**American Planning Association**
**Georgia Chapter**

*Making Great Communities Happen*

# Impact Assessment and Cost-Benefit Analysis

## AICP EXAM REVIEW

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# Core Concepts: the "rational" framework for decision analysis

- Goals
- Objectives
- Alternatives
- Impacts
- Criteria [singular=criterion]
- Constraint

- Goals: "what is sought to accomplish or attain"

- Objectives: "measurable sub-components or operationalization of goals"

# Goals and Objectives

- Goals
  1. Fishable/swimmable waters
  2. Adequate affordable housing
  3. Transportation capacity sufficient to demand
  4. Reduction of contagious disease
  5. Decrease in solid waste landfill volume

- Objectives
  1. Nitrogen levels "below" national standards
  2. Median housing price less than 3x median family income
  3. LOS C or better on all county roads
  4. No new cases of measles
  5. Reduction of SW volume by 35% compared to 2000.

- Alternatives: "options of means available, by which, it is hoped the objectives can be attained"

1. curved row planting on croplands
2. expansion of land supply through conversion of abandoned inner city industrial land
3. bike lane construction program
4. free vaccinations for school children
5. curbside pickup of recyclable waste

- Impacts: "positive and/or negative consequences of alternatives, including benefits and costs, direct and indirect."

1. Reduced nitrogen runoff
2. Decreased number of affordable housing units
3. Reduced vehicle miles traveled
4. Reduced cases of measles
5. Decreased landfill deposits

- Criterion: "rule or standard by which to rank the alternatives in order of desirability"

1. Minimize nitrogen discharge
2. Maximize affordable units produced
3. Maximize additional traffic lane capacity
4. Minimize new cases of communicable disease
5. Minimize annual volume of landfill deposits

# Key Criteria Types:

- Technical feasibility
  - Effectiveness
  - Adequacy
- Economic and financial possibility
  - Fiscal benefits and costs to government
  - Total societal benefits and costs
- Equity
- Risk and Uncertainty
- Reversibility
- Political viability
- Administrative operability
- Other types of criteria: security, liberty, rights

- Constraint: "Condition within criteria that sets a firm limit on choice of alternatives"

1. Georgia surface water quality standard for N
2. Capital expenditures no greater than $50 mill.
3. No reduction in vehicular Level of Service
4. Immunization rate of at least 98%
5. No new costs to owners of rental housing

Figure 4.1 The iterative nature of analysis.
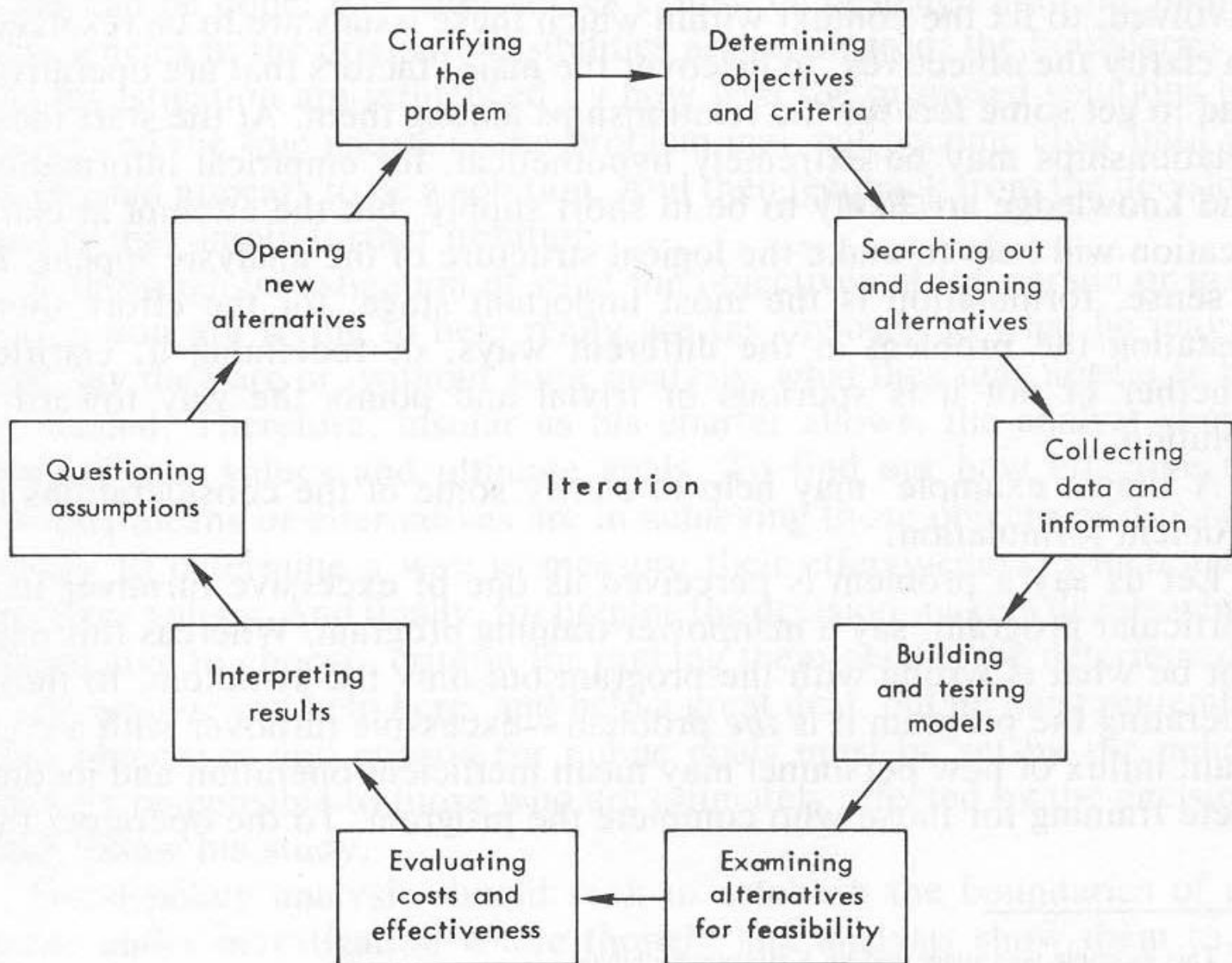
# Environmental Impact Assessment

- US: NEPA (1969)
  - §102
- Other mandates include:
  - Canada 1973
  - Australia 1974
  - Columbia 1974
  - UK
  - Netherlands 1981
  - Japan 1984
  - Thailand
  - Phillipines
  - EU 1985

- Guidelines:
  - US CEQ 1978
  - OECD 1974 & 1979
  - UNEP 1980
- US States:
  - California 1st: SEPA
  - Florida DRI Ch. 380 1972
  - Many others
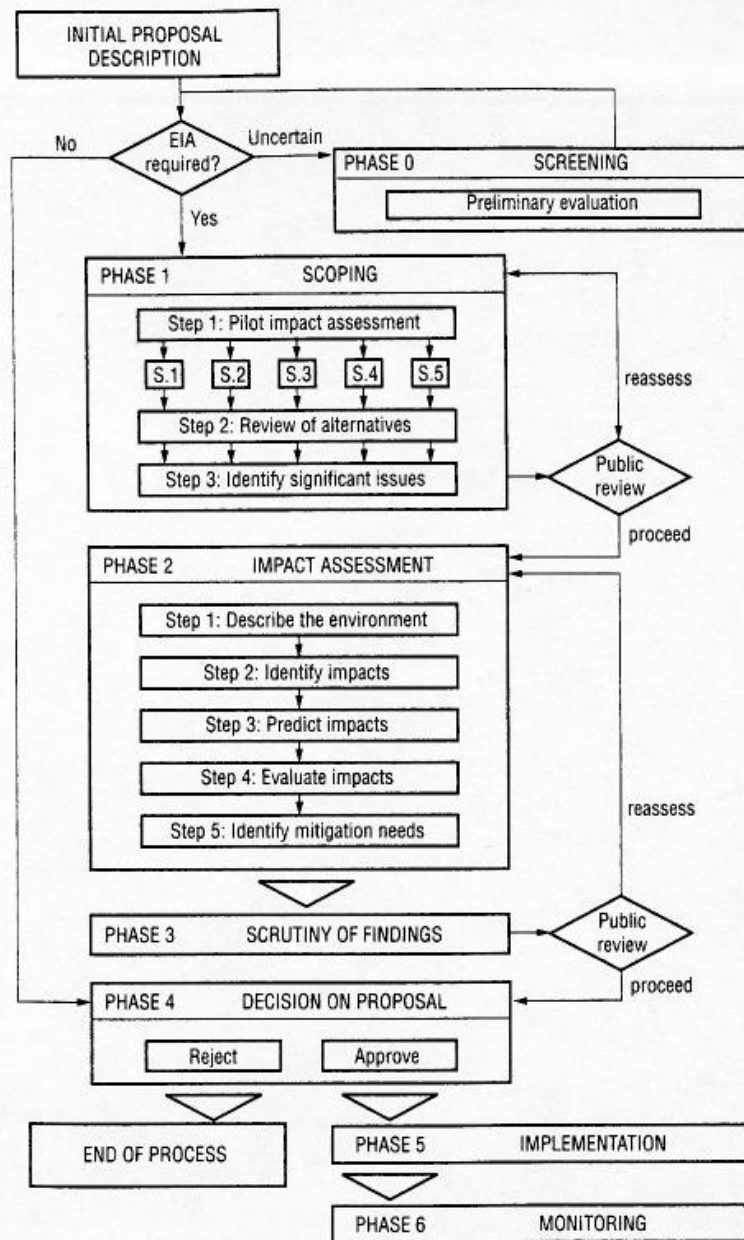
**Table 1.1** Content of an EIS for US federal proposals as required by CEQ (1978).

*Summary*

*Statement of purpose and need*

*Alternatives including proposed action*
        Discussion of all options considered
        Discussion of 'no–action' option
        Identification of agency-preferred alternative
        Discussion of mitigation measures

*Affected environment*
        Baseline environmental description of area affected by each alternative

*Environmental consequences*
        Environmental impact of each alternative
        Unavoidable effects
        Relationship between local short-term use of environment and enhancement of
            long-term productivity
        Irreversible and irretrievable commitment of resources

*List of preparers*

# EIA Early Issues and Results

- Early implementation: few no build decisions; immense wasted paperwork; some changes to project design (Andrews 1974; Ortolano and Hill 1975)

- 1978 CEQ guidelines: negative declarations; scoping

## Box 18.2—Possible Effects of Environmental Impact Assessment

**Possible Effects of EIA on Projects**

- Withdrawal of unsound project
- Legitimization of sound project
- Selection of improved project location
- Reformulation of plans
- Redefinition of goals
- Mitigation of project impacts

    Dropping damaging elements of proposed project

    Minimizing adverse effects by scaling down or redesigning project

    Repairing or restoring environment adversely affected

    Creating or acquiring environments similar to those adversely affected

**EIA as an Impetus for Administrative Change**

- Often increases access of citizens, NGOs, and other agencies to information on project
- Enhances interagency coordination
- Affects power relations between ministries, increases power of environmental agencies

*Source:* Ortolano and Shepherd (1995).

# Major families of EIA methods

- Checklists
- Matrices
  - Leopold matrix (USGS)
- Overlays
  - McHargian
  - GIS Land Suitability
- EQ Indices
  - Battelle Columbus EES

- Valuation tradeoff models
  - WRAM (ACOE)
  - HES (USFWS)
  - SWT (Haimes)
- Adaptive Assessments
  - C.S. Holling
  - Simulation modelling

**Table 1.3** Checklist of impact categories for land development projects (summarized from Schaenam 1976).

1 *Local economy*
Public fiscal balance
Employment
Wealth

2 *Natural environment*
Air quality
Water quality
Noise
Wildlife and vegetation
Natural disasters

3 *Aesthetics and cultural values*
Attractiveness
View opportunities
Landmarks

4 *Public and private services*
Drinking water
Hospital care
Crime control
Feeling of security
Fire protection
Recreation – public facilities
Recreation – informal settings
Education
Transportation – mass transit
Transportation – pedestrian
Transportation – private vehicles
Shopping
Energy services
Housing

5 *Other social impacts*
People displacement
Special hazards
Sociability/ friendliness
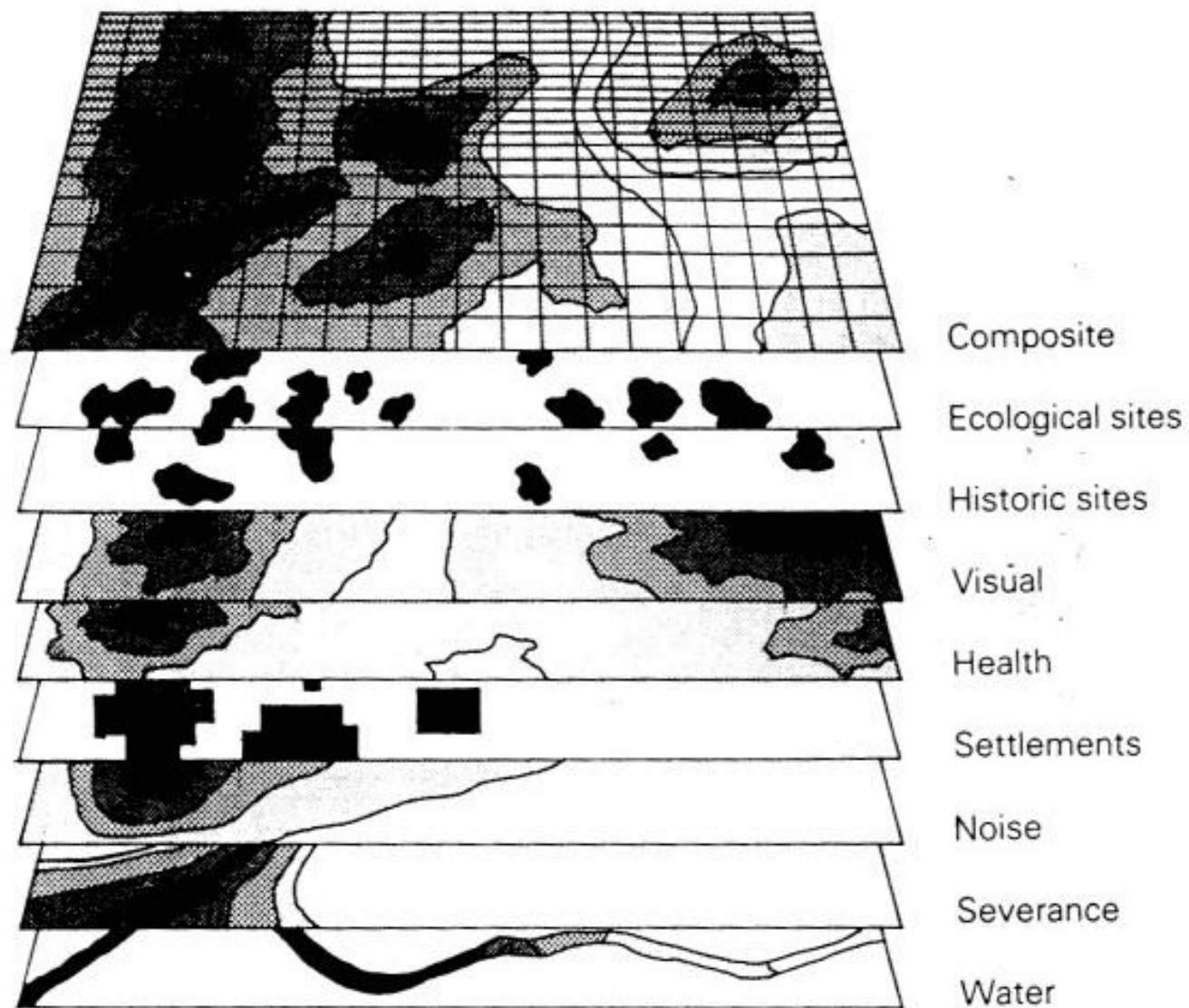Privacy
Overall contentment with neighbourhood

## Instructions

1. Identify all actions (located across the top of the matrix) that are part of the proposed project
2. Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible
3. Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, the least, (no zeros). Before each number place + (if the impact would be beneficial). In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e.g. regional vs. local); 10 represents the greatest importance and 1, the least (no zeros)
4. The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers

Sample matrix

| | a | b | c | d | e |
|---|---|---|---|---|---|
| a | 3/1 | | | | 8/5 |
| b | 7/2 | 5/3 | 3/1 | 9/7 | |

**A. Modification of regime**
- a. Exotic flora or fauna introduction
- b. Biological controls
- c. Modification of habitat
- d. Alteration of ground cover
- e. Alteration of ground water hydrology
- f. Alteration of drainage
- g. River control and flow modification
- h. Canalization
- i. Irrigation
- j. Weather modification
- k. Burning
- l. Surface or paving
- m. Noise and vibration

**B. Land transformation and construction**
- a. Urbanization
- b. Industrial sites and buildings
- c. Airports
- d. Highways and bridges
- e. Roads and trails
- f. Railroads
- g. Cables and lifts
- h. Transmission lines, pipelines and corridors
- i. Barriers including fencing
- j. Channel dredging and straightening
- k. Channel revetments
- l. Canals
- m. Dams and impoundments
- n. Piers, seawalls, marinas and sea terminals
- o. Offshore structures
- p. Recreational structures
- q. Blasting and drilling
- r. Cut and fill
- s. Tunnels and underground structures

**C. Resource extraction**
- a. Blasting and drilling
- b. Surface excavation
- c. Subsurface excavation and retorting
- d. Well drilling and fluid removal
- e. Dredging
- f. Clear cutting and other lumbering
- g. Commercial fishing and hunting

## Proposed actions

**CHEMICAL CHARACTERISTICS**

**1 Earth**
- a. Mineral resources
- b. Construction material
- c. Soils
- d. Land form
- e. Force fields and background radiation
- f. Unique physical features

**2 Water**
- a. Surface
- b. Ocean
- c. Underground
- d. Quality
- e. Temperature
- f. Recharge
- g. Snow, ice and permafrost

**Figure 1.2** A section of the Leopold matrix (Courtesy US Geological Survey).

Composite

Ecological sites

Historic sites

Visual

Health

Settlements

Noise

Severance

Water

**Figure 1.5**    The use of overlays to show environmental impacts.

# Environmental impacts

## Ecology 240

**Societies and populations**
Terrestrial
- (14) Browsers and grazers
- (14) Crops
- (14) Natural vegetation
- (14) Pest species
- (14) Upland game birds

Aquatic
- (14) Commercial fisheries
- (14) Natural vegetation
- (14) Pest species
- (14) Sport fish
- (14) Water fowl

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**Habitats and communities**
Terrestrial
- (12) Food web index
- (12) Land use
- (12) Rare and endangered species
- (14) Species diversity

Aquatic
- (12) Food web index
- (12) Rare and endangered species
- (12) River characteristics
- (14) Species diversity

**100**

**Ecosystems**
Descriptive only

## Environmental pollution 402

**Water pollution**
- (20) Basin hydrologic loss
- (25) BOD
- (31) Dissolved oxygen
- (18) Fecal coliforms
- (22) Inorganic carbon
- (25) Inorganic nitrogen
- (28) Inorganic phosphate
- (16) Pesticides
- (18) pH
- (28) Stream flow variation
- (28) Temperature
- (25) Total dissolved solids
- (14) Toxic substances
- (20) Turbidity

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**Air pollution**
- (5) Carbon monoxide
- (5) Hydrocarbons
- (10) Nitrogen oxides
- (12) Particulate matter
- (5) Photochemical oxidants
- (10) Sulfur oxides
- (5) Other

**52**

**Land pollution**
- (14) Land use
- (14) Soil erosion

**28**

**Noise pollution**
- (4) Noise

**4**

## Esthetics 153

**Land**
- (6) Geologic surface material
- (16) Relief and topographic character
- (10) Width and alignment

**32**

**Air**
- (3) Odour and visual
- (2) Sounds

**5**

**Water**
- (10) Appearance of water
- (16) Land and water interface
- (6) Odour and floating materials
- (10) Water and surface area
- (10) Wooded and geologic shoreline

**52**

**Biota**
- (5) Animals — domestic
- (5) Animals — wild
- (9) Diversity of vegetation types
- (5) Variety within vegetation types

**24**

**Manufactured objects**
- (10) Manufactured objects

**10**

**Composition**
- (15) Composite effect

## Human interest 205

**Educational/scientific packages**
- (13) Archeological
- (13) Ecological
- (11) Geological
- (11) Hydrological

**48**

**Historical packages**
- (11) Architecture and styles
- (11) Events
- (11) Persons
- (11) Religions and cultures
- (11) 'Western frontier'

**55**

**Culture**
- (14) Indians
- (7) Other ethnic groups
- (7) Religious groups

**28**

**Mood/atmosphere**
- (11) Awe/inspiration
- (11) Isolation/solitude
- (4) Mystery
- (11) 'Oneness' with nature

**37**

**Life patterns**
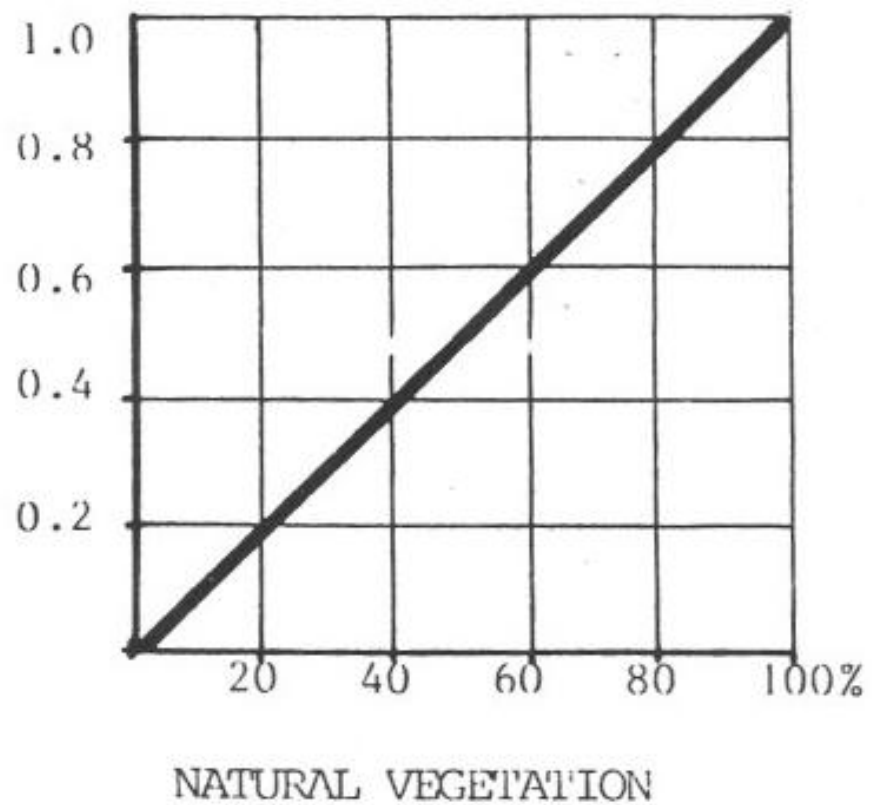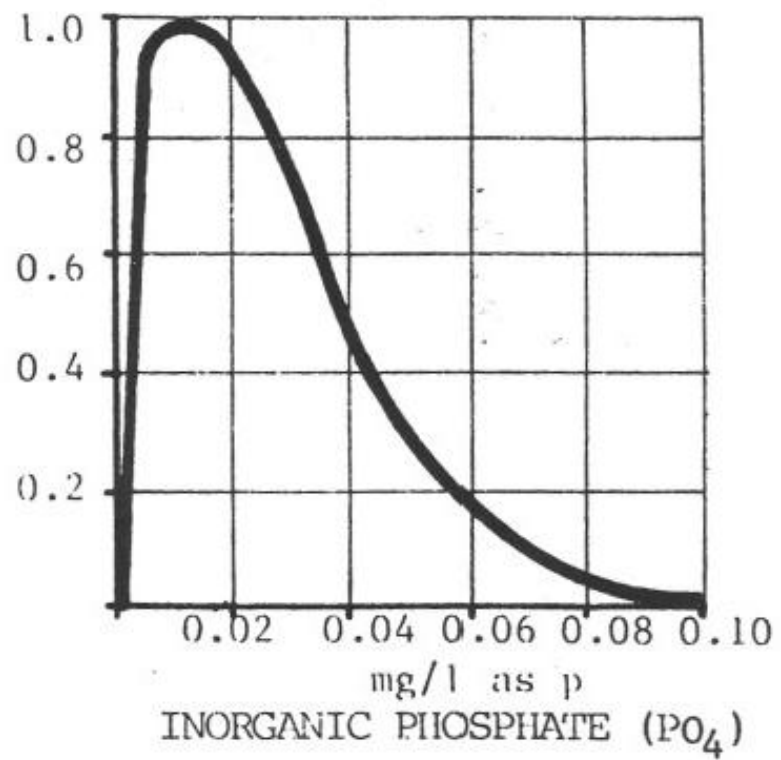- (13) Employment opportunities
- (13) Housing
- (11) Social interactions

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INORGANIC PHOSPHATE (PO$_4$)

mg/l as p



NATURAL VEGETATION

**Table 3.5 Criteria for Assessing EIA Processes**

| Criteria | Example Indicators |
|---|---|
| Rigorous | Sound, independent, and unbiased application of scientific standards and protocols |
| | Conducive to integration and application of scientific and technical knowledge and methods |
| | Conducive to participation by scientists |
| | Explicit and substantiated assumptions, findings, interpretations, conclusions, and recommendations |
| | Facilitates contribution to scientific knowledge base |
| Comprehensive | Thorough treatment of relevant physical, biological, social, cultural, and economic effects |
| | Conducive to addressing interrelationships and cumulative effects |
| | Conducive to a broad definition of problems and opportunities |
| | Conducive to a holistic perspective |
| Systematic | Provides an explicit and traceable decision-making basis |
| | Systematically identifies and assesses potential objectives |
| | Systematically identifies, assesses, and applies methods |
| | Systematically identifies and assesses options and impact management methods |
| | Systematically identifies, predicts, and manages potential effects |
| Substantive | Guided by environmental values and ideals |
| | Conducive to integration of environmental knowledge and perspectives |
| | Facilitates substantive contribution to enhanced environmental quality |
| | Conducive to realization of sustainability |
| Practical | Efficient and effective use of available resources |
| | Proven and credible methods and procedures, consistent with good practice |
| | Clearly defined, appropriate, and realistic roles and responsibilities |
| | Focuses on major issues and trade-offs |
| | Conducive to decision making and implementation |
| | Realistic expectations and standards |
| Democratic | Conducive to maintenance and enhancement of stakeholder influence |
| | Accommodates and applies traditional knowledge |
| | Conducive to delegation of authority to stakeholders and local communities |
| | Sensitive to political implications |
| | Provides for and potentially conducive to stakeholder acceptance |
| Collaborative | Conducive to stakeholder understanding and involvement |
| | EIA process jointly defined and undertaken with stakeholders |
| | Facilitates consensus building |
| | Facilitates conflict resolution |
| | Roles and responsibilities jointly defined with participants |
| Ethical | Facilitates procedural and distributional fairness |
| | Process guided and shaped by ethical imperatives and standards |
| | Conducive to recognizing rights and meeting responsibilities of interested and affected parties |
| | Explicitly addresses ethical issues, implications, trade-offs, and dilemmas |
| | Conducive to addressing social and environmental fairness, equity, and justice concerns from multiple perspectives |
| Adaptive | Conducive to anticipation of and rapid adaptation to changing circumstances |
| | Facilitates creative identification and exploration of problems and opportunities |
| | Designed to match and evolve with context |
| | Conducive to systematic consideration of risks and uncertainties |
| Integrative | Conducive to the integration of diverse values, forms of knowledge, perspectives, and ideals |
| | Considers implications for and from related decisions |
| | Facilitates integration with proposal planning |
| | Adapts, integrates, and transcends individual disciplines, professions, and EIA types |
| | Links and integrates (where appropriate) EIA with related environmental management forms and levels |

# Benefit Cost Analysis

- Public Sector oriented tabulation of –

  benefits (to whomever they accrue)

  costs (to whomever they accrue)

- Intended to identify "Kaldor Hicks efficiency"
- Contrast with "Pareto efficiency".

# Pareto v. Kaldor Hicks

- Pareto efficiency: Someone is made better off; no one is made worse off.

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- Pareto efficiency: Someone is made better off; no one is made worse off.

- Kaldor-Hicks efficiency:  Gainers **could** compensate losers and still be better off.

- Contrast with Fiscal Impact Assessment

# BCA considers:

- Benefits (E)
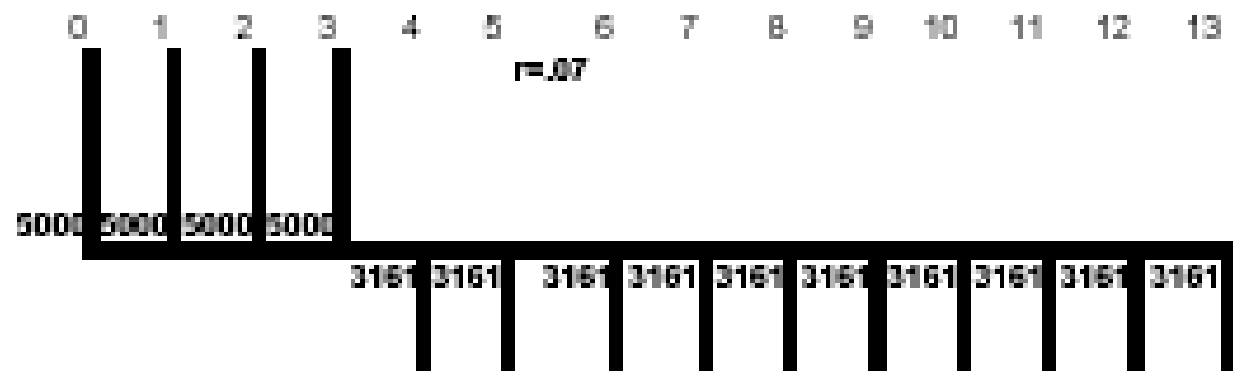- Capital Costs (K)
- OMR Costs (M)
- Disbenefits (D)

# Benefits and costs to whom?

- The agency proposing the project
- The jurisdiction authorizing the project
- The residents of the jurisdiction
- The firms in the jurisdiction
- Extra-territorial residents/citizens
- Future generations

# We have to consider the timing of payments, or cash flow.

A student borrows $5,000 per year for four years from a student loan program. Interest accrues at 7% per year, compounded annually. All payments are deferred until the end of the four year period. Then, payments of $3,161 per year are made by the former student for ten years to repay the loan.

    a) Diagram the cash flow.

    b) How much interest is paid?

r=.07

0   1   2   3   4   5   6   7   8   9   10   11   12   13

5000 5000 5000 5000

3161 3161   3161 3161 3161 3161 3161 3161 3161   3161

b.   interest = ($3161 x 10) - (5000 x 4) = $11,610

# KALDOR HICKS CRITERION:

$$PV(NB) = PV(E - M - D - K)$$

Choose any alternative whose PVNB>0

# Possible Park Projects

| Alternative | PVNB |
|---|---|
| Greenway | $ 3.4 Million |
| Ballfields | $ 900,000 |
| Urban vest pocket park | $-1.2 Million |
| Wildlife habitat | $ 650,000 |

# Present Value

- What is $100 next year worth to you in today's dollars?

- How much can you earn on a liquid, risk-free investment?

- Assume 3%  >>  103% * $Today = $100 next year

    >>   $100/1.03 = $Today = $92.59

$$FV = (E-M) \times (1+r)^t$$

$$PV = \frac{(E-M)}{(1+r)^t}$$

The expenditure of $5,000 four years from now is preferable to the expenditure of $3,000 now.
*True or False?*   Assume 10% discount rate.

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PV ($5,000 at T=4) = ?

$PV = FV / (1+i)^4$

$= \$5{,}000 / (1+0.10)^4$

The expenditure of $5,000 four years from now is preferable to the expenditure of $3,000 now. *True or False?* Assume 10% discount rate.

PV ($5,000 at T=4) = ?

PV = FV / $(1+i)^4$

= $5,000 / $(1+0.10)^4$

= $5,000 / 1.46

= $3,425

The expenditure of $5,000 four years from now is preferable to the expenditure of $3,000 now.
*True or False?*    Assume 10% discount rate.

PV ($5,000 at T=4) = ?

$$PV = FV / (1+i)^4$$
$$= \$5,000 / (1+0.10)^4$$
$$= \$5,000 / 1.46$$
$$= \$3,425$$

$3,425 > $3,000

Statement is False.

# What's in a Discount Rate?

**Annual Net Benefits (B-C), ($MM)**

|  | Year 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Proposal A** | (100) | 0 | 8 | 11 | 13 | 14 | 15 | 176 |  |  |  |  |  |  |  |  |  |
| **Proposal B** | (100) | (5) | (5) | 0 | 5 | 11 | 12 | 14 | 17 | 20 | 23 | 25 | 27 | 28 | 29 | 330 |  |

### NPV@ Discount Rates

|  | 8% | 12% | 16% |
|---|---|---|---|
| Proposal A | $43.35 | $15.74 | ($4.08) |
| Proposal B | $86.54 | $19.31 | ($18.74) |
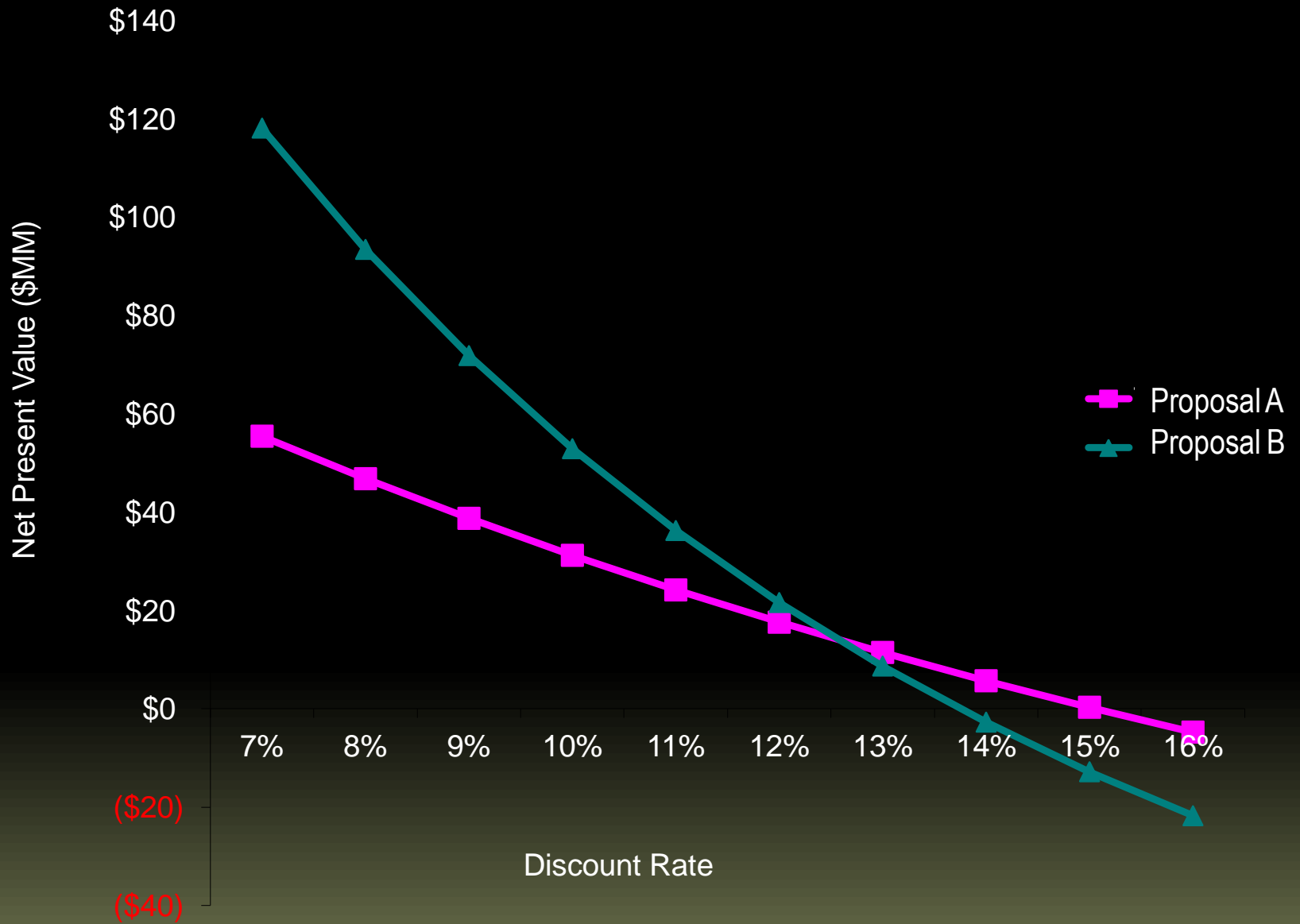
# Enhanced BCA

Reagan's E.O. 12291 (1981):

"In promulgating new regulations, reviewing existing regulation, all agencies, to the extent permitted by law, shall adhere to the following requirements:

a) Administrative decisions shall be based on adequate information concerning the need for and consequences of proposed government action:

b) **Regulatory action, shall not be undertaken unless the potential benefits to society for the regulation outweigh the potential costs to society**;

c) **Regulatory objectives shall be chosen to maximize the net benefits to society**;

d) **Among alternative approaches to any given regulatory objective, the alternative involving the least net cost to society shall be chosen**; and

e) Agencies shall set regulatory priorities with the **aim of maximizing the aggregate net benefits to society,** taking into account the condition of the particular industries affected by regulations, the condition of the national economy, and other regulatory actions contemplated for the future."

# Techniques for Monetization

- Changes in productivity and value of output
  - Physical changes in production are valued using market prices for inputs and outputs. Boundaries of analysis are broadened so as to include all benefits and costs, regardless of whether they occur within the project's ordinary boundaries or beyond them.
- Cost of illness
  - Underlying damage function relates the level of pollution (exposure) to the degree of health effect.
- Opportunity costs
  - The cost of using resources for unpriced purposes can be estimated by using the forgone income from other uses of the resource as a proxy
- Cost-Effectiveness Analysis
- Preventative Expenditures/Replacement Costs/Relocation Costs
  - Expenditures individuals undergo to avoid or mitigate environmental problems

# WHAT DO YOU DO WHEN THE ALTERNATIVES ARE MUTUALLY EXCLUSIVE?

Max (PVNB)=PV(E-M-D-K)

# Mutually exclusive alternatives

| Alternatives for River Development/Protection | PVNB |
|---|---|
| Floodplain zoned for green space only | $ 2.5 Million |
| Limited floodway protection + recreational use of remaining floodplain | $ 3.6 Million |
| Riverside shopping development | $ 1.7 Million |

# CAPITAL CONSTRAINT?

Combine independent alternatives into packages and choose the package with Max(PVNB)

# Park Projects
# Capital Constraint = $3 Million

| Alternatives | PVNB | K |
|---|---|---|
| Greenway | $3.4 Million | $2 Million |
| Ballfields | $900,000 | $2 Million |
| Urban Vest Pocket Park | $-1.2 Million | $3 Million |
| Wildlife Habitat | $650,000 | $1 Million |

# BENEFIT COST RATIO APPROACH:

# B/C= PV[(E-D)/(M+K)]

Conventional BC Ratio

*Choose any alternative with B/C>1
•Highly sensitive to specification of D and M
•Mutually exclusive alts: choose greatest B/C

# Eastern Leon Power Line Route

| ALT | E | M | D | K | (E-D)/ (M+K) |
|---|---|---|---|---|---|
| Mahan Dr. | $14M | $2.5 M | $ 5M | $5.4 M | 1.14 |
| CSX/ Alford Arm | $14M | $2 M | $ 1M | $8.9 M | 1.19 |

# B/C=PV[(E-M-D)/K]

Modified BC Ratio:
Choose any alternative with B/C>1

Preferred formulation for iterative decisions

# Eastern Leon Power Line Route

| ALT | E | M | D | K | (E-M-D)/(K) |
|---|---|---|---|---|---|
| Mahan Dr. | $14M | $2.5 M | $ 5M | $5.4 M | 1.20 |
| CSX/ Alford Arm | $14M | $2 M | $ 1M | $8.9 M | 1.24 |

# Planning Evaluation

- Goals, Objectives, Alternatives, Criteria, Constraints
- Single v. Multiple Objective Analyses
- Monetary, Monetized, Intangible
- Risk and Uncertainty