ICP MODELLING & MAPPING: FUTURE CHALLENGES: INTEGRATING RESOURCE USE, INDUSTRIAL DEVELOPMENT AND TRANSBOUNDARY AIR POLLUTION ON A GLOBAL SCALE

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PROTOCOL SUCESSES

- HELSINKI SULPHUR PROTOCOL 1985
- NOX PROTOCOL 1988
- OSLO VOC PROTOCOL 1991
- OSLO PROTOCOL ON FURTHER SULPHUR EMISSION REDUCTIONS 1994
- ÅRHUS HEAVY METAL PROTOCOL 1998
- ÅRHUS PERSISTENT ORGANIC POLLUTANT (POP) PROTOCOL 1998
- GÖTEBORG MULTIPROTOCOL; ACIDIFICATION, EUTROPHICATION AND GROUND LEVEL OZONE 1999
- 2012 REVISED GÖTEBORG MULTIPROTOCOL

- 2001 – EU NATIONAL EMISSION CEILINGS DIR. (NEC; 2001/81/EC)
- 2016 – REVISED NATIONAL EMISSIONS CEILING DIRECTIVE (2016/2284/EU)
- REVISION OF PROTOCOLS COMING IN 2020

TARGET ECOSYSTEM PORTFOLIO EVOLVED WITH TIME

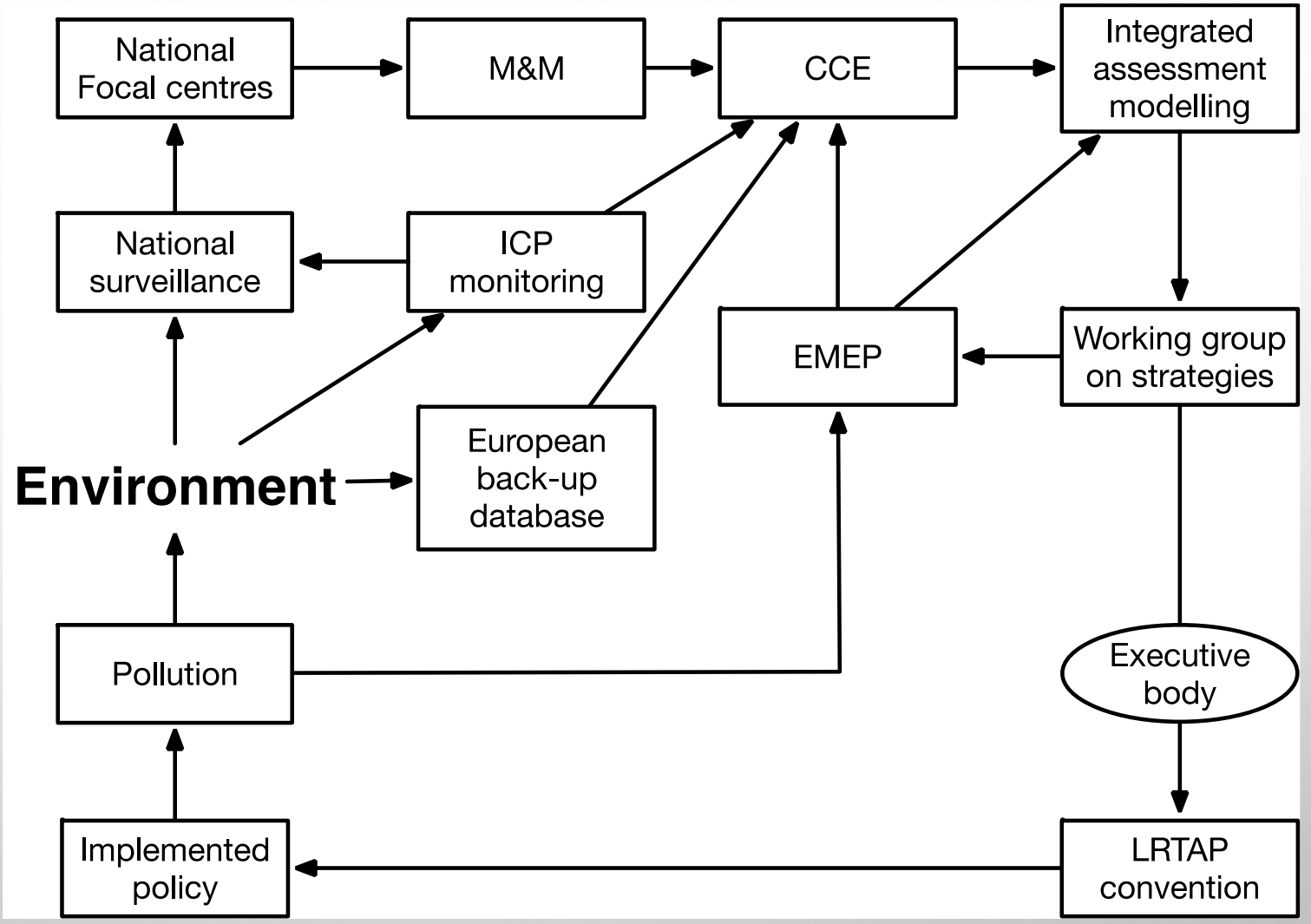
- FISH IN RIVERS AND LAKES
  - SWEDEN, NORWAY, USA, SCOTLAND, CANADA AND FINLAND
- STREAM AND LAKE ECOLOGY
  - MULTIPLE FISH SPECIES, ZOOPLANCTON, BENTHIC ORGANISMS, CRUSTACEANS
- TREE AND FOREST HEALTH;
  - FOREST DIEBACK, NEEDLE LOSSES, GROWTH IMPACTS, TREE SPECIES
- SOILS, TREES, FOREST HEALTH
  - INVOLVEMENT OF SOIL CHEMISTRY, SOIL MICROBIOLOGY FUNCTIONS, ROOT APPARATUS FUNCTIONS, TREE AND FOREST STAND VITALITY, REJUVENATION SUCCESS RATES, FOREST MANAGEMENT PURPOSES
- BIODIVERSITY
  - GROUND VEGETATION CHANGE OVER LONG TIME. HIGH PROFILE PLANTS THREATENED, CAUSING POLITICAL WILL, NEW CONCERTED MODELLING EFFORTS. ONLY A FEW COUNTRIES ONBOARD, SOME FELL OFF..
- WHOLE WATERSHED VIEW OF THE STREAMS AND LAKES, LANDSCAPE ECOSYSTEM VIEW, LOOKING AT ALL (FOREST, VEGETATION, FAUNA, BIODIVERSITY, GROUNDWATER)
  - INTEGRATED WATERSHED SYSTEMS MODELLING

TARGET ECOSYSTEMS STEP-UP

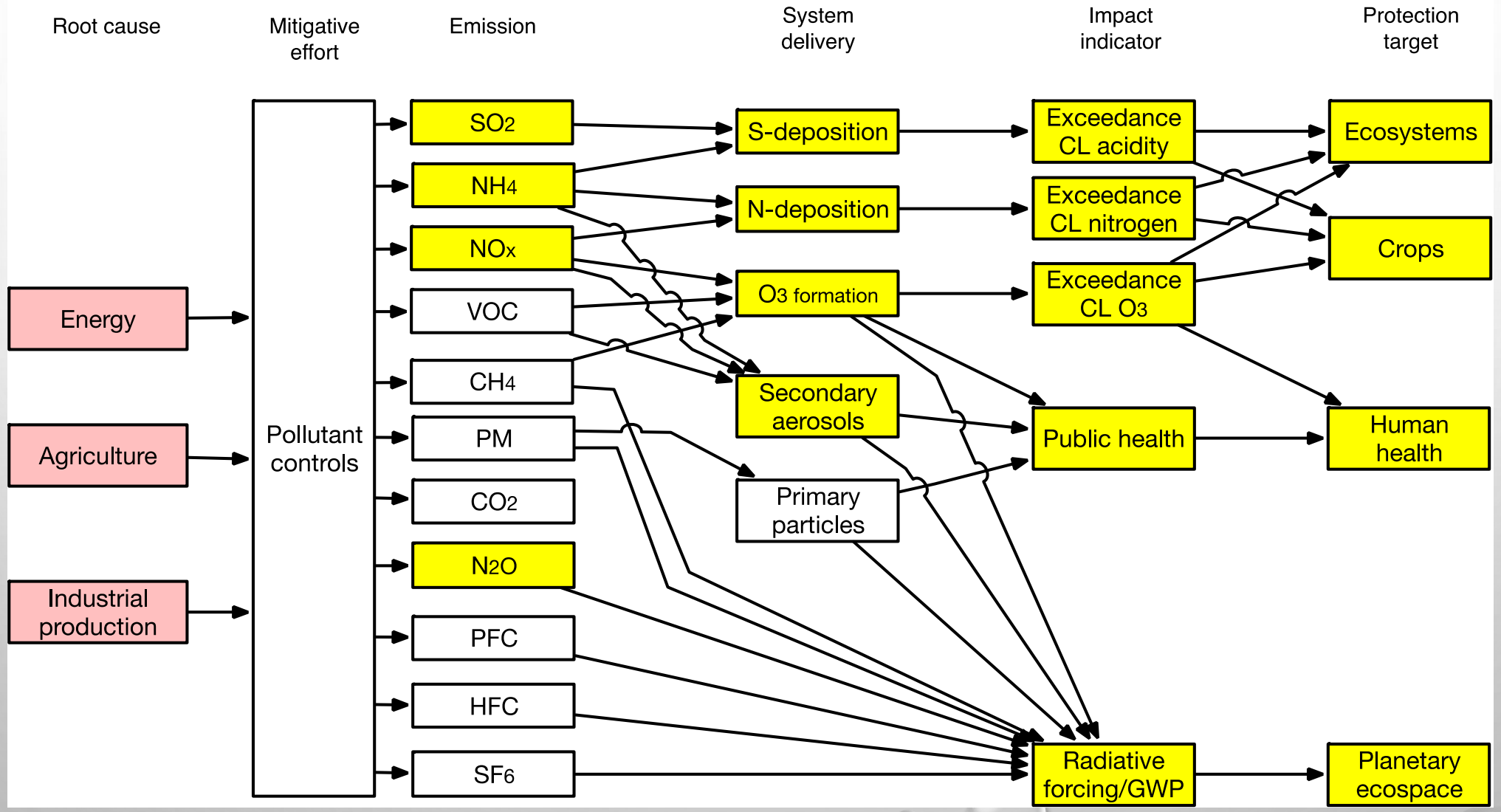
- AQUATIC ECOSYSTEMS
  - FRESHWATER ECOSYSTEMS
  - MARINE ECOSYSTEMS
- TERRESTRIAL ECOSYSTEMS
  - PRODUCTIVE FOREST
  - ECOFORESTS
  - OPEN LANDS
  - VISIBILITY AND REDUCED ATMOSPHERIC TRANSPARENCE (ALPENBLICK)
- TECHNICAL ECOSYSTEMS;
  - MATERIALS AND INFRASTRUCTURES, CORROSION, STRUCTURAL INTEGRITY
  - THREATS TO COMMERCIAL FISHERIES AND FISH FARMING
- CULTURE AND HUMAN SOCIETY
  - CORROSION AND LOSS OF KNOWN AND HIDDEN CULTURAL HERITAGE AND HISTORICAL MONUMENTS.
  - LOSS OF OLD CULTURAL HABITS IN NATURE RECREATION
- HUMAN ECOSYSTEMS
  - HUMAN HEALTH, HOSPITALIZATIONS, SOCIETY COSTS
  - MORTALITY AND LIFE EXPECTANCY
  - CONSUMPTION, SOCIETY, LIFE QUALITY AND WELLBEING

National focal centres, M&M, CCE and the LRTAP System

An adaptive, iterative system



Multi-pollutant Multi-effect relationships under the LRTAP Convention and EC Thematic Strategy on Air Pollution



CHALLENGES IN ALL ARENAS

- POLICY
  - POLICY CHALLENGES, POLITICAL FOCUS DRIFT, DIFFERENT POLITICAL DISCOURSE
- PUBLIC PERCEPTION AND MEDIA CHALLENGES
  - *GOOD, IT WAS SOLVED AND THE PROBLEM IS GONE!*
  - *NEVER WAS A PROBLEM!.....*
  - *?....DON'T KNOW WHAT THAT IS....*
- RESEARCH
  - …..IS BECOMING MORE SPECIALIZED AND NARROW
  - ….GENERATION-SHIFT FROM PIONEERING RESEARCH GROUPS TO NEW BASIC RESEARCH
  - ….FUNDING MOVING FROM ENVIRONMENTAL AGENCIES TO NATIONAL RESEARCH COUNCILS AND EU RESEARCH FUNDING RESULTING IN EMPOVERISHMENT OF ENVIRONMENTAL AGENCIES AND AUTHORITIES

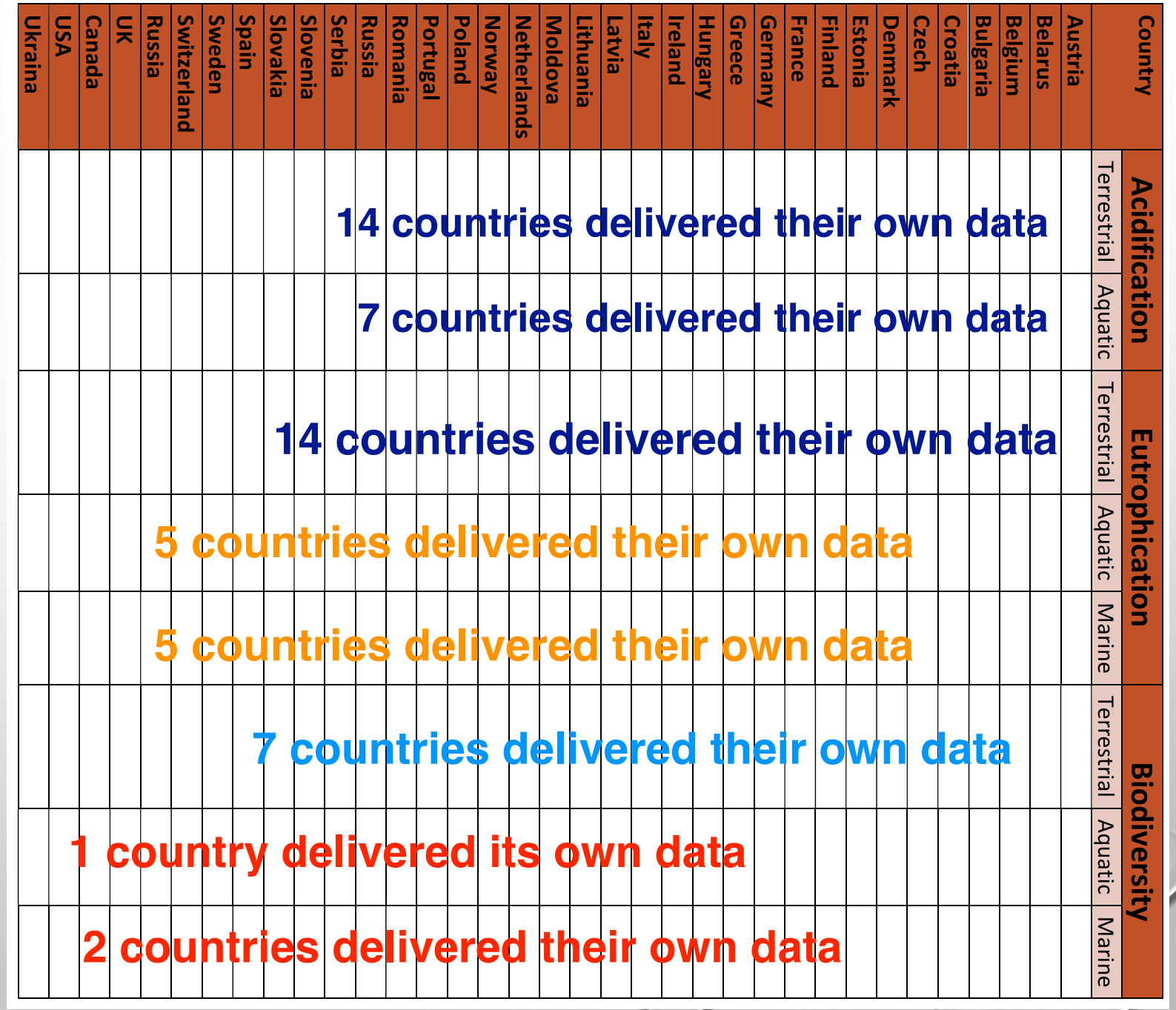
POLITICAL RE-ORIENTATIONS

- A GENERAL TREND OF LESS FOCUS ON ENVIRONMENTAL POLICY AND ACTION
  - BROADENING GAP BETWEEN PUSHING FOR MORE ECONOMIC GROWTH AND ENVIRONMENTAL PROTECTION POLICIES IN MANY COUNTRIES
  - PUSH FOR ROLL-BACK OF FEDERAL ENVIRONMENTAL PROTECTION REGULATIONS IN THE UNITED STATES AND BRITAIN, THE POPULIST VIEW OF REJECTION OF COMPETENCE GAINING SPACE
  - PRIVATIZATIONS OF THE STATE ORGANIZATION
- FAILING FUNDING
  - …FOR AIR POLLUTION RESEARCH AND NATIONAL WORKING GROUPS ON MAPPING AND MODELLING
  - …..FOR APPLIED INTEGRATED ECOSYSTEM ASSESSMENT MODEL DEVELOPMENT
- THE LRTAP WORK IS A SUCCESS, BUT STILL FAR FROM BEING FINISHED
  - THE WORK IS SEEN AS A SUCCESS AND IT IS PERCEIVED AS FINISHED AND COMPLETED
  - ANTI-ENVIRONMENTALISTS CLAIM THAT SINCE THE FOREST DID NOT DIE OFF AND THE FISH DID NOT DISAPPEAR, THE WHOLE THING WAS EXAGGERATED AND UNNECESSARY. SUCH STATEMENTS FIT SOME POLITICAL FORCES IGNORING SCIENCE
  - POLICY MOVE-ON TO OTHER AREAS OF IMMEDIATE INTEREST AND THE MONEY GOES AWAY

THE CURSE OF BEING SUCCESSFUL

- **ACIDIFICATION** IS STILL THERE, LESS THAN BEFORE, BUT STILL IMPACTING VULNERABLE ECOSYSTEMS AND TARGETS; NITROGEN POLLUTION IS THE MAIN ACIDITY CAUSAL LINK
- THE JOB ON **NITROGEN** AND N-EUTROPHICATION HAS STARTED, DONE SOME DISTANCE, BUT LESS THAN HALF HAS BEEN DONE
- **OZONE** AND **PARTICULATE MATTER** IS ADDRESSED, BUT POLLUTANT PRODUCTION APPEARS TO INCREASE FASTER THAN MITIGATION EFFORTS CAN MITIGATE
- **BIODIVERSITY**
  - ONLY A FEW TEST APPLICATIONS HAVE BEEN DONE
  - A PROPER CITICAL LOADS ASSESSMENT USING EXITING TOOLS AND DATABASES ARE BOTH POSSIBLE AND DESIREABLE. MANY COUNTRIES HAVE GIVEN UP AND DO NOT PLAN TO DO ANYTHING.
  - GOOD MODEL APPROACHES ARE AVAILABLE; **EMPIRICAL METHODS**, **FORSAFE-VEG**, **FORSAFE-MOVE**, **FORSAFE-ECOPLANT**, **VSD-MOVE**, **VSD-PROPS**, **VSD-BERNE**, **VSD-VEG**.
  - BIODIVERSITY STILL HAS POOR PROTECTION FROM NITROGEN AND SULPHUR POLLUTION, CLIMATE CHANGE AND DETERIORATION IS STILL GOING ON.
  - THE LINKAGE TO LANDUSE, TERRESTRIAL LANDSCAPE MANEGEMENT AND CLIMATE CHANGE MUST BE PROPERLY ADRESSED IN THE POLICY FOR BIODIVERSITY AND A STANDARD SHOULD BE SET FOR HOW TO DO CRITICAL LOADS.

MUCH HAS BEEN DONE, THERE IS MORE LEFT TO DO….



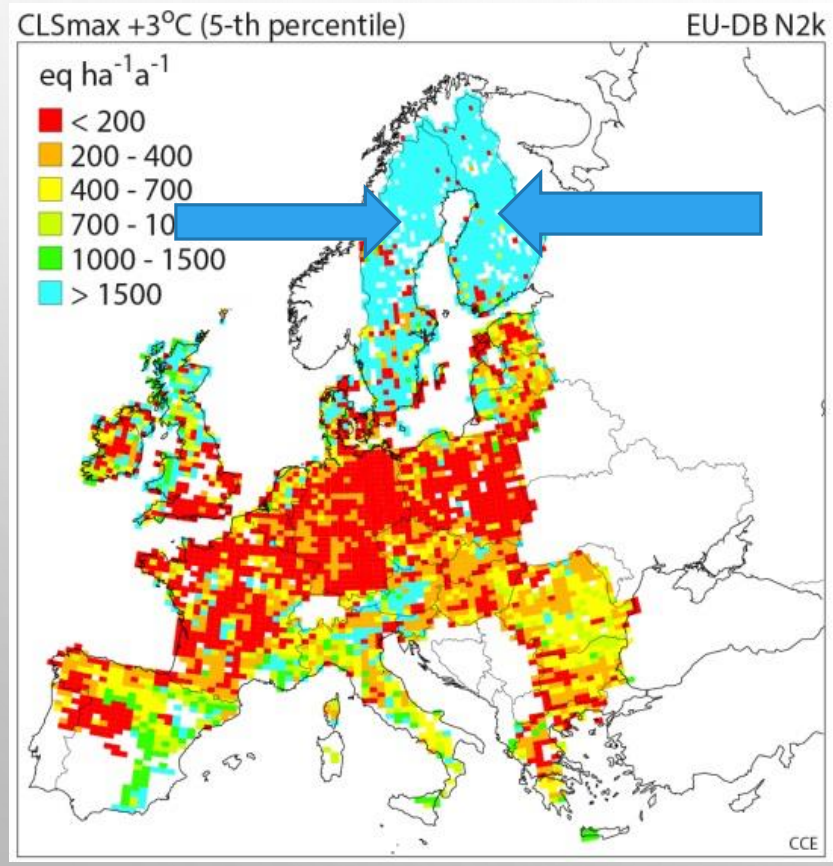
SCIENTIFIC CHALLENGES

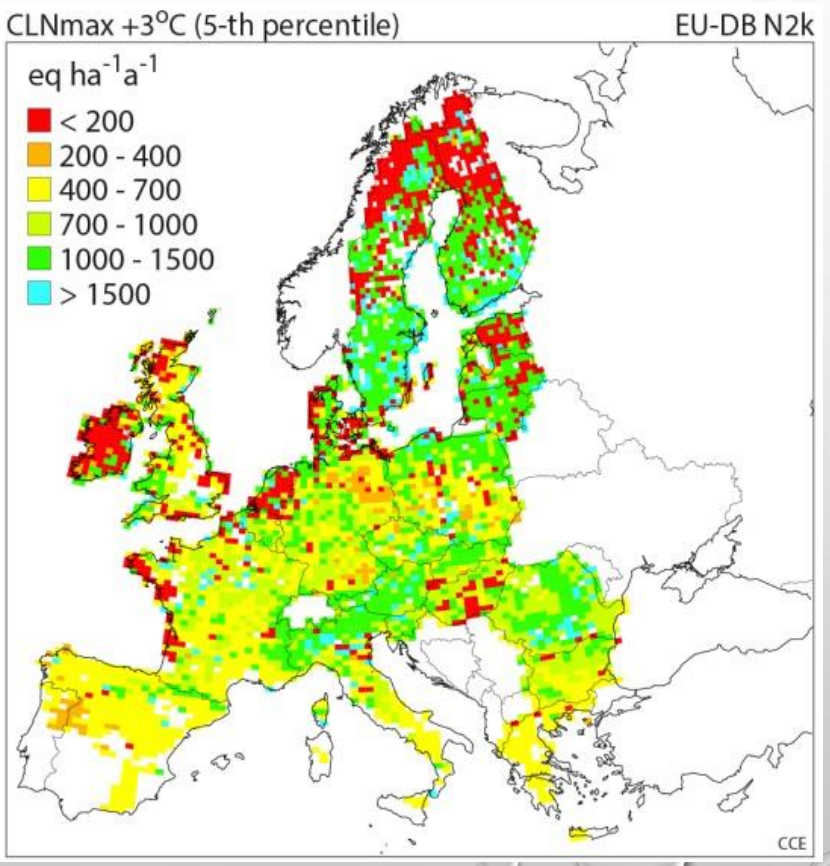
- MUCH OF THE SCIENTIFIC CHALLENGES HAVE BEEN VERY CLEVERLY SOLVED
- PUTTING IT ALL TOGETHER AS INTEGRATED MODELLING SYSTEMS:
  - FOR TERRESTRIAL SYSTEMS: USE THE MODELS WE HAVE
  - FOR AQUATIC SYSTEMS: INCLUDE EUTOPHICATION, INCLUDE BRACKISH SYSTEMS, MARINE SYSTEMS. APPROACH BIODIVERSITY.
- UNIFIED MODEL FOR THE WATERSHED, UNIFYING SLOPES, SOILS, GROUNDWATER, RUNOFF, LAKES AND VEGETATION (**FORSAFE-2D**)
- CONNECT AIR POLLUTION, CHEMICAL POLLUTION AND CLIMATE CHANGE TOWARDS HUMAN HEALTH

SYNERGIES AND TRADE OFFS BETWEEN AIR POLLUTION, CLIMATE AND NATURE POLICIES:

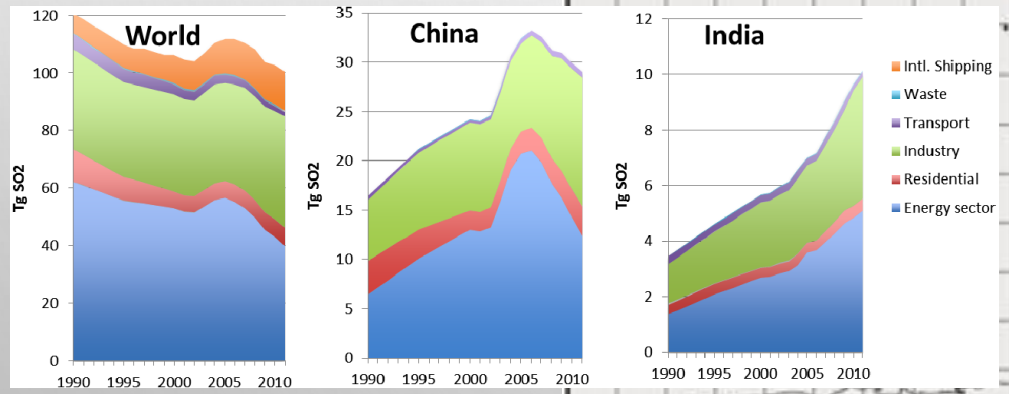
Natura 2000 critical loads of biodiversity for sulphur (left) and for nitrogen (right) under a +3°C increase of the annual mean surface temperature

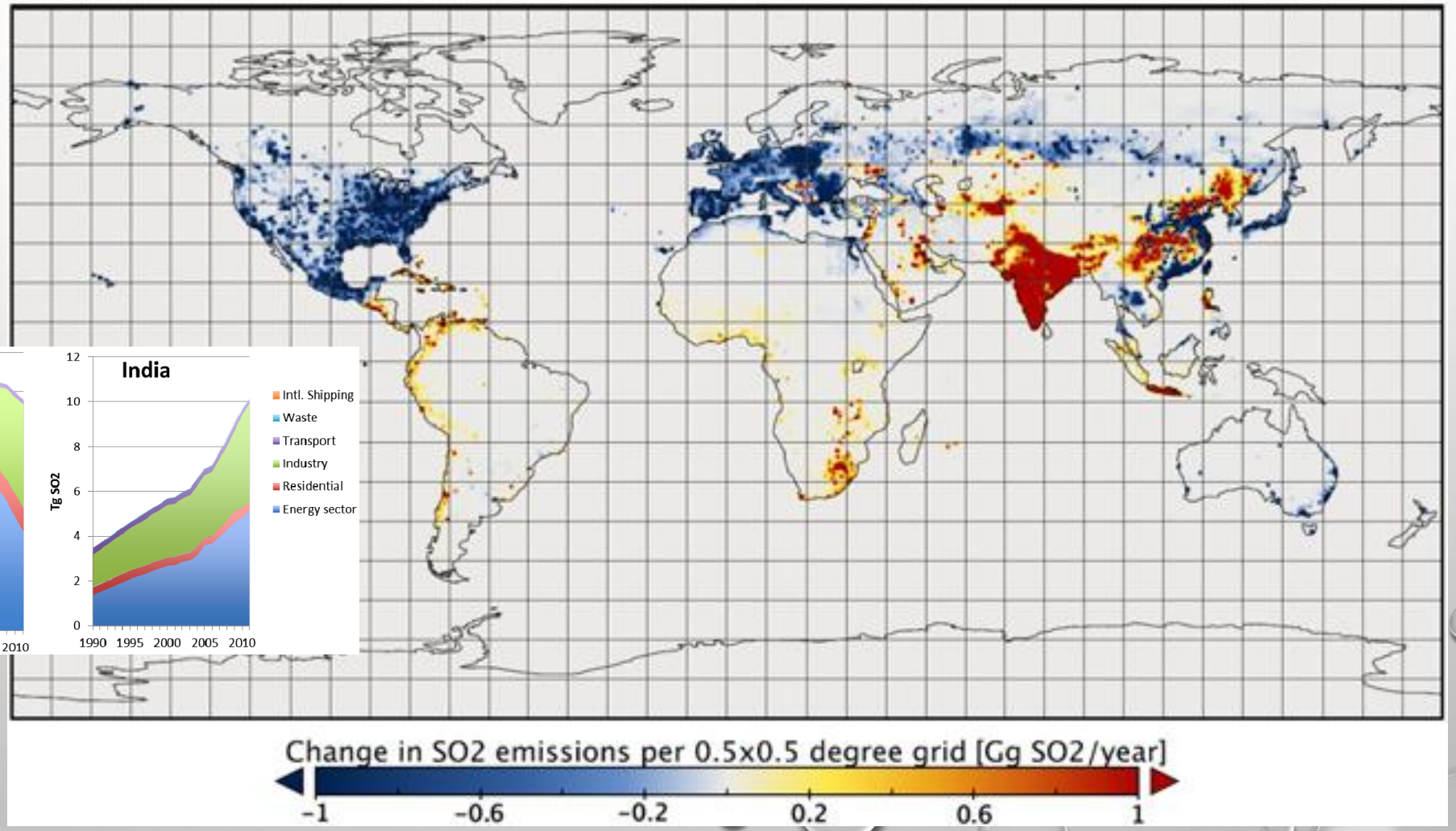
Source: CCE Final Report 2017



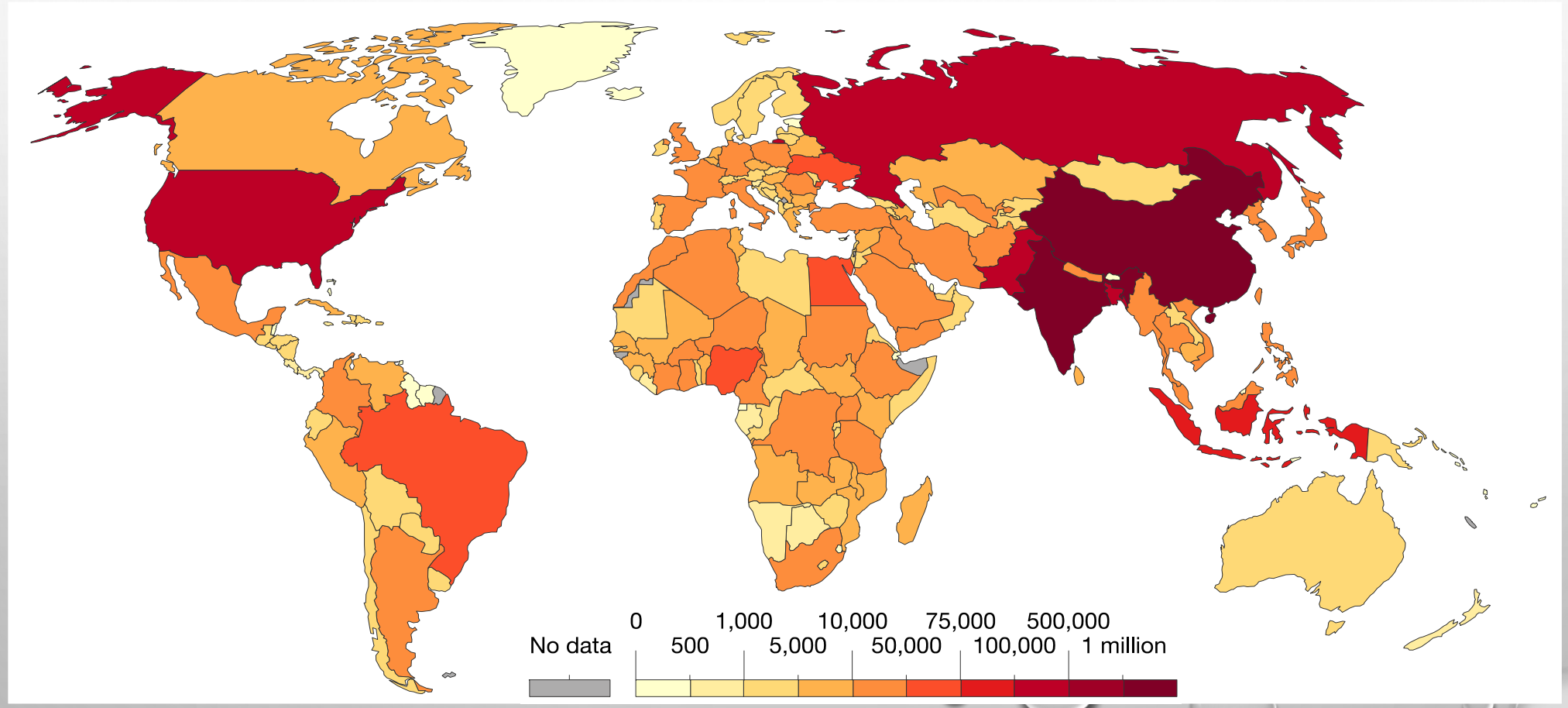


GLOBAL SULPHUR POLLLUTION GOES BOTH WAYS



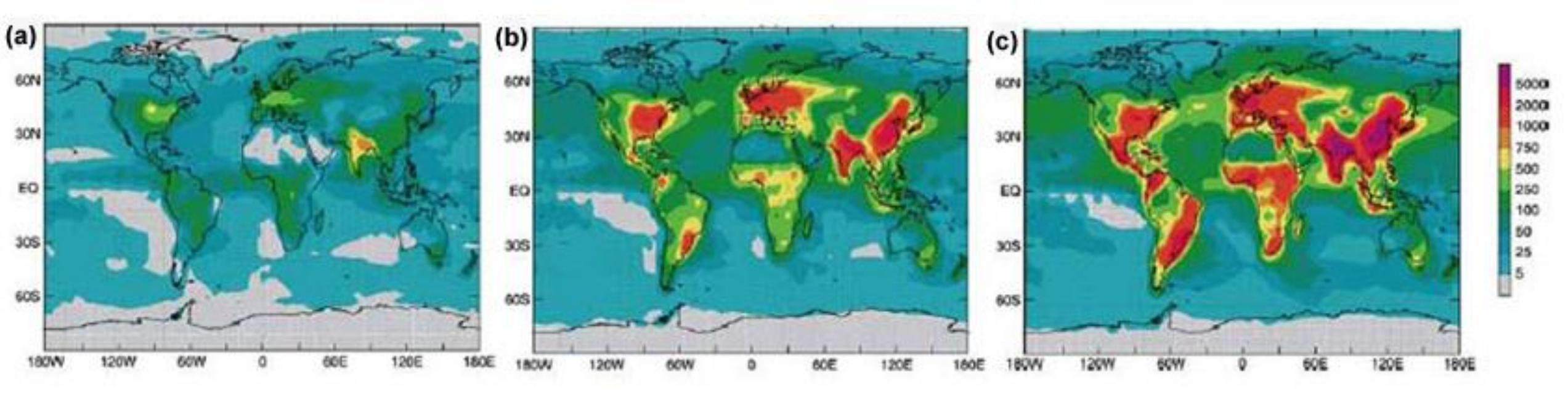


GLOBAL DEATHS PER YEAR AS A RESULT OF OUTDOOR PARTICULATE MATTER AND O_3 AIR POLLUTION. IN ADDITION WE SHOULD ADD EFFECT OF SO_2 AND NO_X, POPS, ENDOCRINE DISRUPTORS, OZONE AND VOCS



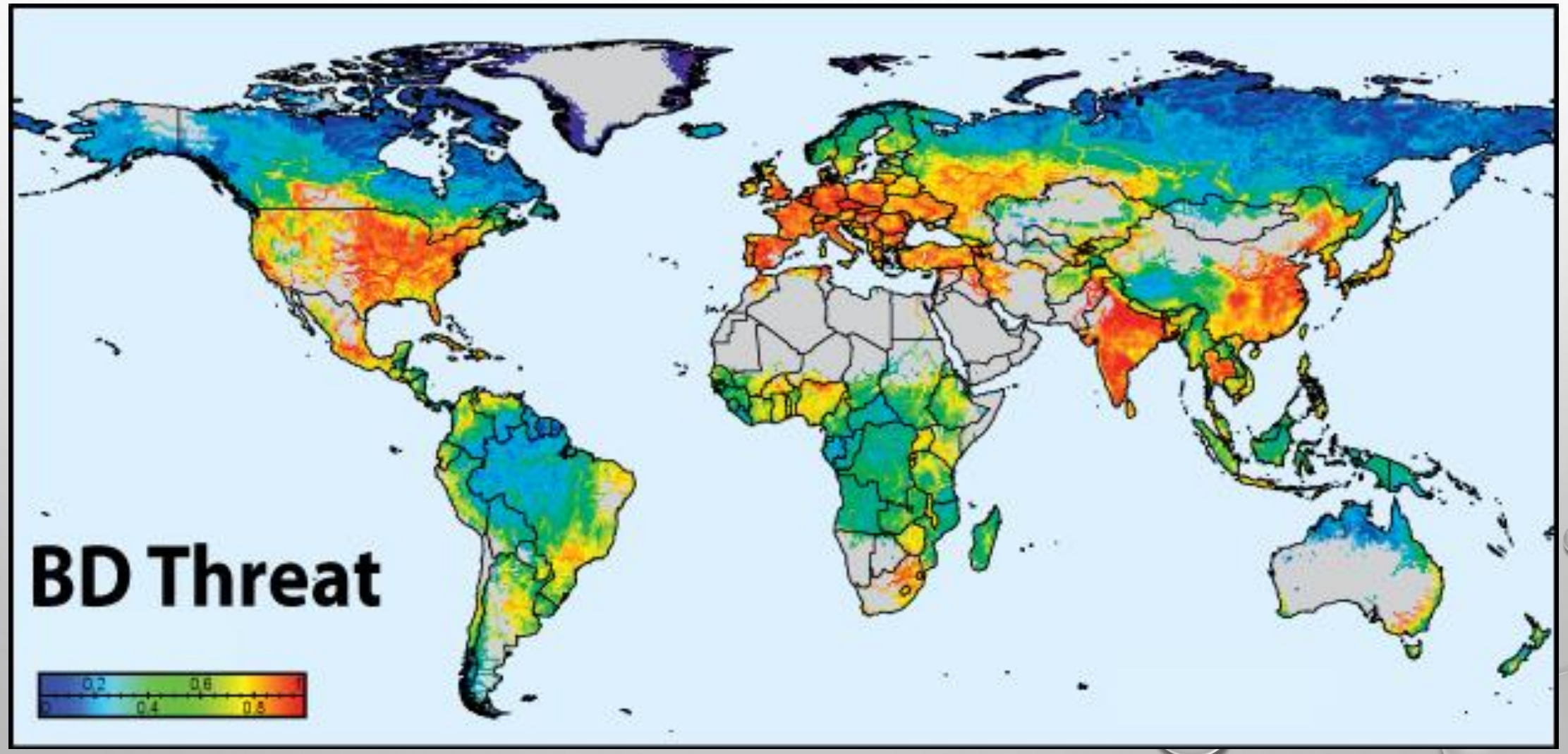
SPATIAL PATTERNS OF TOTAL INORGANIC NITROGEN DEPOSITION ARE PREDICTED TO GET WORSE…. (mg $N/m^2/yr$)

GALLOWAY *ET AL.*, (2004). NITROGEN CYCLES: PAST, PRESENT, AND FUTURE. *BIOGEOCHEMISTRY* 70:153-226 HTTP://IBL.COLORADO.EDU/GALLOWAY_2004.PDF



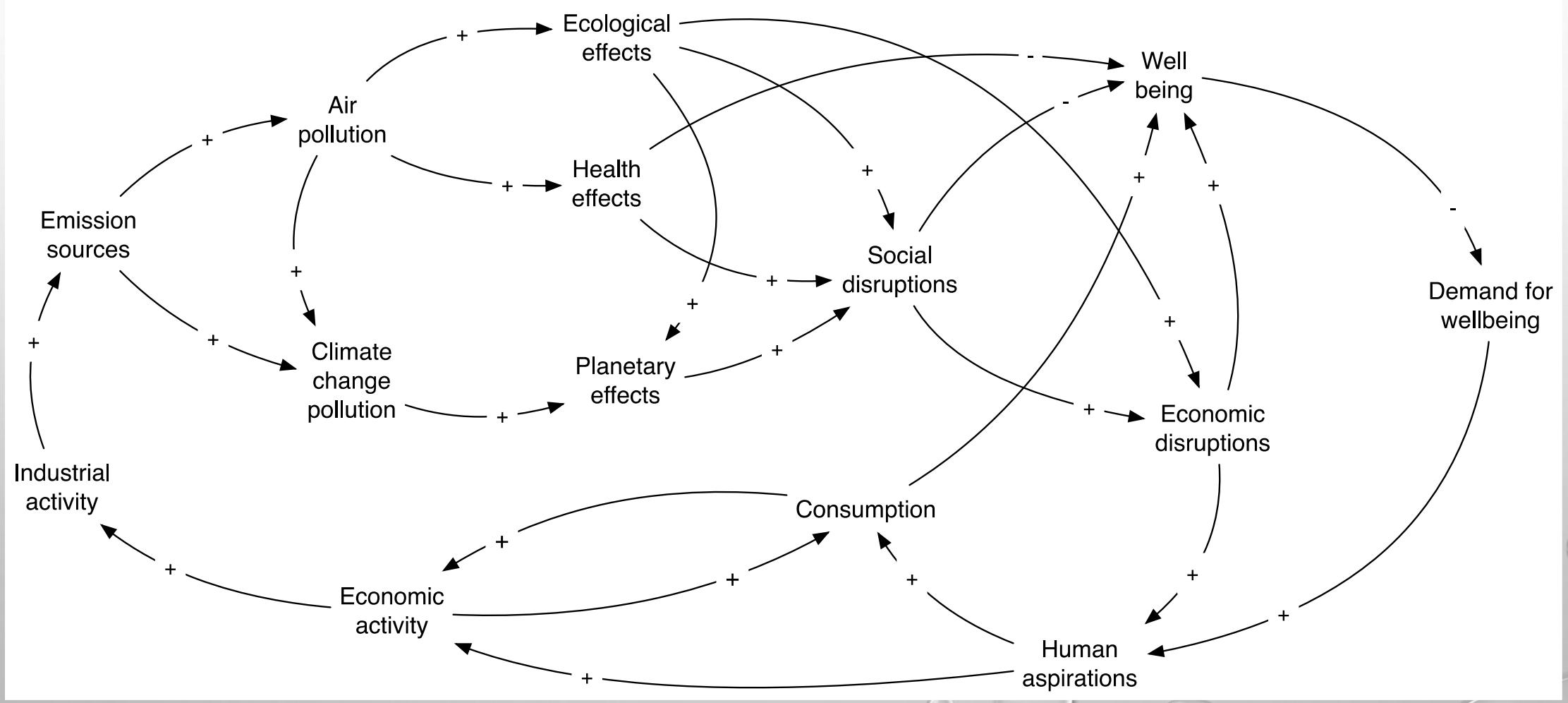
1860 1990 2050

GLOBAL BIODIVERSITY IS IN BAD SHAPE

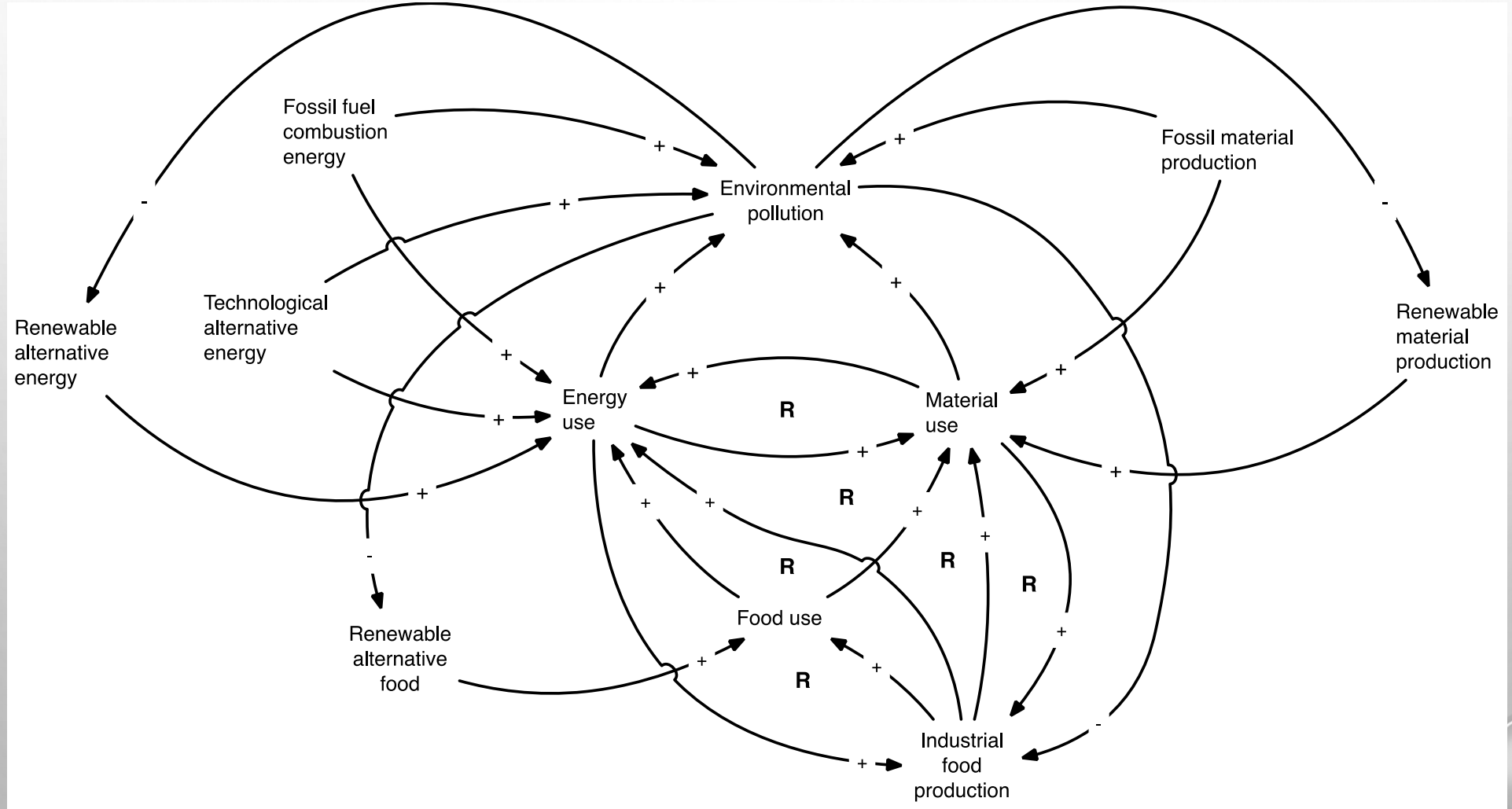


OCEANS ARE SUFFERING FROM NITROGEN, ……THEN ADD IN PLASTICS AND CO_2 OCEAN ADSORPTION OVERLOAD

THE BIGGER PICTURE COMES INTO PLAY



ENERGY USE, MATERIALS USE, FOOD USE, THEY ARE ALL LINKED TO HOW WE RUN SOCIETY



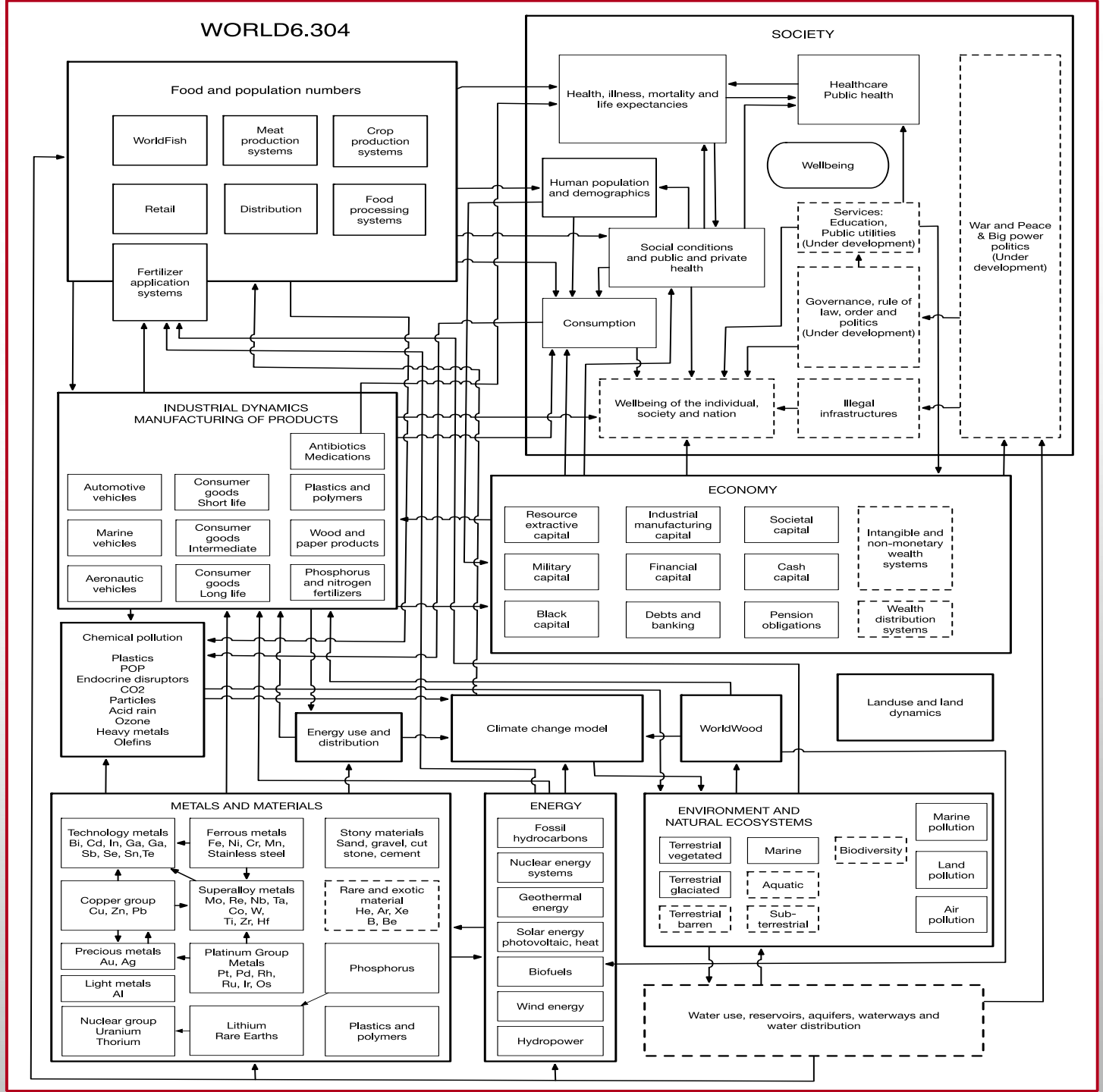
MODELLING THE LARGER PICTURE:

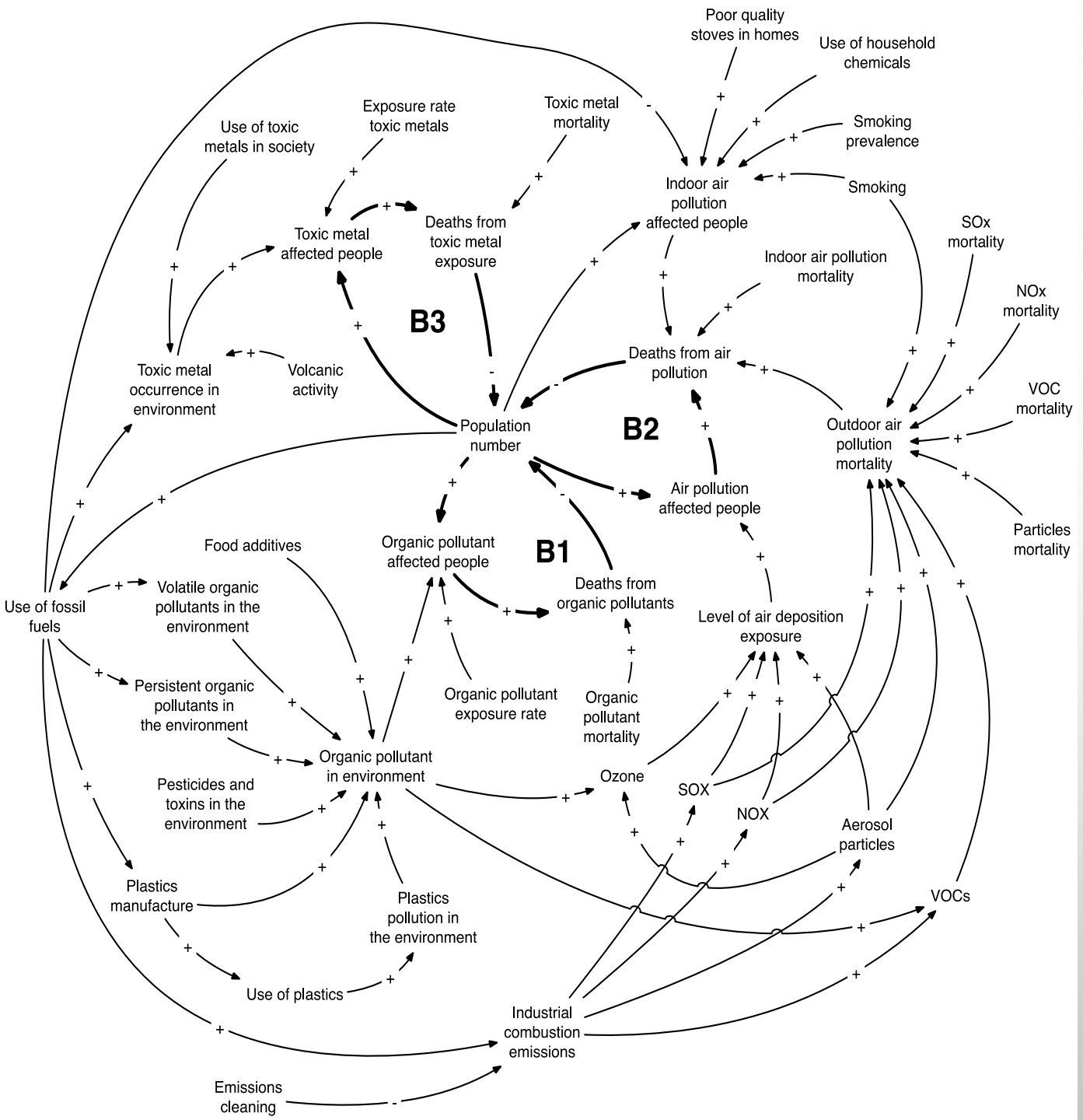
WORLD6

GLOBAL POLLUTION IS THE SYMPTOM OF SOMETHING FUNDAMENTALLY WRONG IN THE WORKINGS OF SOCIETY

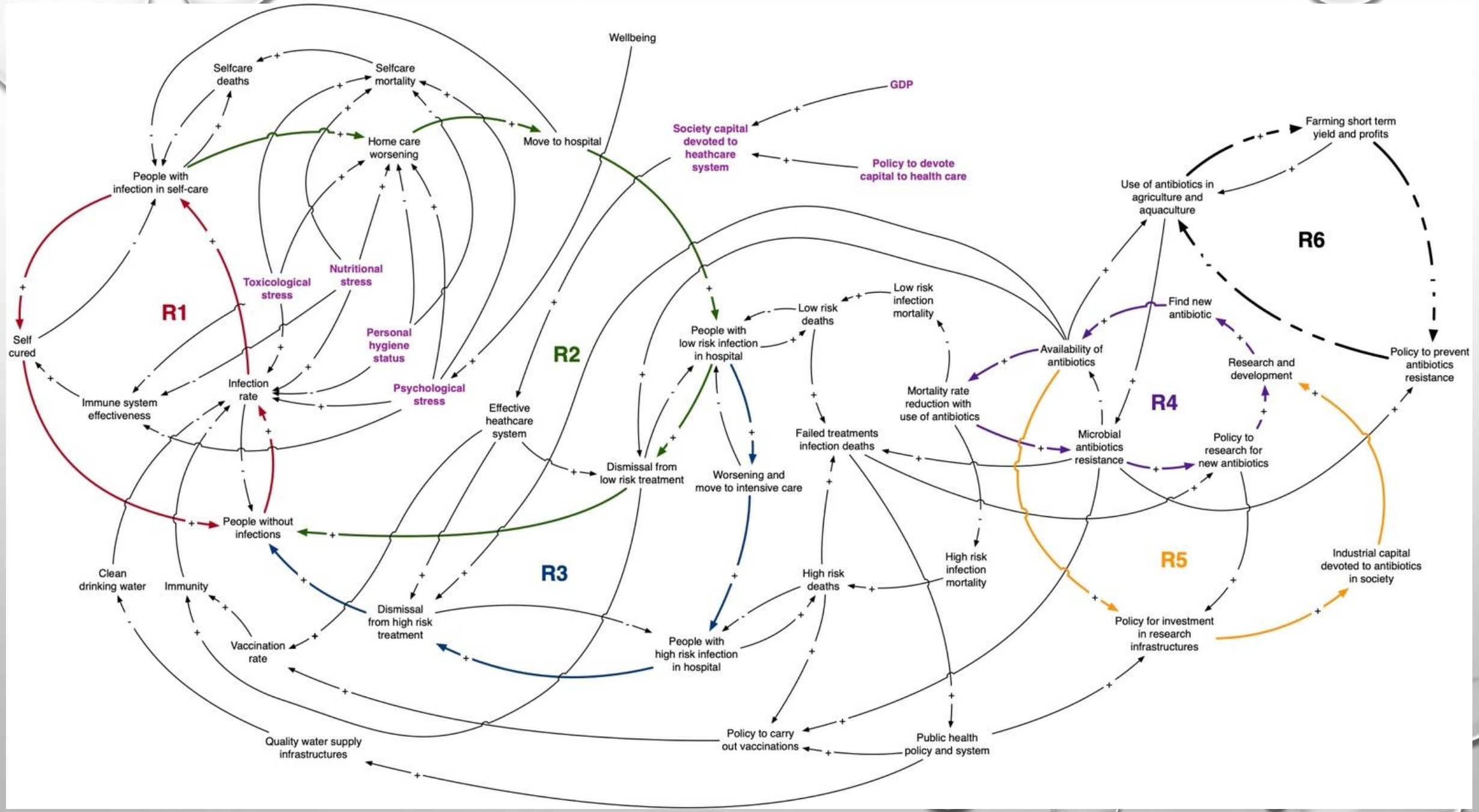
ONGOING MODEL DEVELOPMENT SINCE 2012 IN SWEDEN, GERMANY & ICELAND

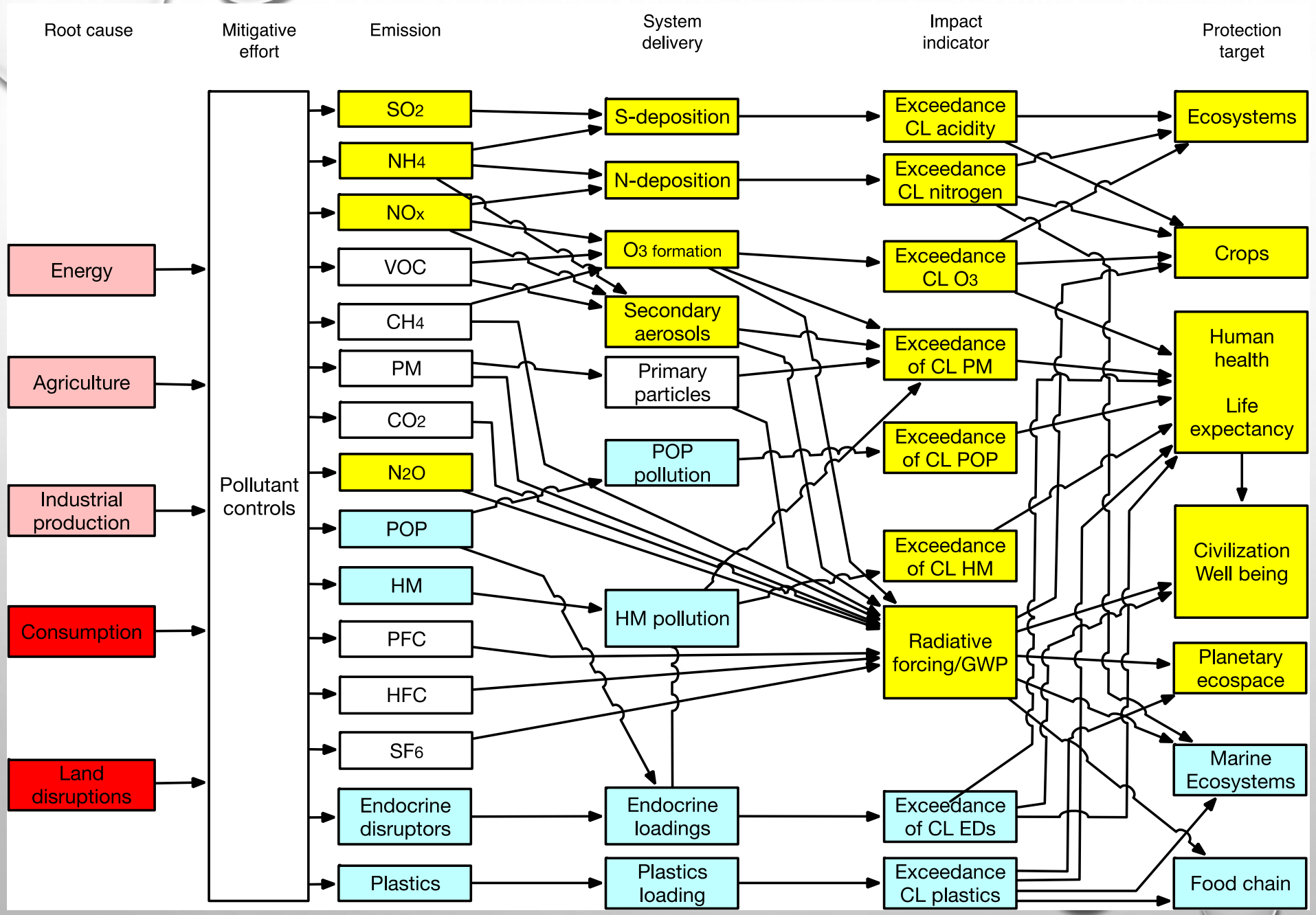
Sverdrup et al., 2012, 2014, 2015, 2016, 2017, 2018, 2019, Sverdrup and Ragnarsdottir 2011, 2014, Koca et al., 2018, Sverdrup and Olafsdottir 2017, 2018, 2019





GETTING HEALTH AND MORTALITY EFFECTS INTO THE MODELS ARE IN PROGRESS WITH THE WORLD6 INTEGRATED ASSESSMENT MODEL


Wellbeing
Selfcare deaths
Selfcare mortality
GDP
Society capital devoted to heathcare system
Policy to devote capital to health care
Farming short term yield and profits
Home care worsening
Move to hospital
People with infection in self-care
Use of antibiotics in agriculture and aquaculture
R6
Toxicological stress
Nutritional stress
R1
Low risk infection mortality
Low risk deaths
Find new antibiotic
Self cured
Personal hygiene status
R2
People with low risk infection in hospital
Availability of antibiotics
Policy to prevent antibiotics resistance
Research and development
Infection rate
Psychological stress
Immune system effectiveness
Effective heathcare system
Mortality rate reduction with use of antibiotics
R4
Failed treatments infection deaths
Microbial antibiotics resistance
Policy to research for new antibiotics
Dismissal from low risk treatment
Worsening and move to intensive care
People without infections
High risk infection mortality
R5
Industrial capital devoted to antibiotics in society
Clean drinking water
Immunity
R3
High risk deaths
Dismissal from high risk treatment
Policy for investment in research infrastructures
Vaccination rate
People with high risk infection in hospital
Policy to carry out vaccinations
Public health policy and system
Quality water supply infrastructures



Linking the future multi-pollutant, multi-effect relationships and the wellbeing of mankind

CONCLUSIONS

- THE WORK UNDER THE **LRTAP**-CONVENTION HAS BEEN **VERY SUCCESSFUL**
- THE **LRTAP** WORK IS **FAR FROM FINISHED**
- THERE ARE SERIOUS CHALLENGES TO CONTINUING THE MODELLING & MAPPING LRTAP WORK. THERE IS **INADEQUATE FUNDING** ACROSS THE WHOLE BOARD.
- THE NITROGEN ISSUES ARE WELL UNDERSTOOD, BUT THE ASSESSMENT WORK HAS NOT BEEN COMPLETED, **BIODIVERSITY** IS LARGELY **NOT PROTECTED** FROM AIR POLLUTION, CLIMATE CHANGE OR HUMAN LANDUSE. **THE INTEGRATED MODELS ARE READY AND WELL VALIDATED**
- PARTICLES, OZONE, ENDOCRINE DISRUPTORS, ORGANIC POLLUTANTS REMAIN AS MAJOR CONSERNS FOR ECOSYSTEMS AND HUMAN HEALTH
- DEVELOPMENT OF NEW INTEGRATED GLOBAL MODELS IS NECESSARY AND SHOULD BE URGED.