

Biofuels-Local impacts with special regard to water issues

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CLUWRR**

**IEA Bioenergy Task 38 Workshop in Cooperation with the Salzburg State
Government**

**Transportation Biofuels: For greenhouse gas mitigation, energy security or
other reasons; Session 3 : Other impacts, benefits and goals Symposium**

Tuesday, 5 February 2008

Salzburg, Austria



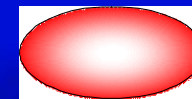
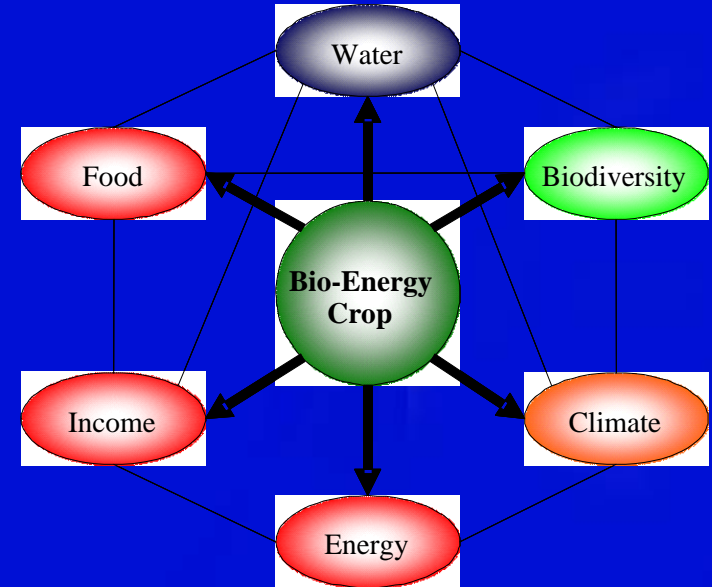
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Bio-energy Impacts?

- ◆ **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?**



Human Dimensions




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

Forestry-Based Bioenergy for Sustainable Development

Providing regulatory and impact assessment frameworks, furthering sustainable forestry based biomass and biofuel production policies and reducing associated risks

Modern biomass and biofuel use is increasing rapidly in most developing countries. Rising fossil fuel prices, energy security, climate change and population growth are the main drivers for the renewed interest in using woody crops for biodiesel, heat and electricity production. Existing forest resources cannot meet the demand in many countries including India, China, South and Eastern Africa; where logging bans are in place to protect the remaining natural forests. To meet new wood-fuel requirements additional woodlots and bioenergy plantations are now being extensively promoted. However, changes in land use are always associated with environmental and social impacts and associated business risks.



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?

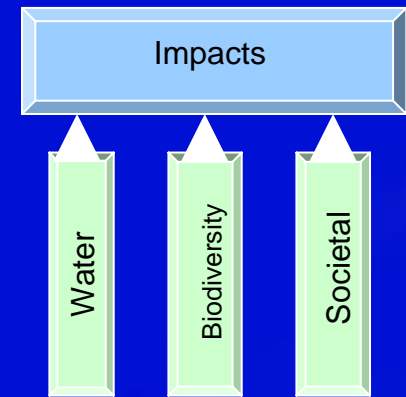
- In dry zone water use may be similar or less than indigenous vegetation
- But poor yields unless rainfall $> \sim 900$ mm or irrigated – direct competition with agricultural crops and commercial forestry

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	Change in large system ecological processes and social services	Change in biodiversity <ul style="list-style-type: none"> - Species extinction - Biome loss - Biodiversity richness 	Net greenhouse gas forcing: <ul style="list-style-type: none"> - Carbon sequestration - Albedo change - Gaseous/aerosol emissions - Life cycle - Net radiative forcing 	Millennium Development Goals <ul style="list-style-type: none"> Poverty alleviation Global food security Global political stability Impacts on global food and fuel markets (World Trade Organization)
TRANSBOUNDARY	Change in transboundary water systems			
NATIONAL	Change in ecological reserve for rivers	Change in biodiversity <ul style="list-style-type: none"> - Species extinction - Intactness of habitat - Introduction of alien invasive species 	Power density (Wm^{-2})	Macro-economic indicators (e.g. GDP, GBI, balance of payments)
PROVINCIAL/STATE	Change in total streamflow and available water to downstream users		Energy Return on Energy Investment (EROEI)	National food security
	Movement towards Catchment Closure		National carbon accounting (e.g. change in total national carbon emissions, carbon emissions per capita, etc.)	Employment indicators <ul style="list-style-type: none"> - Jobs/ha vs Jobs/W (i.e. employment measured either by jobs created per unit of land or per unit of energy produced)
	Irrigation need			
LOCAL GOVERNMENT	Change in seasonality of streamflow	Change in ecosystem services provided by biodiversity <ul style="list-style-type: none"> - 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
CATCHMENT	Change in security of supply			Equity of distribution (i.e. winner/losers across class, gender, age & urban/rural distinctions, for full product life cycle)
	Change in depth to groundwater or yield of groundwater			Household food security (producing food vs earning money)
COMMUNITY	Change in water quality			Employment indicator <ul style="list-style-type: none"> - Jobs/village
HOUSEHOLD				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)

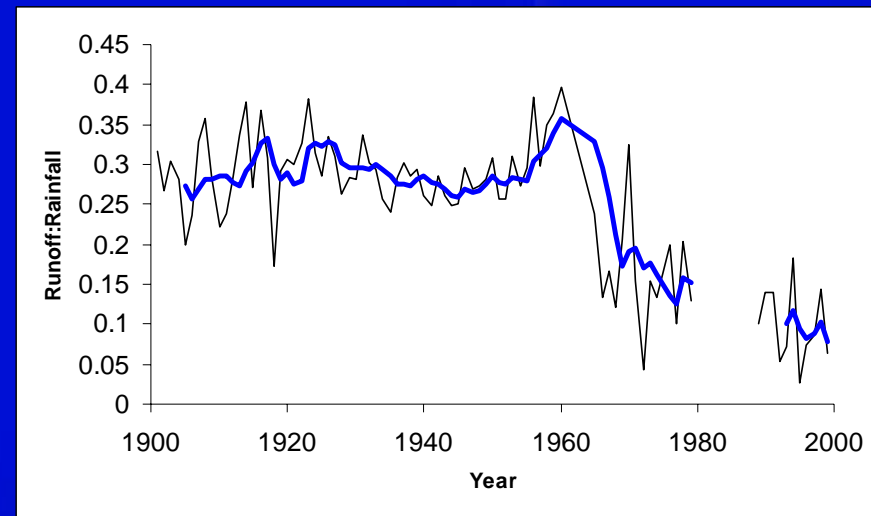
but probably more important is :

- 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 Q_s ?

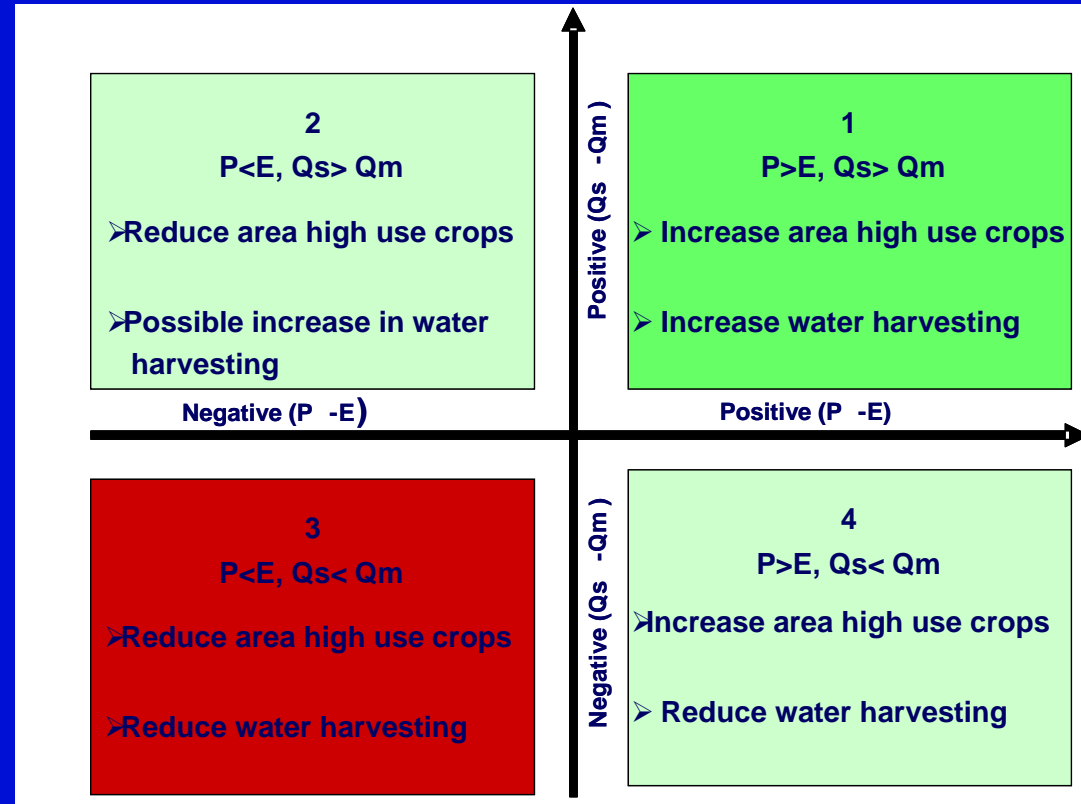
◆ Quadrant approach, Combinations indicate:

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 plantations

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.”



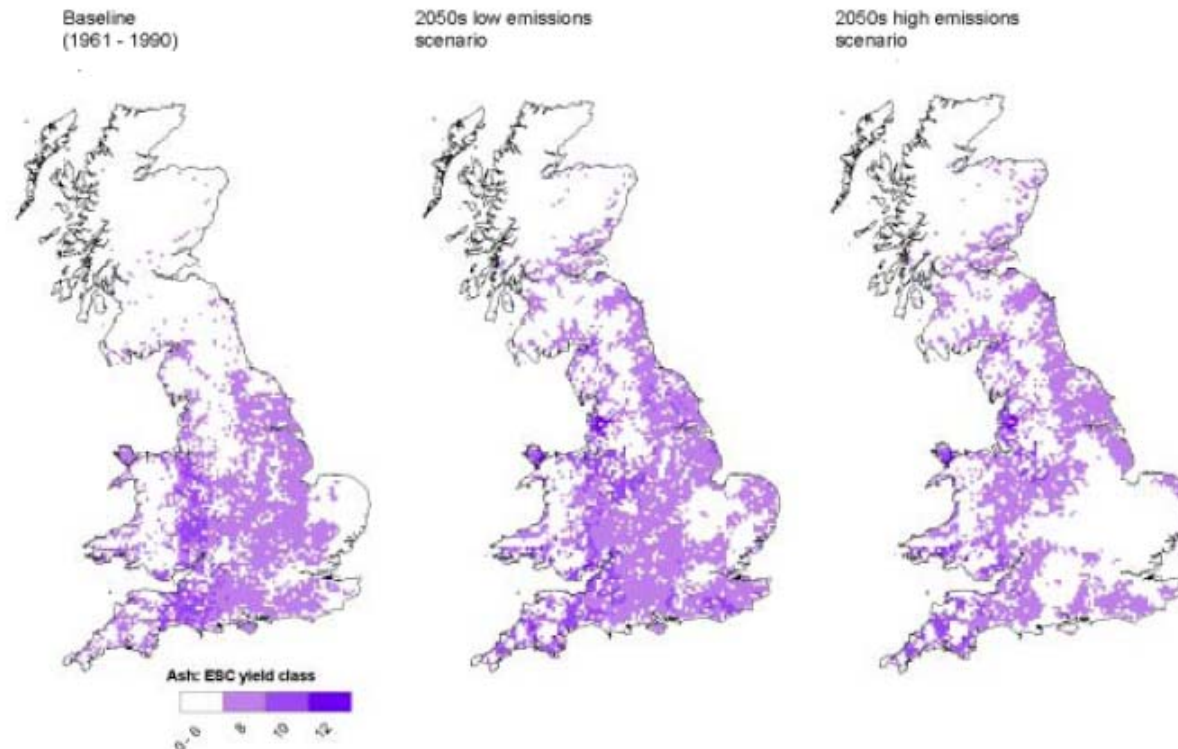
Table 6 Carbon Storage per Ha – SRF

Species	Average Tonnes CO ₂ stored over 100 year period
Alder	238
Ash	341
Birch	242
Poplar	205
Sycamore	326
<i>E gunnii</i>	275
<i>E nitens</i>	290
<i>Nothofagus</i>	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.

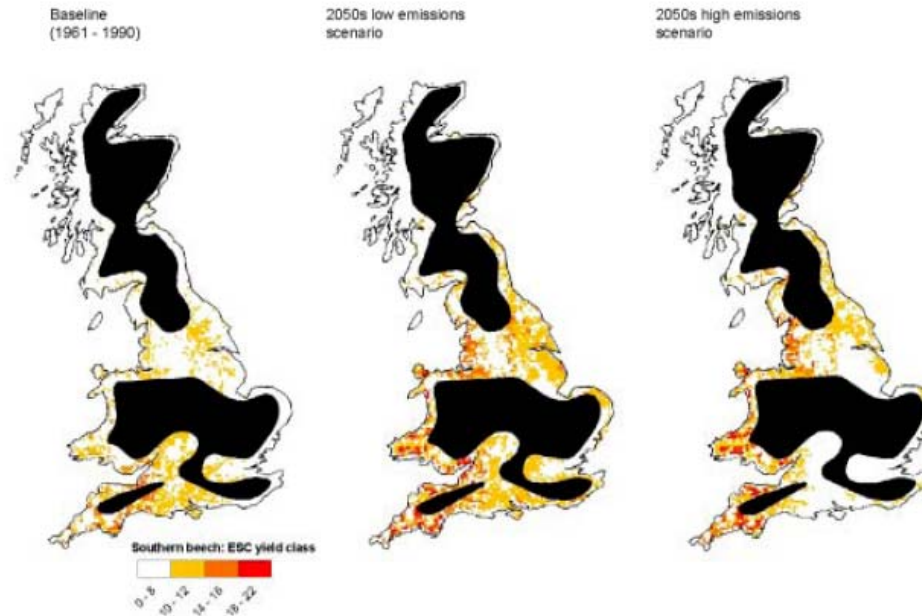


UK- Energy plantations under future climate change scenarios



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

Source: Carnet, Grace and Booth, 1999



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?

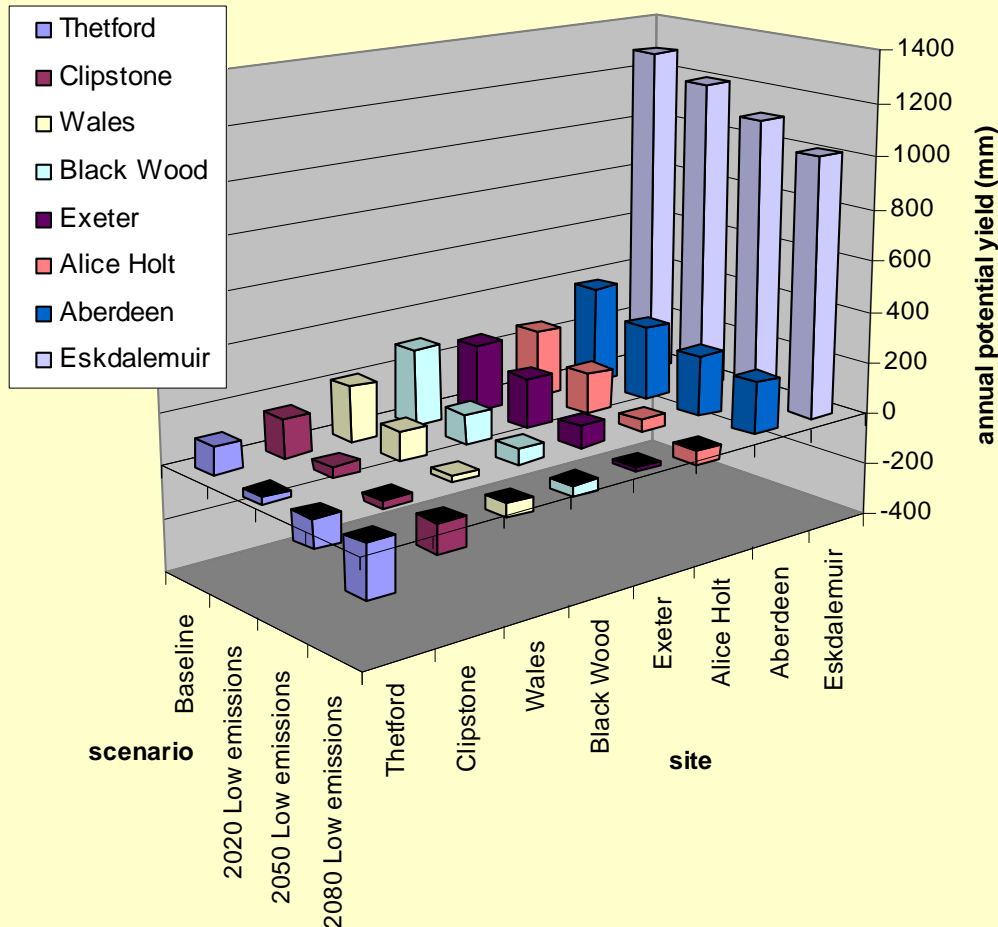
Table 7 Yield Information

Species	Dry Tonnes/h a/annum	Rotation	Yield - Dry T/ha per rotation	Yield - Dry T/ha over 50 years	Average for timber rotation, Dry T/ha/ann
<i>Species</i>					
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
<i>E gunnii</i>	9.0	12	108	450	
<i>E nitens</i>	15.0	8	120	750	
<i>Nothofagus</i>	11.8	12	142	590	6.5
<i>SRC Species</i>					
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

Potential water yield, all sites and scenarios

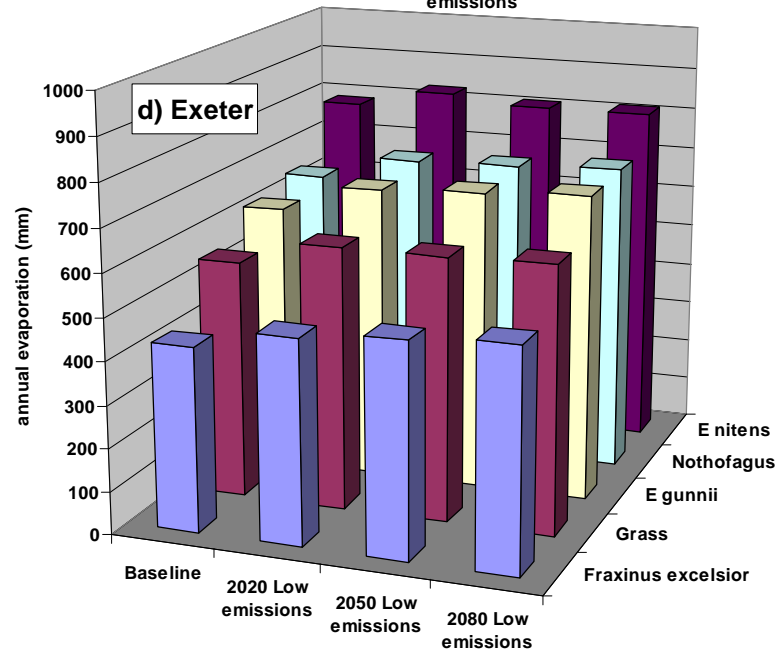
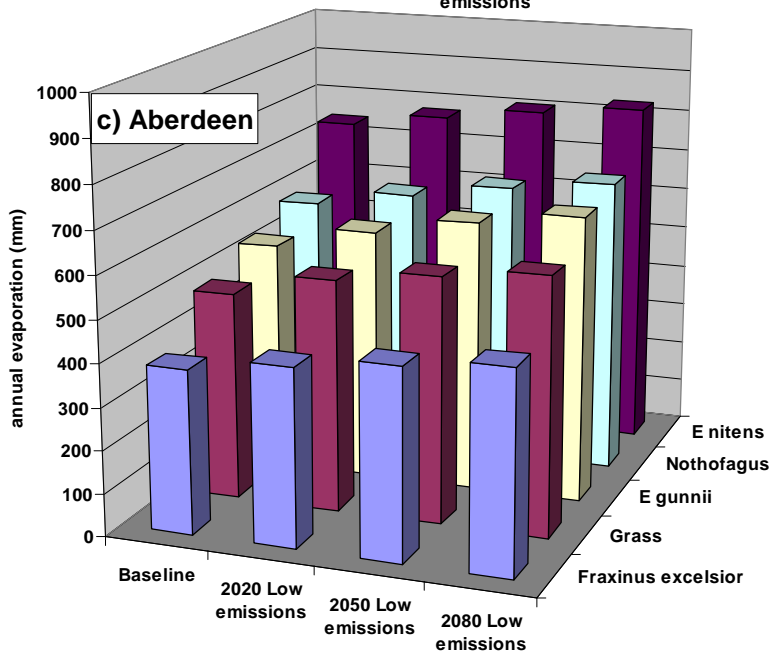
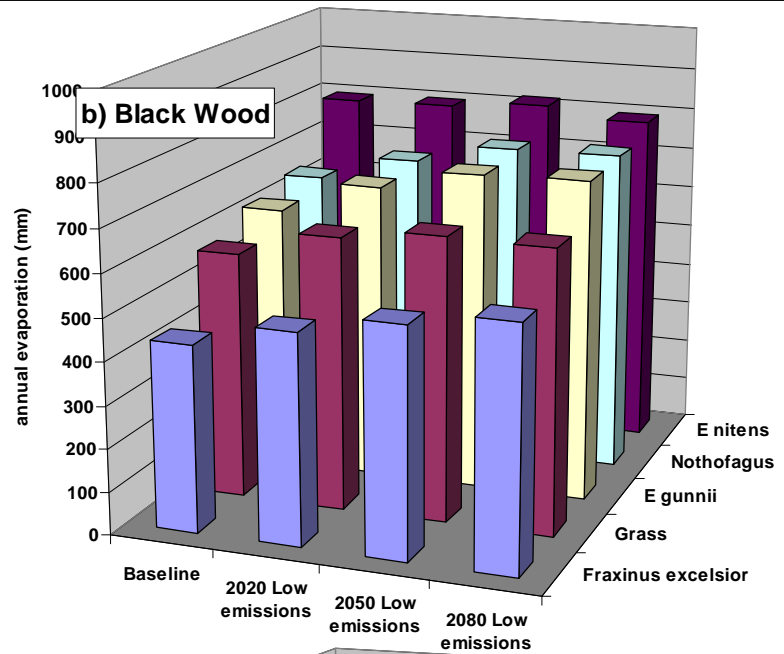
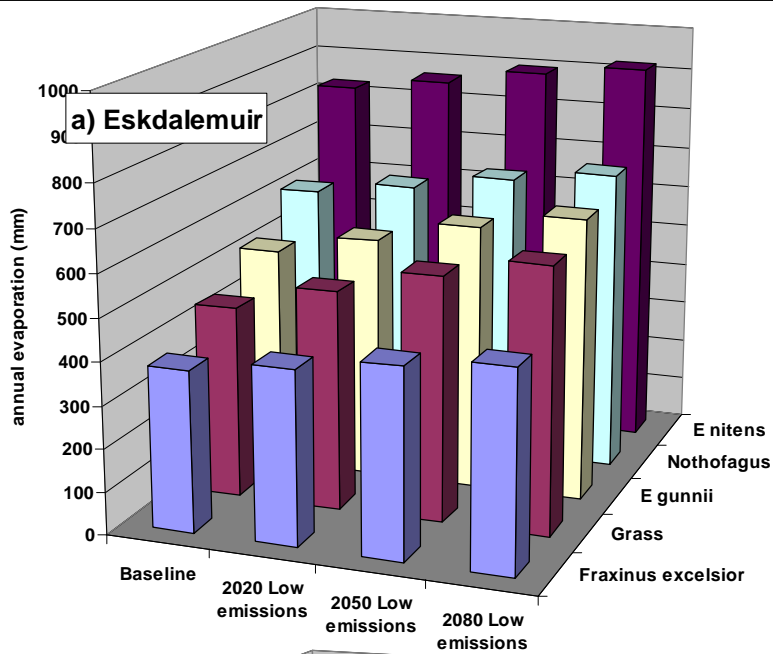


❖ Assess the range of water resource impacts of 4 energy tree species:

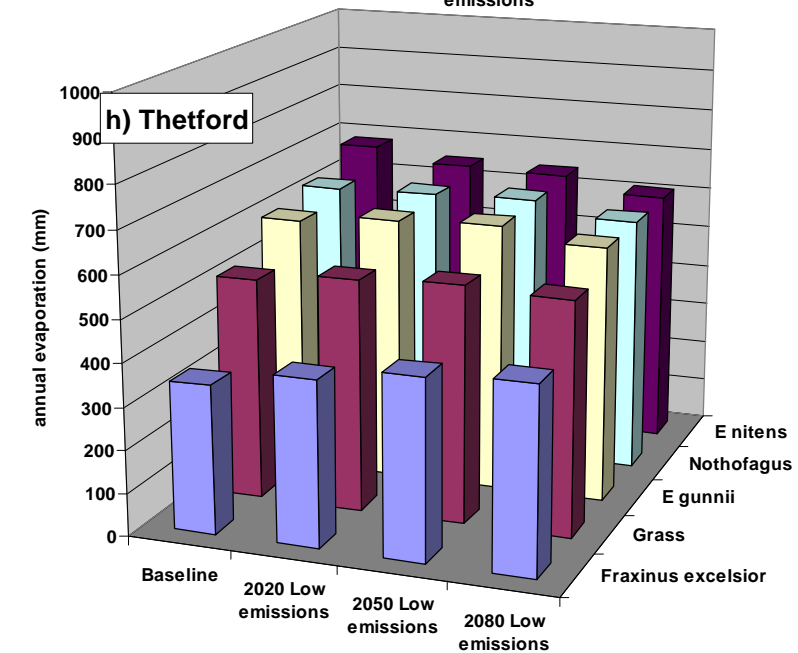
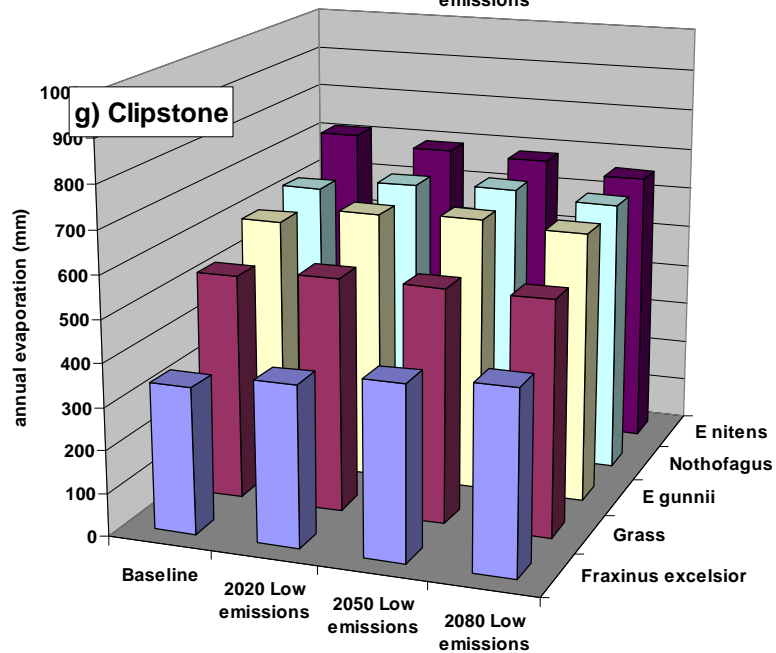
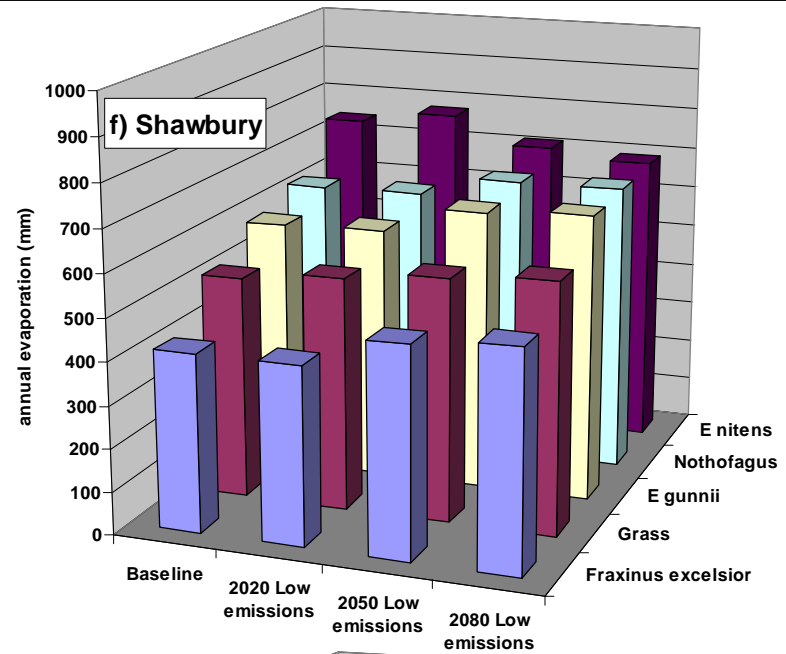
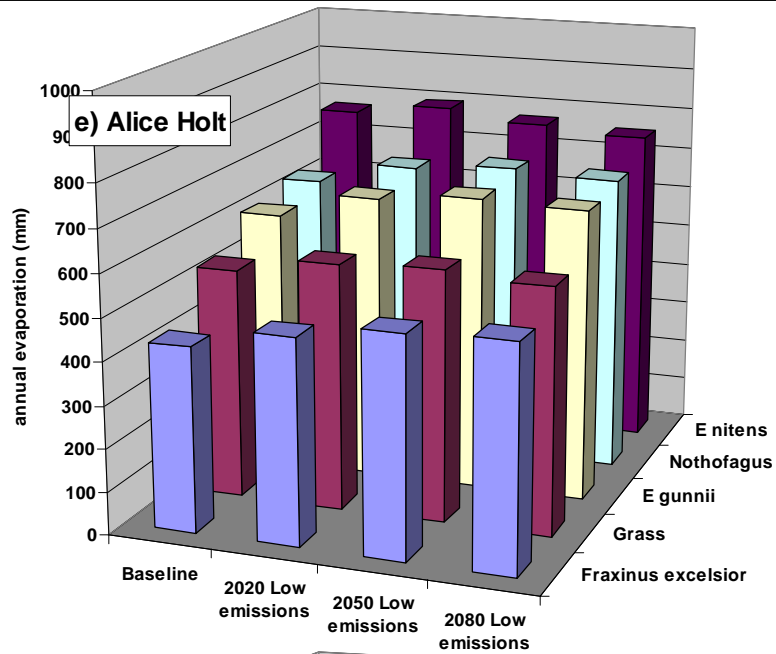
Eucalyptus nitens
E. gunnii,
Nothofagus,
Fraxinus excelsior

at 8 UK locations under present and future climates.

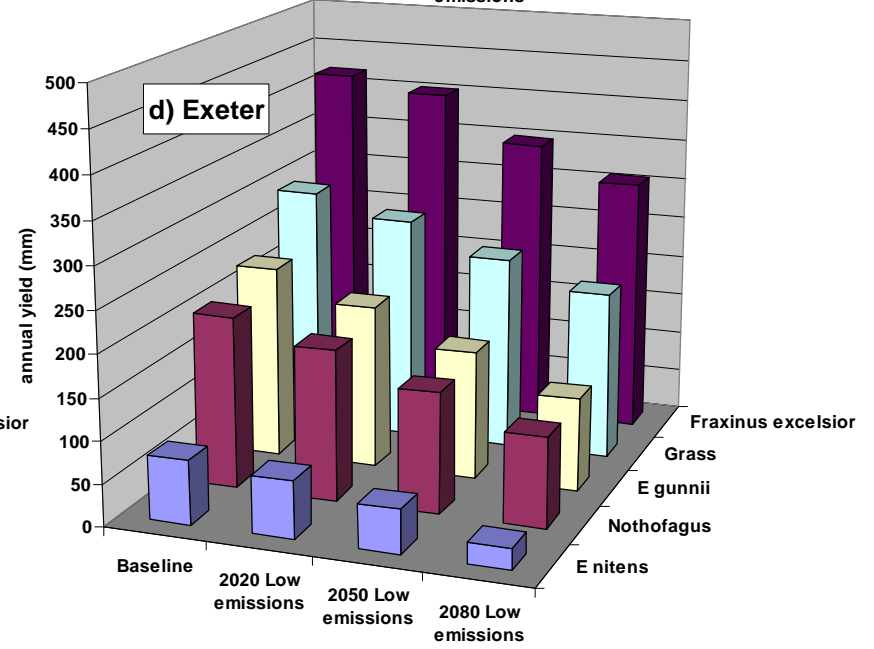
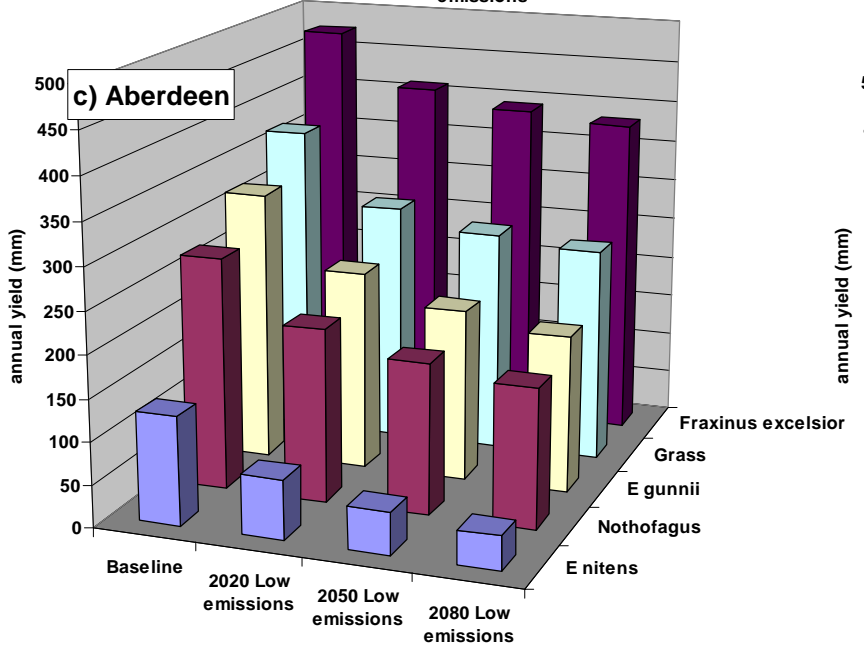
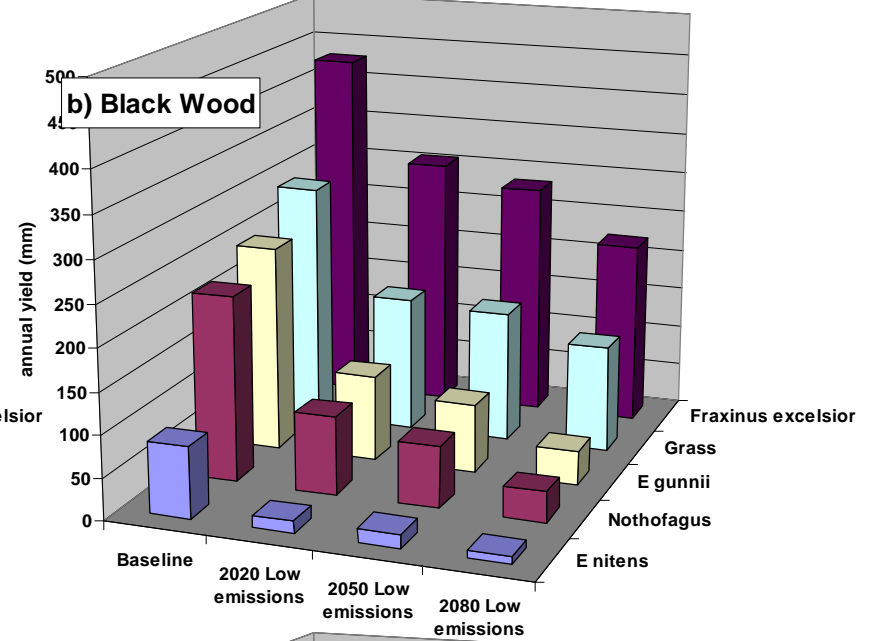
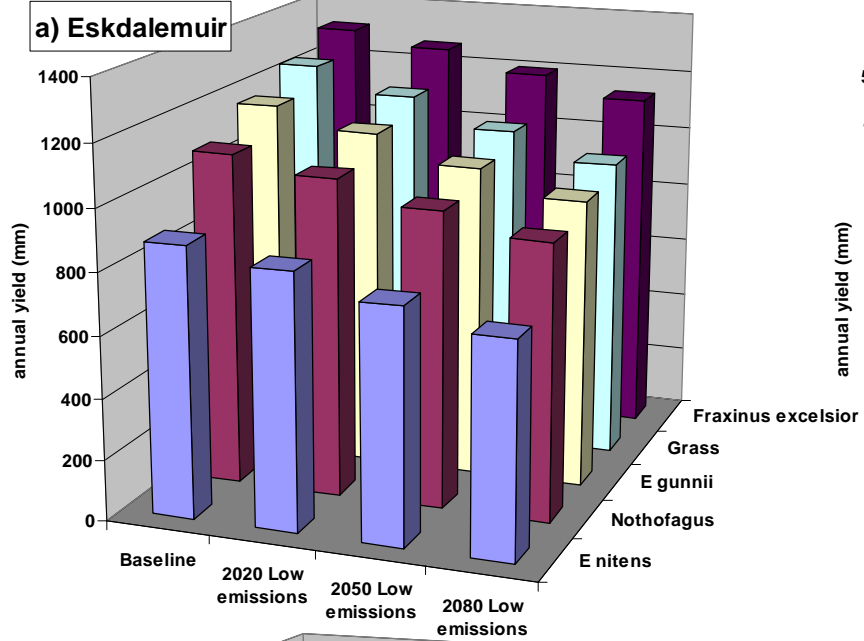
❖ EARWIG weather generator calibrated on UKCIP02 climate scenarios shows 'potential annual water yield' (Rain-PE) -ve at all, except wet sites by 2080.



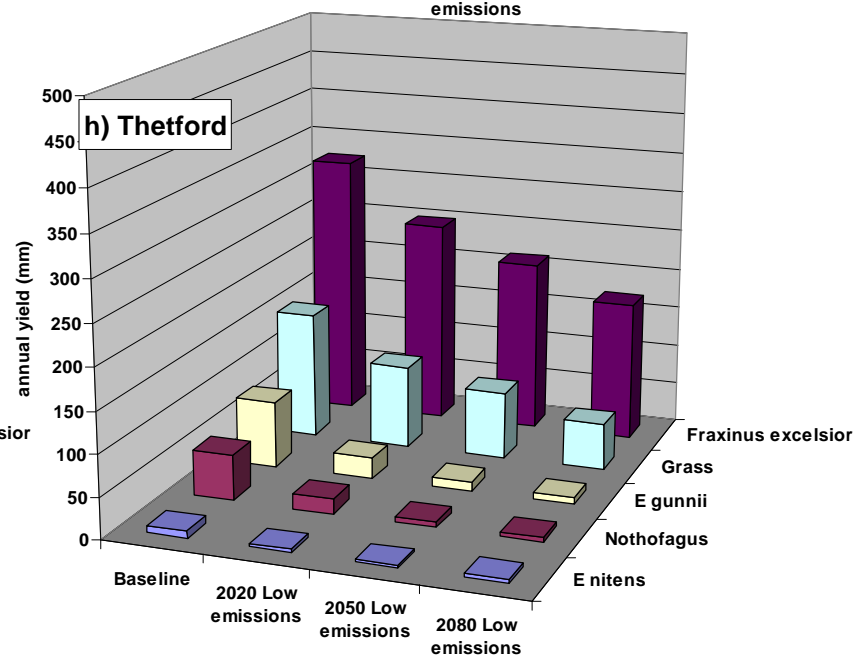
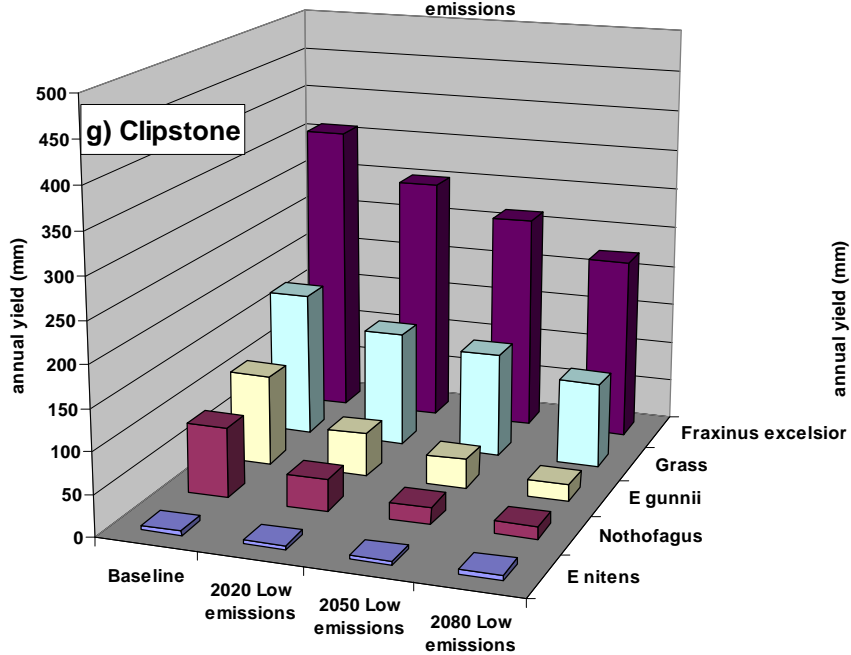
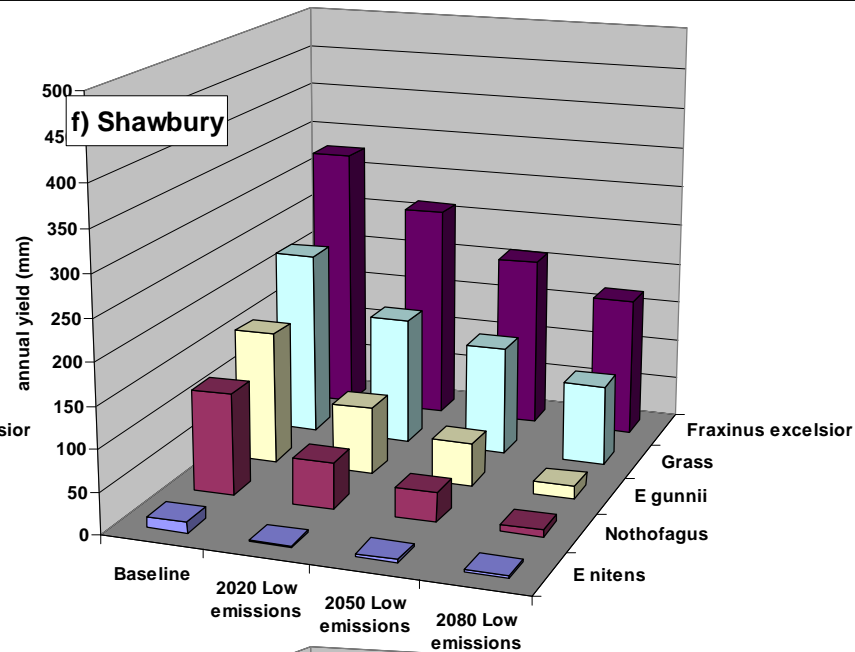
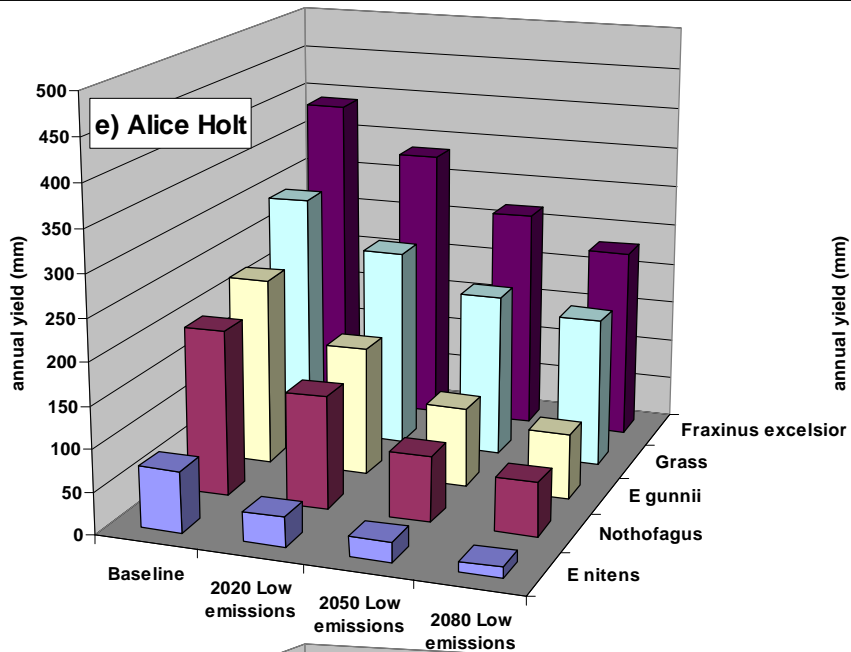
**Mean annual evaporation for all species and all Low Emission climate change scenarios
–wetter sites**



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?

The screenshot shows the IUFRO website interface. At the top, there is a navigation bar with links for DISCOVER IUFRO, SCIENCE IN IUFRO, WHO IS WHO, EVENTS, PUBLICATIONS, REGIONS, and MEMBERSHIP. Below this is a search bar and a login/register section. The main content area is titled "Forests and Water Interactions" and features a sidebar with a menu of divisions and task forces. The main text includes a section for the Task Force Coordinator, Jan R. Calder, and a detailed "Background" section discussing the need for the task force. It also outlines the aims of the task force, terms of reference, and working methods.

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SCIENCE IN IUFRO / TASK FORCES

Forests and Water Interactions

Task Force Coordinator:
[Jan R. Calder](#), United Kingdom

Background

New policy drivers are underpinning forestry schemes in many regions of the world. 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?

The role of forests in relation to the sustainable management of water resources remains a contentious issue in many parts of the world. This is despite a significant advance in scientific understanding of forest and water interactions based on almost a century of research in forest hydrology. Uncertainty, and in some cases confusion, persists because of difficulties sometimes in translating research findings between countries and regions, between different catchment scales, between different forest types and species, and between different forest management regimes. There has also been a failure to effectively communicate results to policy makers and planners and to challenge entrenched views.

The IUFRO Task Force on Forests and Water Interactions will aim to:

- > Identify the process whereby a consensus can be obtained amongst the forest hydrology community on the key forest and water interaction issues – recognizing and making explicit any caveats with respect to uncertainties in our knowledge about the interactions;
- > Highlight issues that remain poorly understood as the focus for further policy –relevant research;
- > Contribute to the development of a framework for assessing the cost/benefits of forestry schemes in relation to: timber production, biodiversity, societal, environmental and water resource factors;
- > Unite approaches developed for "Sustainable Forest Management" with those developed for "Integrated Water Resources Management"

Terms of Reference

The Task Force will prepare policy briefs supported by case/demonstration studies on the above topics.

The Task Force will contribute to, and where necessary help to organize, meetings and workshops to explore Forest and Water interaction issues and encourage/facilitate improved dialogue and information exchange both among and between forest scientists and policymakers.

In this regard the terms of reference were discussed at the IUFRO sponsored conference on Forests and Water in a Changing Environment in Beijing, China from 8-10 August 2006 and will be subject to ongoing review. The Task Force will also contribute to the 5th Ministerial Conference on the Protection of Forests in Europe (MCPFE), Warsaw, 2007.

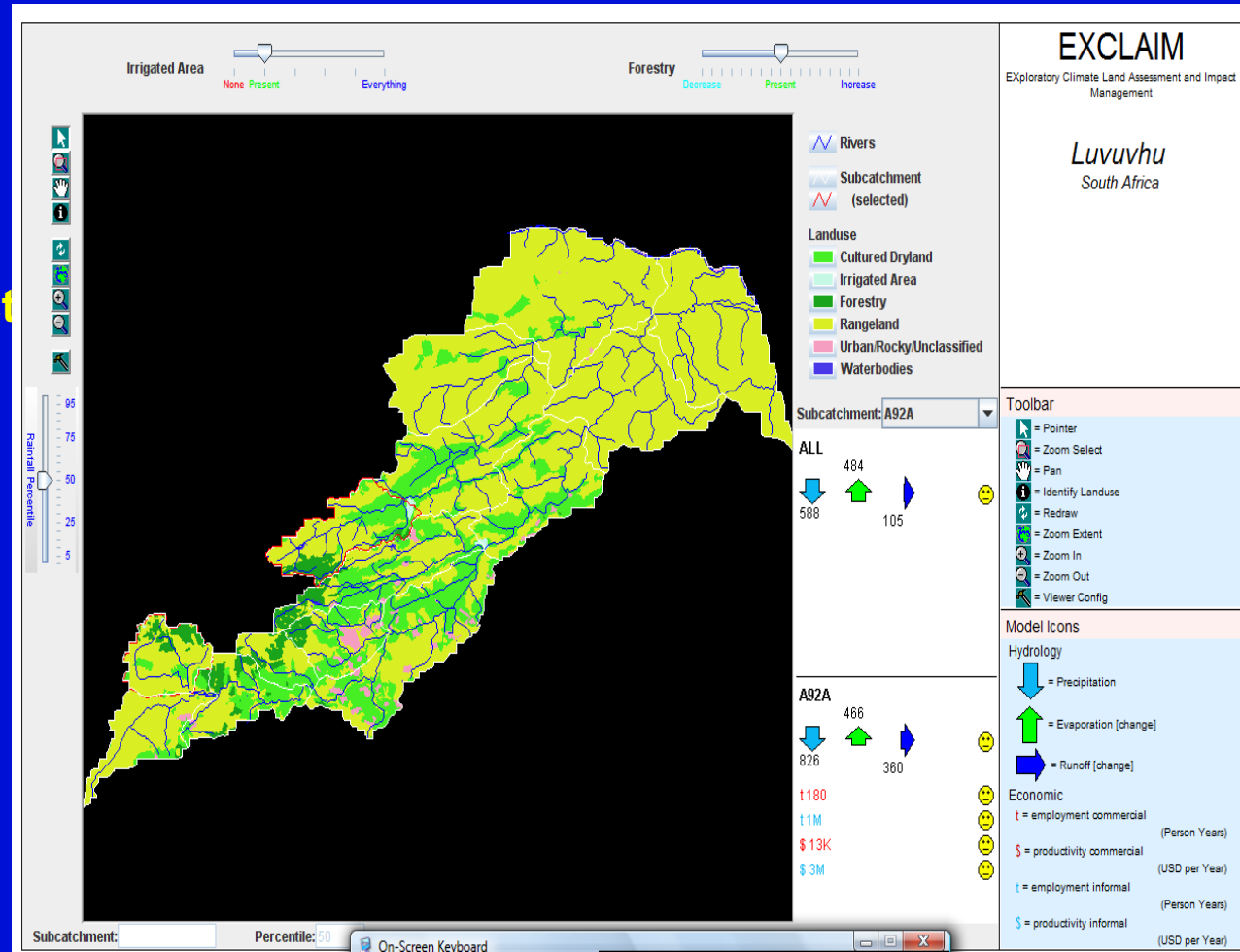
Members and working methods of the Task Force on Forest and Water Interactions

The Task Force will consist of a small international core group that will include a balanced representation of forest hydrologists and policymakers who have an interest in forest and water issues. The Task Force will aim to develop a larger network of contributing members with interests in land and water management, the provision of environmental services, socio-economics, bio-energy, and climate change, as these relate to forest and water impacts. These members will be invited to participate in meetings, provide specialist input to specific problems, provide reviews of material prepared on behalf of the Task Force and, on occasion, represent the Task Force at meetings.

Send comments to [Jan R. Calder](#) (Coordinator)

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

