Warsaw University
Warsaw Ecological Economics Center

# RECOCA

## WP7 – Regional Cost Effectiveness Models

## WP8 – Cost Minimization Model

Mikołaj Czajkowski

miq@wne.uw.edu.pl

# RECOCA – the cost minimization model

- RECOCA economic modeling
  - WP7 – Regional cost effectiveness models
  - WP8 – Cost Minimization Model
- Bottom up approach
  - 10x10 km grid cells (17533)
    - GIS data – natural conditions, present state
    - Association with the Baltic Sea regions, watersheds, countries
  - Measures (5-7)
  - Retention (grid-cell specific)
  - Cost
- Nonlinear optimization problem

# The cost minimization model

- The model sets and variables:
  - $n \in \{N, P\}$ – nutrients
  - $r = 1..7$ – the Baltic Sea Regions
  - $t_r^n$ – target nutrient loadings to each region
  - $m = 1..M$ – measures to be applied
  - $g_r = 1..G_r$ – overland grid cells $\left(\sum_{r=1}^{R} G_r = 17533\right)$
  - $q_{g_r m}$ – scale of application of measure $m$ in grid cell $g_r$
  - $\overline{q}_{g_r m}$ – potential (maximum scale) of application of measure $m$ in grid cell $g_r$
  - $l_{g_r}^n\left(q_{g_r m}\right)$ – reduction of nutrient $n$ as a function of $q_{g_r m}$ (measured at the river mouth)
  - $c_{g_r m}\left(q_{g_r m}\right)$ – cost of application of measure $m$ in grid cell $g_r$ as a function of $q_{g_r m}$

# The cost minimization model

- The cost minimization problem:

$$\min \sum_{r=1}^{R} \sum_{g_r=1}^{G_r} \sum_{m=1}^{M} c_{g_r m}\left(q_{g_r m}\right) \quad \text{s.t.} \quad \begin{cases} \forall\limits_{n \in \{N,P\}} \quad \forall\limits_{r=1..R} \quad \sum\limits_{g_r=1}^{G_r} \sum\limits_{m=1}^{M} l_{g_r}^{n}\left(q_{g_r m}\right) \geq t_r^n \\ \forall\limits_{r=1..R} \quad \forall\limits_{g_r=1..G_r} \quad \forall\limits_{m=1..M} \quad 0 \leq q_{g_r m} \leq \overline{q}_{g_r m} \end{cases}$$

- Search for a scale $q_{g_r m}$ to which each measure $m$ should be applied in each grid cell $g_r$ of each Baltic Sea region $r$ so that the resulting N and P reductions are at least their targets for this region $t_r^n$ and the costs are minimized

# The cost minimization model

- The results:
  - How much of each measure to apply in each grid-cell
  - For each grid cell:
    - Measures
    - Nutrient reductions
    - Costs
  - Aggregation
    - Watersheds (117)
    - Countries (14)
    - GIS

# Data requirements (1)

- Target nutrient reductions
  - With / without mixing included
- Retention coefficients (for each grid cell, for each nutrient)
- Natural conditions GIS data
  - Cropping structure (no. of crops)
  - Root zone loss function variables (e.g. precipitation, temperature, soil type, etc.)
- Measure-specific data
  - Mineral fertilizer reductions (N)
    - Current fertilization levels (potential + other constraints)
    - General effect function $R^{n}_{g_r}\left(q_{g_r m}\right)$
      - 4 farm types vs. one generic root-zone loss function
      - No. of crops
    - Yields functions + prices of crops, prices of fertilizer, other

# Data requirements (2)

- Measure-specific data cont.
  - Livestock reduction (N)
    - Current levels (potential + other constraints)
    - Effects function $R_{g_r}^n\left(q_{g_r m}\right)$
      - Enters as a variable in a general root-zone loss function?
    - SGM (opportunity costs)
  - Catch crops (N)
    - Area where introducing catch crops is possible, taking into account currently grown catch crops (grid cell level) – potential
    - General effect function $R_{g_r}^n\left(q_{g_r m}\right)$
      - A new variable for optimization problem – area of each crop?
    - Decrease in productivity (if any)?
    - Additional benefits – fodder, savings in mineral N fertilizer?

# Data requirements (3)

- Measure-specific data cont.
  - Wastewater treatment plants (N/P)
    - Disaggregate into separate measures:
      - Not connected (i)
      - Primary treatment (ii)
      - Secondary treatment (iii)
      - Tertiary treatment (iv)
    - No. of people connected to each type (for potential)
    - Potentials for improvements (mutually exclusive) – find an *a priori* cost-effective measure
    - Efficiency of treatment
    - Costs of treatment and collection

# Data requirements (4)

- Measure-specific data cont.
  - Wetlands (N/P)
    - Area of organic soils (FAO) less industrialized areas (Corinne) = potential?
    - General effect function $R_{g_r}^{n}\left(q_{g_r m}\right)$
    - GIS data:
      - Whatever grid-cell level variables enter the effect function
      - Type of land (for estimating opportunity cost)
  - NOx (energy, transport) – generic approach
  - P-free detergents – generic approach
  - Other?