Forest Research

Pine-tree lappet moth (*Dendrolimus pini*) future climate evaluation

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Dendrolimus pini – Pine-tree Lappet Moth

- Serious defoliator of pine forests in central and eastern Europe
- Feeds on various pine species and other conifers - causes severe conifer defoliation & death
- *PtLM* outbreaks can cover 000's ha of pine forests esp. Poland & Germany
- 233,000ha of forest in Poland required **direct control** to reduce damage (1946-95)
- 83,700ha damaged in NE Germany (1993-96)

Pine-tree lappet in Britain

- Not considered native to Britain – only occasional rare sightings of males in southern and eastern England
  - Surrey- 1748
  - Norfolk- 1809
  - Isle of White- 1996
  - Cornwall- 2003
  - Kent- 2004
  - Guernsey- 1989 to 2004 (5 records)
  - Jersey- 2005 to 2008 (3 records)
- British Records – Kiltarlity, near Inverness
- First record - 1 male moth caught in light trap - Inverness- July 2004
- 2004-08: 13 males moths captured in Scotland - 11 from one location
- 3x as many moths caught in 2008 compared to 2007 using same technique/ location
- No obvious signs of damage yet at this or any other site

Why is it here? Is it breeding?

- Migrant males ?
- Plant debris (on used forest machinery) ?
- On imported plants ?
- Accidental introduction ?
- Might be a native species that might have remained unrecorded ?

BUT

- Glue banding in 2009 confirmed 7 breeding sites in discrete area - 1400 ha pine plantations
- Caterpillars feed on Sitka spruce in the lab

Is climate change expanding PtLM range?

Figure 3 - Annual mean temperature (°C) for Scottish regions, 1914 to 2004, with smoothed curve. The vertical dashed line marks the position of 1961.

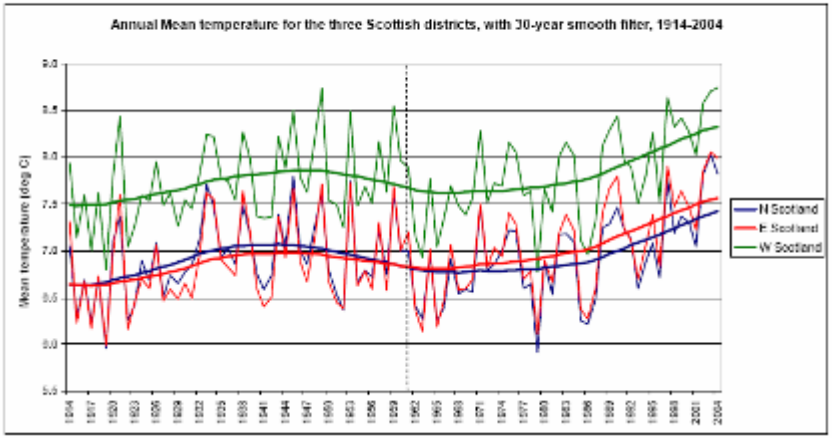
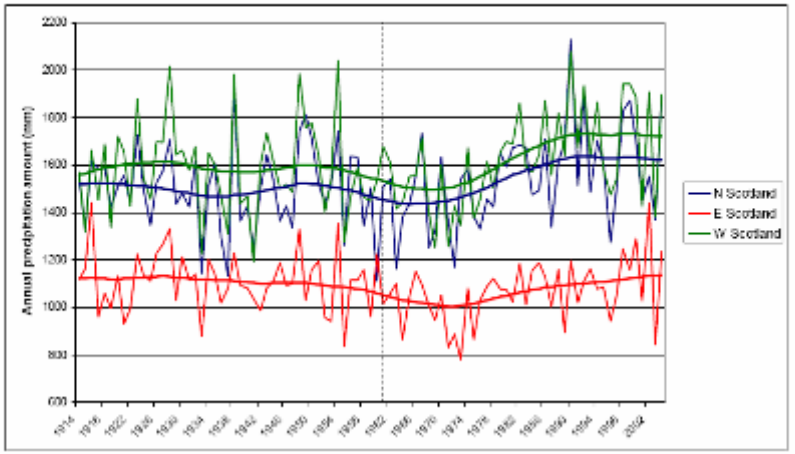


Figure 23 - Annual precipitation amount (mm) for Scottish regions, 1914 to 2004, with smoothed curve



Mean Change T degC	1961-2004			
	North Scotland	East Scotland	West Scotland	Scotland
Spring	*1.03*	**1.23**	**1.20**	**1.14**
Summer	**1.06**	**1.12**	**1.08**	**1.08**
Autumn	*0.64*	*0.68*	*0.66*	*0.66*
Winter	1.03	*1.39*	*1.31*	*1.22*
Annual	**0.92**	**1.08**	**1.04**	**1.00**

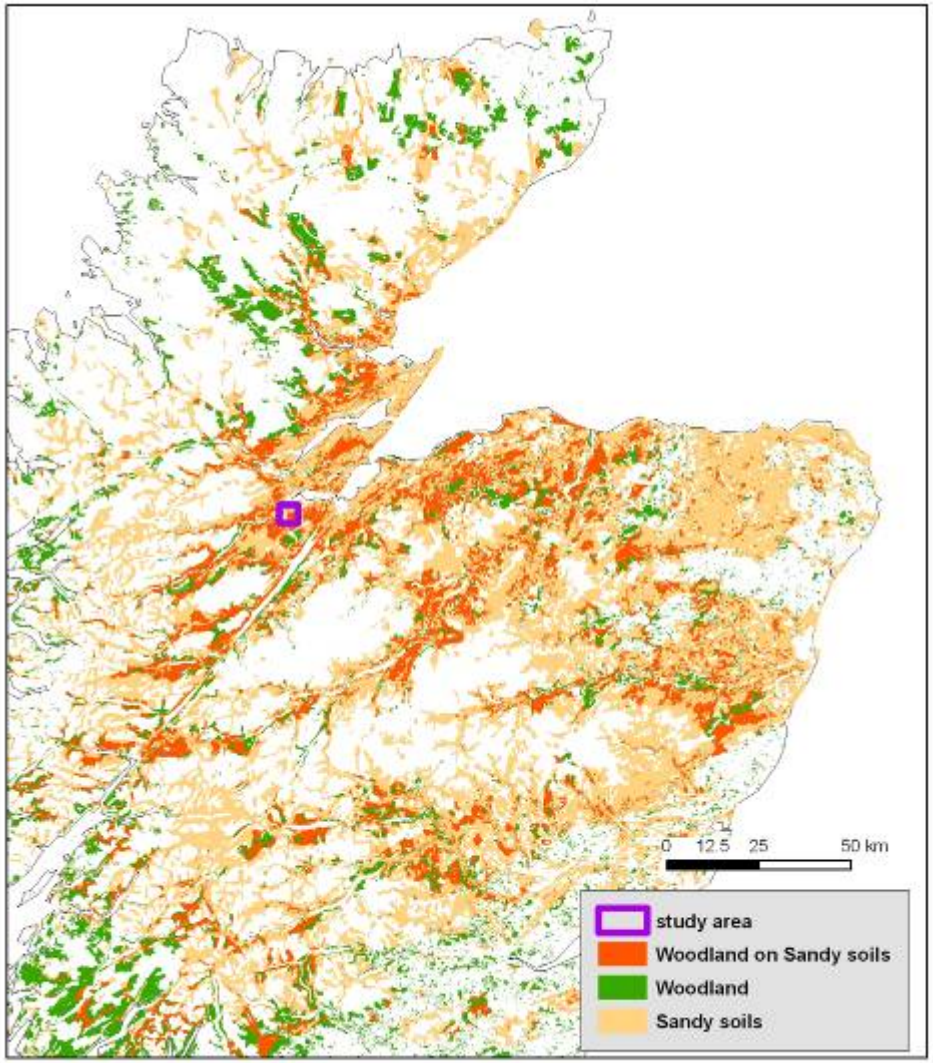
Mean Change P %age	1961-2004			
	North Scotland	East Scotland	West Scotland	Scotland
Spring	16.2	9.4	17.3	14.8
Summer	-7.0	0.2	7.3	-0.6
Autumn	5.3	22.2	5.9	9.1
Winter	**68.9**	**36.5**	**61.3**	**58.3**
Annual	**21.0**	*18.4*	**23.3**	**21.1**

Barnett, C., J. Hossell, M. Perry, C. Procter and G. Hughes (2006)

Denrolimus pini (PtLM) ecology

- *PtLM* prefers
  - sandy freely draining soils
  - cold dry winters
  - warm summers
- Preferred host tree is *Pinus sylvestris* but other conifers at risk

Map shows all woodland on freely draining podzols, sands, ironpans, and podzolic brown earths



Climatic indicator of *PtLM* outbreak severity

- Seljaninov's hydrothermal coefficient (SHC)
- Combined measure of summer warmth and summer rainfall
- In Poland SHC is used to indicate areas of frequent outbreaks of *PtLM*

Selyaninov's hydrothermal coefficient

$$SHC = \frac{P}{\sum_{T>10} \frac{T}{10}}$$

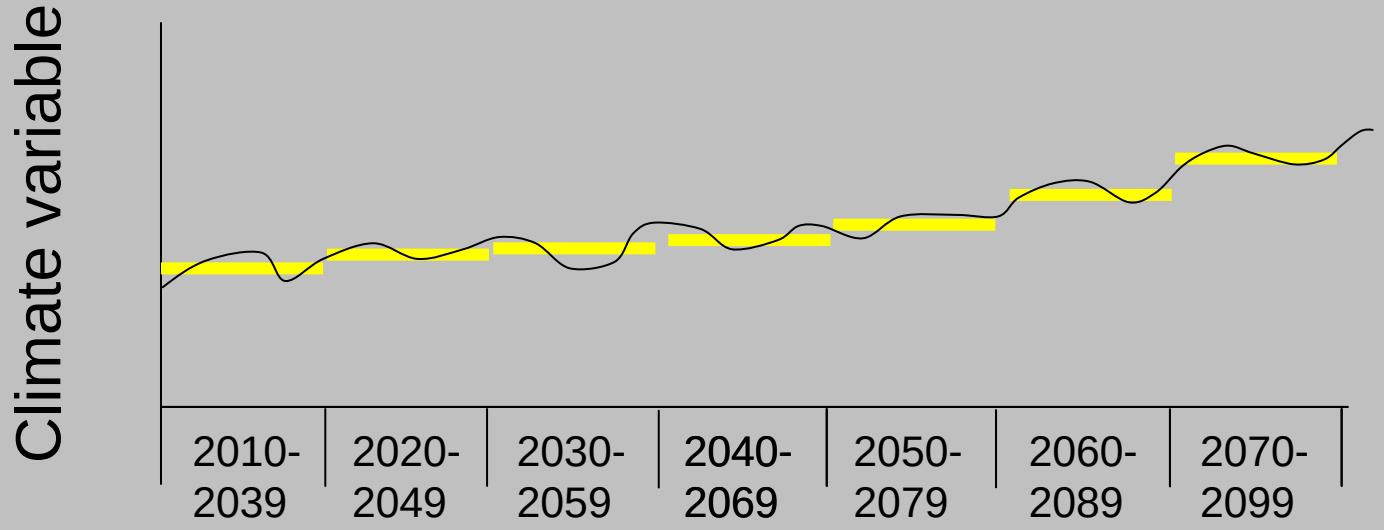
0.4 - 0.7	very dry
0.7 - 1.0	dry
1.0 - 1.3	insufficiently wet
> 1.3	wet

[1] **Seljaninov's hydrothermal coefficient provides an example of a joint action of two fundamental abiotic factors. It is calculated according to the formula: (precipitation total x 10) divided by temperature (active) total. The coefficient values from 1.0 to 1.5 characterize an optimal humidity of a region, above 1.6 – its excess and below 1.0 – deficit. The most dangerous outbreaks of pine moth occur on areas in Poland with the lowest (1.2) value for Seljaninov's coefficient (Lesniak, 1976a).**

- SHC values 1.0-1.5 show suitable climate for PtLM
- SHC around 1.2 associated with critical outbreaks

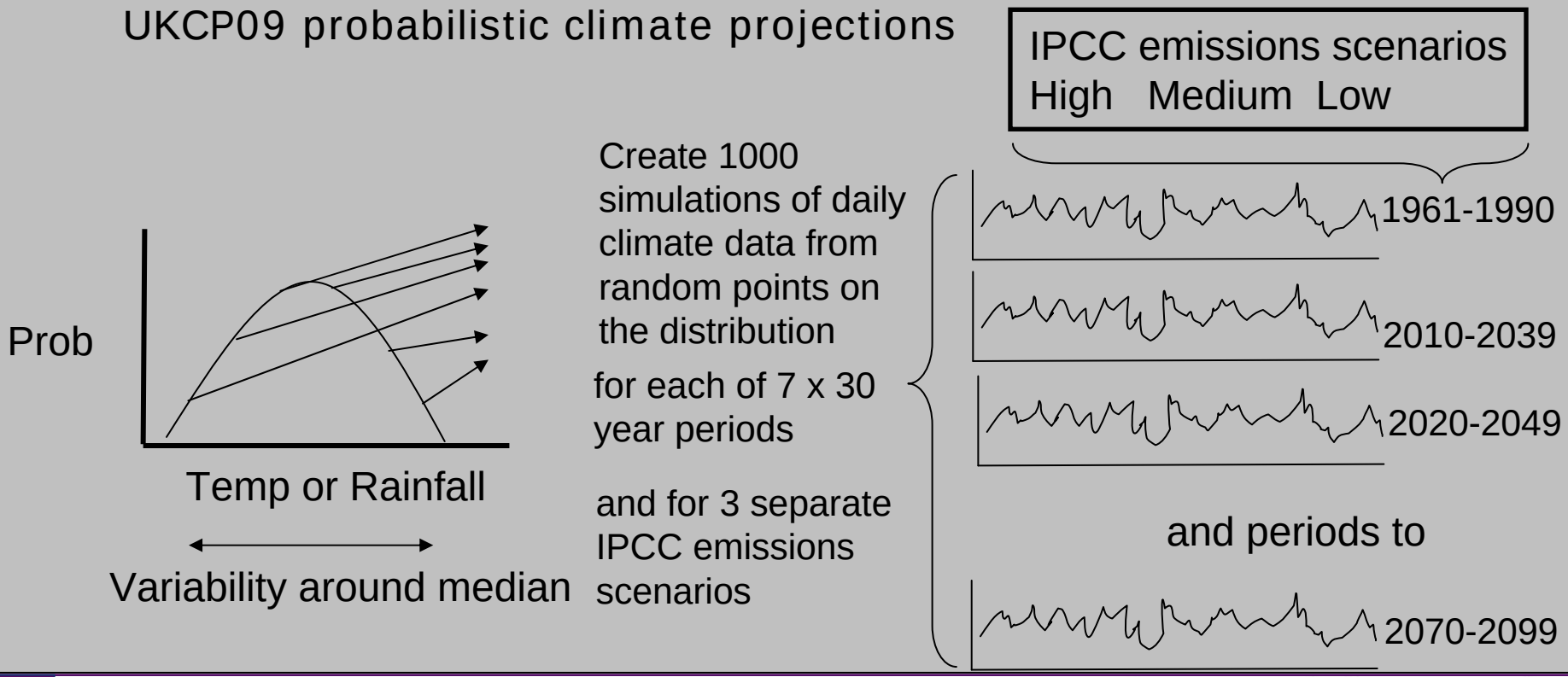
UKCP09 Weather Generator - Projections

- UKCP09 climate projections
  - Weather generator
    - Daily simulations of climate variables (include)
      - Temperature – min, max, mean
      - Precipitation
    - Timescale daily simulations 2010 to 2099
      - Arranged in 30 year periods – e.g. 2020-2049
      - 7 periods at decadal intervals 2010-2039, 2020-2049, etc to 2070-2099



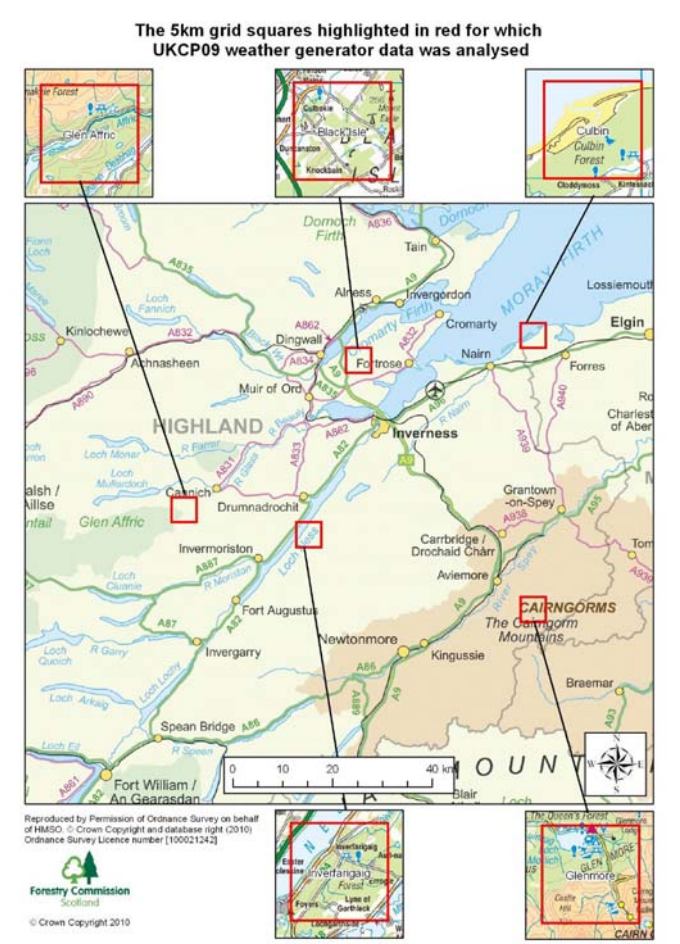
Method: UKCP09 WG & Seljaninov's coeff

- Sample UKCP09 Weather Generator – spatial resolution 5km x 5km squares and temporal resolution of daily values based on 30 year climatic averages
- Calculate a mean temperature for each month and the total rainfall for months where mean T>=10 ^{0}C
- Calculate Seljaninov's coefficient
- Incorporate climate change projections and uncertainty from the UKCP09 probabilistic climate projections

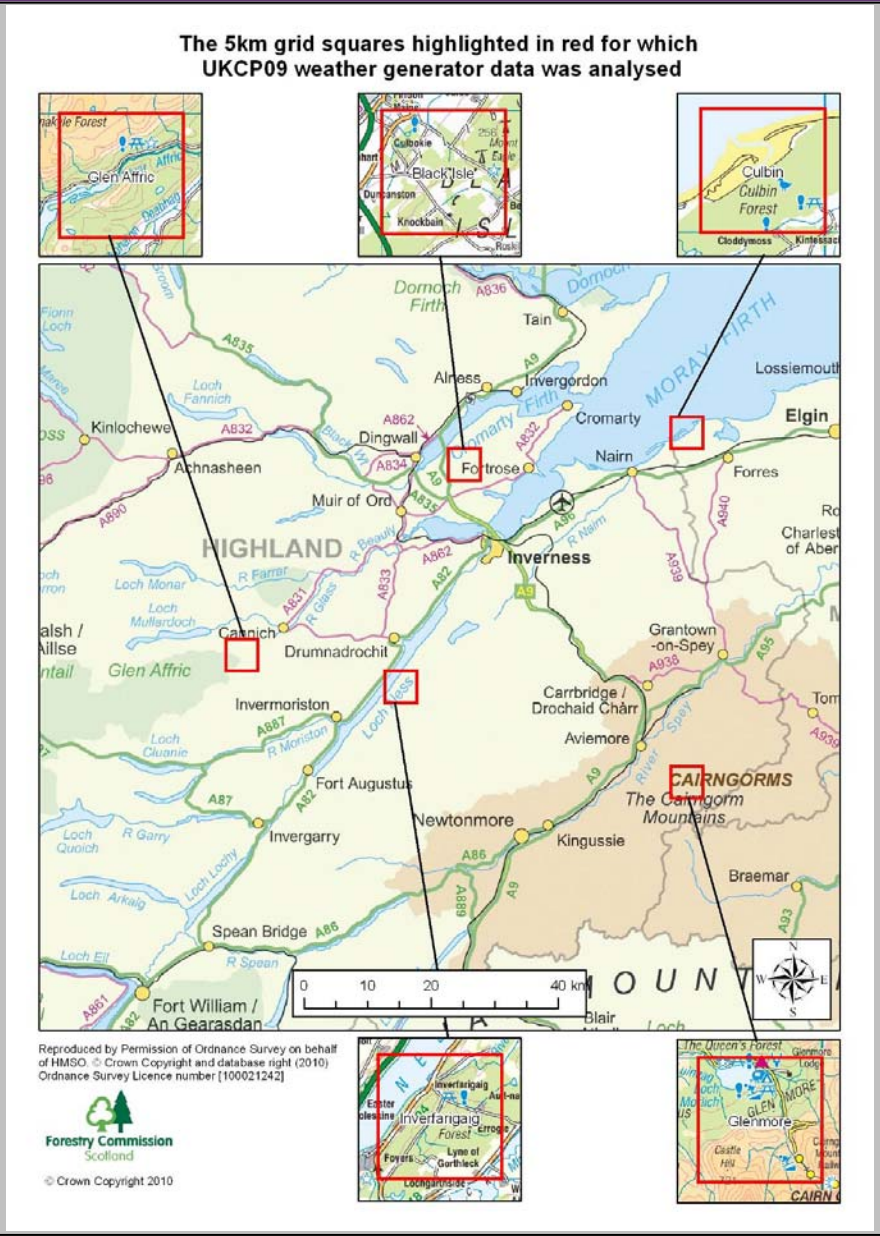


Sample square for UKCP09 data

- Sample WG for 5 5kmx5km squares containing Scots pine forest in North East Scotland – 1) Glen Affric 2) Black Isle 3) Culbin 4) Great Glen 5) Glen More

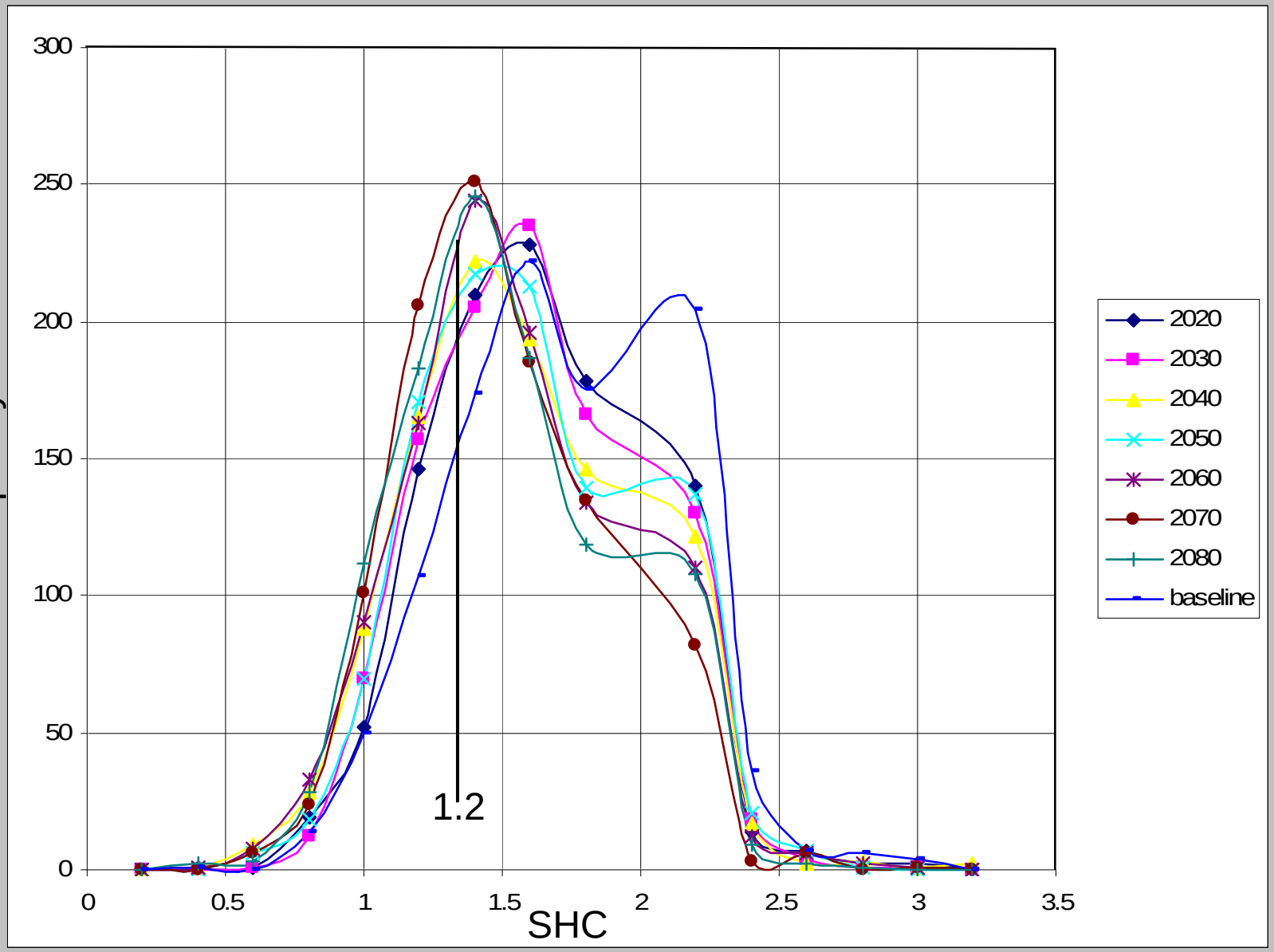


Additional data for December 2010 meeting

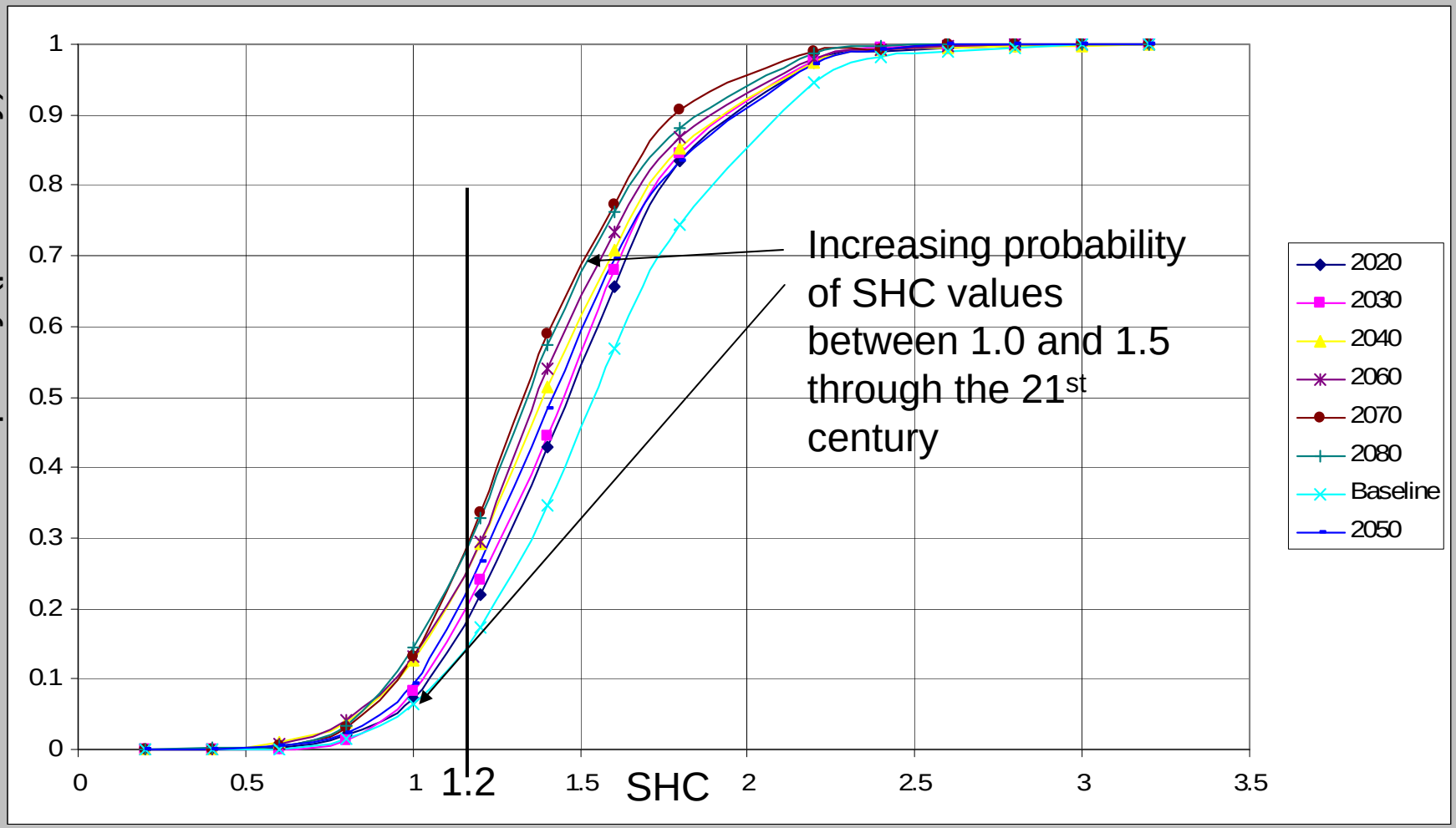


- Data extracted from UKCP09 climate projections – Weather Generator (WG)
  - Daily simulations of climate variables (include)
    - Temperature – min, max, mean
    - Precipitation
  - Timescale daily simulations 2010 to 2099
    - Arranged in 30 year periods – e.g. 2020-2049
    - 7 periods at decadal intervals 2010-2039, 2020-2049, etc , to 2070-2099

Beauly - Low emissions scenario IPCC B1



Beauly - Low emissions scenario IPCC B1



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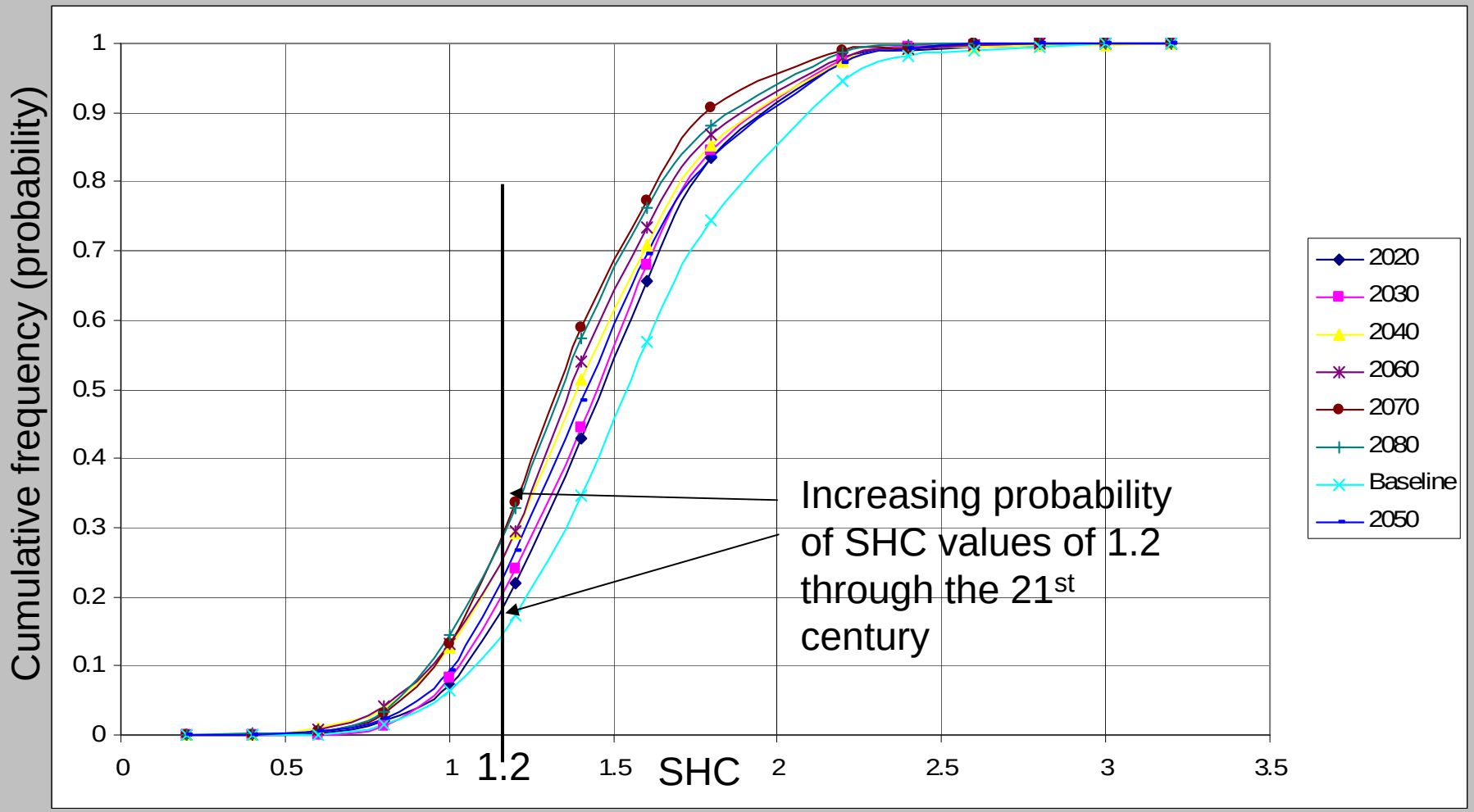
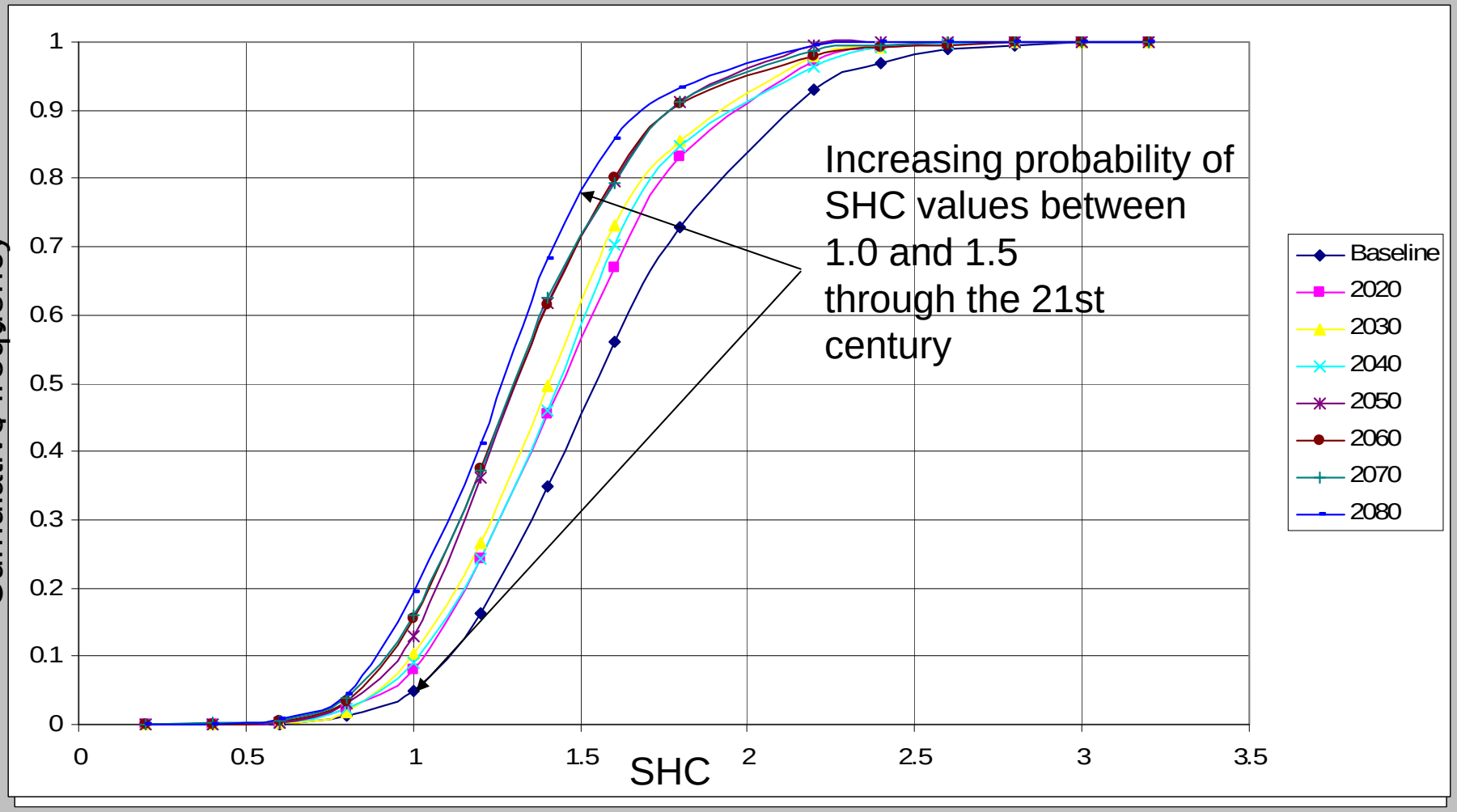


Beauly - High emissions scenario IPCC A1FI



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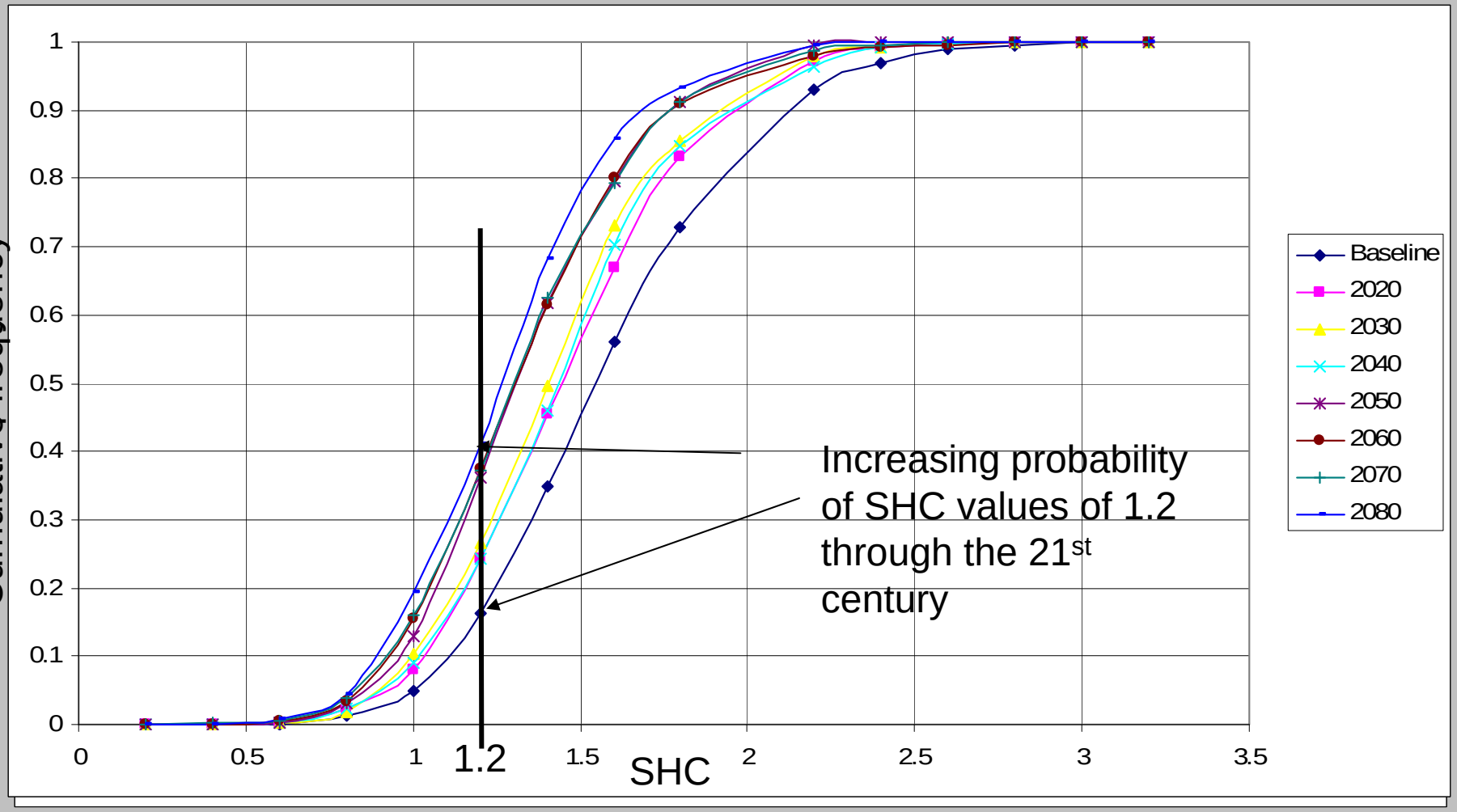
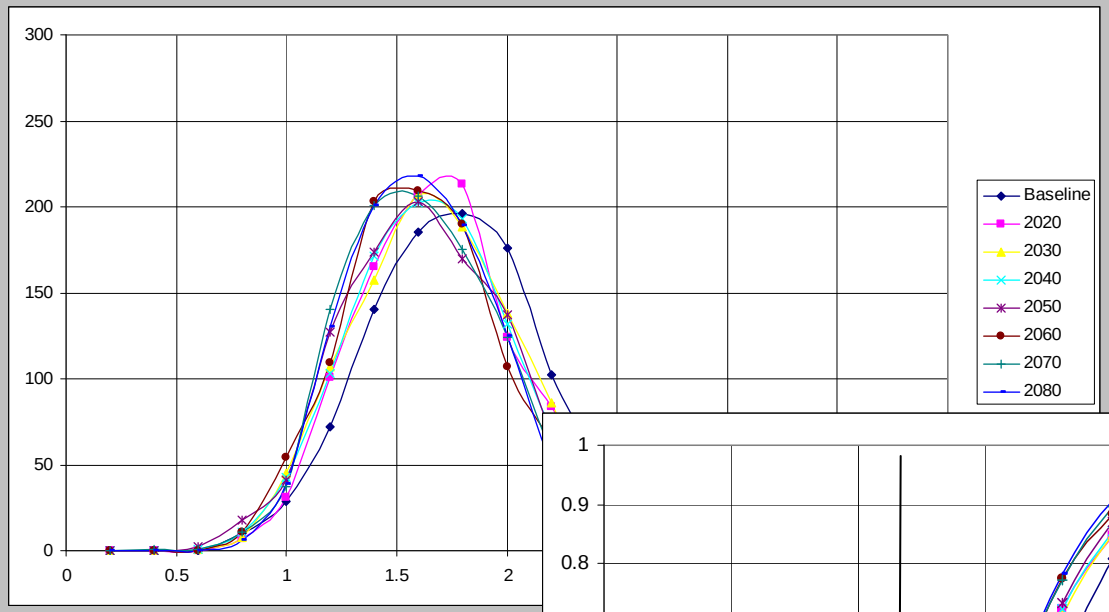
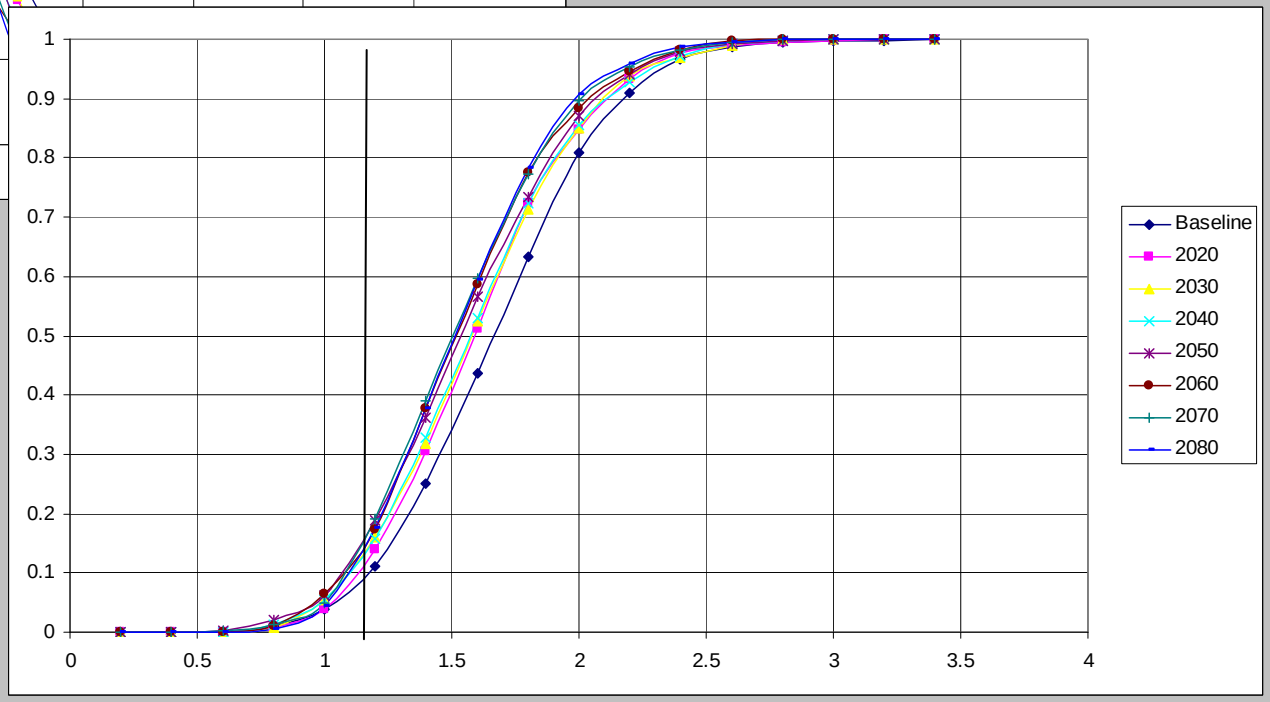


Inverfarigaig – NH500200 – cell 2550825





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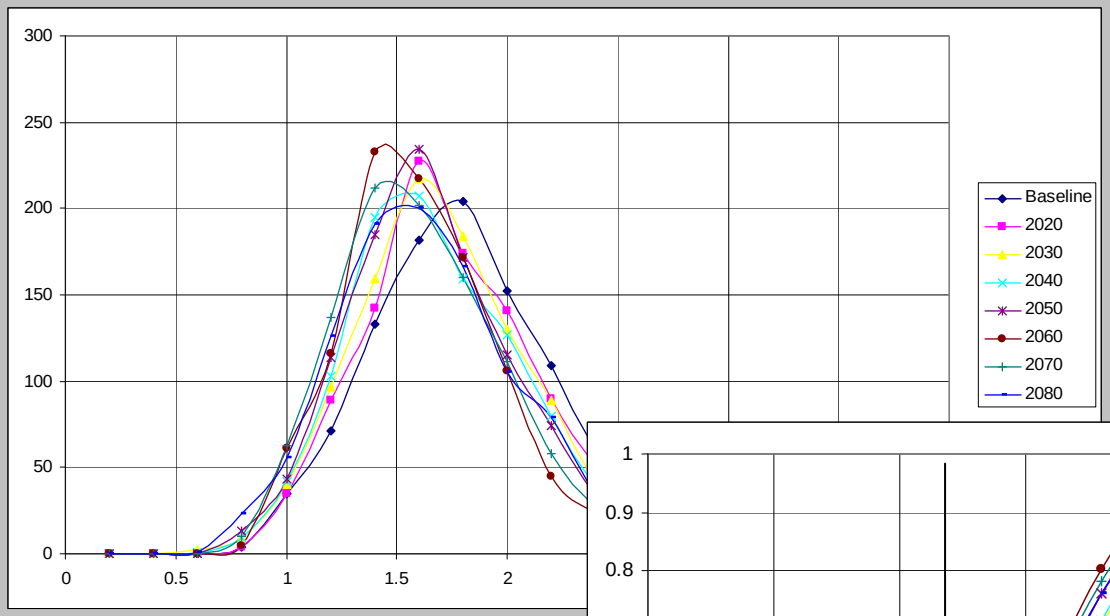
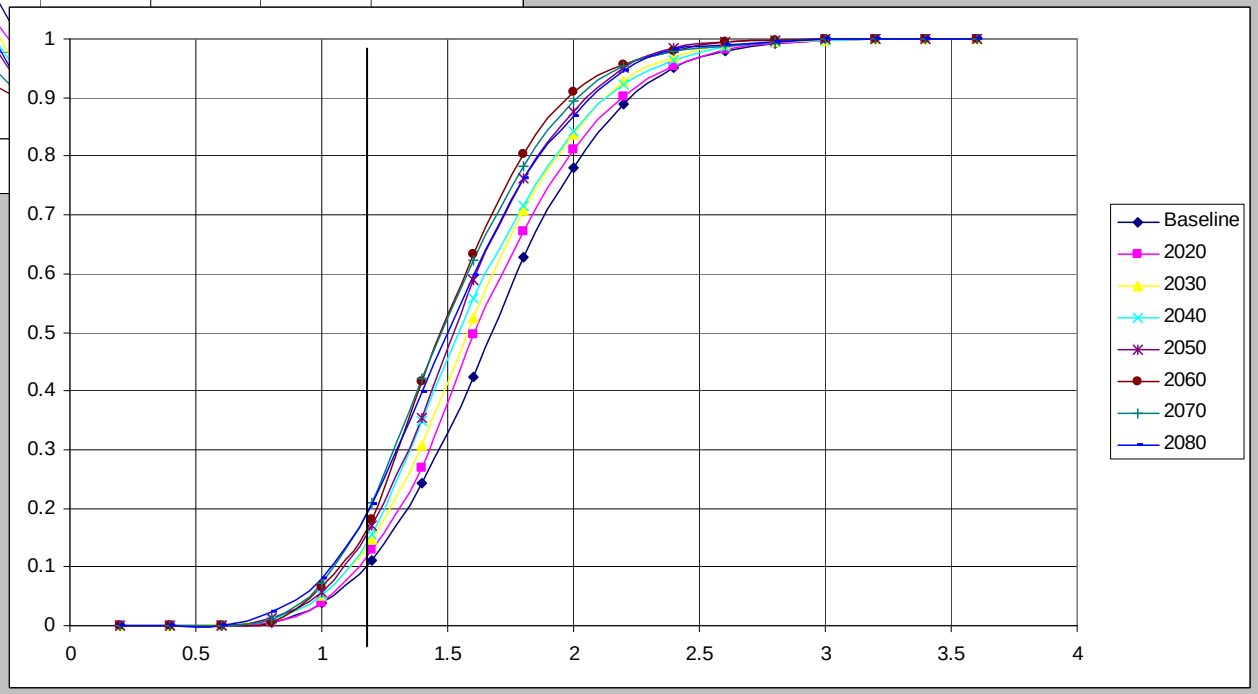
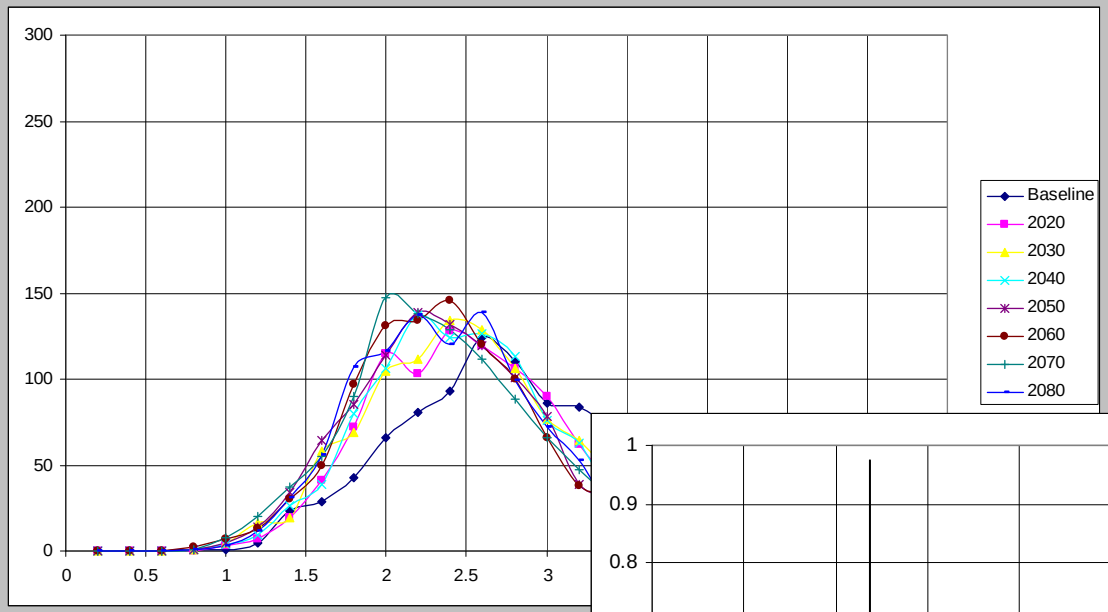
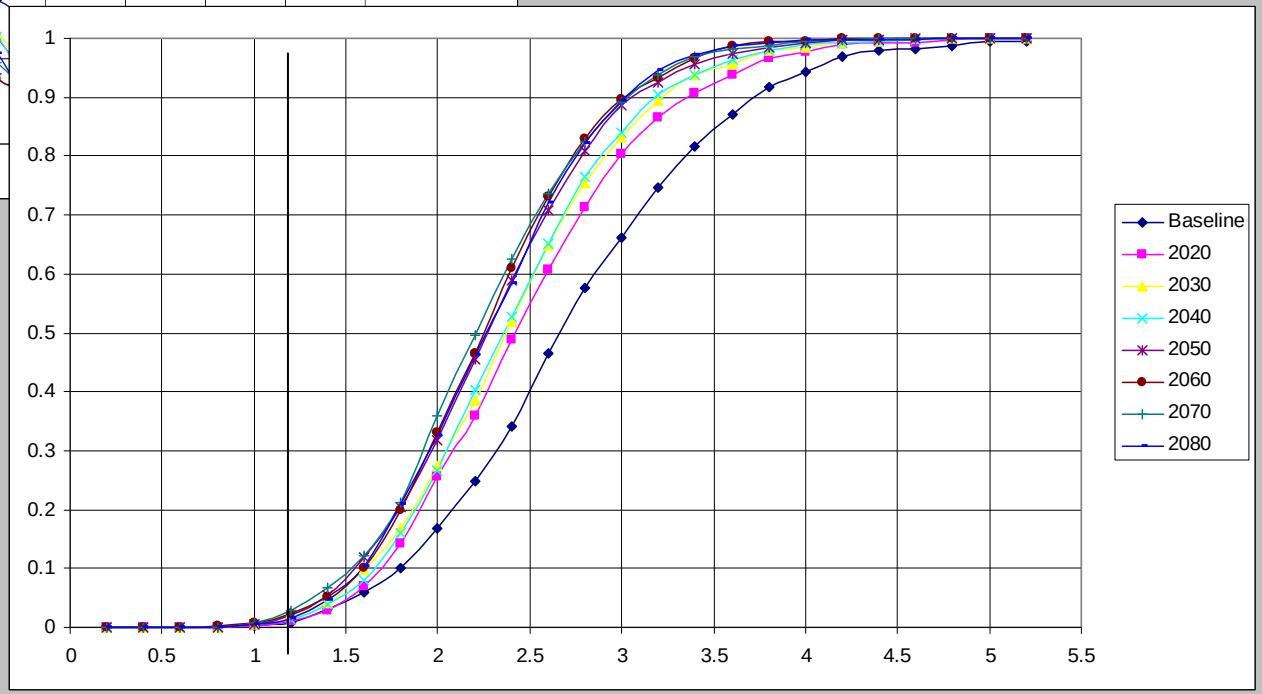




Glenmore – NH950050 – cell 3000810





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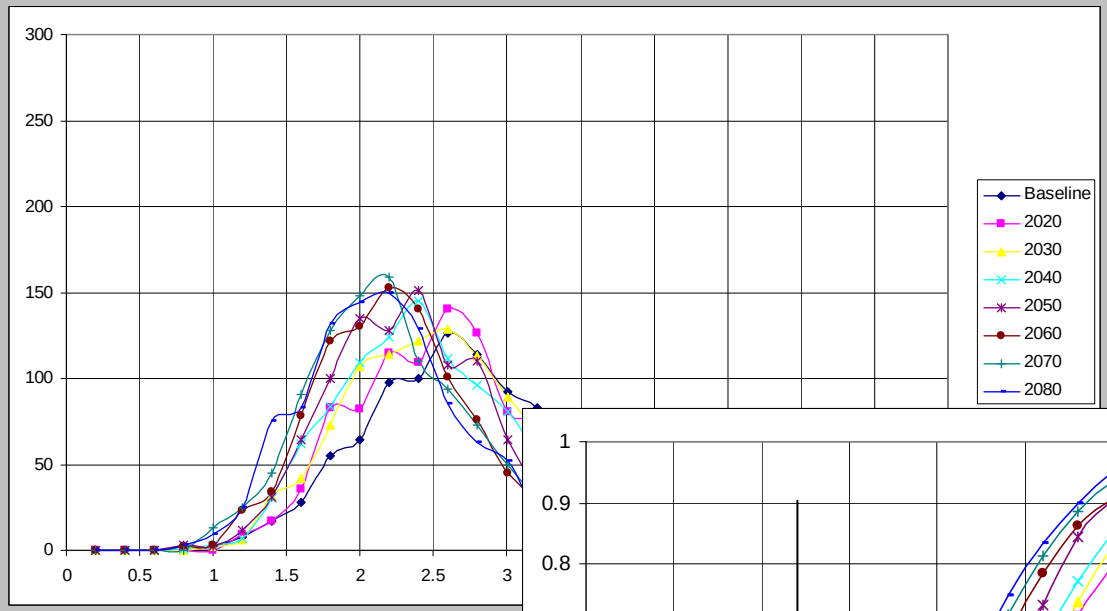
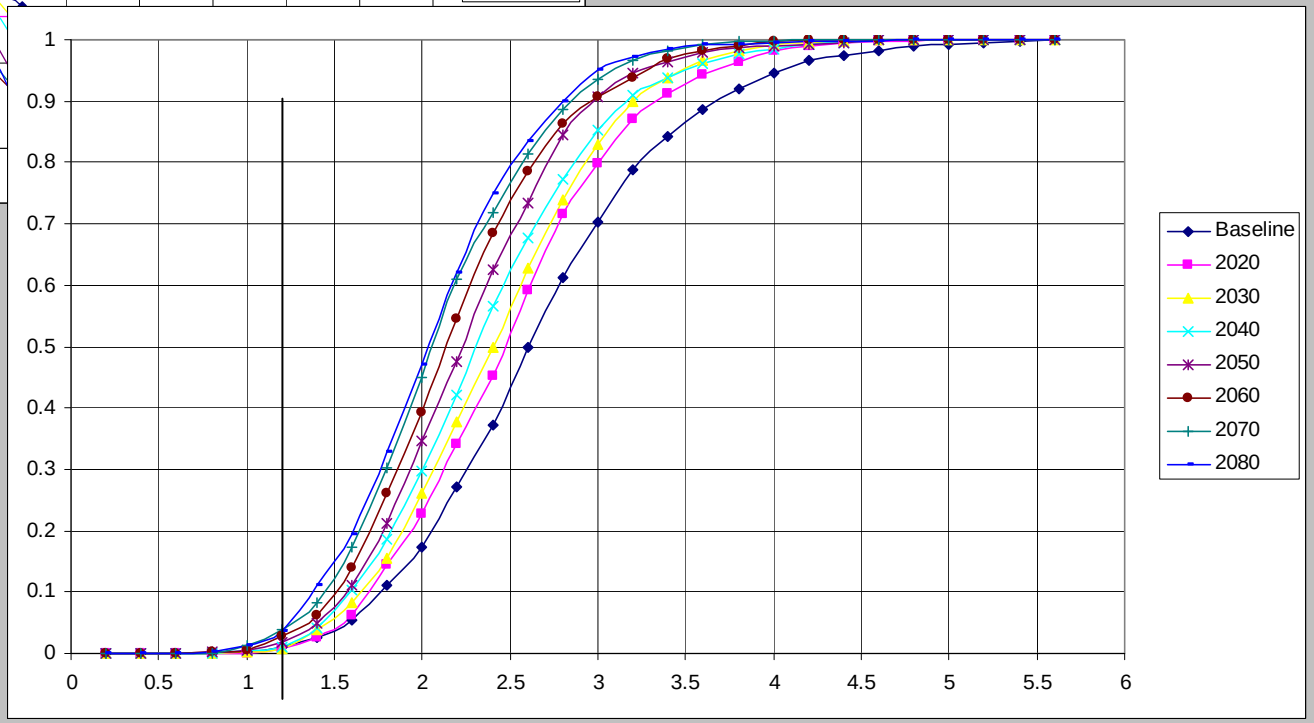
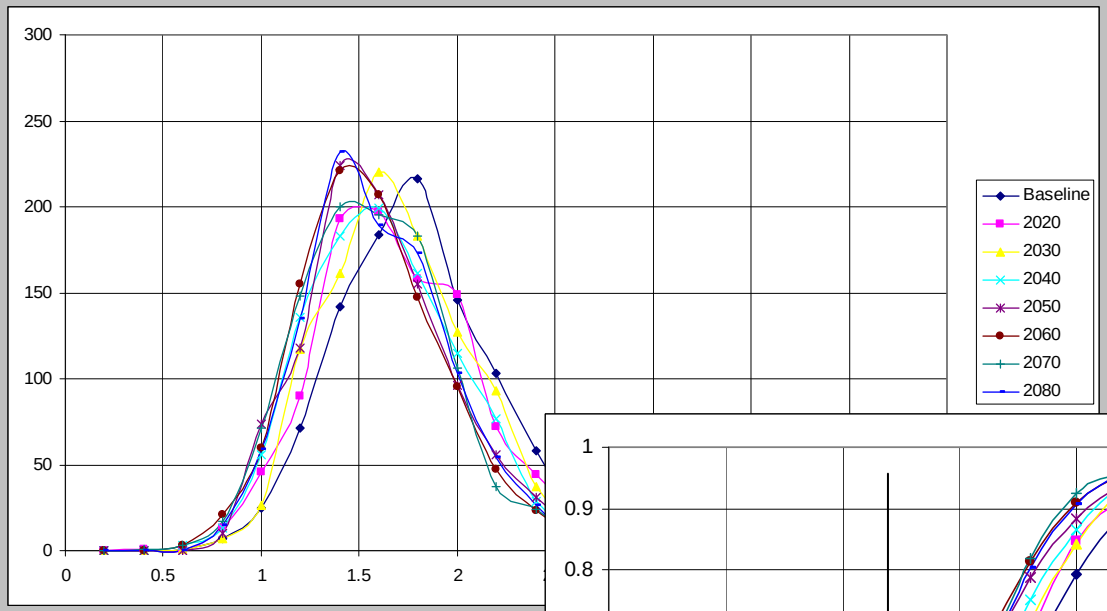
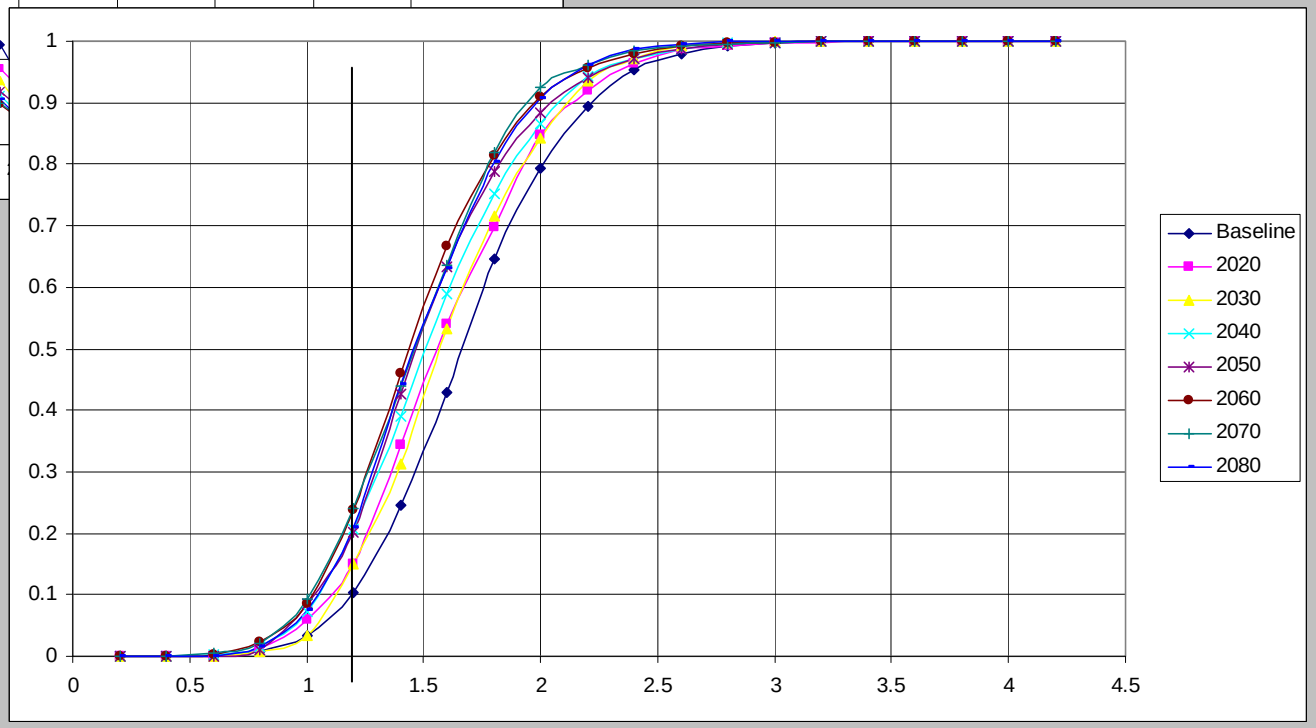


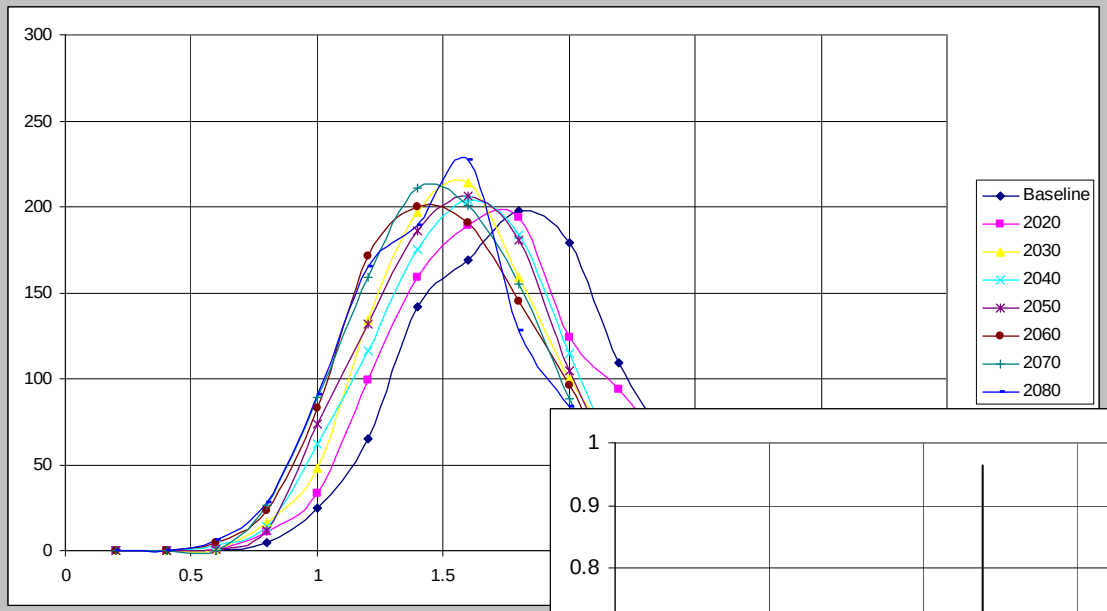


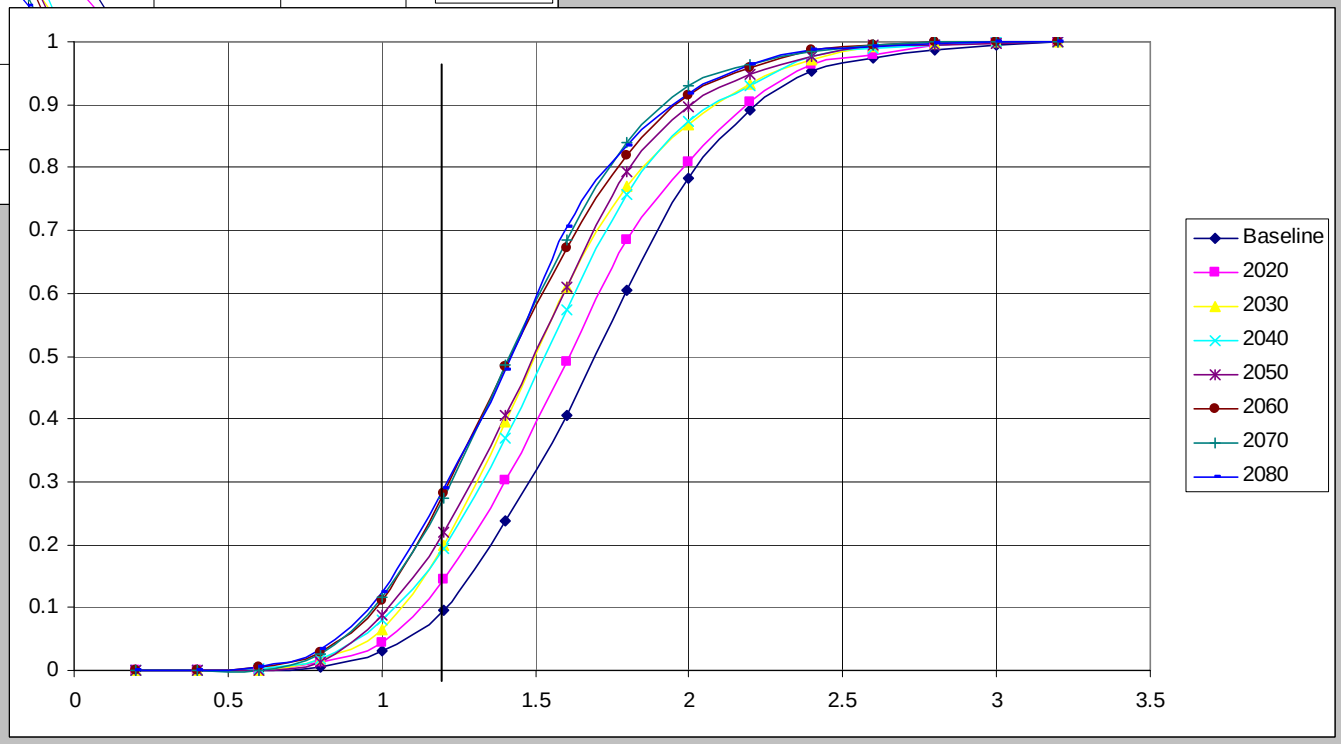
Black Isle – NH600550 – cell 2650860



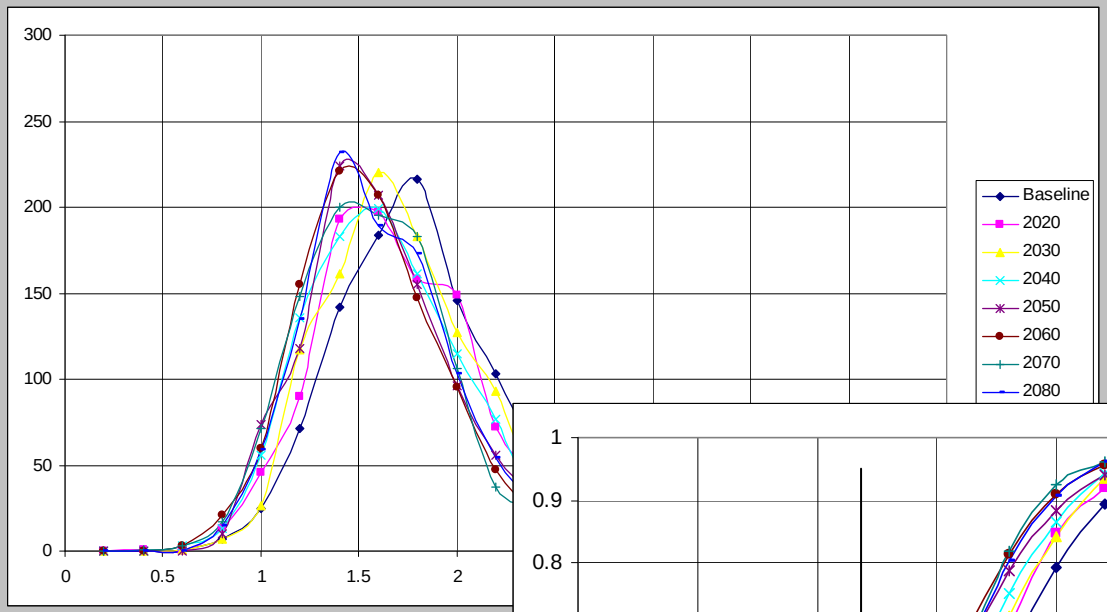


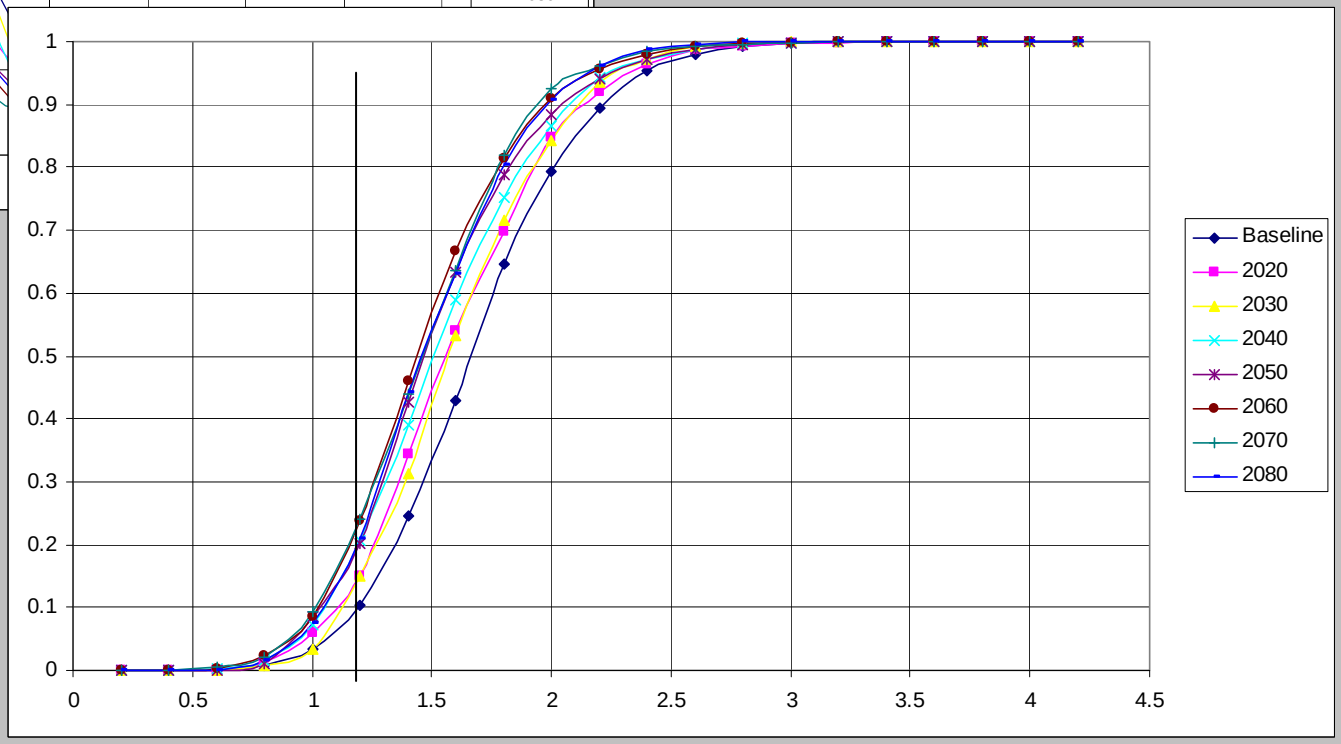
Black Isle – NH600550 – cell 2650860



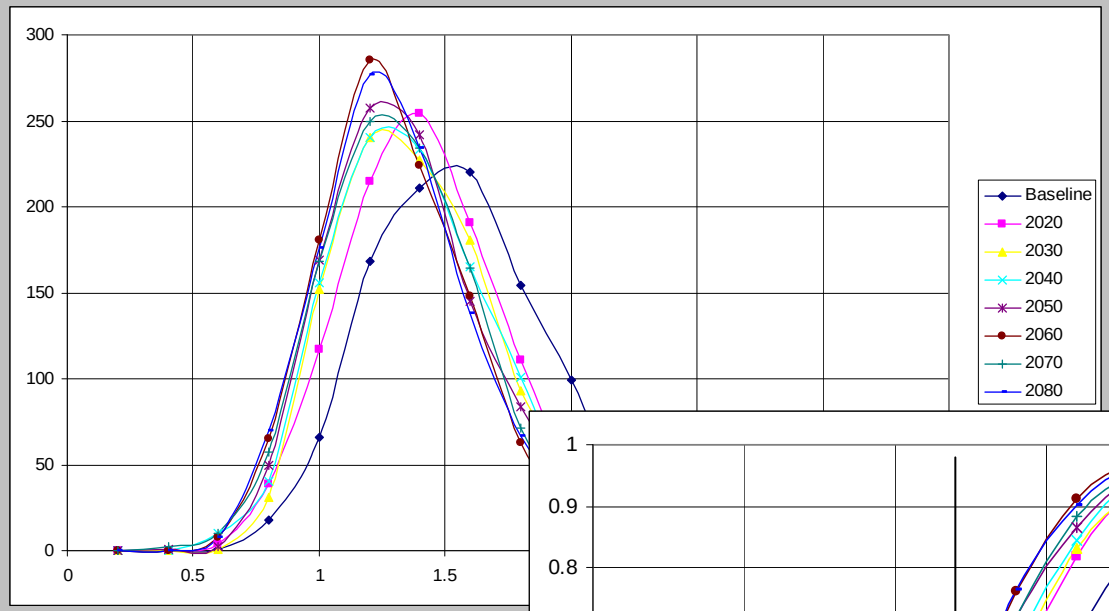


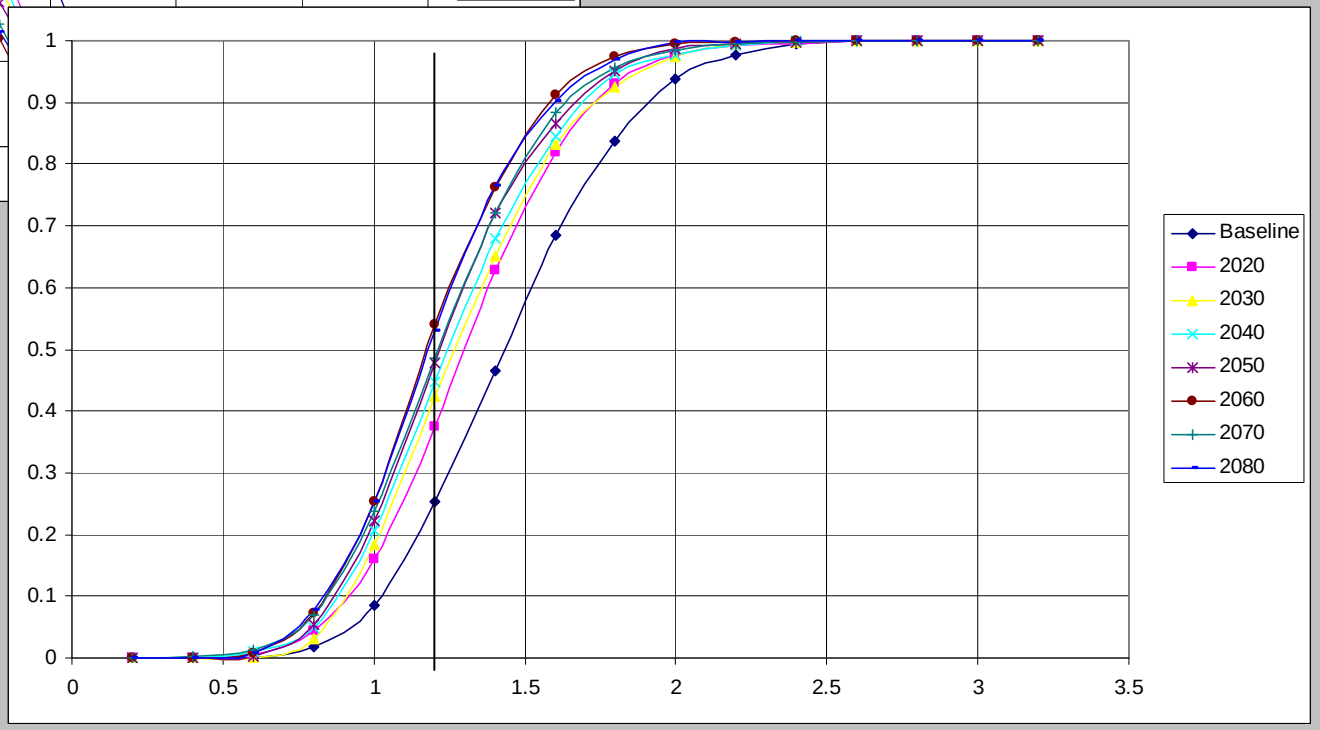
Culbin – NH950600 – cell 3000865



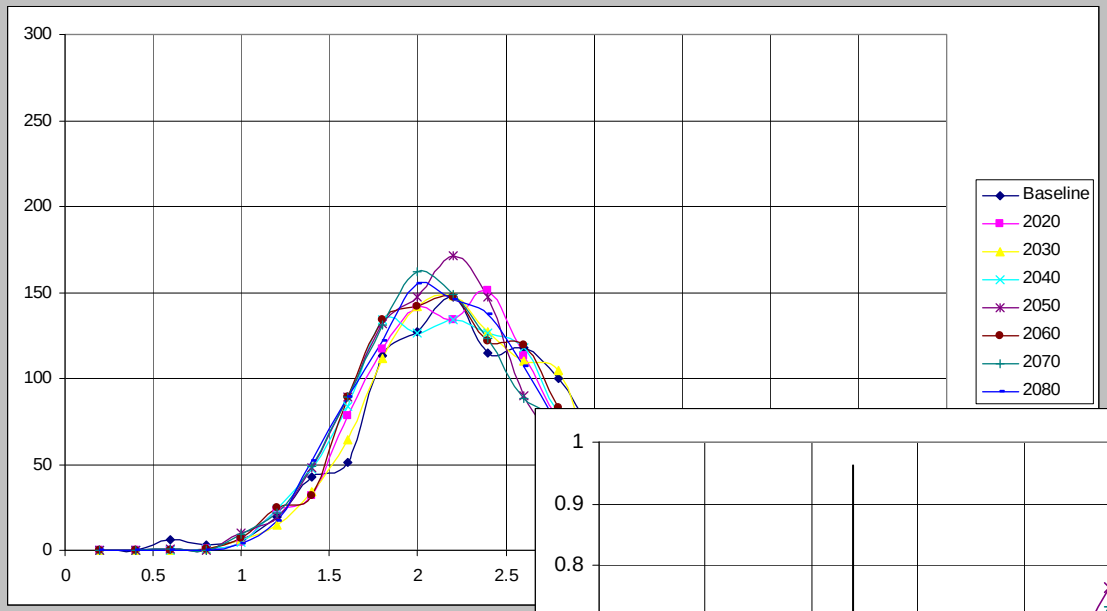


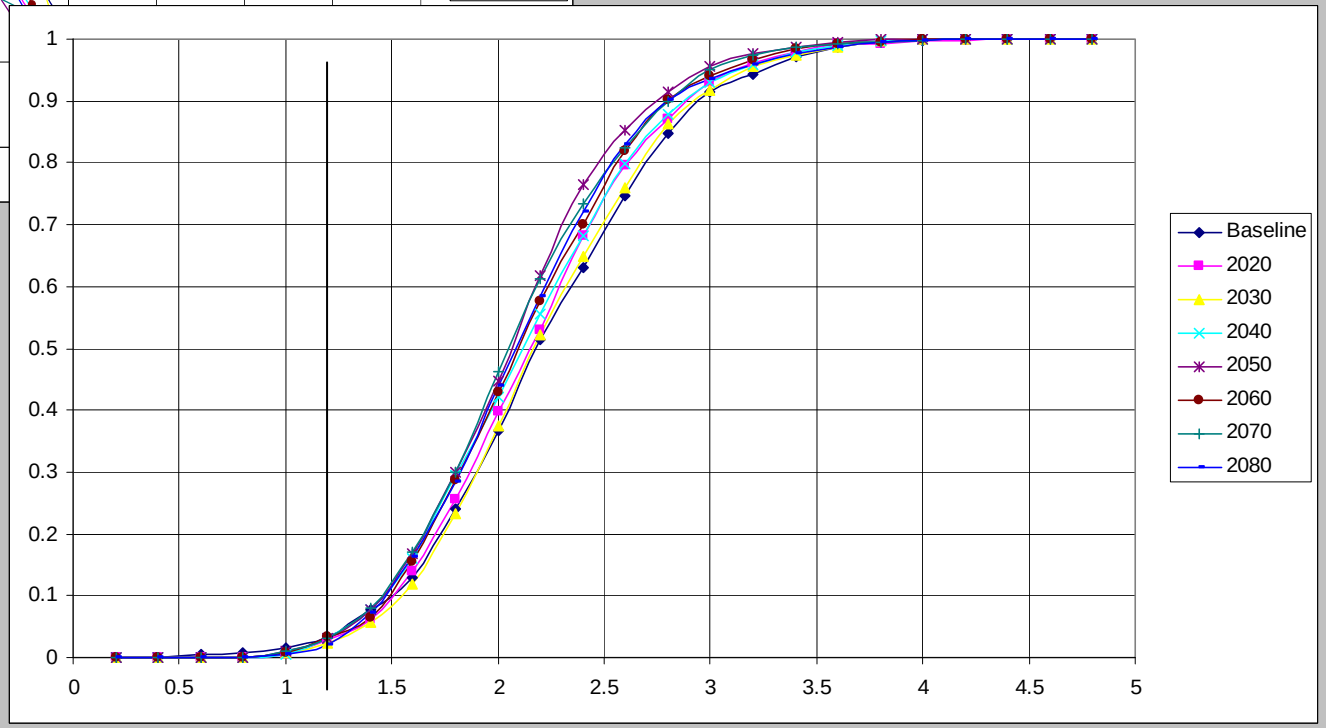
Culbin – NH950600 – cell 3000865



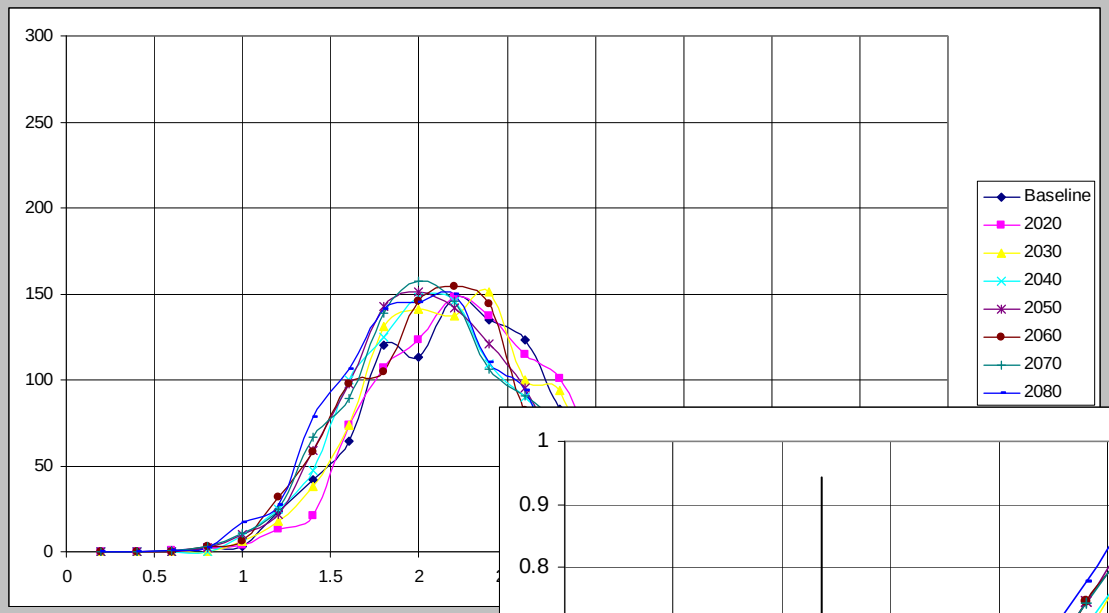


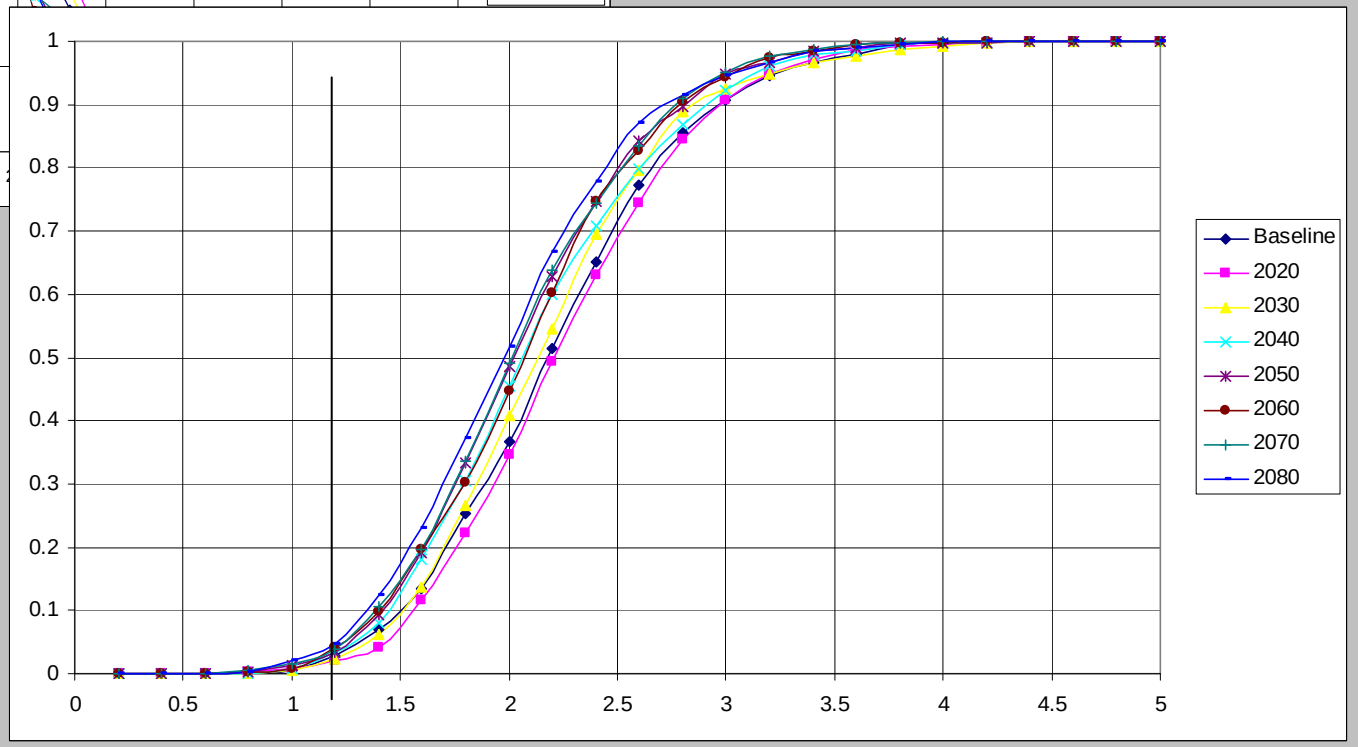
Glen Affric – NH250250 – cell 2300830





Glen Affric – NH250250 – cell 2300830





Probability of different SHC values in 21st C

			Forest					
Emissions	SHC value	Period	Glenmore	Glen Affric	Great Glen	Beauly	Black Isle	Culbin
Low	1.0	baseline	0.01	0.01	0.04	0.05	0.07	0.04
		2050	0.02	0.02	0.05	0.06	0.08	0.08
		2080	0.02	0.02	0.06	0.07	0.09	0.10
	1.2	baseline	0.01	0.01	0.09	0.12	0.16	0.16
		2050	0.02	0.02	0.13	0.17	0.22	0.22
		2080	0.02	0.03	0.15	0.20	0.26	0.26
	1.5	baseline	0.05	0.08	0.30	0.45	0.33	0.34
		2050	0.08	0.11	0.45	0.60	0.52	0.55
		2080	0.10	0.12	0.50	0.70	0.58	0.59
High	1.0	baseline	0.01	0.01	0.04	0.05	0.04	0.08
		2050	0.02	0.02	0.06	0.10	0.10	0.22
		2080	0.03	0.03	0.09	0.20	0.14	0.27
	1.2	baseline	0.02	0.04	0.10	0.17	0.10	0.25
		2050	0.03	0.05	0.16	0.36	0.21	0.48
		2080	0.04	0.06	0.20	0.40	0.30	0.54
	1.5	baseline	0.04	0.07	0.32	0.45	0.32	0.58
		2050	0.10	0.15	0.48	0.70	0.50	0.80
		2080	0.16	0.18	0.53	0.80	0.60	0.85

Key			
	Seljaninov's coefficient value		
p values	1.0	1.2	1.5
0.0-0.39	low risk	low risk	low risk
0.4-0.69	medium risk	medium risk	medium risk
0.7-1.0	high risk	high risk	high risk

Decadal frequency of SHC 1914-2006 - Culbin

Decade	Vdry	Dry	Iwet	Wet
SeljaninovC	0.4 to 0.7	0.7 to 1.0	1.0 to 1.3	over 1.3
1914-1919*	0	0	2	4
1920-1929	0	0	0	10
1930-1939	0	0	1	9
1940-1949	0	0	1	9
1950-1959	1	0	1	8
1960-1969	0	0	1	9
1970-1979	0	2	0	8
1980-1989	0	0	2	8
1990-1999	0	0	3	7
2000-2006**	0	1	1	5
* 6 years of data (1914-1919)				
** 7 years of data (2000-2006)				

Conclusions

- Ecology of the pine-tree lappet moth - preference for infertile, sandy textured soils, summer climatic conditions that are warm and dry, and for cold winters
- Soils formed from till and diamicton of the Moine schists around the Moray Firth are sandy in texture and infertile, supporting a large area of plantation and Caledonian pine woods
- Climatic analysis using the weather generator simulations for projected emissions scenarios shows that the summer climatic conditions will become warmer and drier in north eastern Scotland throughout the 21st century
- Winter climate will become milder, although there will be years in which colder winter conditions prevail
- Increasing probability of SHC values suitable for pine-tree lappet moth (between 1.0 and 1.5) for Black Isle, Beauly and Culbin forests (in increasing magnitude) will occur in Low and High emissions scenarios
- Glen Affric, Great Glen and Glenmore will not have suitable summer climates for pine-tree lappet moth during the 21st century
- Black Isle, Beauly and Culbin forests (in increasing magnitude) have the highest probability (6-8 years per decade) of SHC values suitable for pine-tree lappet moth in both 2050 and 2080. The probability of critical SHC values of 1.2 increases to 3-5 years per decade
- There will be an increase in the likelihood of ideal climatic conditions for outbreaks in consecutive years. This could make outbreaks more serious and damaging
- Further research on natural predators and winter climatic conditions needed to understand whether pine-tree lappet moth could become a serious pest in Scotland