those who have not responded to medication.

FUTURE FINANCIAL SUCCESS

ECONOMIC IMPACT

$6.1 billion increase in high school graduates' lifetime annual income.

School performance affects both near-term well-being and long-term success. Having green views from classrooms and common spaces to schools can improve students' capacity to direct attention and feel less stressed. Green high school campus landscapes are linked to higher graduation rates.

ADULTS

DEPRESSION AND STRESS

ECONOMIC IMPACT

$17.9 billion savings on annual healthcare costs.


MOBILITY & QUALITY OF LIFE

ECONOMIC IMPACT

$12.8 billion savings on annual healthcare costs.

Reduced transportation costs and improved quality of life. Nature exposure improves physical health and reduces the risk of chronic diseases.

OLDER ADULTS

HYPERTENSION

ECONOMIC IMPACT

$61.3 billion savings on annual healthcare costs.

Hypertension, or high blood pressure, is one of the five most expensive conditions impacting older adults. Nature exposure can decrease diastolic and systolic blood pressure.

Cognitive Disorders

ECONOMIC IMPACT

$81.3 billion savings on annual healthcare costs.

Cognitive Disorders are the leading cause of severe disability in the U.S. Nature exposure can improve cognitive function and delay the onset of cognitive decline.

Contributing Analysts:
Dr. Stephen Grado & Marcus Measells, MSU; Dr. Alicia Robbins, Weyerhaeuser
Urban Forests for Human Health:  
A Focused Economic Valuation

Healthy trees are rooted in research!  
Donate at www.treefund.org

Cultivating Innovation in Arboriculture and Urban Forestry
TREE Fund • 552 S. Washington St., Ste. 109, Naperville, IL 60540
<table>
<thead>
<tr>
<th>Strength of Evidence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRONG</td>
<td>Experimental Study (i.e., a randomized controlled trial)</td>
</tr>
<tr>
<td>MODERATE</td>
<td>Quasi-experimental Study</td>
</tr>
<tr>
<td>PROMISING</td>
<td>Correlational Study with statistical controls for selection bias</td>
</tr>
<tr>
<td>DEMONSTRATES A RATIONALE</td>
<td>Well-specified logic model informed by research or evaluation</td>
</tr>
</tbody>
</table>

source: PearsonSchool.com
Trees & Health Valuation Potential

- cancer
- diabetes, respiratory illness, asthma, healing/recovery
- cardiovascular disease, mental disease, ADHD

strength of evidence
clinical illness & disease incidence
<table>
<thead>
<tr>
<th>Illness or Disease</th>
<th>Annual Costs (U.S.)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital stay/recovery</td>
<td>$1.1 trillion (2017)</td>
<td><a href="https://debt.org">debt.org</a></td>
</tr>
<tr>
<td>Diabetes</td>
<td>$327 billion (2017)</td>
<td><a href="https://diabetes.org">American Diabetes Association</a></td>
</tr>
<tr>
<td>Mental disease</td>
<td>$201 billion (2013)</td>
<td><a href="https://healthaffairs.org">Health Affairs journal</a></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>$200 billion (2015)</td>
<td><a href="https://cdc.gov">Centers for Disease Control &amp; Prevention</a></td>
</tr>
<tr>
<td>ADHD</td>
<td>$143 billion (2013)</td>
<td><a href="https://aacap.org">American Academy of Child and Adolescent Psychiatry</a></td>
</tr>
<tr>
<td>Asthma</td>
<td>$82 billion (2013)</td>
<td><a href="https://thoracic.org">American Thoracic Society</a></td>
</tr>
<tr>
<td>Respiratory illness</td>
<td>$36 billion (2010)</td>
<td><a href="https://chest.org">American College of Chest Physicians</a></td>
</tr>
</tbody>
</table>
Trees & Health Valuation Potential

- physical activity, weight control, UV screen, better sleep
- birth outcomes, pain relief, crime reduction, thermal comfort, social cohesion
- stress, anxiety, mental function, immune function

Strength of evidence

Health & wellness

‘Protection’
Avoided Costs = Health Savings

Is green land cover associated with less health care spending? Promising findings from county-level Medicare spending in the continental United States

Douglas A. Becker a, Matthew H.E.M. Browning a, b, Ming Kuo a, Stephen K. Van Den Eeden c
Urban Trees & Human Health

- Literature Review
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Urban forest management for human health
‘Trees are Good’ but could they be better?

have evidence re: trees & health
are associated cost reductions & savings
perhaps expand policy and goals?

• canopy goals: 35-40%
• connectivity: 20 – 50 minute walks
• address pollen concerns
• enable activity (forest bathing, walking loops)
Tree Planting for Health

Views from Within

Connect Experiences

Create Refuge

Human Dimensions of Urban Forestry and Urban Greening

What's New?

Nature and Consumer Environments
Research about how the urban forest influences business district visitors.

Trees and Transportation
Studies on the value of having quality landscapes in urban roadways.

Civic Ecology
Studies of human behaviors and benefits when people are active in the environment.

Policy and Planning
Integrating urban greening science with community change.

Urban Forestry and Human Benefits
More resources, studies and links...

Projects Director
Kathleen L. Wolf, Ph.D.

Green Cities: Good Health
human health & well-being research

www.naturewithin.info