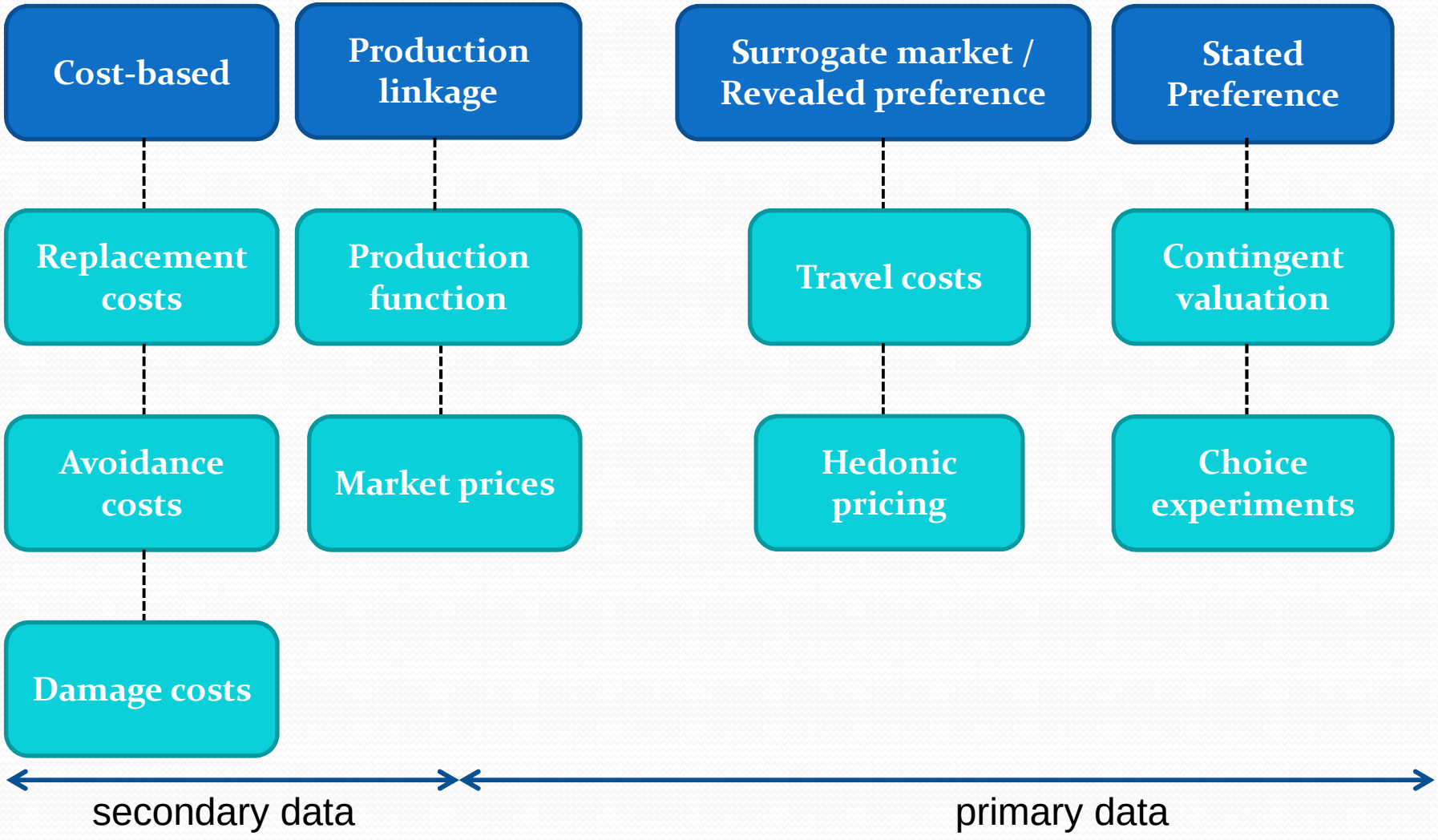
Nonmarket Valuation of Ecosystem Services

Methods for Quantifying Benefits of Ecosystem Services

Some materials from this presentation are based on http://www.ecosystemvaluation.org/

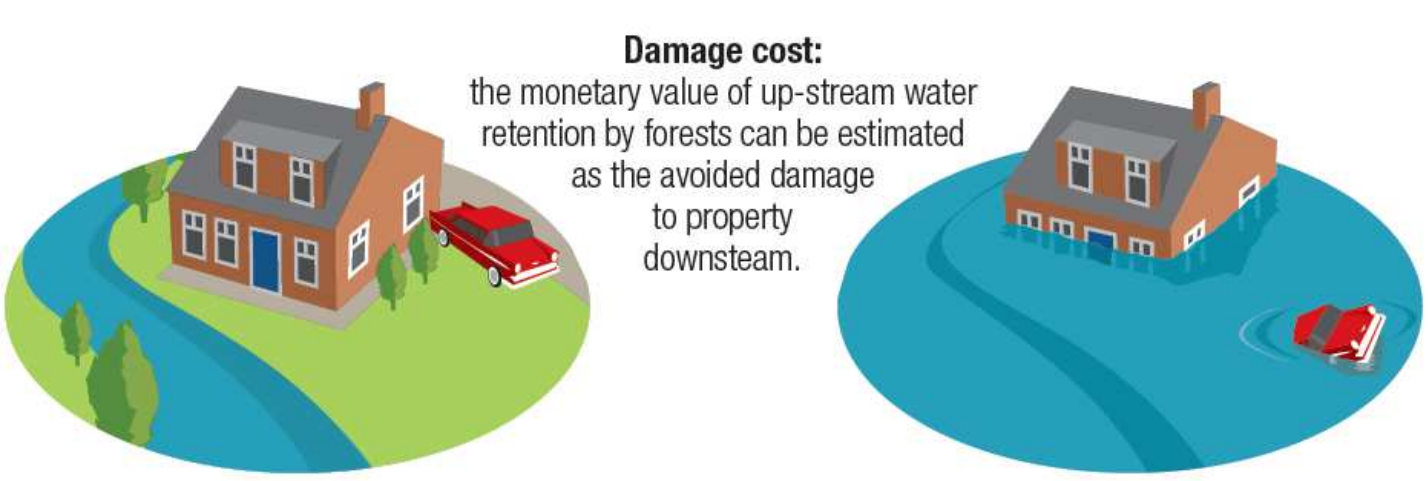
Monetisation techniques



Cost-based methods

Cost-based approach

- Not strictly a measure of value



- Logic: If people incur costs to avoid damages caused by lost ecosystem services, then those services must be worth at least what people paid to replace them

Cost-based approach

- **Example**: Suppose that an invasive weed reduces the ability of a wetland to protect neighbouring areas from flooding

- First, conduct an assessment to determine:
  - the current level of flood protection
  - the expected level of protection if the invasive species is eradicated/established

Cost-based approach

- **Damage costs**: Compare probable flood damage with and without invaded wetland
- **Replacement cost**: Cost estimate for providing a substitute for the lost services, e.g., a retaining wall or a levee

- **Mitigative and avertive expenditures**: Estimate the money that owners have spent protecting their properties from the possibility of flooding, e.g., purchasing insurance or elevating buildings

Replacement Costs

Mitigative and Avertive Expenditures

Damage Costs

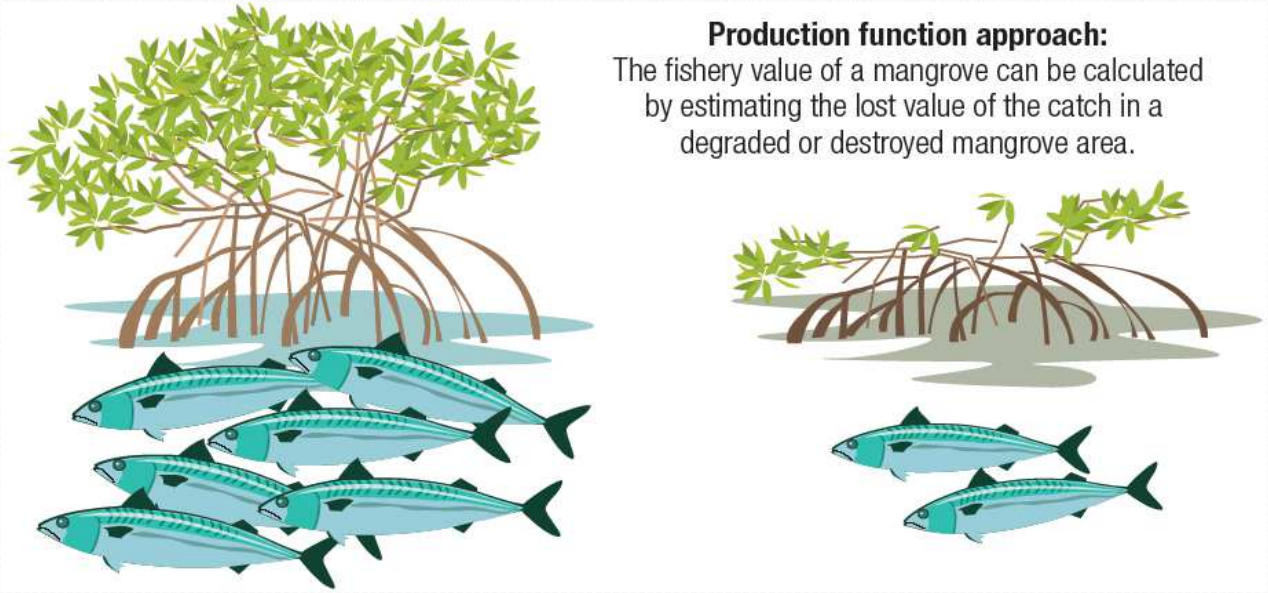
Cost-based approach

- Often good data
  - Value at risk (e.g., houses, production facilities)
  - Engineering cost estimates
  - Observable expenditures
- Cost-based: under- and overestimates of actual value possible
- Technology and resource should be substitutes

Production linkages

Production function approach

- Applied in cases where ecosystem services are used to produce a marketed good



- Can be used for complex ecological relations and intermediate/supporting services

Production function approach

- **Example**: An invasive aquatic predator decreases population that controls algae in a drinking water reservoir

- First, specify the system, i.e., the relationship between the invasive species and the output (drinking water)

$$algae = f(algae\_control(invasive\_predator))$$

$$drinkingwater = p_{trans} \times qty_{water} + p_{filter} \times qty_{filter}(algae) + p_{chem} \times qty_{chem}(algae)$$

Production function approach

- Second, parameterise the model for different invasive control options

$$algae = f(algae\_control(invasive\_predator))$$

$$drinkingwater = p_{trans} \times qty_{water} + p_{filter} \times qty_{filter}(algae) + p_{chem} \times qty_{chem}(algae)$$

- Compare the costs of invasive control options with the reduced costs of providing clean water at expected algae levels

Production function

- Good data and useful for valuing indirect impacts
- Can be technically challenging
  - Relations to final good need to be known and paramaterised
- Links to final good only, so can underestimate total value

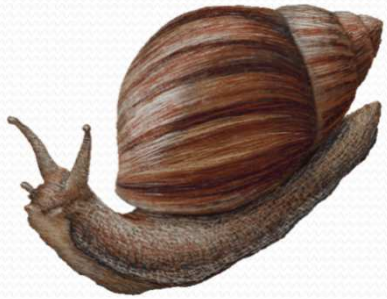
Market prices

Market prices approach

- Estimates the economic value of ecosystem products or services that are bought and sold in commercial markets

- Very robust, but generally for provisioning services

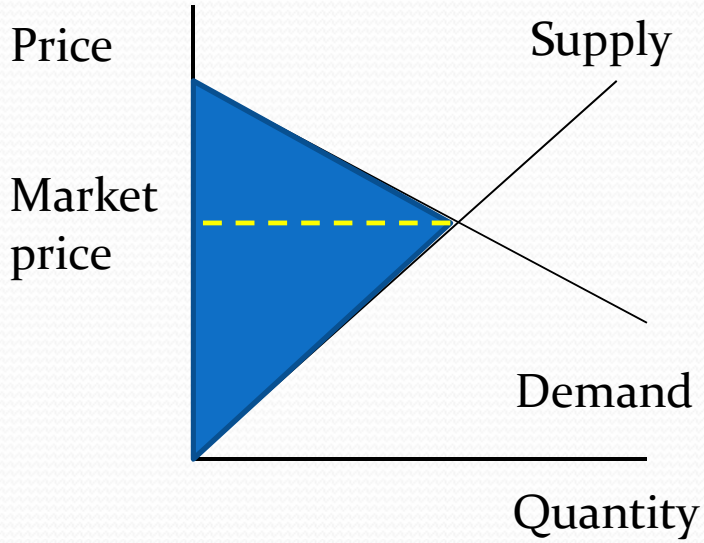
Market prices approach



- **Market prices (fast and easy)**
- Make a list of commodities that are affected by the invasive species
  - e.g., cabbages, coconuts, diving trips, tourist stays
- Obtain expected production impact (secondary sources)
  - e.g., number of kgs of cabbage destroyed per giant African snail
- Obtain unit values of commodities from secondary sources or by visiting several markets and taking averages
  - e.g., price per kg of cabbage

Market price approach

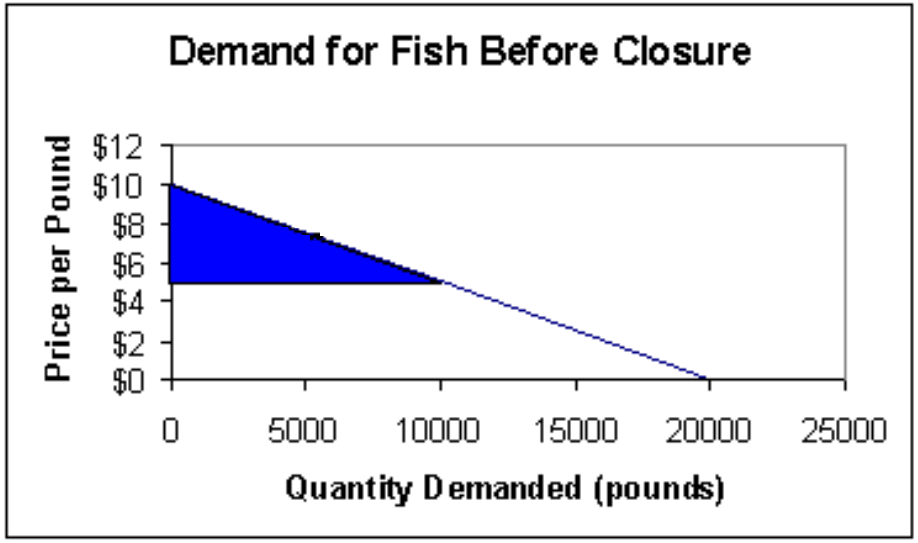
- **Economic surplus (thorough)**



- Calculate the difference between economic surplus before the arrival of an invasive species and after its arrival

Market price approach

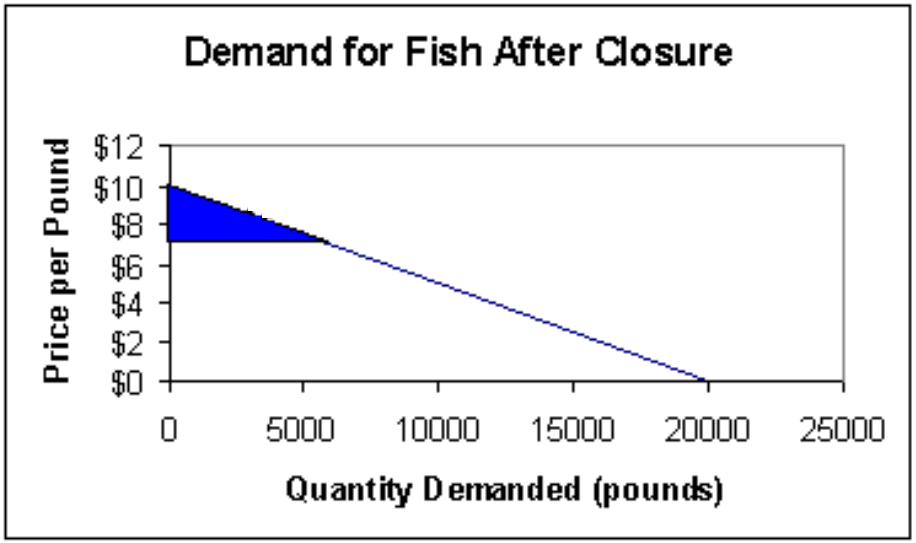
- **Example**: suppose that an invasive species causes a commercial fishery to cease operating
- Suppose that the market price for fish before closure is $5 per pound



- Area of upper triangle before closure: 10,000 * $5 / 2 = $25,000

Market price approach

- After the closure, the market price of fish rose from $5 to $7 per pound, and the total quantity demanded decreased to 6,000 pounds per year



- Area of upper triangle after closure: 6,000 * $3 / 2 = $9,000
- Difference: $25,000 - $9,000 = $16,000

Market price approach

- Lower triangle can be calculated from data

- Before the closure, 10,000 pounds of fish were caught
  - Fishermen were paid $1 per pound → Total revenue = $10,000

  - It costs $0.50 per pound caught for bait and fuel
    → total variable costs = $5,000

  - Area of lower triangle before the closure: $10,000 - $5,000 = $5,000

Market price approach

- After the closure, 6,000 pounds were caught.
  - Total revenues after the closure = $6,000
  - Variable cost increases to $.60 because boats have to travel further to fish

    → Total variable cost after the closure = $3,600
  - Area of lower triangle after the closure: $6,000 - $3,600 = $2,400.
- Difference: $5,000 - $2,400 = $2,600

Market price approach

- Economic surplus lost due to the invasive species
  - Differences in upper + lower triangles

- Thus, the benefits of eradicating the invasive species in this fishery: $16,000 + $ 2,600 = $18,600

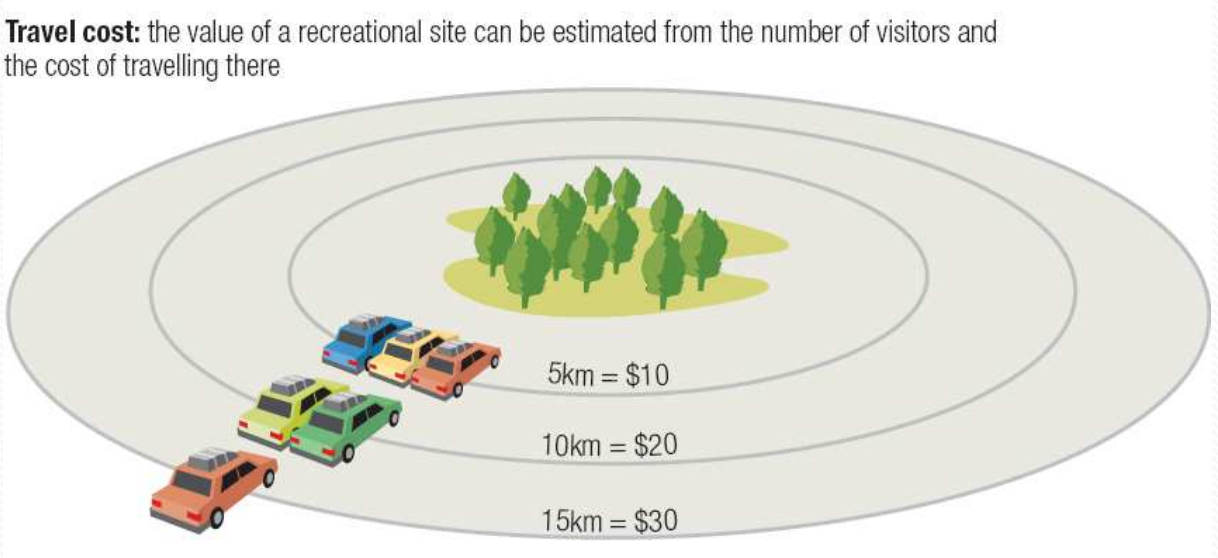
Market price

- Good data
- Generally straightforward
- Links to final good only, so can underestimate total value

Surrogate market approach

Surrogate market approach

- **Travel cost** used to estimate economic use values associated with ecosystems that are linked with tourism



- Logic: the time and travel costs that people incur to visit a site represent the value that they put on that site

Surrogate market approach

- **Example**: invasive mustelids in a forest threaten the birds that are popular with tourists. A nearby forest has already been invaded by mustelids.

- **Approach #1**: Conduct a survey at both forests to ask:
  - Where visitors come from
  - How many times they visited the site in the past year
  - Whether the ***only*** purpose of their trip is to see this forest
  - Time and money spent to reach the site
  - Time and money spent at the site
  - The value of the respondent's time (e.g., hourly wage)

Surrogate market approach

- Develop a spending profile of visitors from each location, e.g.:
  - The average visitor from Europe spends $250 to reach one forest and $50 at the site, visits only once, spends 3 days at the site, and earns $200 per day → the value of the site for a European visitor is $250+$50+3x$200=$900
- Use visitor records from each of the forests to multiply these figures by the number of visitors from each location

	Site 1 Amount / visitor	Site 1 # of visitors	Site 1 total	Site 2 Amount / visitor	Site 2 # of visitors	Site 2 total
European	$900	1000	$900,000	$600	700	$420,000
Local	$960	3500	$3,360,000	$280	1800	$504,000
TOTAL			$4,260,000			$924,000

- Estimate benefit of eradication = $4,260,000-$924,000 = $3,336,000

Surrogate market approach

- **Approach #2**: Conduct a survey at both forests to ask:
  - (all previous questions)
  - **How many bird species they expected to see**

- Regress total paid on other variables to estimate the contribution of each species seen

$$total\_paid = \beta_0 + \beta_1 species + \beta_2 num\_visits + \beta_3 spending + ... + \varepsilon$$

- Benefit of mustelid control via value of presence of bird species

$$spending = \beta_0 + \beta_1 species + \beta_2 num\_visits + \beta_3 distance + ... + \varepsilon$$

Surrogate market approach

- **Hedonic pricing** estimates economic value of ecosystems that are linked to market goods

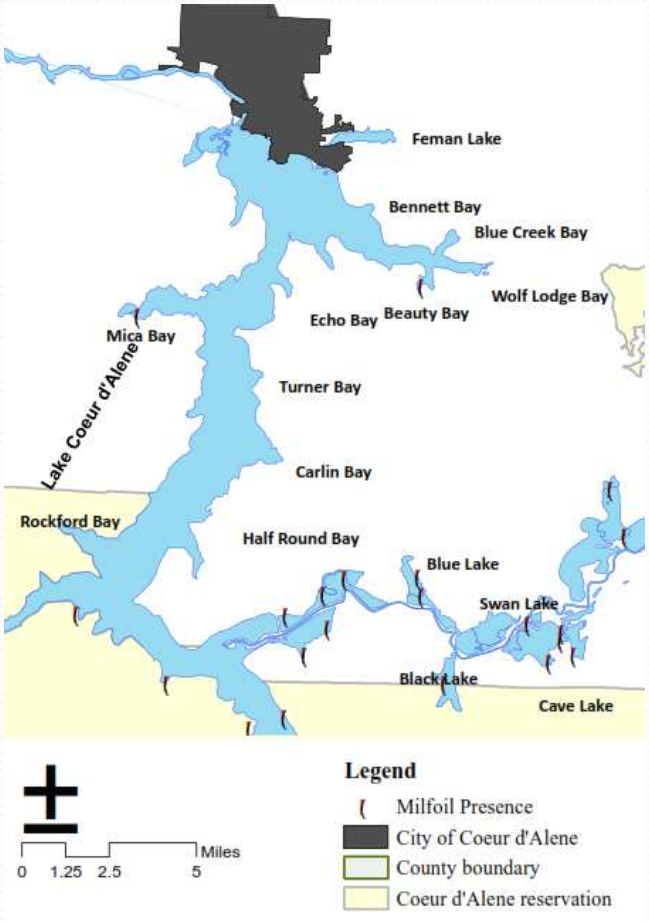
- Logic: people pay more for goods associated with high environmental quality

Surrogate market approach

- **Example**: invasive weed is decreasing lake aesthetics

- **Get data on**:
  - Property prices
  - Property characteristics
  - Indicator for IAS impact

- **Conduct statistical analysis**
  - Spatial econometric techniques



Surrogate market approach

- Good data
- Can be time and data-heavy
- Strong focus on tourism and resources related to property

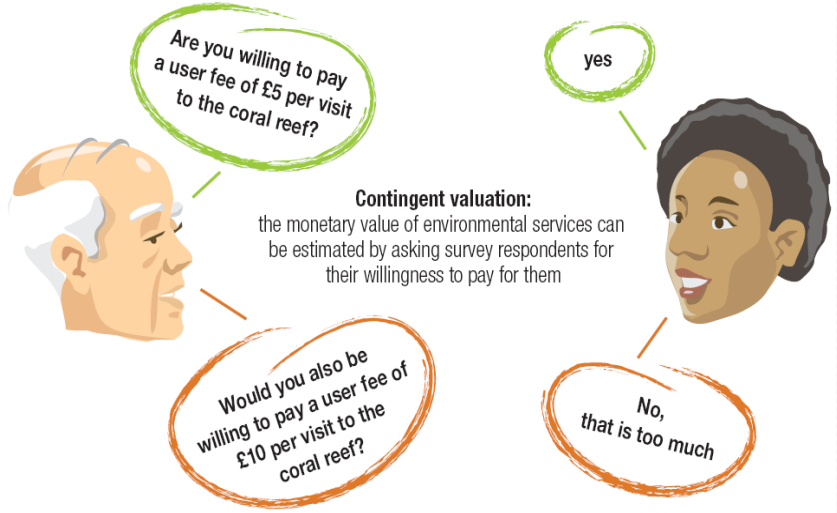
Stated preference method

Contingent Valuation

Choice Experiments

Stated preference method

- Widely used but controversial approach to ask people
  - How much they are willing to pay/must be paid for keeping/losing specific ecosystem services



- People respond to hypothetical scenarios, hence the name **contingent valuation**

Contingent Valuation

Choice Experiments

Stated preference method

- Used for (non-use) ecosystem services such as
  - Sense of place
  - Aesthetics
  - Bequest
  - Existence
  - Habitat and/or biodiversity provision
  - …

Contingent Valuation

Choice Experiments

Stated preference method

- **Example**: Suppose that invasive grass carp was outcompeting endemic, non-commercial freshwater fish, threatening up to nine species with extinction. You want to value invasive species control, in $, to understand the benefits of protection.
- Design and test survey questions
- Conduct the survey using a random sample
- Calculate the average willingness to pay for your sample and multiply by the total population to estimate the total willingness to pay

Contingent Valuation

Choice Experiments

Stated preference method

- *Suppose that a proposal to establish an Endangered Fish Trust Fund was on the ballot in the next nationwide election. By law, the funds could only be used to improve habitat for fish. If the Endangered Fish Trust Fund would cost your household $10 every year, would you vote in favor of it?* ***YES*** */* ***NO***
  - If yes, would you be willing to pay $11? Would you be willing to pay $12?...until the respondent says “no”
  - If no, would you be willing to pay $9? Would you be willing to pay $8?...until the respondent says “yes”

Stated preference method

Two volunteers

please step outside for a moment

Stated preference method

- Jamaica has rich biodiversity and high endemism. Jamaica is ranked 5th among Caribbean islands for endemic plants and 1st for endemic birds. Approximately 98% of Jamaica's 514 land snails are endemic as well 76% of her reptiles and all 22 species of frogs.
- Invasive alien species are non-native animals, plants, and organisms that threaten native species through predation, competition, and the transmission of diseases. They may also affect the economy in cases where these native species are harvested commercially.
- As an island, Jamaica is vulnerable to invasive alien species because of its small size and its geographic isolation. The small Asian mongoose was introduced to Jamaica in 1872 to kill rats. It is believed that the mongoose has contributed to the possible extinction of two of Jamaica's endemic ground nesting birds - the Jamaica petrel (*Pterodroma caribbaea*) and Jamaican paruraque (*Siphonorhis americana*) as well as the Giant galliwasp (*Celestrus occiduus*) the black racer (*Alsophis ater*).
- The small Asian mongoose poses a major threat to the endemic Jamaican iguana (*Cyclura collei*), but scientists have developed new methods to exclude mongoose from areas where the iguana breeds and lives.
- Would you be willing to pay $1 per year in additional taxes to protect the Jamaican iguana from the small Asian mongoose?

Stated preference method

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- The small Asian mongoose poses a major threat to the endemic Jamaican iguana (*Cyclura collei*), but scientists have developed new methods to exclude mongoose from areas where the iguana breeds and lives.
- Would you be willing to pay $100 per year in additional taxes to protect the Jamaican iguana from the small Asian mongoose?

Stated preference method

- **Anchor-point bias**: By providing a specific starting value, the survey is providing a clue about what management of invasive species might be worth, i.e., the starting value influences respondents' willingness to
  - Solution: Randomize starting values

Stated preference method

- **Instrument may be irrelevant to survey respondents**:
  If your survey respondents don't pay taxes, for example, willingness to pay for national programs is irrelevant
  - Solution: Ask willingness to pay in time or willingness to accept

Contingent Valuation

Choice Experiments

Stated preference method

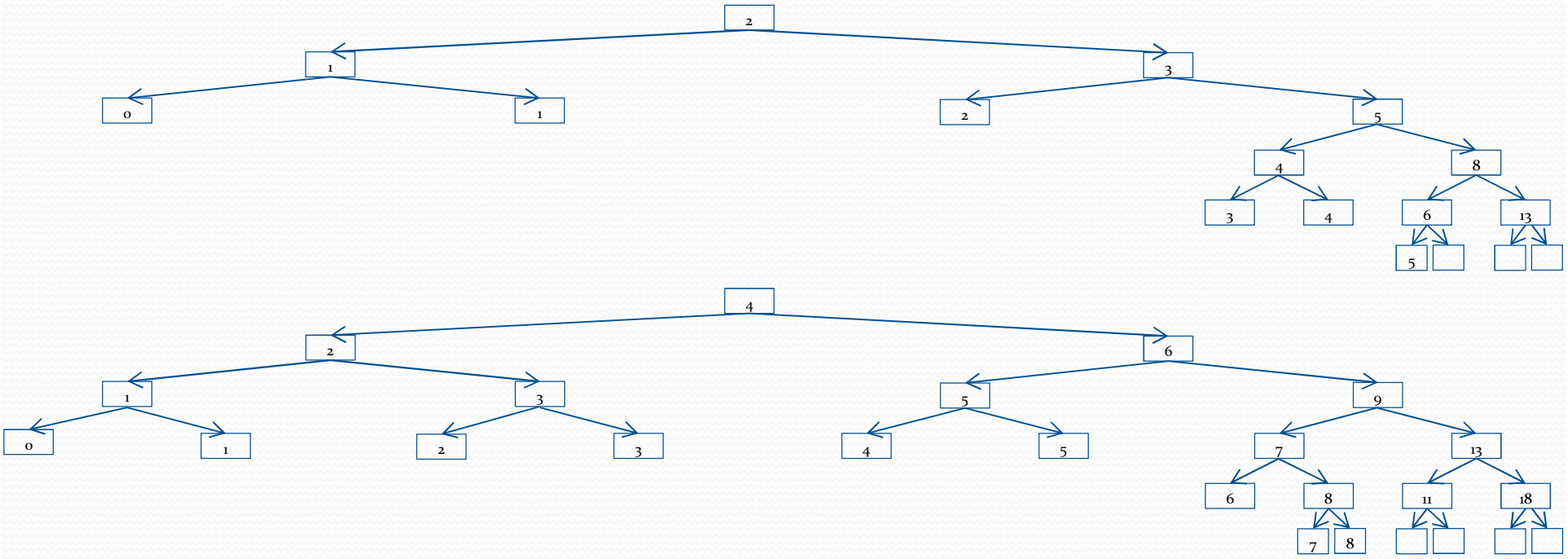
- **Social desirability bias**: Respondents may overstate willingness to pay in order to obtain approval
  - Solution: Write the survey in neutral language

Contingent Valuation

Choice Experiments

Stated preference method

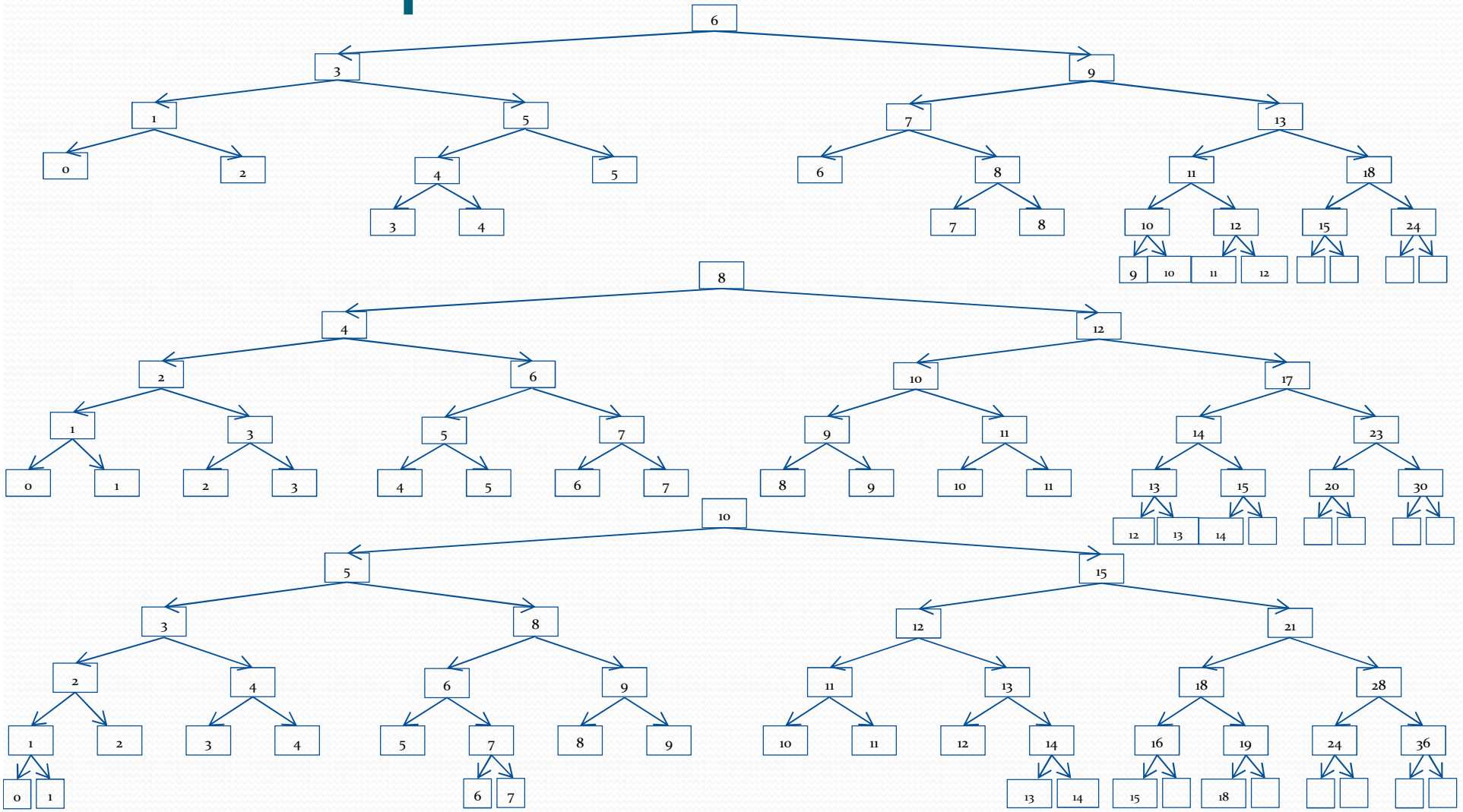
- *Imagine that the researchers at the University of the South Pacific developed a new way to completely control the small Asian mongoose in this village. Unfortunately, for this project to work, it would require every adult in the village to volunteer some of his or her time in addition to any time already given to the village. Would your household be willing to volunteer XXX hours per week?*



Contingent Valuation

Choice Experiments

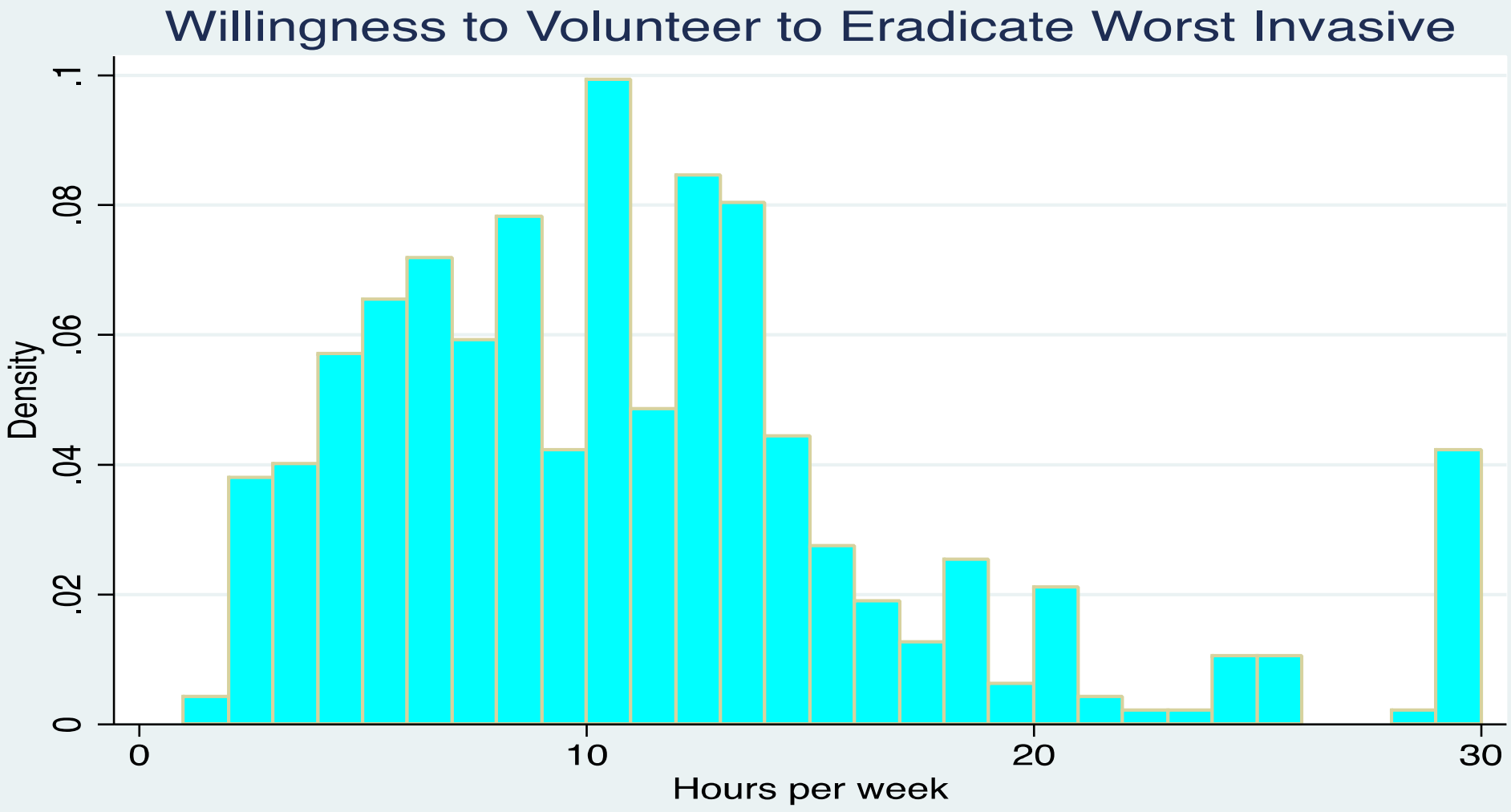
Stated preference method



Contingent Valuation

Choice Experiments

Stated preference method



Stated preference method

- **Choice experiments** differ from contingent valuation because are inferred from the hypothetical tradeoffs rather than asking willingness to pay directly
  - Which bundle of ecosystem services and payment do you prefer?
  - How much would you pay to preserve this ecosystem service?

- Especially suited for multiple impacts

Contingent Valuation

Choice Experiments

Stated preference method

- **Example**: A coral reef protects the shore from coastal erosion, provides habitat for commercial fish, and is a popular tourist destination. Invasive crown of thorns are threatening the reef. You want to value invasive species control, in $, to understand the benefits of protection.
- Design and test survey questions
- Conduct the survey using a random sample
- Calculate the average value of protection for your sample and multiply by the total population to estimate the value of protection

Contingent Valuation

Choice Experiments

Stated preference method

Scenario 2

Number of crown of thorns:
none low **medium** high

Coastal protection
very low low **medium** high

Fish stock
low **medium** high very high

Number of dive trips
low **medium** high very high

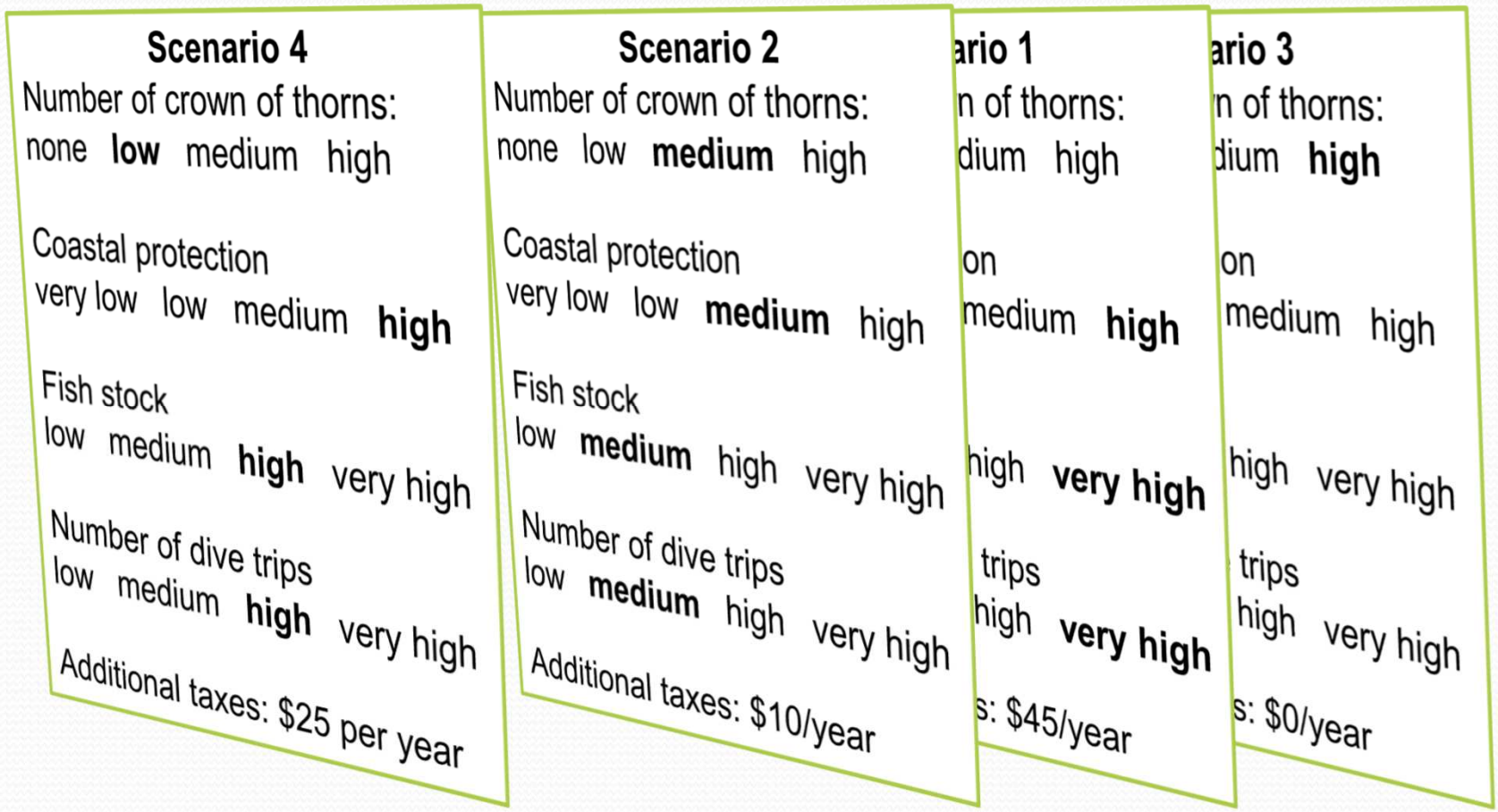
Additional taxes: $10 per year

Contingent Valuation

Choice Experiments

Stated preference method

- *Please rank the following scenarios:*



Stated preference method

- **With a limited number of choices, values are by definition imprecise**
  - e.g., What if people would pay $24, but not $25?
  - In the previous example, they would choose the $10 option
  - Solution: Increase the number of options (but note that this increases survey complexity)
- **Instrument may be irrelevant to survey respondents**: If your survey respondents don't pay taxes, for example, willingness to pay for national programs is not a useful measure
  - Solution: Ask how they would allocate the national budget

Contingent Valuation

Choice Experiments

Stated preference method

- *In 2008, the government spent about $700 million on defence; public order and safety; economic affairs such as construction, mining, transportation, and labour; environmental protection such as water pollution, soil erosion, and control of harmful species such as the African tulip tree and the small Asian mongoose; housing and community amenities; health; recreation, culture, and religion; education; and social protection such as the Family Assistance Program.*
- *Imagine that this pile of beans represents all the money that the government can spend on all of these things. If you were the budget minister, how much would you allocate to each of these categories?*

Contingent Valuation

Choice Experiments

Defense	Public order and safety	Economic affairs (construction, mining, labour, transport)
Environmental protection & control of harmful species	Housing and community amenities	Health
Recreation, culture, religion	Education	Social protection

Contingent Valuation

Choice Experiments

Environmental protection & control of harmful species

Environmental protection

Control of harmful species

Contingent Valuation

Choice Experiments

Control of harmful species

African tulip tree

Bulbul

Taro beetle

Indian mongoose

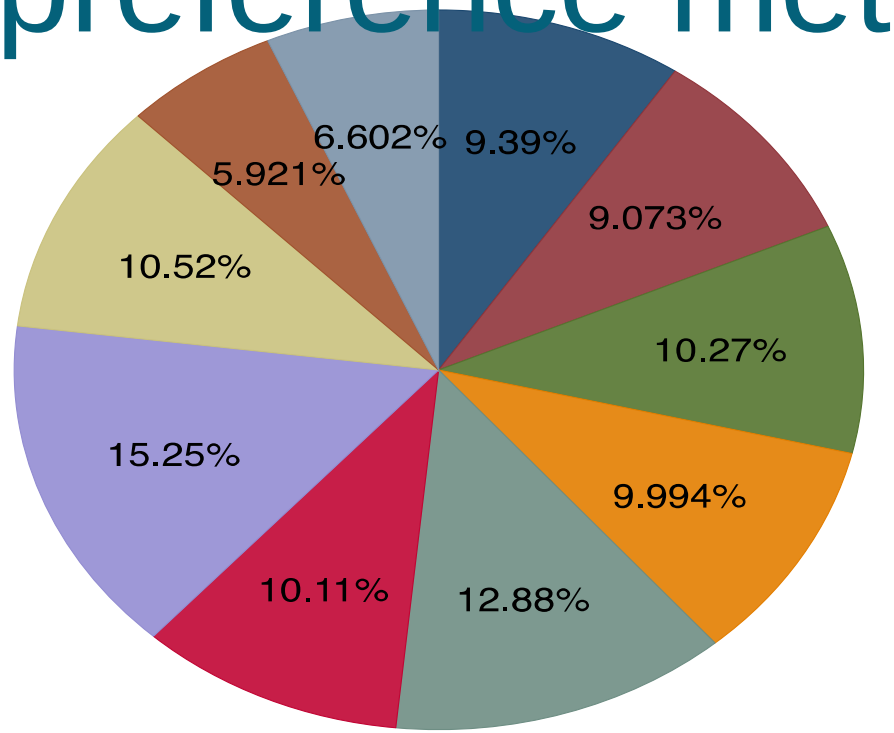
Merremia

Other

Contingent Valuation

Choice Experiments

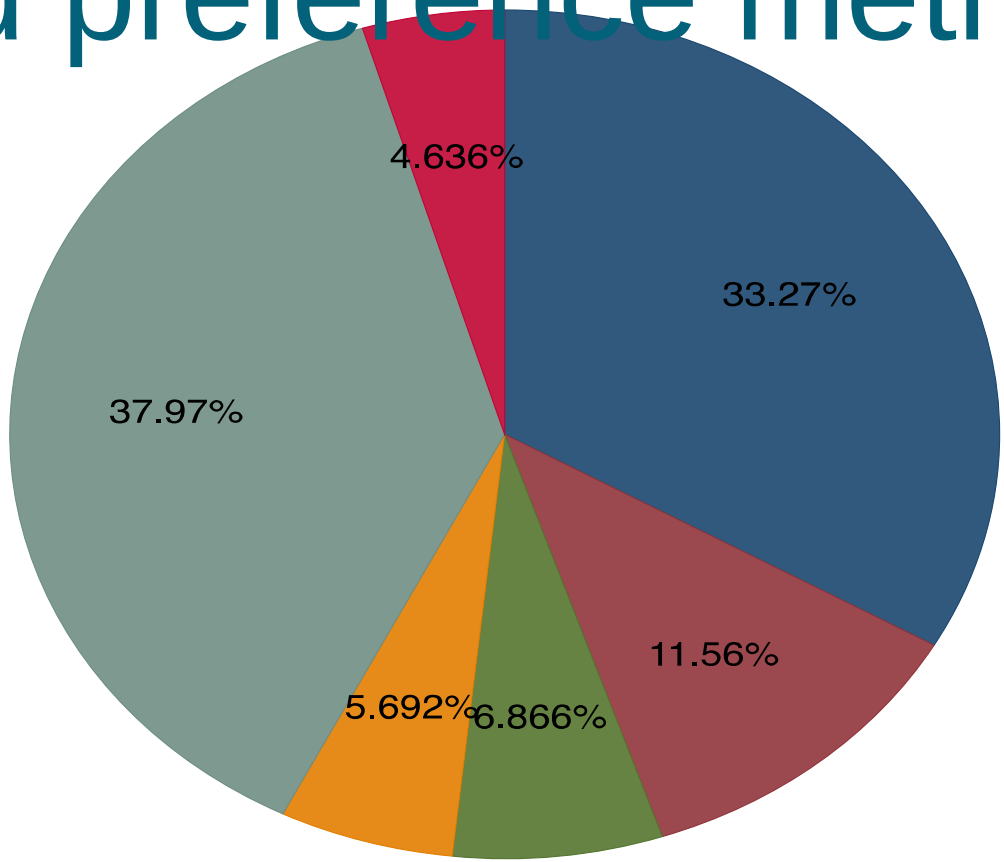
Stated preference method



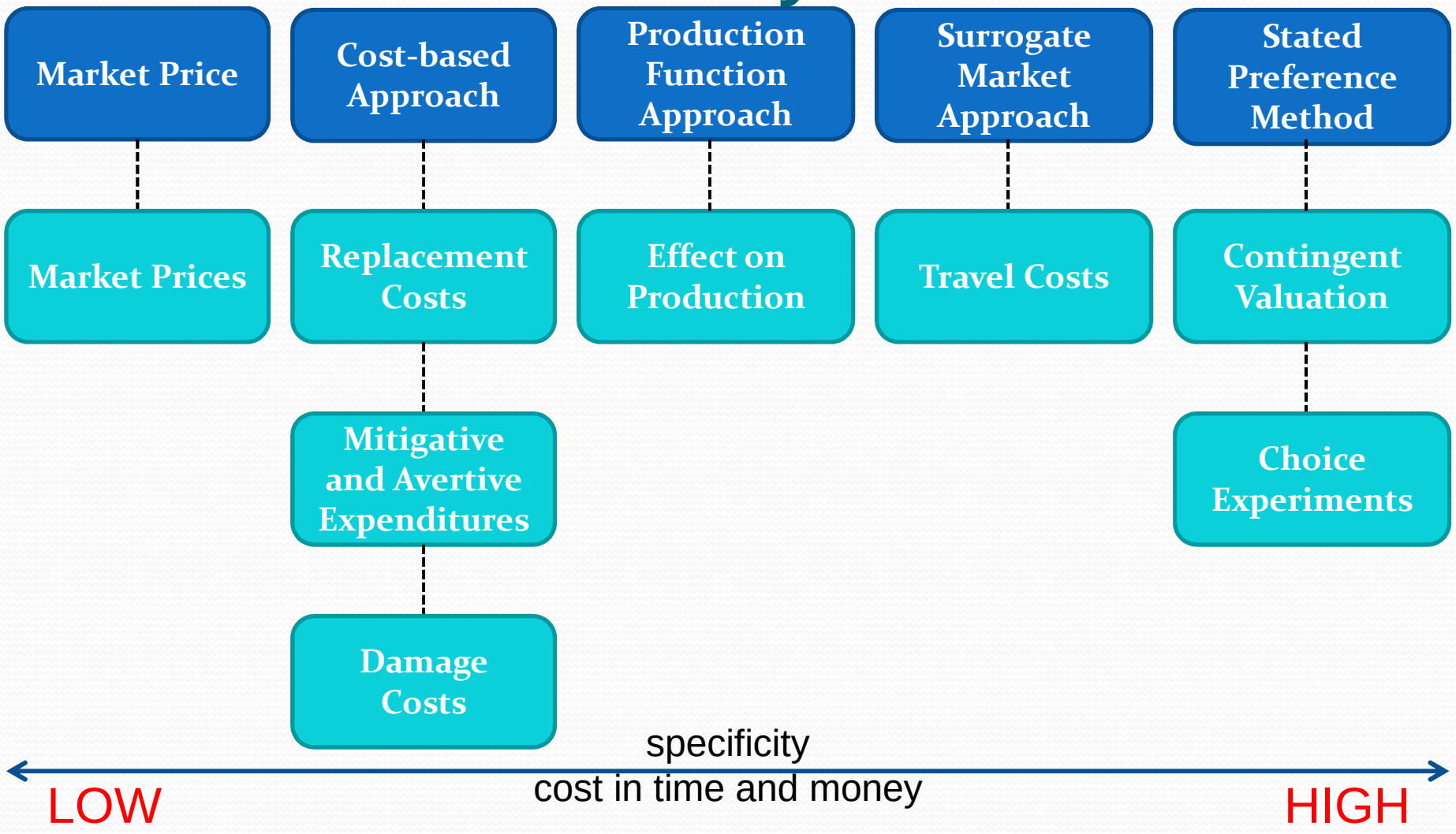
Contingent Valuation

Choice Experiments

Stated preference method



Methods for quantifying benefits of ecosystem services



Leftover slides

Replacement Costs

Mitigative and Avertive Expenditures

Damage Costs

Cost-based approach

- **More examples**:
  - Valuing the services of native pollinators by measuring the rental cost of honey bees
  - Valuing erosion protection services of a forest by measuring the cost of removing sediment from downstream areas
  - Valuing the water purification services of a wetland by measuring the cost of treating water with chemicals
  - Valuing storm protection services of coastal wetlands by measuring the cost of building retaining walls
  - Valuing fish habitat and nursery services by measuring the cost of fish breeding and stocking programs

Replacement Costs

Mitigative and Avertive Expenditures

Damage Costs

Cost-based approach

- We are never sure if people (can) respond truthfully
  - Answering a question is not identical to behaviour
  - Unfamiliar goods: recreation vs sacred site