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Economic evaluation of alternative urban park designs that conserve irrigation water

Professor David Pannell & Dr Claire Doll
UWA Centre for Environmental Economics and Policy
CSI UWA Webinar Series, 03/06/2025

Benefit-Cost Analysis (BCA)

What is Benefit-Cost Analysis?

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- One of the most important tools of economics
- Used to assess initiatives ("projects")
  - Future potential projects
  - Past completed projects
- Extremely flexible
- Extremely widely used

The essential question

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- **Do overall benefits exceed overall costs?**
- Sounds simple
- Challenging to answer

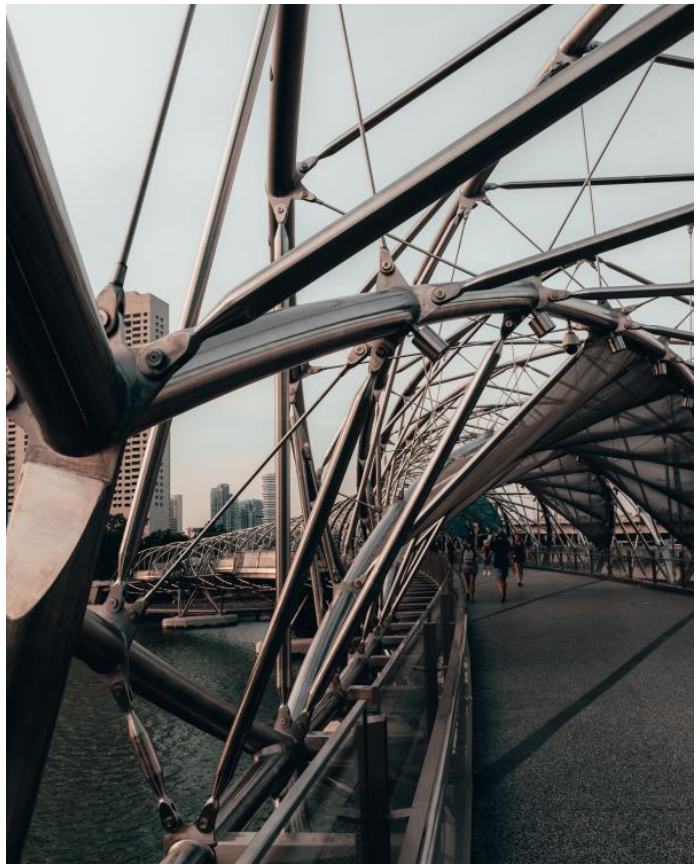

Photo: Zhu Hongzhi on Unsplash.com (open access)

Conducting a BCA

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- Requires a lot of information
- Needs to be collected and consolidated systematically and logically
- Work with the relevant body

Photo: David Pannell

Supporting decisions

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- Is helpful for supporting decisions
  - Systematic
  - Transparent
  - Evidence-based
- Not a simple prescription for a decision
  - Other considerations
  - Who will pay

With versus without principle

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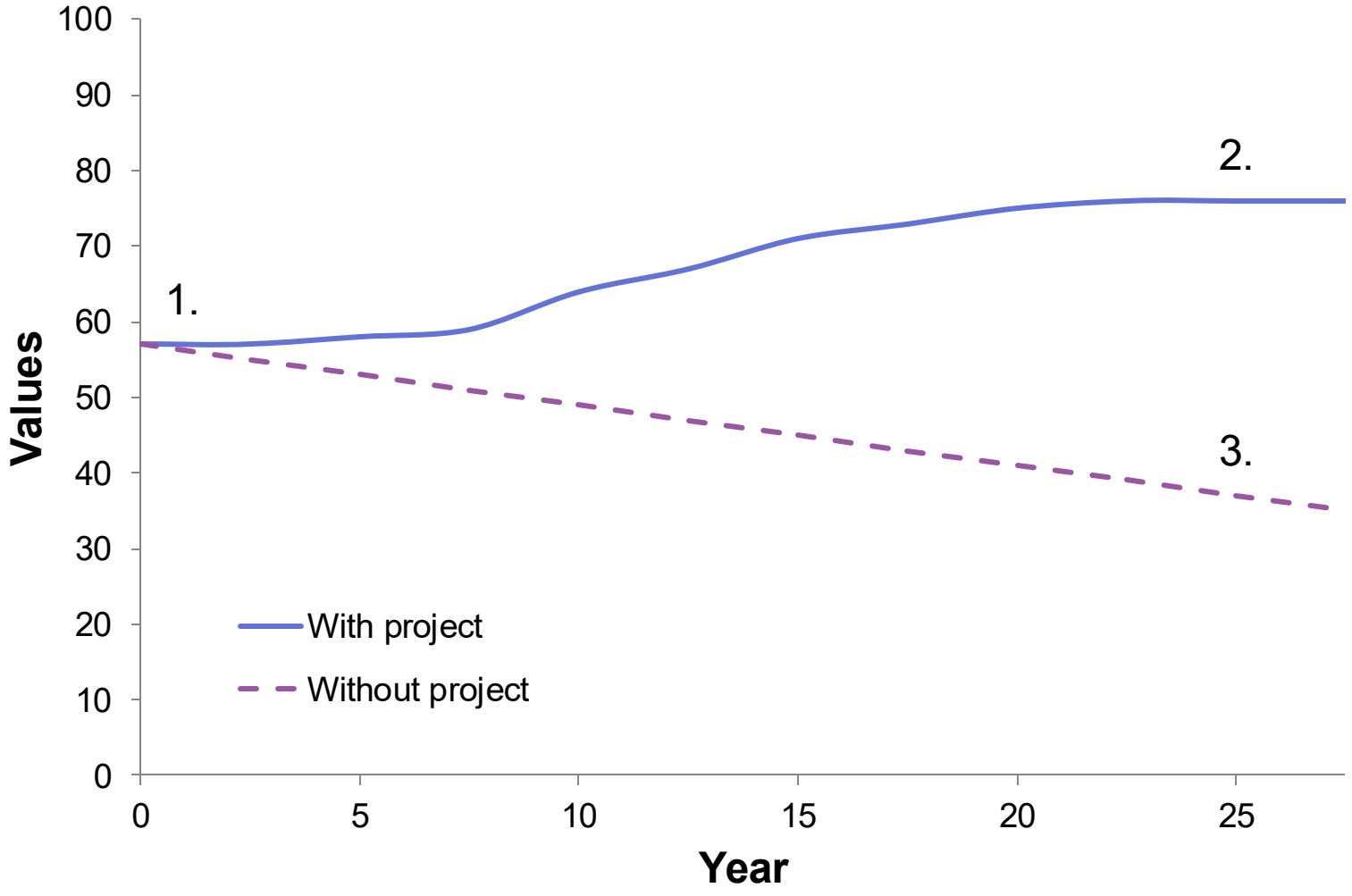

How are benefits measured?

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- BCA needs benefits to be measured in monetary or monetary-equivalent terms
- Allows benefits from different projects to be compared
- Allows benefits to be compared with costs for the same project
- Standard method is “willingness to pay”
  - If people had to pay for the benefit, what is the most they would be prepared to pay?

Willingness to pay

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- Overall WTP for a project includes all of the different benefit types
- And potentially dis-benefits
- No need to break it down into its component elements
- E.g. Reduced water pollution
  - Aesthetically pleasing environment
  - Benign physical environment
  - Recreational satisfaction
  - Spiritual-philosophical contentment

Four key benefit categories

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- Market benefits
- Non-market benefits
- Reduced or delayed costs
- Reduced risk

Accounting for time

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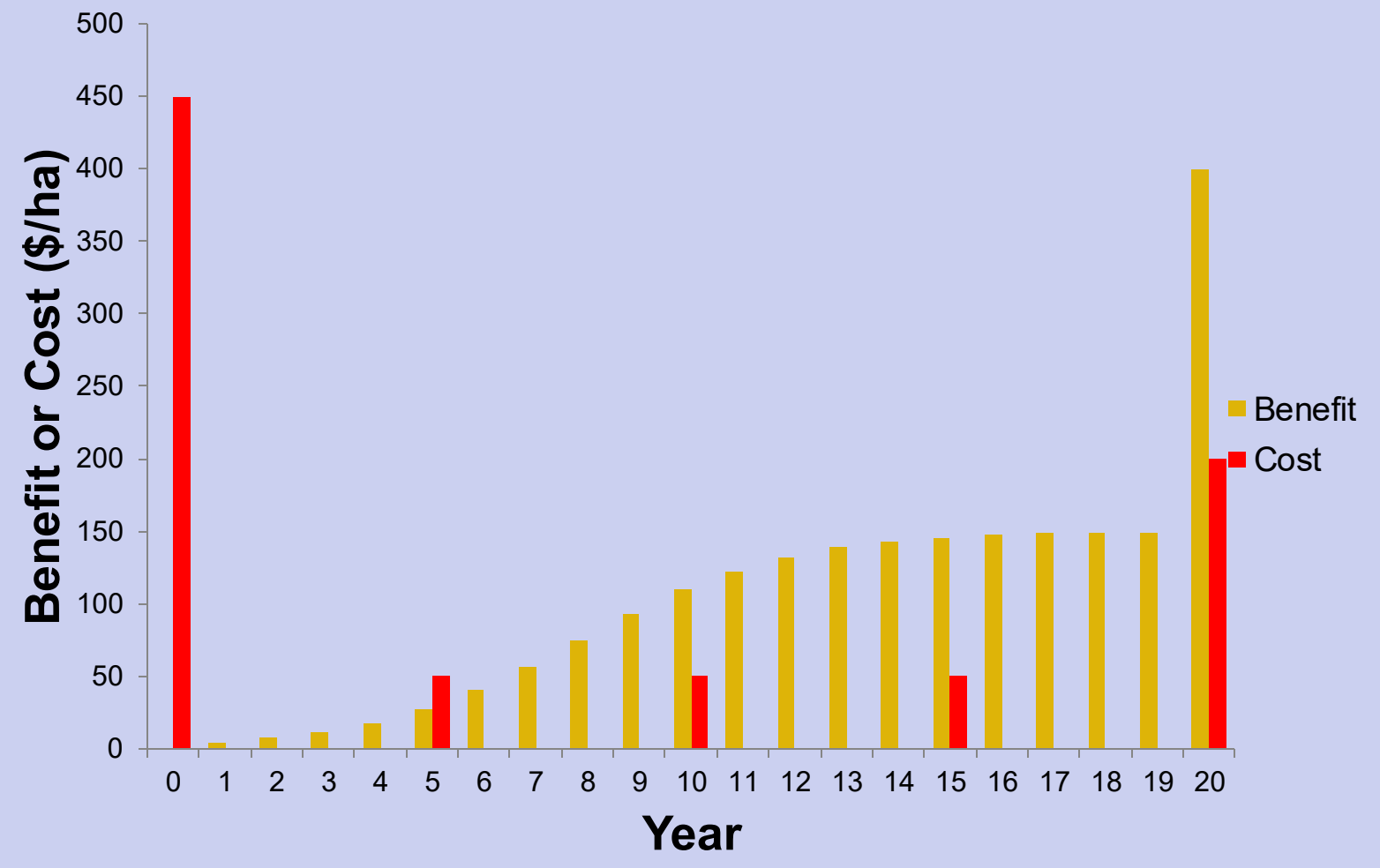

- Convert future benefits and costs to present values to make them comparable
- Adjust for inflation and "opportunity cost of capital"
- Discounting

Other complexities that can be captured

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- Risks of project failure
- Distribution of benefits and costs amongst stakeholders
- Behaviour change
- Recognised errors and pitfalls
  - Double counting benefits
  - Including multiplier effects
  - Poor definition of the without-project scenario
  - Logically inconsistent project definitions
  - Including depreciation costs

Case Study

Project background

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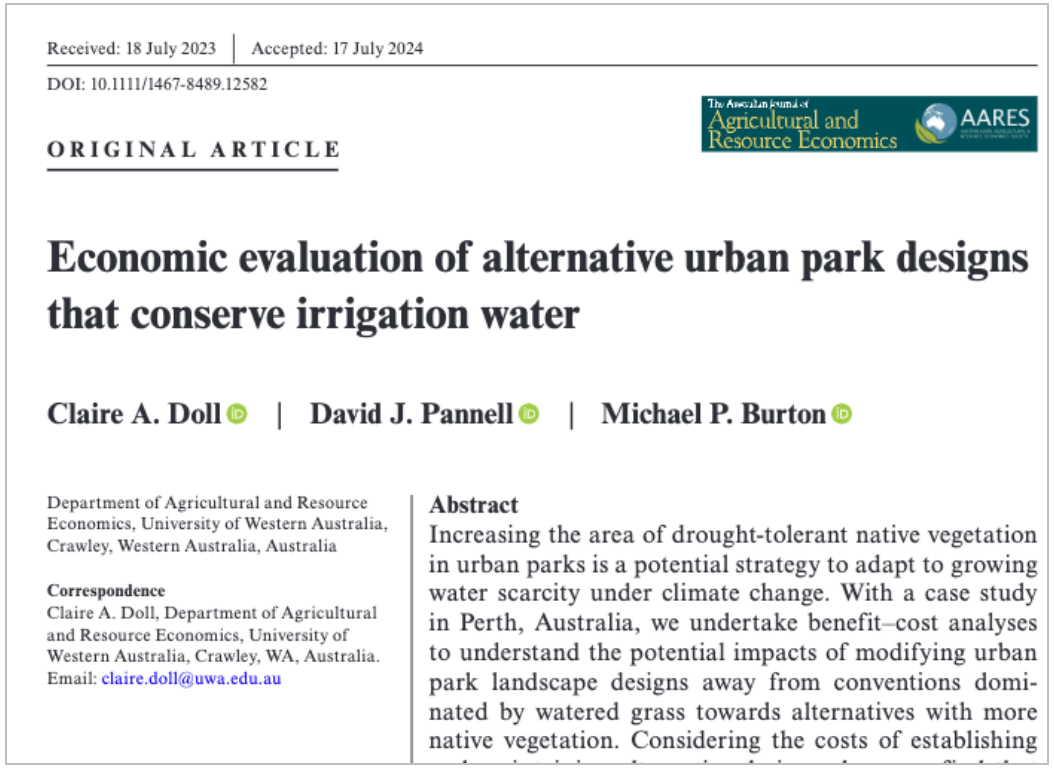
- How can local governments continue to provide welfare-enhancing parks under rising water scarcity?
  - What is the optimal mix of groundcovers in urban parks?



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ORIGINAL ARTICLE

Economic evaluation of alternative urban park designs that conserve irrigation water

Claire A. Doll | David J. Pannell | Michael P. Burton

Department of Agricultural and Resource Economics, University of Western Australia, Crawley, Western Australia, Australia

Correspondence
Claire A. Doll, Department of Agricultural and Resource Economics, University of Western Australia, Crawley, WA, Australia.
Email: claire.doll@uwa.edu.au

Abstract
Increasing the area of drought-tolerant native vegetation in urban parks is a potential strategy to adapt to growing water scarcity under climate change. With a case study in Perth, Australia, we undertake benefit–cost analyses to understand the potential impacts of modifying urban park landscape designs away from conventions dominated by watered grass towards alternatives with more native vegetation. Considering the costs of establishing

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Benefits: choice experiment study

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- Survey development with park managers
- 1532 responses collected

- WTP ($/HH/year) for a change from a baseline to alternative park designs
  - 80% watered grass, 20% mulch

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Are greenspaces too green? Landscape preferences and water use in urban parks

Claire A. Doll *, Michael P. Burton, David J. Pannell, Curtis L. Rollins

The University of Western Australia, Department of Agricultural and Resource Economics, Crawley, WA 6009, Australia

Example choice set (tax increase)

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CURRENT DESIGN	PROPOSED DESIGN
80% Watered Grass Ground cover	**100% Watered Grass** **Ground cover**
20% Mulch Ground cover	-
Moderate Tree Canopy cover	**High Tree** **Canopy cover**
$200 INCREASE in annual council rate or rent	**$300** **INCREASE in annual council rate or rent**
	

Preferences for alternative park designs that differ in their watering requirements

Example choice set (tax decrease)

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CURRENT DESIGN	PROPOSED DESIGN
80% Watered Grass Ground cover	-
-	**100% Native Vegetation** **Ground cover**
20% Mulch Ground cover	-
Moderate Tree Canopy cover	**Low Tree** **Canopy cover**
$200 INCREASE in annual council rate or rent	**$50** **INCREASE in annual council rate or rent**
	

0-100%:
Watered grass (WG)
Non-watered grass (NWG)
Native vegetation (NV)
0-40%:
Mulch (M)

Low, Moderate, High

$0 - $400

37 different design combinations

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Conditional logit model results

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	Estimate	Standard Error
Status quo	0.023	0.100
Tax (+)	-0.007***	0.001
Tax (-)	-0.005***	0.001
Tree	0.085***	0.011
Tree^2	-9.92 e^{-4}***	1.75 e^{-4}
Watered grass	0.048***	0.007
Watered grass^2	-4.81 e^{-4}***	-3.40 e^{-5}
Non-watered grass	0.002	0.007
Non-watered grass^2	-7.95 e^{-5}**	-3.51 e^{-5}
Native vegetation	0.029***	0.007
Native vegetation^2	-2.06 e^{-4}***	-3.25 e^{-5}
Mulch^2	-1.20 e^{-4}	1.67 e^{-4}

Optimal groundcover mix

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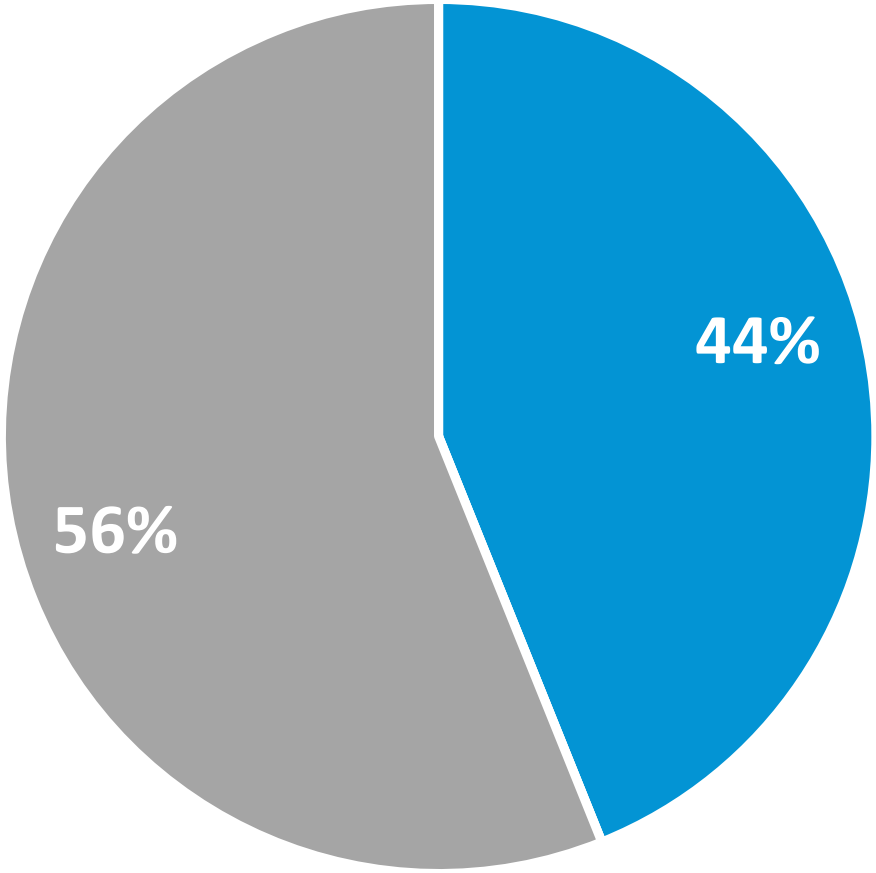
- Preferred mix is split between native vegetation and watered grass

- Willingness-to-pay for changes from baseline to optimal: $213 / household/ year



Alternative designs in BCA

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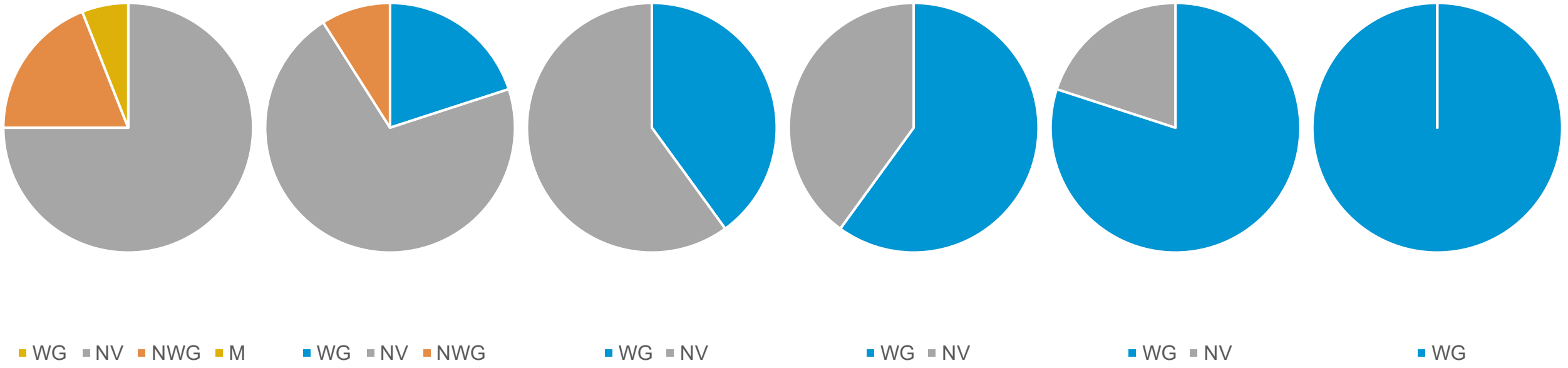
- 6 alternative designs: constrained optimizations

Design 1 | Design 2 | **Design 3** | Design 4 | Design 5 | Design 6



Benefit assumptions

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Design	Park groundcover composition (%)				WTP ($/HH/yr)
	Watered grass	Native veg.	Non-watered grass	Mulch	
Baseline	80	-	-	20	n/a
Design 1	-	75	19	6	**42.49**
Design 2	20	71	9	-	**158.94**
Design 3	40	60	-	-	**211.83**
Design 4	60	40	-	-	**187.14**
Design 5	80	20	-	-	**81.22**
Design 6	100	-	-	-	**-105.92**

Cost assumptions

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Cost category	Groundcover	Avg. ($/m²)
Site preparation	Watered grass	6
	Non-watered grass	6
	Native vegetation	21
	Mulch	22
Planting	Watered grass	15
	Non-watered grass	11
	Native vegetation	17
	Mulch	7
Irrig. system	Watered grass	14
Water trucks	Native vegetation	5
Maintenance	Watered grass	4
	Non-watered grass	3
	Native vegetation	4
	Mulch	3

INFFEWS

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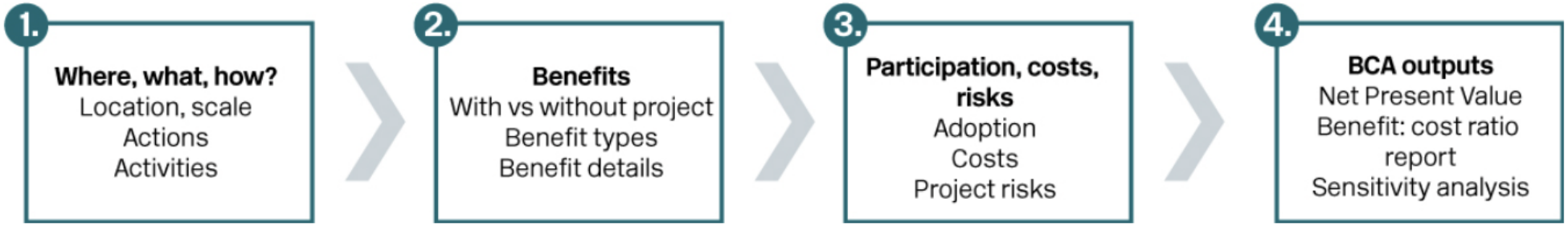
- Investment Framework for Economics of Water Sensitive Cities
- BCA tool developed by Pannell & Iftekhar
  - Iftekhar, M. S., & Pannell, D. J. (2022). Developing an integrated investment decision-support framework for water-sensitive urban design projects. *Journal of Hydrology*, 607, 127532.



BCA details

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- No competing land uses
- 1 hectare park (changes to existing & establishing new park)
- 30-year analysis period
- 4% real discount rate
- 352 households affected
- 2 years to full benefits
- Default water cost – no fee, groundwater license
- 0.15 risk of failure to deliver project benefits
- & sensitivity analyses
  - Average values & WTP = 0

Net Present Values ($'000)

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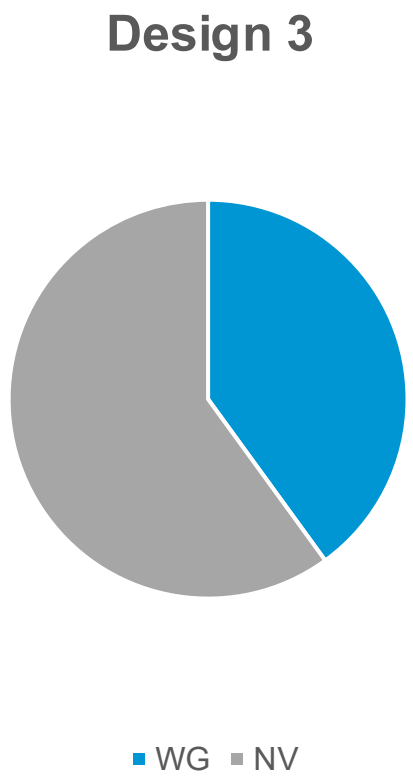
Design	New park	Existing park
Design 1	226	-7
Design 2	670	379
Design 3	**864**	**623**
Design 4	748	582
Design 5	295	215
Design 6	-494	-537



Annualized benefits and costs

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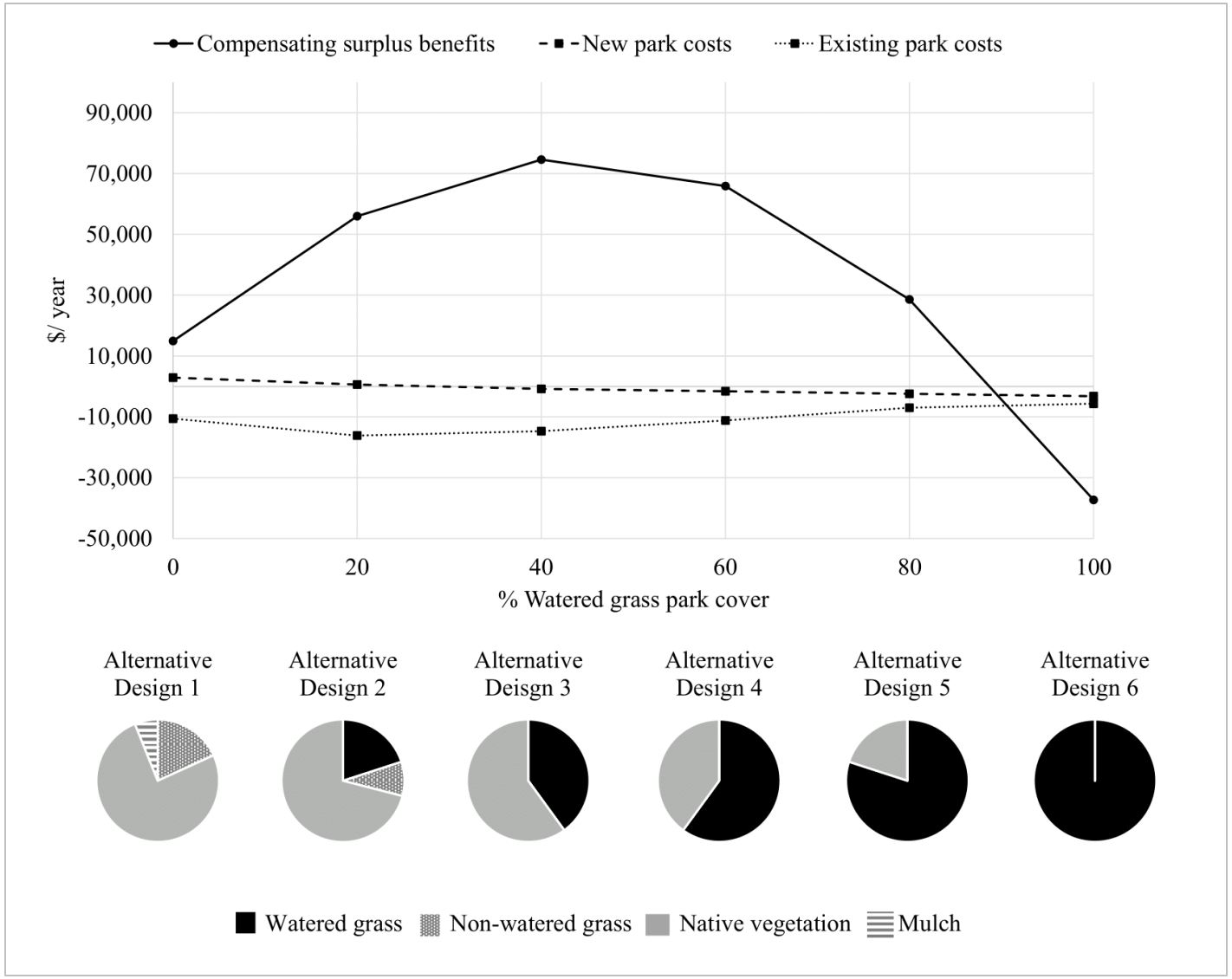

Key factors driving NPV in Design 3

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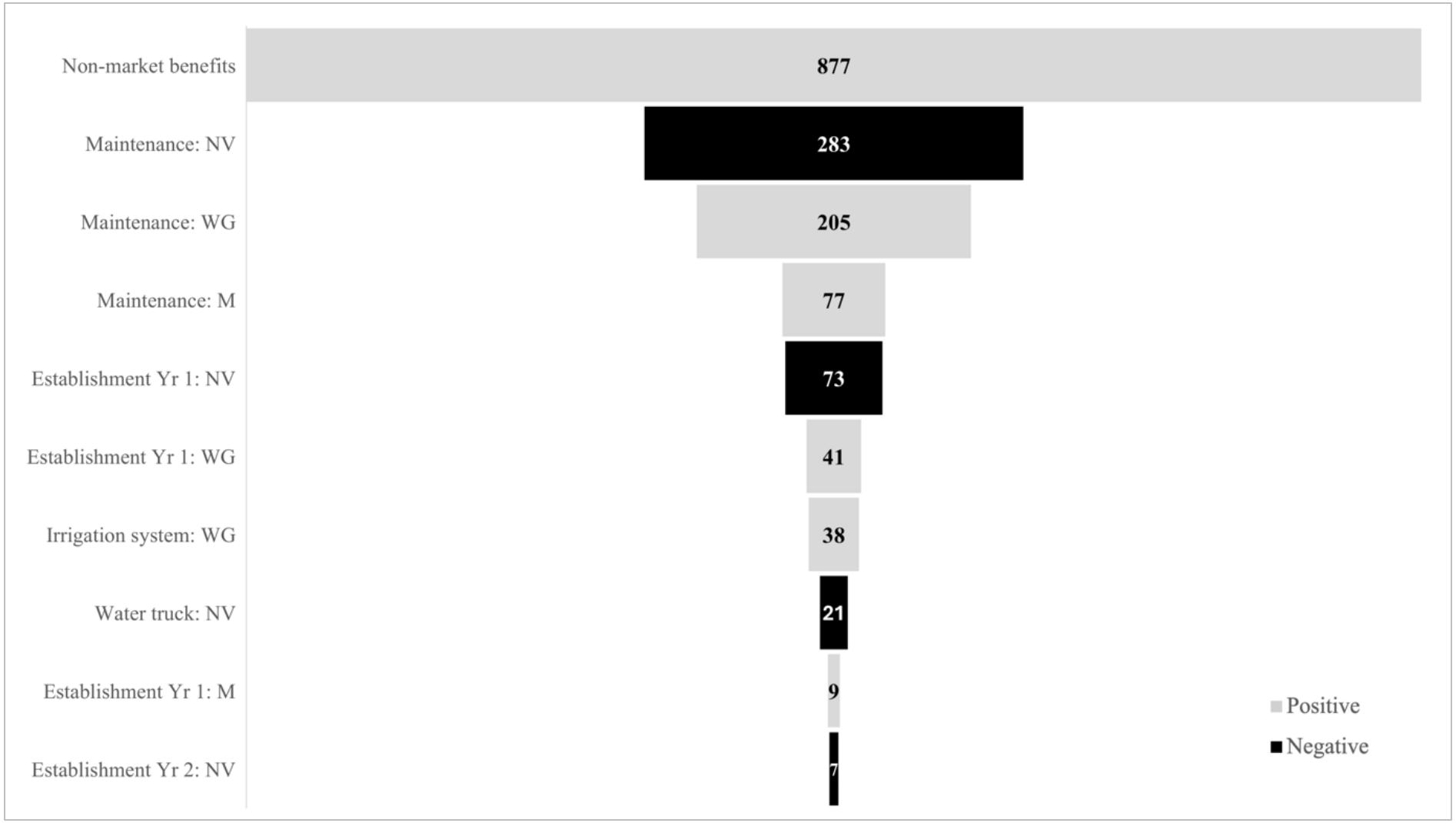

Sensitivity analysis

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Design	New park		Existing park	
	NPV ($'000)	Probability NPV>0	NPV ($'000)	Probability NPV>0
Design 1	275	0.81	21	0.42
Design 2	703	1.00	397	0.94
Design 3	887	1.00	642	1.00
Design 4	764	1.00	596	1.00
Design 5	295	1.00	210	1.00
Design 6	-496	0.00	-539	0.00

- Based on benefits alone
  - 56% native vegetation
  - 44% watered grass
- With costs
  - 60% native vegetation
  - 40% watered grass

What is the optimal mix of different groundcovers in urban parks?

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Councils may **conserve water** while also **benefitting the public** and **saving costs** by designing parks with more **native vegetation**