Biofuels-Local impacts with special regard to water issues

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UNIVERSITY OF NEWCASTLE

CLUWRR Centre for Land Use and Water Resources Research

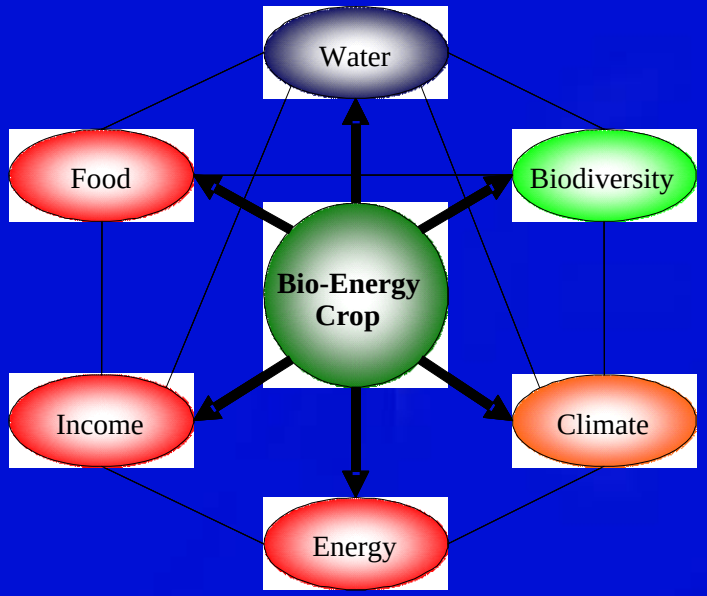
Bio-energy Impacts?

- **Throughout the world bio-energy is promoted for :**
  - **Bio-fuel**
  - **Carbon sequestration – climate benefits**

  - **But what about?**
  - **Amenity and social benefits.**
  - **Environmental**
  - **Biodiversity**

- **Not always are the water resource costs and other tradeoffs (food) taken into account.**

- **Is there a need for an improved impact assessment framework or dissemination tool to assist policy makers and planners in making evidence based decisions on Bio-Energy and land use policy?**



Determining Local Impacts – Recent Initiatives

1. **Re-Impact - Determining water resource, societal, biodiversity, GHG forcing impacts of bioenergy plantations –China, India, South Africa, Uganda- funded by the EU.**

2. **FC commissioned research to understand water resource impacts of Energy plantations in UK under present and future climates (not strictly transport biofuels unless 2nd generation)**

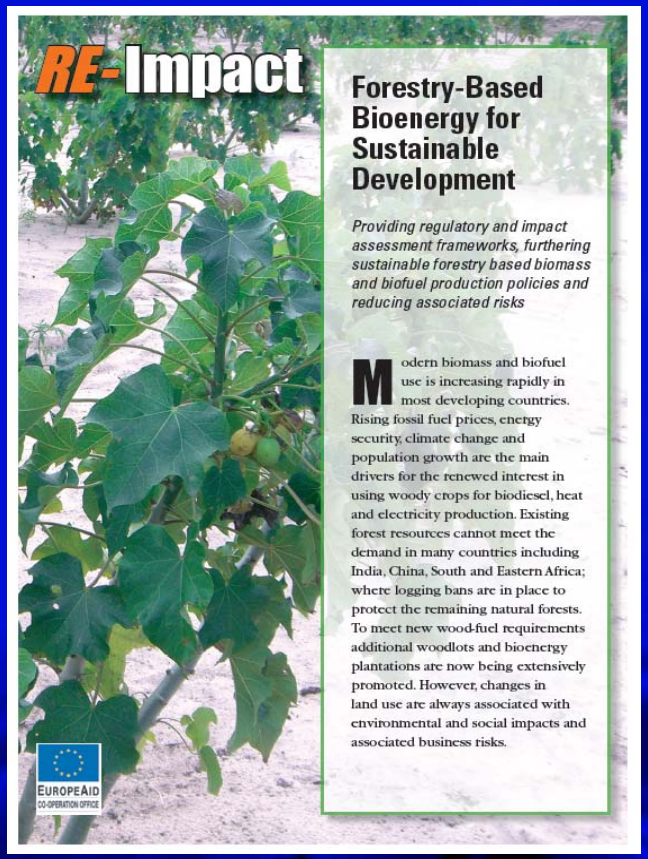
3. **IUFRO task force on forest and water interactions – UN Expert Panel on Adaptation of Forests to Climate Change - IRGC project on governance of bioenergy**

4. **EXCLAIM dissemination tool**

RE-Impact - Background

Increases in price of energy - renewed interest in bio-energy but:

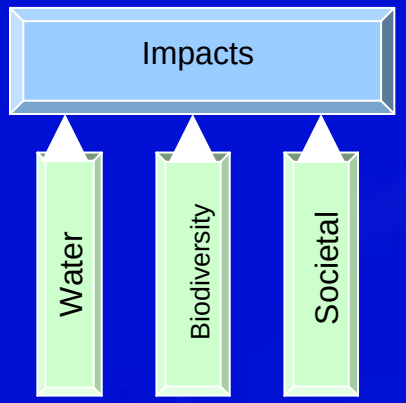
- **How much water will be consumed in the growing of these crops?**
- **For sugar based alcohol fuels, 20,000 litres water for each litre of fuel ? Jatropha 1-10,000 litres?**
- **Will bio-energy schemes move catchments further towards closure?**
- **Biodiversity and societal impacts - though direct impact of the forests and the indirect impacts on the water regime?**



RE–Impact – producing an Impact assessment framework

Jatropha example:

13,000,000 ha Jatropha plantation required to achieve India 2011 target of 20% bio-diesel



Water Impacts?

- In dry zone water use may be similar or less than indigenous vegetation
- But poor yields unless rainfall >~900mm or irrigated – direct competition with agricultural crops and commercial forestry

Societal Impacts?

- Plan to plant up ‘wastelands’ but not much land in India not used by someone
- Who will be the winners and losers of such a large change in land use ?

Biodiversity Impacts?

- RSA concerns about Alien invasion - Jatropha probably not a problem as seeds toxic to most animals and not easily windspread
- Replacement of indigenous vegetation

Impact assessment framework – based on SEA from South Africa

RE-Impact prototype Sustainability Framework for forestry based bio-energy projects

SCALE	WATER	BIODIVERSITY	CLIMATE CHANGE (Greenhouse gas emissions/sequestration)	SOCIO-ECONOMICS
GLOBAL TRANSBOUNDARY	Change in large system ecological processes and social services Change in transboundary water systems	Change in biodiversity - Species extinction - Biome loss - Biodiversity richness	Net greenhouse gas forcing: - Carbon sequestration - Albedo change - Gaseous/aerosol emissions - Life cycle - Net radiative forcing	Millennium Development Goals Poverty alleviation Global food security Global political stability Impacts on global food and fuel markets (World Trade Organization)
NATIONAL PROVINCIAL/STATE	Change in ecological reserve for rivers Change in total streamflow and available water to downstream users Movement towards Catchment Closure Irrigation need	Change in biodiversity - Species extinction - Intactness of habitat - Introduction of alien invasive species	Power density (Wm^2) Energy Return on Energy Investment (EROEI) National carbon accounting (e.g. change in total national carbon emissions, carbon emissions per capita, etc.)	Macro-economic indicators (e.g. GDP, GBI, balance of payments) National food security Employment indicators - Jobs/ha vs Jobs/W (i.e. employment measured either by jobs created per unit of land or per unit of energy produced)
LOCAL GOVERNMENT CATCHMENT COMMUNITY HOUSEHOLD	Change in seasonality of streamflow Change in security of supply Change in depth to groundwater or yield of groundwater Change in water quality	Change in ecosystem services provided by biodiversity - Provisioning (food, wood) - Regulating impacts (floods, droughts) - Regenerative capacity (supportive services) - Soil degradation	Ability to access and use CDM funds (i.e. Clean Development Mechanism, an arrangement for carbon credit accounting under the Kyoto Protocol)	Household income Equity of distribution (i.e. winner/losers across class, gender, age & urban/rural distinctions, for full product life cyle) Household food security (producing food vs earning money) Employment indicator - Jobs/village Risk of failure Human health impact (e.g. poisons from Jatropha) Vulnerability

Water Impacts - future challenge

Jatropha Water Impacts?

- Virtual water to be considered (1-10,000 for 1 litre bio-diesel)

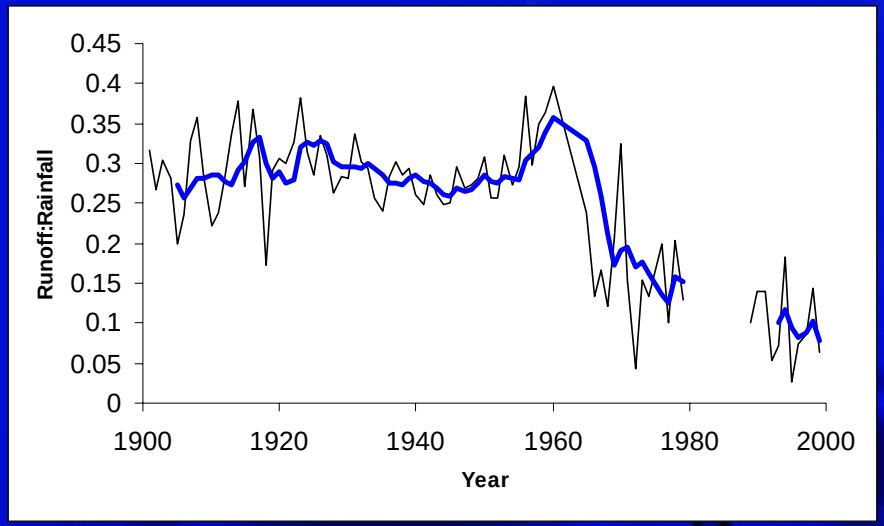
but probably more important is :

- What is evaporation as proportion of rainfall?
- Is it more or less than indigenous vegetation?
- Blue and green accounting? Ethanol based fuels also use blue water in processing (20,000 for 1 litre bio-diesel)

Challenge for the future:

Can we find jatropha varieties which will give reasonable bio-diesel yields yet not use all the rainfall in dry zone regions ?

- a dry zone crop yielding bio-diesel and water
- help move away from catchment closure
- the silver bullet!



Annual time series of the runoff:rainfall coefficient for the Krishna Basin at Vijayawada

Meeting water sustainability criteria -Quadrant Approach

- **Bioenergy crop as one crop in a land use mix:**

  - GREEN WATER < Precipitation, E<P?

  - BLUEWATER -Are there surface flows Qs?

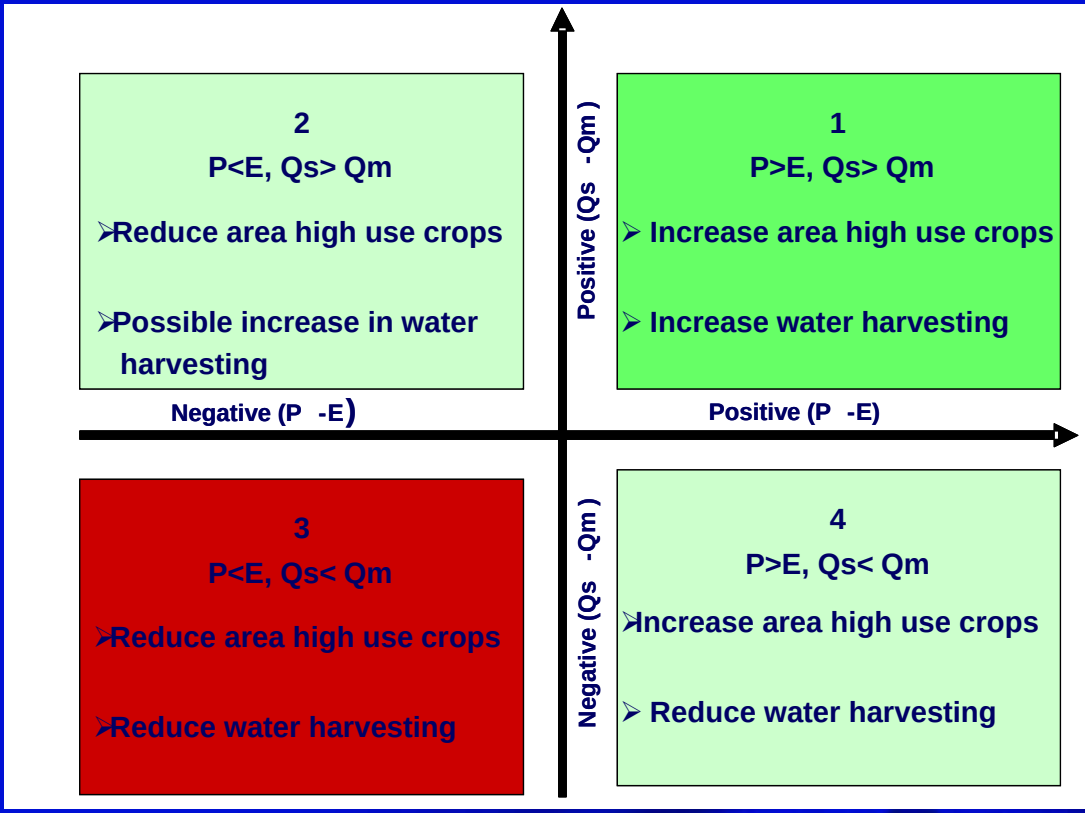
- **Quadrant approach, Combinations indicate:**

  1 opportunity for increased irrigation Benefits from further SWC

  2 Reduce irrigation/ forestry Benefits from further SWC ?

  3 Reduce irrigation/ forestry NO overall benefits from further SWC

  4 opportunity for increased irrigation : NO overall benefits from further SWC



Many examples of SWC promoted in type 3- where E>P, No surface flows or tank spills within last 5 years!

UK Research on energy planatations

LTS report recommends further research on three main areas:

- **growth rates and yields of SRF**
- **the economics of SRF**
- **the water use of SRF stands**

Concerns:

"the high water use by some species, particularly eucalypts, which in certain parts of Britain could threaten water supplies. Further research is recommended to develop clear guidance for potential growers and land-use authorities on the areas where SRF would and would not be acceptable. "


Forestry Commission - News - potential seen to develop short-rotation forestry for wood fuel - Windows Internet Explorer

Great Britain

Forestry Commission

7 MARCH 2006

NEWS RELEASE No: 8225

Issued jointly with Defra

POTENTIAL SEEN TO DEVELOP SHORT-ROTATION FORESTRY FOR WOOD FUEL

Short-rotation forestry, by which fast-growing trees are cultivated and harvested between eight and 20 years after planting, appears to have potential as a source of renewable fuel for heat and power generation in Great Britain, according to a study undertaken for the Forestry Commission and Defra.

However, the study authors advise that a number of issues need to be addressed before short-rotation forestry could be widely established.

The two departments commissioned the review of possible environmental impacts of short-rotation forestry (SRF) as part of ongoing investigations and development of the wider mix of contributions that forestry can make to climate change mitigation and sustainable energy production. This mix includes energy crops, sawmill residues, and wood from existing forest and woodland.

Interest in SRF has been growing as part of the drive to develop renewable, carbon-lean alternatives to non-renewable fossil fuels such as oil, gas and coal. The build-up in the atmosphere of greenhouses gases, such as carbon dioxide, as a result of humans burning non-renewable fossil fuels is widely accepted as contributing to climate change.

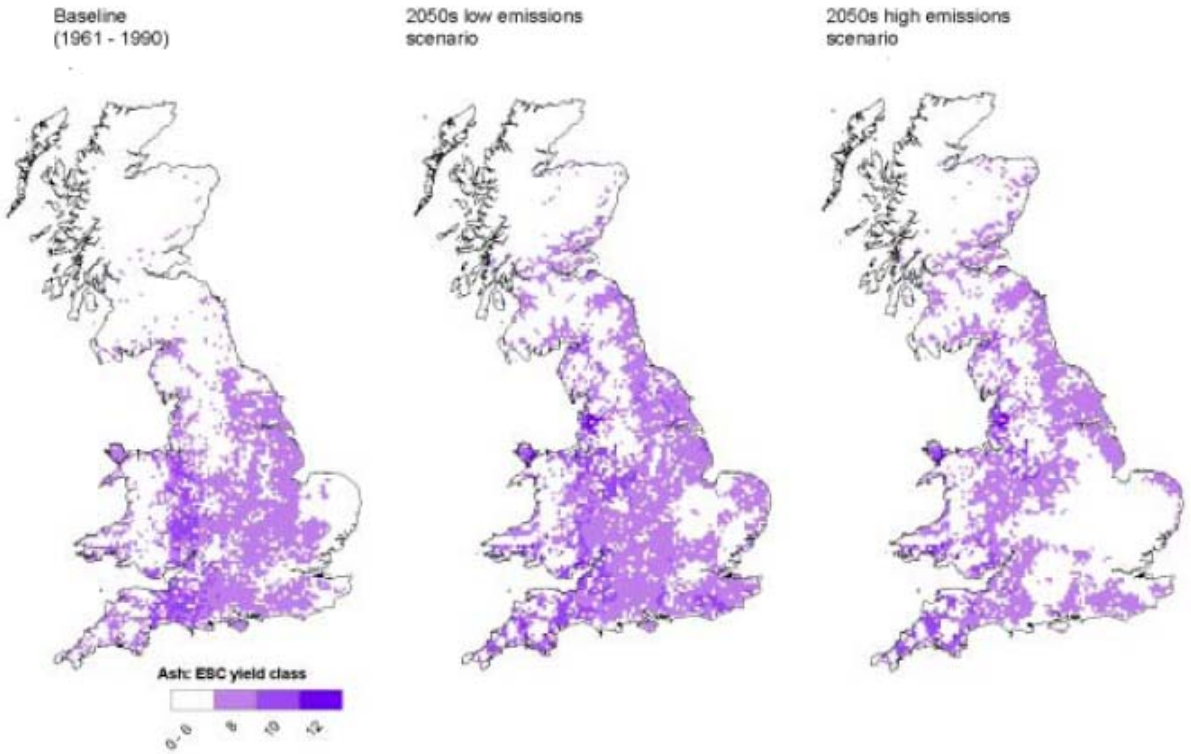
The study looked at the potential impacts of SRF on biodiversity, soils, hydrology, pests and diseases, archaeology

Table 6 Carbon Storage per Ha – SRF

Species	Average Tonnes CO_2 stored over 100 year period
Alder	238
Ash	341
Birch	242
Poplar	205
Sycamore	326
E gunnii	275
E nitens	290
Nothofagus	363

UK- Energy plantations under future climate change

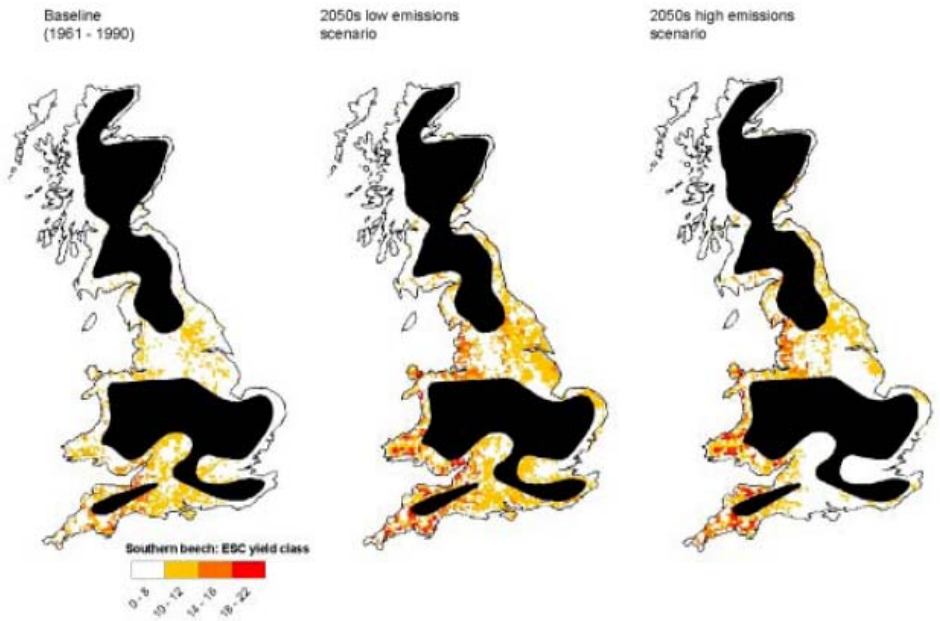
Figure 2 . Predicted yield distribution for ash in the baseline climate, and scenarios for low and high emissions in 2050.



UK- Energy plantations under future climate change scenarios

Figure 4. Predicted yield distribution for rauli (*Nothofagus nervosa*) in the baseline climate, and scenarios for low and high emissions in 2050

Source: Cannell, Grace and Booth, 1989



Water resource impacts under future climate change scenarios?

CLUWRR currently investigating, in collaboration with FC the range of likely water resource impacts associated with energy plantation species under:

- **Present**
- **Future**

climate scenarios.

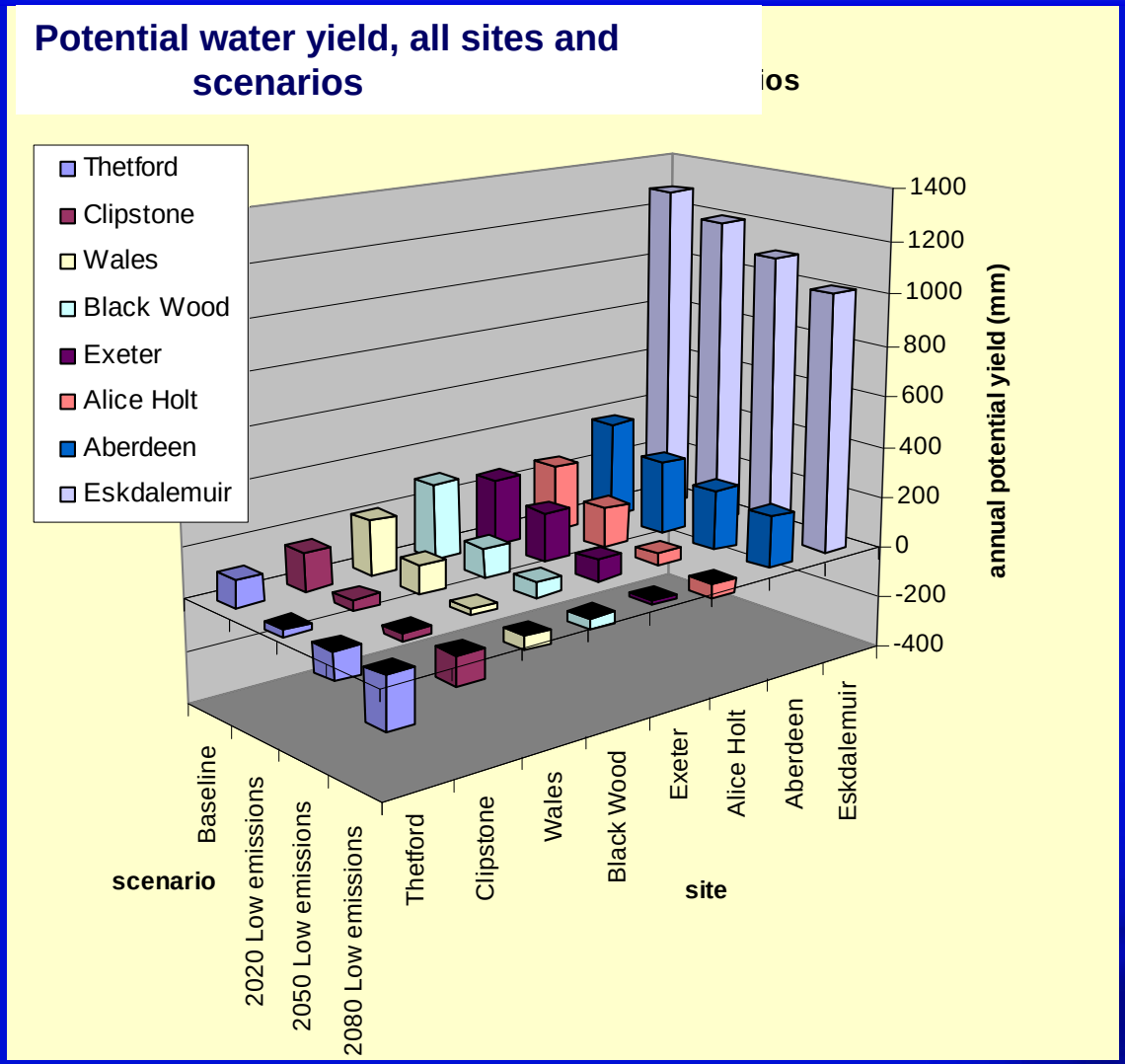
Raises questions:

Will difference between forest and short crop evaporation increase or decrease for future climate change scenarios?

Table 7 Yield Information

Species	Dry Tonnes/ha/annum	Rotation	Yield – Dry T/ha per rotation	Yield - Dry T/ha over 50 years	Average for timber rotation, Dry T/ha/an
Species					
Alder	5.0	20	100	250	
Ash	7.4	20	148	370	4.5
Birch	5.0	20	100	250	
Poplar	5.6	14	78	280	
Sycamore	7.0	20	140	350	4.5
E gunnii	9.0	12	108	450	
E nitens	15.0	8	120	750	
Nothofagus	11.8	12	142	590	6.5
SRC Species					
Willow / Poplar	8	3	24	400	

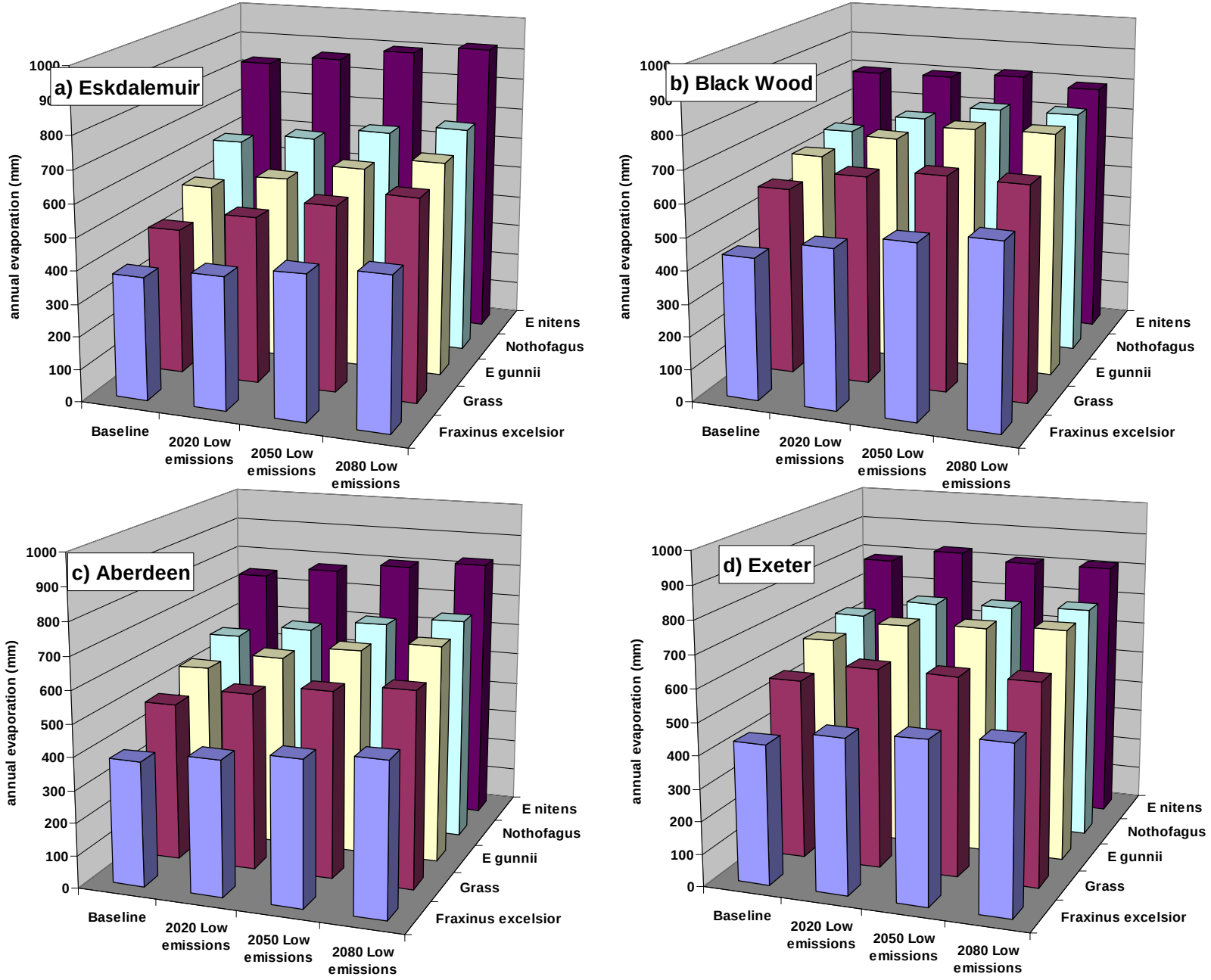
SRF FC- Scenario study evaluation of the water resource impacts of energy plantations in the UK using HYLUC modelling



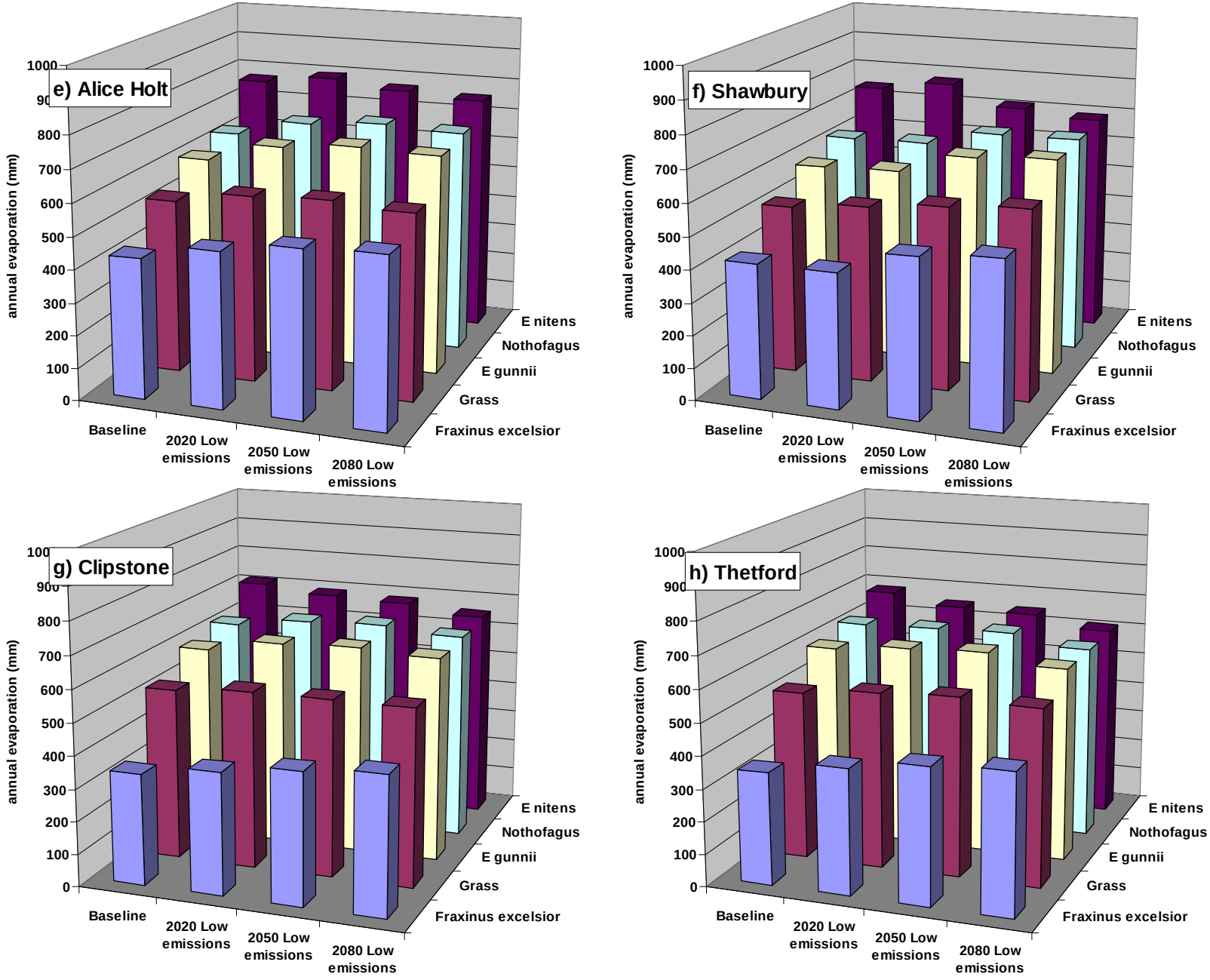
- **Assess the range of water resource impacts of 4 energy tree species:**
  - ***Eucalyptus nitens***
  - ***E. gunnii,***
  - ***Nothofagus,***
  - ***Fraxinus excelsior)***

  at 8 UK locations under present and future climates.

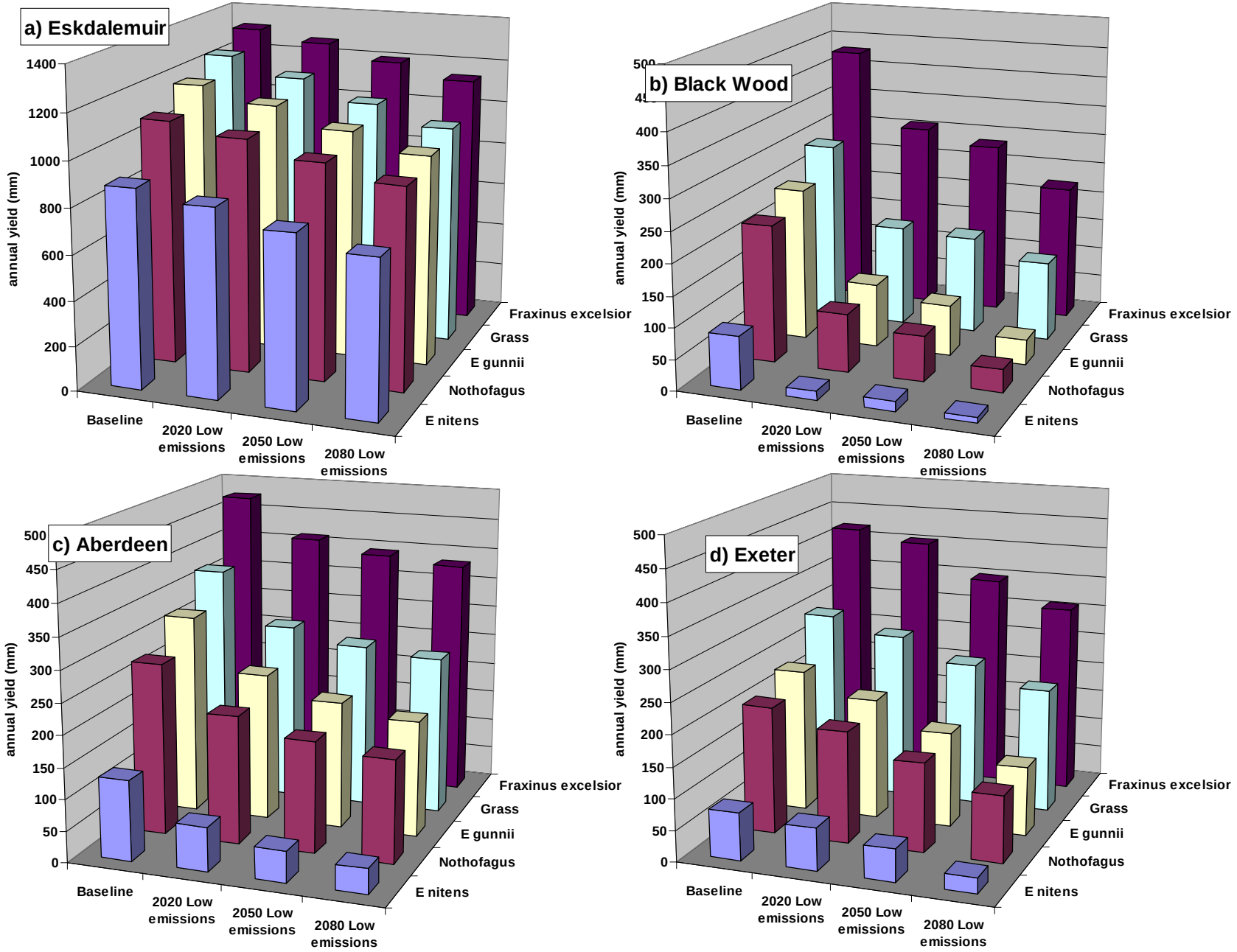
- **EARWIG weather generator calibrated on UKCIP02 climate scenarios shows 'potential annual water yield' (Rain-PE) -ve at all, except wet sites by 2080.**



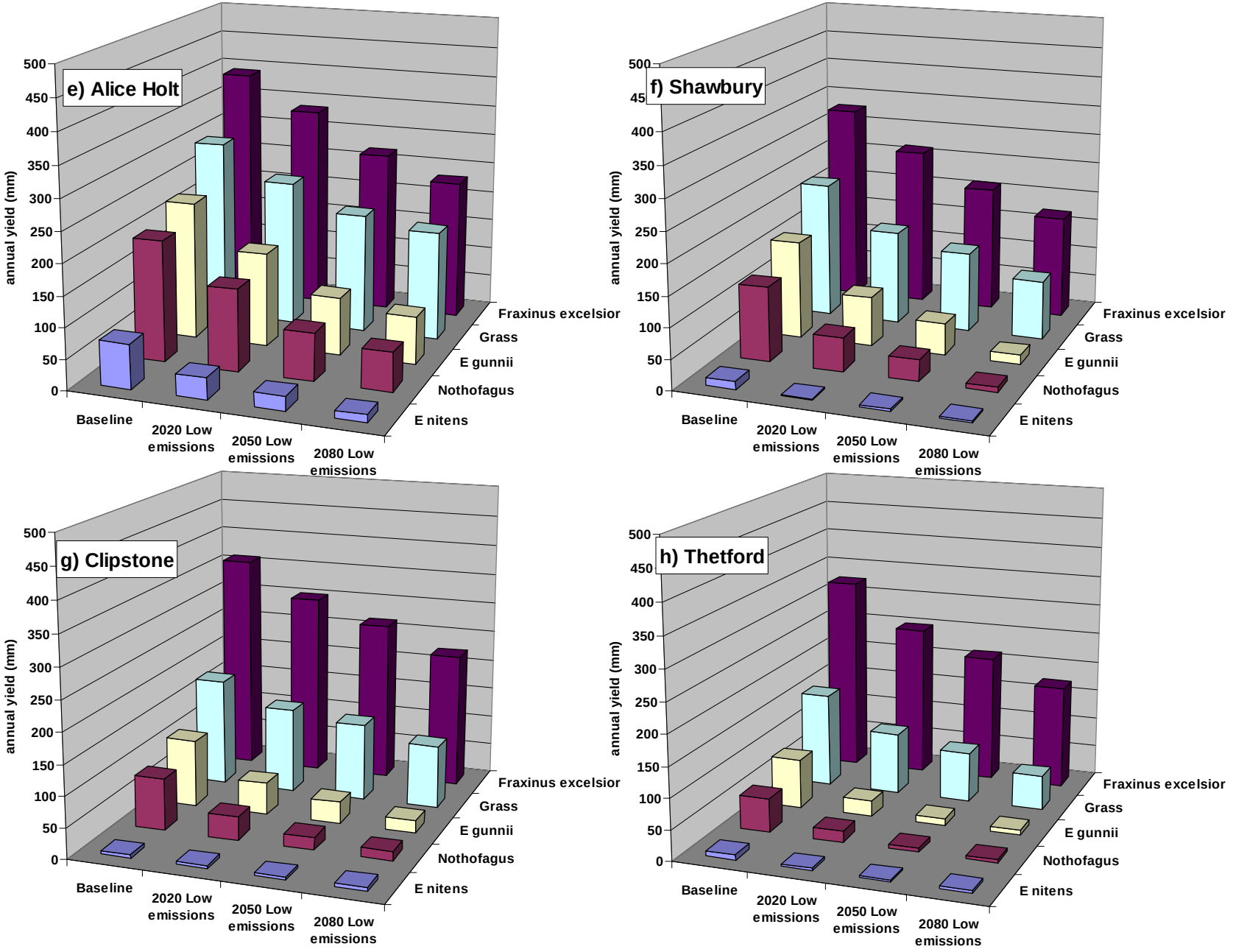
Mean annual evaporation for all species and all Low Emission climate change scenarios –wetter sites



Mean annual evaporation for all species and all Low Emission climate change scenarios - drier sites



Mean annual water yield for all species and all Low Emission climate change scenarios -wetter sites



Mean annual water yield for all species and all Low Emission climate change scenarios -drier sites

SRF FC- Scenario study conclusions (Calder, IR , Nisbet, T., Harrison JA (2008)

An evaluation of the impacts of energy tree plantations on water resources in the UK under present and future UKCIP02 climate scenarios. Water Resour, Res. In press)

Under the present climate all tree species (excepting Fraxinus excelsior,)at all sites have greater mean annual evaporation, (8 to 84%) and reduced water yields (-6 to -97%), compared with grass.

Under future climate scenarios, as compared with present baseline conditions:

- **At the drier sites and for the species with the highest evaporation rates; E. nitens and Nothofagus, evaporation rates will decrease.**
- **At wetter sites, and for all species, evaporation rates will increase.**
- **Water yields will reduce for all species. Drier sites show the greatest percentage reductions: grass, 63%; E. gunnii, 95% at Thetford by 2080. At Eskdalemuir (wettest site) reductions are grass, 21%; E. gunnii, 24%.**
- **There is a trend towards convergence in water yields from trees and grass covers.**
- **Policy: water impacts seen as major constraint for England**
  Agroforestry to minimise water impacts?

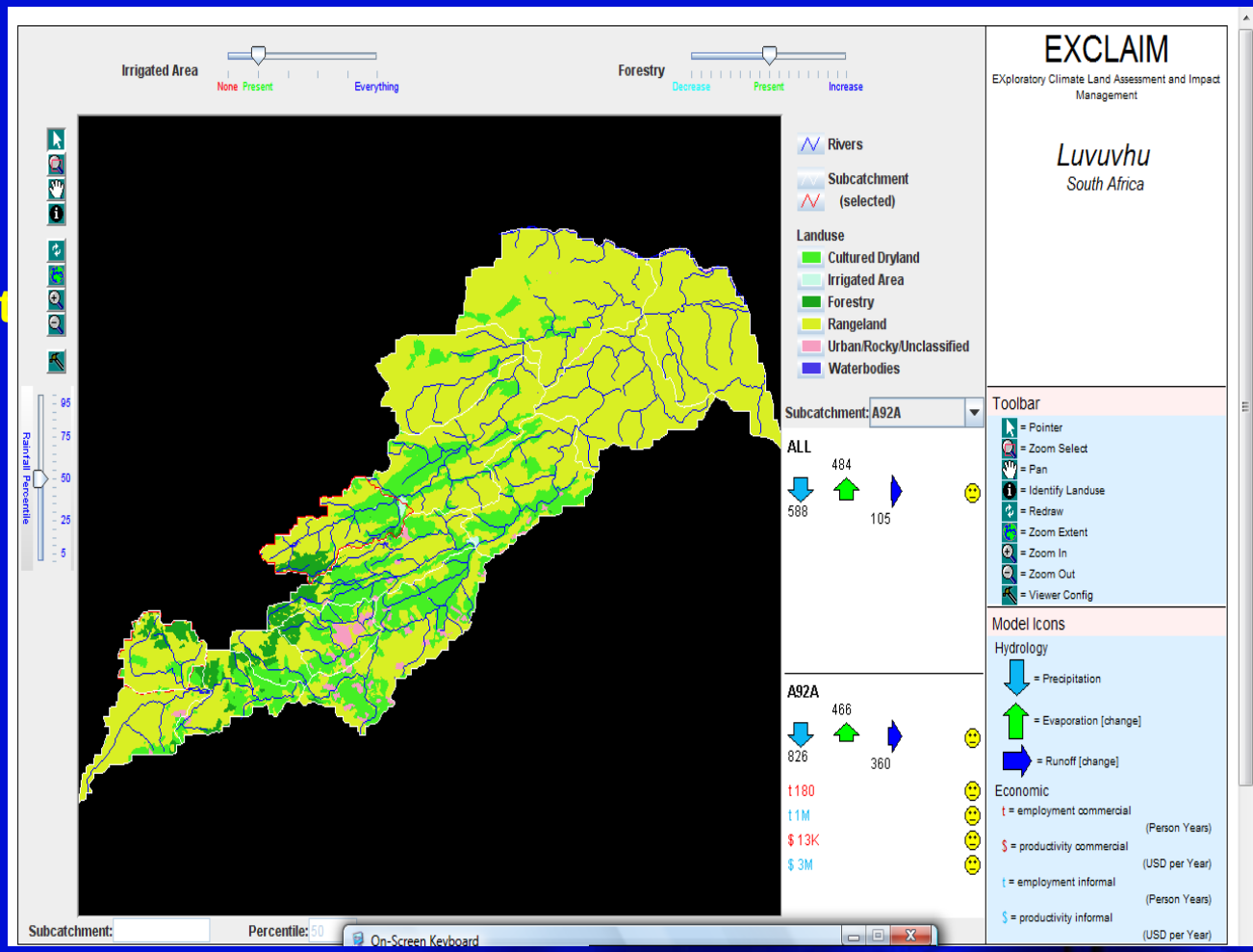
The need for new initiatives- IUFRO Task Force

Task force on Forests and Water Interactions addresses new policy drivers:

- **The recent rises in the price of fossil fuels has led to a renewed interest in forests as alternative sources of possibly lower cost bio-energy.**
- **'Payments for Environmental Services' schemes increasingly focus on forest as the supplier of these services.**
- **But what are the water resource implications of these schemes?**
- **How much water will be consumed in the growing of these crops and what might the costs/benefits be in relation to other societal, biodiversity and carbon sequestration factors?**

New tools - Planning - Dissemination Tools - for watershed management

- **Web based GIS 'Exploratory Climate, Land Assessment, Impact Management' EXCLAIM tool for disseminating to non specialists the impacts of watershed interventions**



Current Applications of EXCLAIM

EXCLAIM used in South Africa, India, Costa Rica, Vietnam

Currently being developed to explore impacts of energy plantations, Jatropha bio-diesel plantations in

- China
- Uganda
- India
- South Africa

Sliders allow impacts of changing land use and climate to be investigated