Perceived Ecosystem Services and Disservices of Natural Treatment Systems (NTS) for Urban Stormwater

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NTS: Engineered ecosystems intended to manage stormwater using primarily natural processes
The services and disservices people perceive NTS provide may influence public acceptance of (or advocacy for) NTS in urban landscape.

Who’s opinions matter?

If NTS designers don’t feel they provide services, then who will?
Outline

• **Study Design**
  - study population: *next generation of NTS designers*
  - stated preference surveys

• **Perceived services and disservices of NTS for urban stormwater**
  - benchmark relative to other urban landscapes (*lawns, gardens, remnant native landscapes*)
  - multifunctional services/disservices bundles (co-associated services/disservices)

• **Drivers of landscape perceptions** (knowledge, attitudes about services/disservices, environmental worldviews, demographics)

*How are NTS perceived and what drives those perceptions?*
Study Design: Study Population

Future NTS Designers

- Civil and Environmental Engineering undergraduate students at the University of California Irvine
- Total surveyed population: 139 students
  → 30% of UCI’s CEE undergrads
  → ~100% of UCI’s sophomore CEE undergraduate cohort

Many students are housed near NTS in the NE portion of campus
(40% of surveyed students)

- Students have the potential to both see NTS routinely and learn about them as part of course curricula
Study Design: *Survey Instrument*

- The survey was delivered to CEE students on-line through the Canvas learning platform
- Photo survey (12 images from across 5 Southern California UC campuses)
- Multiple landscape types were evaluated so that perceptions NTS could be placed in context with other landscapes that they might replace

**Lawns**

**Gardens**
1) Palms
2) Succulents
3) Roses

**Native Landscape**
1) Coastal sage scrub
2) Chaparral

**Green Infrastructure**
1) Swales
2) Biofilters
Study Design: Survey Instrument

Students were asked to determine the degree to which they perceive specific ecosystem services or disservices are associated with the landscape in the photo (on a 1-7 scale)

<table>
<thead>
<tr>
<th>I believe that this system will? (please address each outcome)</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  5  6  7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause allergies</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Increase diversity of animals</td>
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<td></td>
<td></td>
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<tr>
<td>Cool down the urban environment</td>
<td></td>
<td></td>
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<tr>
<td>Attract mosquitos, rats, and other pests</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Make urban landscape more beautiful</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Remove carbon dioxide from the air</td>
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<td></td>
<td></td>
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<tr>
<td>Improve water quality</td>
<td></td>
<td></td>
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<tr>
<td>Soak up urban runoff, reducing flooding</td>
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<td></td>
<td></td>
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<tr>
<td>Require a lot of water (especially in summer)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attract bees, butterflies, and other pollinators</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Provide landscape for relaxation or recreation (walking, picnicking, biking, jogging, cycling, or team sports)</td>
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<tr>
<td>Reduce the visibility of surrounding areas making people feel less safe</td>
<td></td>
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<td></td>
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</tbody>
</table>
Study Design: *Survey Instrument - Drivers*

Students were asked to:

1) Convey their attitude about each ecosystem service or disservice on a 1-7 scale (1: not important to 7: very important)
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2) Answer a series of 10 questions from the New Ecological Paradigm (NEP) scale to evaluate environmental worldviews

<table>
<thead>
<tr>
<th>Balance of Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>The balance of nature is strong enough to cope with the impacts of modern industrial nations</td>
</tr>
<tr>
<td>The balance of nature is delicate and easily upset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limits to Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>We are approaching the limit of the number of people the earth can support</td>
</tr>
<tr>
<td>The earth is like a spaceship with very limited room and resources</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anti-anthropocentrism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants and animals have as much right as humans to exist</td>
</tr>
<tr>
<td>Humans were meant to rule over the rest of nature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Human exemptionalism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human ingenuity will ensure that we do not make the earth unlivable</td>
</tr>
<tr>
<td>Humans will eventually learn enough about how nature works to be able to control it</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ecocrises</th>
</tr>
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<tbody>
<tr>
<td>The so-called &quot;ecological crisis&quot; facing humankind has been greatly exaggerated</td>
</tr>
<tr>
<td>If things continue on their present course, we will soon experience a major ecological catastrophe</td>
</tr>
</tbody>
</table>
**Study Design: Survey Instrument - Drivers**

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1) Convey their attitude about each ecosystem service or disservice on a 1-7 scale  
   (1: not important to 7: very important)

2) Answer a series of 10 questions from the New Ecological Paradigm (NEP) scale to evaluate environmental worldviews

3) Answer a series of environmental and engineering knowledge questions assessing theoretical, experiential, and procedural knowledge

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<th>Experiential</th>
<th>Procedural</th>
</tr>
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<tr>
<td>- Biodiversity</td>
<td>- Seen NTS on campus</td>
<td>- Can correctly identify NTS</td>
</tr>
<tr>
<td>- Urban runoff (define, water quality problem, treated prior to discharge)</td>
<td>- Seen native landscapes on campus</td>
<td>as NTS</td>
</tr>
<tr>
<td>- NTS</td>
<td></td>
<td>- Can correctly identify native landscapes as native</td>
</tr>
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</table>
Students were asked to:

1) Convey their attitude about each ecosystem service or disservice on a 1-7 scale (1: not important to 7: very important)

2) Answer a series of 10 questions from the New Ecological Paradigm (NEP) scale to evaluate environmental worldviews

3) Answer a series of environmental and engineering knowledge questions assessing theoretical, experiential, and procedural knowledge

4) Provide demographic information (race, ethnicity, gender, age, country of origin, and academic major)

Study Design: Survey Instrument - Drivers

12 perceived services/disservices + 4 driver categories
Outline

• **Study Design**
  - study population: *next generation of NTS designers*
  - survey techniques

• **Perceived services and disservices of NTS for urban stormwater**
  - benchmark relative to other urban landscapes (*lawns, gardens, remnant native landscapes*)
  - multifunctional services/disservices bundles (co-associated services/disservices)

• **Drivers of landscape perceptions** (knowledge, attitudes about services/disservices, environmental worldviews, demographics)

• **Implications for the future**
Dominant patterns in urban landscape perception
(co-associated services and disservices)

Principal Component Analysis of student perceptions (2 significant patterns – 45% VE)

1) PC1_{ES}: Landscapes provide many services vs few

2) PC2_{ES}: Landscapes provide primarily
   **bundle 1** services/disservices (*organism-associated services/disservices and lack of safety*) or
   **bundle 2** services/disservices (*regulating & cultural services as well as water waste*)
Urban landscapes were perceived as multifunctional. Different landscapes provide different (characteristic) suites of services/disservices—they are perceived differently.

**Color:** probability that individuals perceive a given landscape provides specific services or disservices.
Urban landscapes were perceived as multifunctional. Different landscapes provide different (characteristic) suites of services/disservices – they are perceived differently.

Lawns are perceived to provide many services (primarily bundle 2): regulating and cultural services but not organism-associated services/disservices.
Urban landscapes were perceived as multifunctional. Different landscapes provide different (characteristic) suites of services/disservices – they are perceived differently.

Native landscapes are split about PC1 (some individuals feel they provide many services and others feel they provide few).

If they provide services or disservices, they are those from bundle 1.
Urban landscapes were perceived as multifunctional
(different landscapes providing different services and disservices)

Gardens are perceived as intermediate between lawns and native landscapes
(provide many services from both bundle 1 and bundle 2)
Urban landscapes were perceived as multifunctional
(different landscapes providing different services and disservices)

NTS are more variously perceived, which may suggest limited social norming
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• **What drives variability in how urban landscapes are perceived** (knowledge, attitudes about services/disservices, environmental worldviews, demographics)

• Implications for the future
NTS Perceptions: Physical Drivers (Siting and Design)

Siting/Design Elements:
- Sited near roads
- Prominent curbs/gutter elements

Few services or disservices

Siting/Design Elements:
- Sited near buildings
- No prominent engineering design elements

Moderate to many services & disservices
Social Drivers of Variability in Perceived Landscape Services/Disservices

Demographics
- Gender (Female)
- Age
- Race (Caucasian, Asian or A. Amer.)
- Country (USA)

Knowledge
- Biodiversity
- Urban runoff
- Native landscapes
- NTS

Environmental worldviews
- Define Biodiv. Var. of Life
- Define Biodiv. Broadly

Attitude about ecosystem services
- Know UR WQ problem
- Know UR Not Treated

Landscape Perceptions
- Define UR
- Path Analysis (many services vs few)
Demographics, knowledge, worldviews, and attitudes all shape landscape perceptions (10-32% VE)
Attitudes about ecosystem services were the strongest predictor of perceived services provisioning
- individuals that thought services were important were more likely to feel landscapes provide many services

Consistent with other literature linking attitudes about specific landscape features or concepts to landscape preferences (first time this has been shown for NTS)
Attitudes were a function of academic major, knowledge about biodiversity, environmental worldviews & race

- Individuals that identified racially as Caucasian were less likely to have a positive attitude about services

- Individuals that were environmental engineering majors, had a pro-environmental worldview, and a broad understanding of biodiversity were more likely to have a positive attitude about services
Knowledge about NTS was an inconsistent driver of landscape perceptions

- Individuals with factual and experiential knowledge of NTS were more likely to think urban landscapes provide services to people

- Procedural knowledge of NTS (the capacity to discriminate NTS from other landscapes) did not influence perceived services provisioning

The relationships we don’t see are as informative as those we do
Knowledge about NTS was an inconsistent driver of landscape perceptions

- Individuals with factual and experiential knowledge of NTS were more likely to think urban landscapes provide services to people
- Procedural knowledge of NTS (the capacity to discriminate NTS from other landscapes) did not influence perceived services provisioning

The relationships we don’t see are as informative as those we do

Does not necessarily mean that knowing what you see is not important
Engineering students had difficulty recognizing NTS in situ

- Engineering students had very limited capacity to identify NTS (only \(~30\%\) of individuals identified NTS as NTS more often than they misidentified other landscapes as NTS)

- Generally uncertain about the accuracy of their landscape classifications (\(~3\) on a scale of 1: not certain to 7: very certain)

Factual knowledge about NTS was orthogonal to procedural knowledge suggesting that students have difficulty translating their factual understanding of NTS into rules or procedures for identifying them.
Engineering students had difficulty recognizing NTS in situ

- **Engineering students had very limited capacity to identify NTS** (only ~30% of individuals identified NTS as NTS more often than they misidentified other landscapes as NTS)

- **Generally uncertain about the accuracy of their landscape classifications** (~3 on a scale of 1: not certain to 7: very certain)

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**Highlights a gap in our current efforts to educate the next generation of NTS designers (contextual understanding)**
Conclusions

Public perception surveys coupled with dimensionality reduction techniques and simple network models are really powerful tools for helping us understand urban landscape preferences and their drivers

• Urban landscapes were perceived as multifunctional, providing characteristic suites of services and disservices

• NTS were more variously perceived than other landscapes (*low familiarity and limited social norming*)

Physical landscape characteristics (*siting and design*) and social drivers (*attitudes about ecosystem services, environmental worldviews, knowledge, and demographics*) all influenced perceived landscape services

• Certain variables (procedural knowledge of NTS) influenced perceived landscape services less than anticipated, and may point to a knowledge gap in the training of future landscape professionals
Most landscapes were perceived to provide all services and some disservices to varying degrees (no landscape was perceived to be unsafe)

- **NTS** were perceived to provide fewer services than other landscapes (includes traditional NTS services like water quality and flood regulation)

- **Gardens** were perceived to provide more services than other landscapes

- **Native landscapes** were perceived to provide more disservices than other landscapes (excepting water waste which was perceived to be highest for lawns)