RMT AFORCE - International Workshop - Forest and Climate Change: adaptation initiatives and new management practices - Nancy, France

EVALUATING ADAPTATION OPTIONS TO COPE WITH DROUGHT EPISODES UNDER FUTURE CLIMATE

CONTRIBUTIONS FROM THE ON LINE WATER BALANCE CALCULATION TOOL BILJOU©

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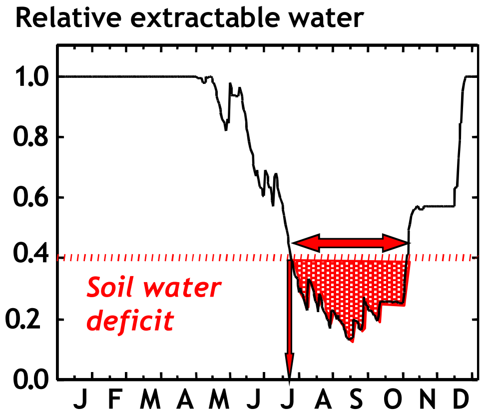
Climate services for drought events

- Climate services for impact and adaptation communities: consequences of past, present and future climate on water cycle, impacts on forest productivity, forest health …
- Needs for drought events quantification: soil water deficit calculation by water balance and drought indices to compare years, stands, sites and contrasting climates



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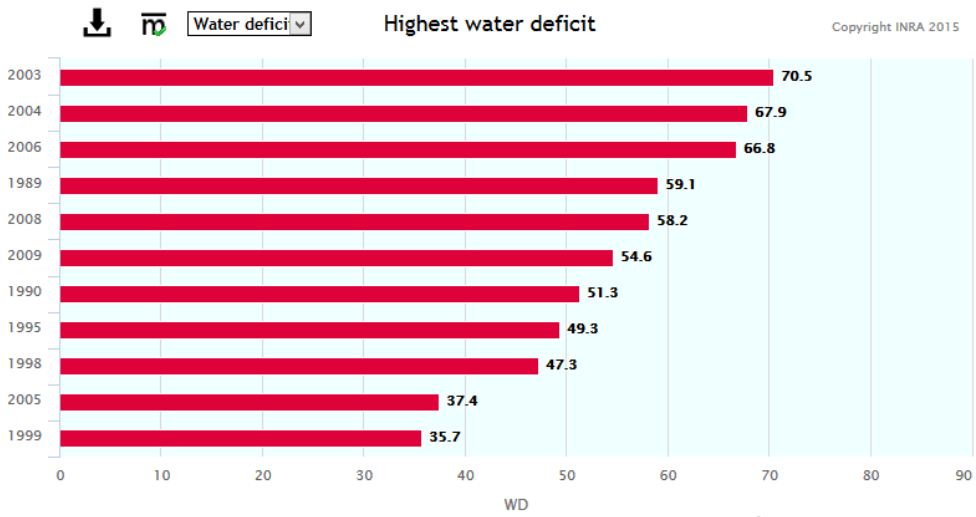
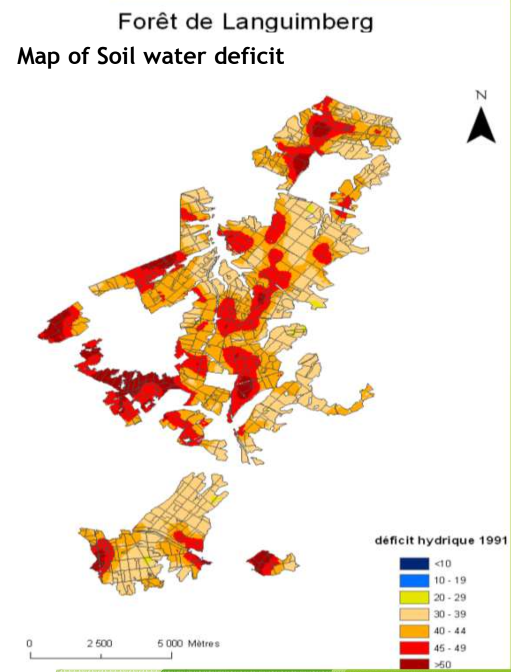




BILJOU

Forest water balance model

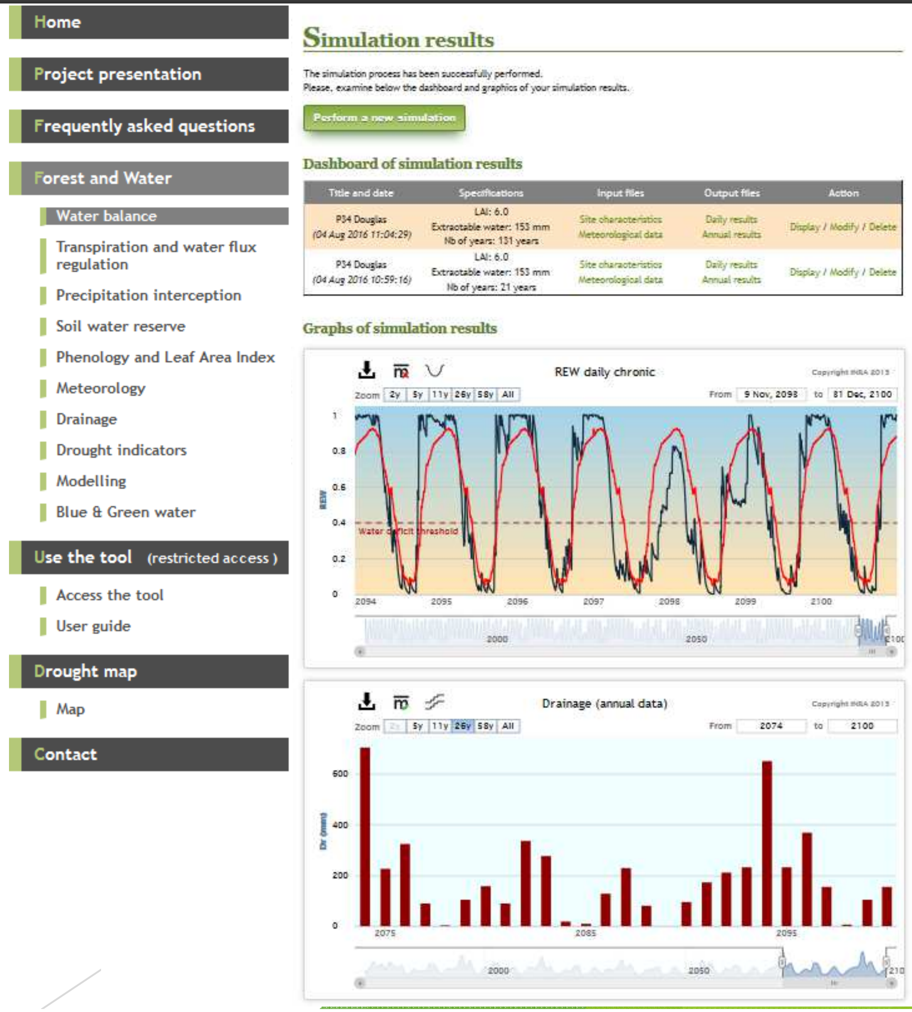
INRA EEF Joint Research Unit Forest Ecology and Ecophysiology

Welcome Nath Breda | Log out

https://appgeodb.nancy.inra.fr/biljou/

- A water balance model firstly published in Ecological Modeling, by Granier et al. 1999
- Since 2010: dissemination to end-users in forest and water management, teachers and researchers from other communities
- One web site, two languages (French / English):
  - E-learning web pages: water balance, transpiration and its regulation, soil water reserve, phenology & LAI, meteorology, runoff, drought indicators, modelling, blue & green water; literature with downloading of pdf files *-> free access*
  - An on line simulation tool: to calculate by yourself the daily water balance of your favourite stands, using their soil and canopy parameters and a daily climatic data file; graphical interface, downloading facilities of data & pictures *-> account to be created and license acceptation*

more than 160 registered users, from 20 countries, more than 6950 runs

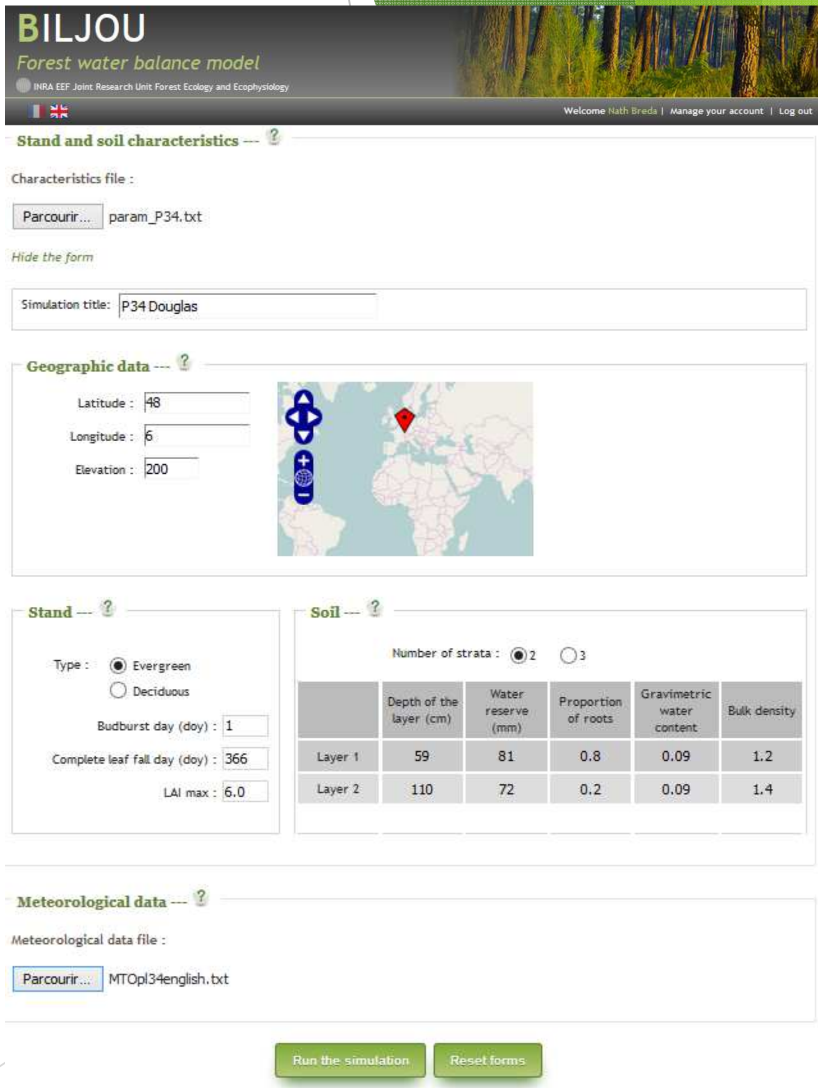


Aims of my talk: illustrate how to test the reduction of drought intensity by several adaptation options using Biljou© on line calculation tool

INRA / 70 ans
VOTRE AVENIR EST NOTRE CULTURE

Case study: changes in drought events of a given Douglas-fir stand

- Stand characteristics:
  - Location: altitude, latitude, longitude
  - Soil properties to be described: soil depth, extractable soil water content, bulk density, fine roots distribution
  - Stand canopy assessment: sempervirent type and leaf area index

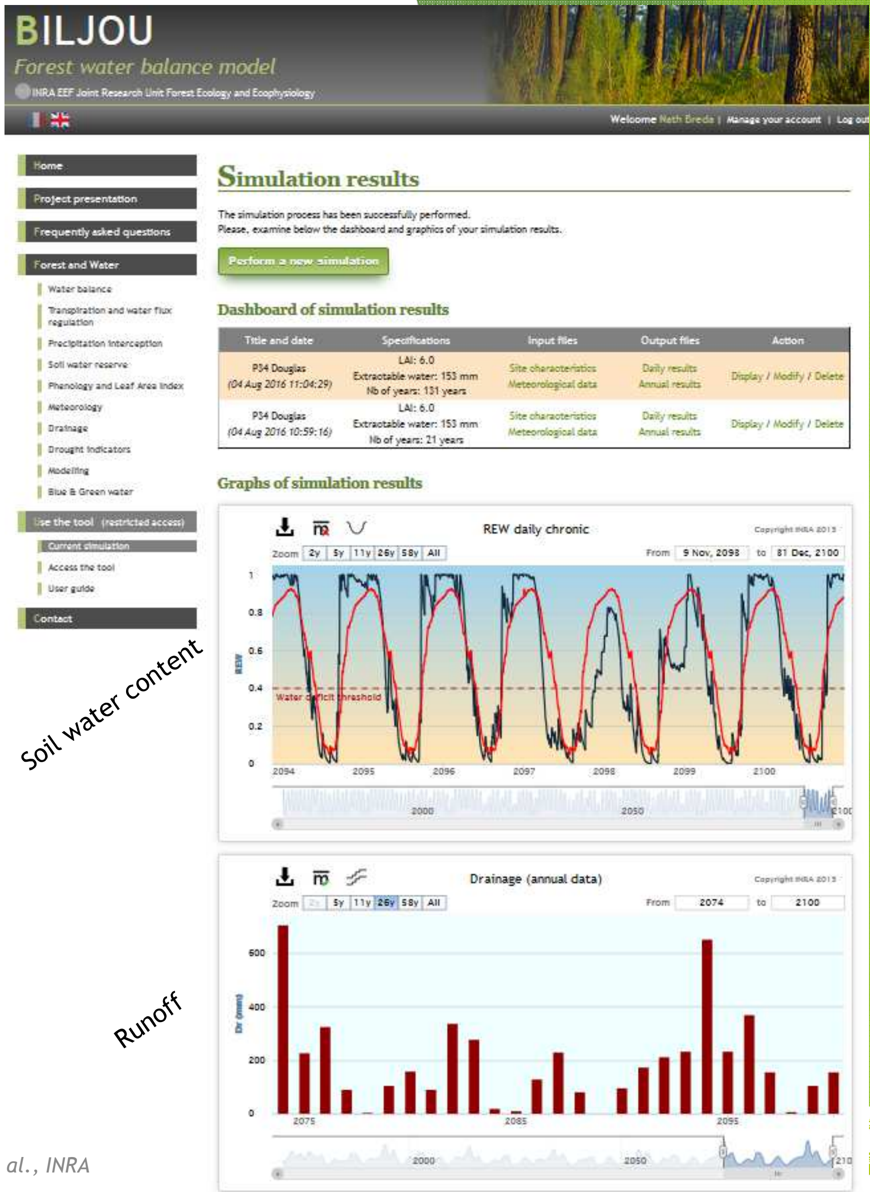


BILJOU© services: the on line calculation tool

Dashboard of simulation results

Title and date	Specifications	Input files	Output files	Action
P34 Douglas *(04 Aug 2016 11:04:29)*	LAI: 6.0 Extractable water: 153 mm Nb of years: 131 years	Site characteristics Meteorological data	Daily results Annual results	Display / Modify / Delete
P34 Douglas *(04 Aug 2016 10:59:16)*	LAI: 6.0 Extractable water: 153 mm Nb of years: 21 years	Site characteristics Meteorological data	Daily results Annual results	Display / Modify / Delete

YEAR	In	PET	AET	TR	Dr	WDdur	WD	WDstart
1989	130	916	568	426	264	128	58,8	166
1990	145	858	592	434	337	102	51,1	195
1991	122	805	566	432	288	81	35,4	187
1992	166	722	608	430	641	39	9,7	220
1993	174	779	686	494	486	0	0	
1994	170	862	646	463	648	64	29	193
1995	141	862	567	414	386	89	49,1	171
1996	162	837	701	524	402	39	7,9	179
1997	159	870	740	564	253	24	3,1	111
1998	160	874	588	416	413	89	47,2	172
1999	178	870	641	450	618	86	35,5	170
2000	179	885	687	496	461	60	30,6	212
2001	185	860	673	475	402	74	28,1	176
2002	161	818	656	483	371	73	19,3	184
2003	127	1043	576	439	382	126	70,3	130
2004	151	896	553	391	437	132	67,7	166
2005	141	923	642	488	179	77	37,2	160
2006	134	961	542	397	299	112	66,7	146
2007	178	829	692	499	295	32	10,9	207
2008	184	842	607	411	564	93	58,1	202
2009	142	918	614	460	363	103	54,4	191



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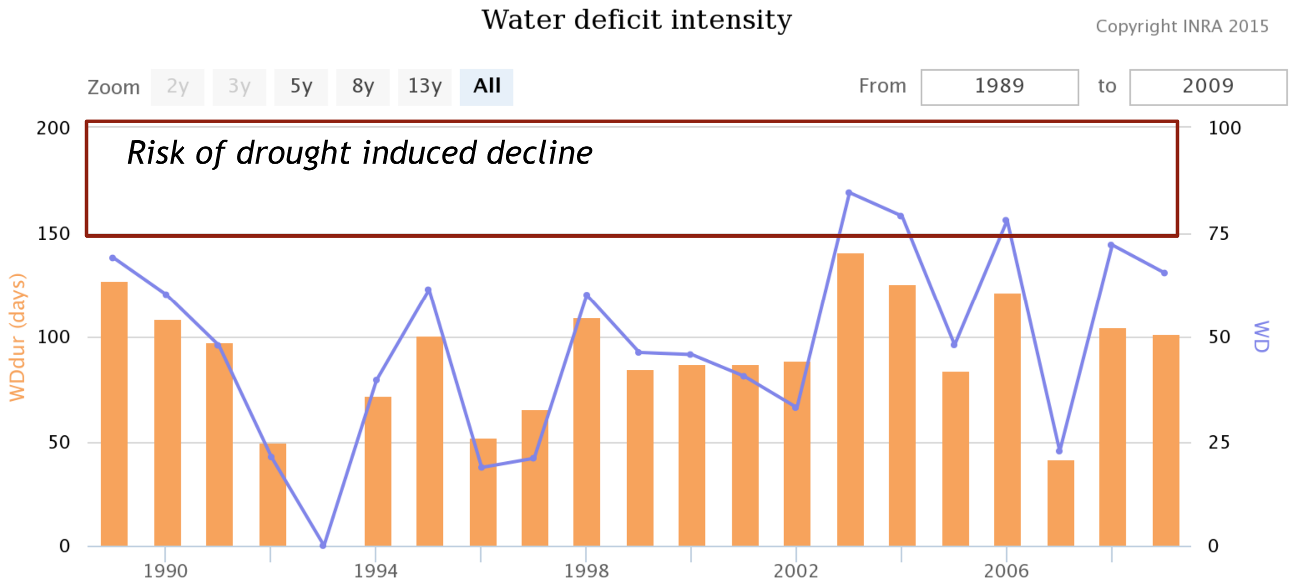
Step 1: Quantifying past soil water deficits by retrospective water balance modelling

- Simulation condition:
  - Observed Canopy type, Soil properties and leaf area index
  - Observed daily climatic data file from a close weather station from National Meteorology Office or from a gridded modelled climatic data (in France: Safran) ; *recommendation: at least 10-30 years to describe inter-annual variability of the climate*



Past risk of drought induced decline: 15%

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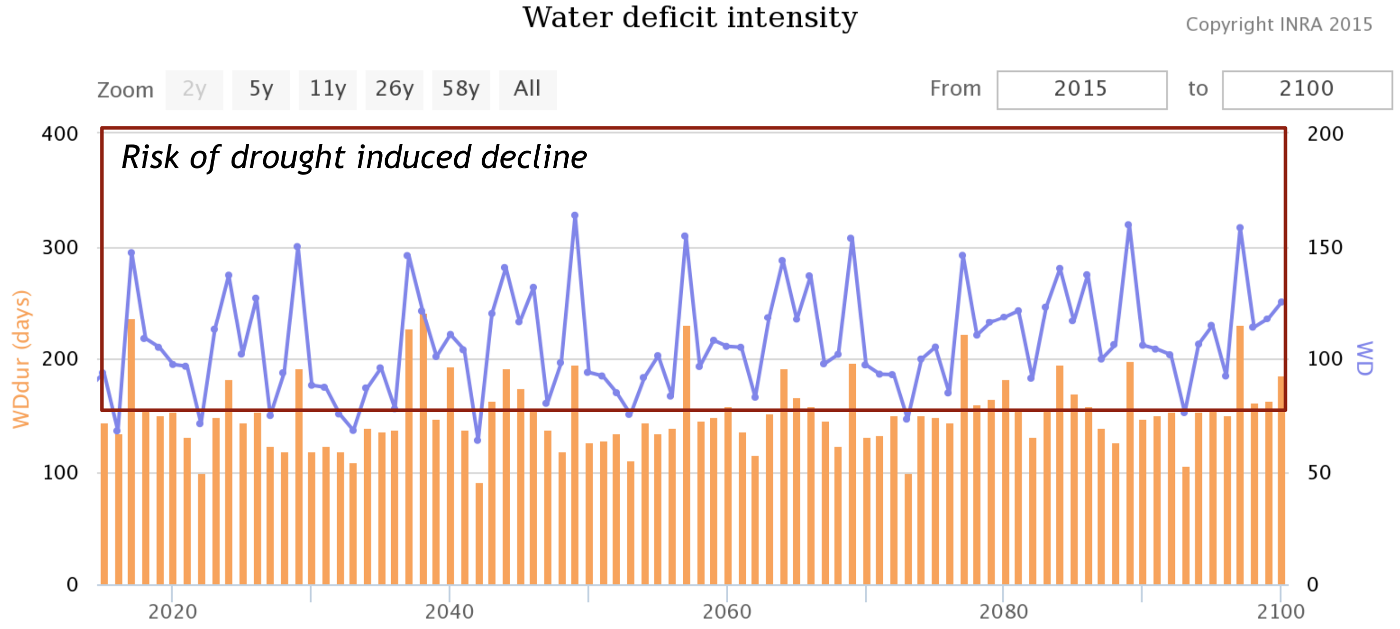
Step 2: Quantifying future soil water deficits using climatic scenarios

- Simulation condition:
  - Keep observed canopy type, soil properties and leaf area index
  - Change climate: daily future data from climatic scenario: rainfall, wind speed, vapour pressure deficit, radiation, temperature ; *recommendation: use several scenarios and methods of disaggregating climatic data from Global Climate Model to Regional Climate Model in order to assess climatic uncertainty*



Future risk of drought induced decline: 94%

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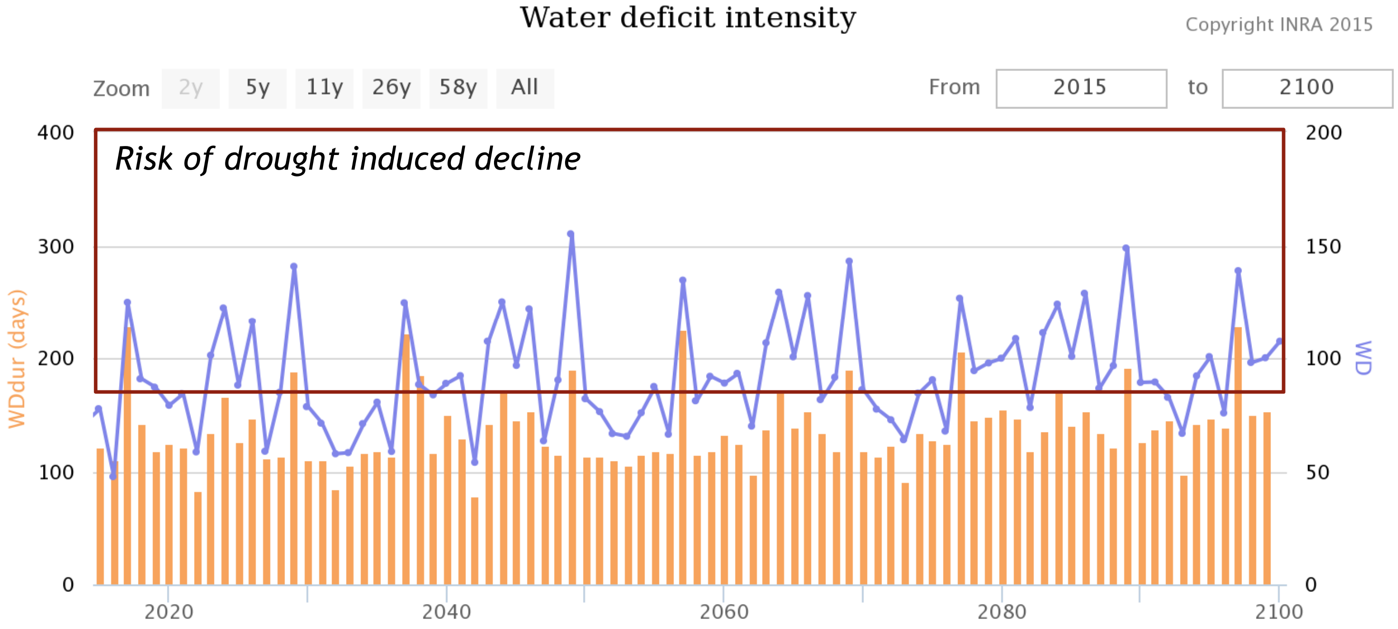
Step 3: testing incremental adaptation thanks to water saving sylviculture (LAI reduction)

- Simulation condition:
  - Keep observed soil properties
  - Keep sempervirent canopy
  - Change leaf area index to a lower value (example: from 7 to 5)
  - Keep daily future climatic data from climatic scenario



Future risk of drought induced decline with incremental adaptation: 60%

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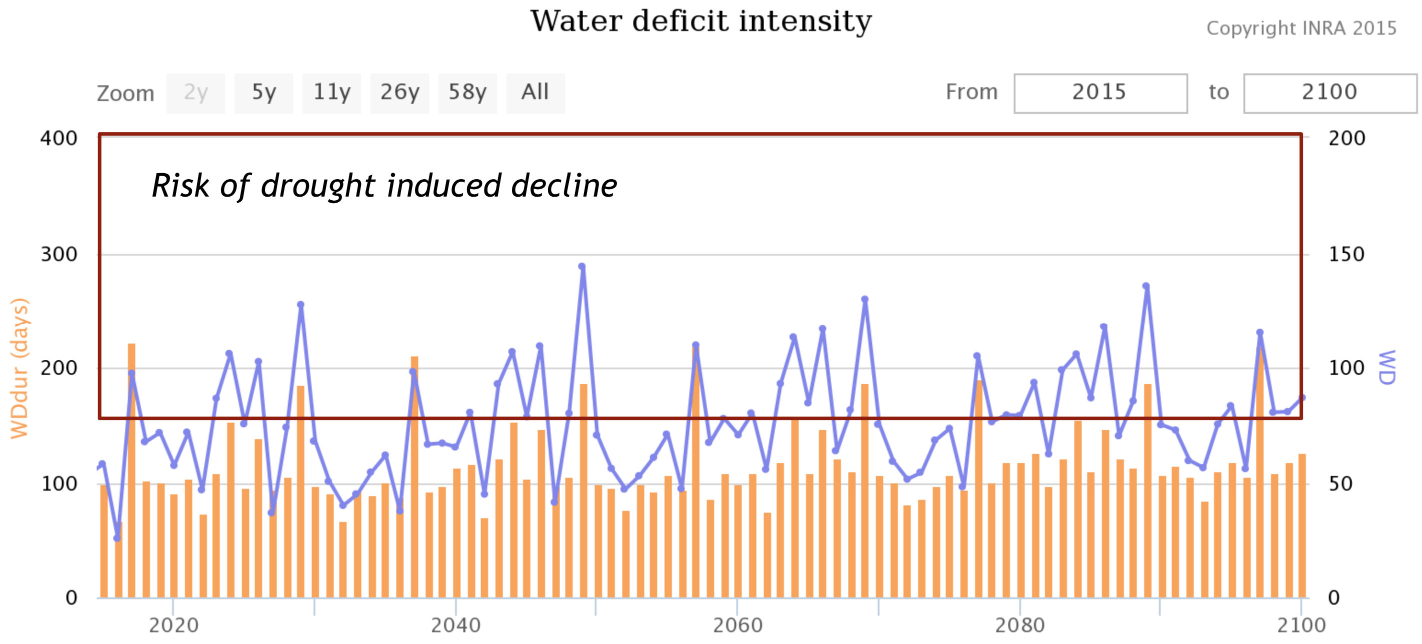
Step 4: Combine soft and hard adaptation options: new Douglas-fir plantation on soil with higher extractable water with lowest LAI

- Simulation condition:
  - Keep observed sempervirent canopy and daily future climatic data from climatic scenario
  - Reduced observed LAI to a lowest value (i.e. from 7 to 4)
  - Change extractable water (i.e. from 100 mm to 150 mm)



Future risk of drought induced decline with relocation & LAI reduction: 49%

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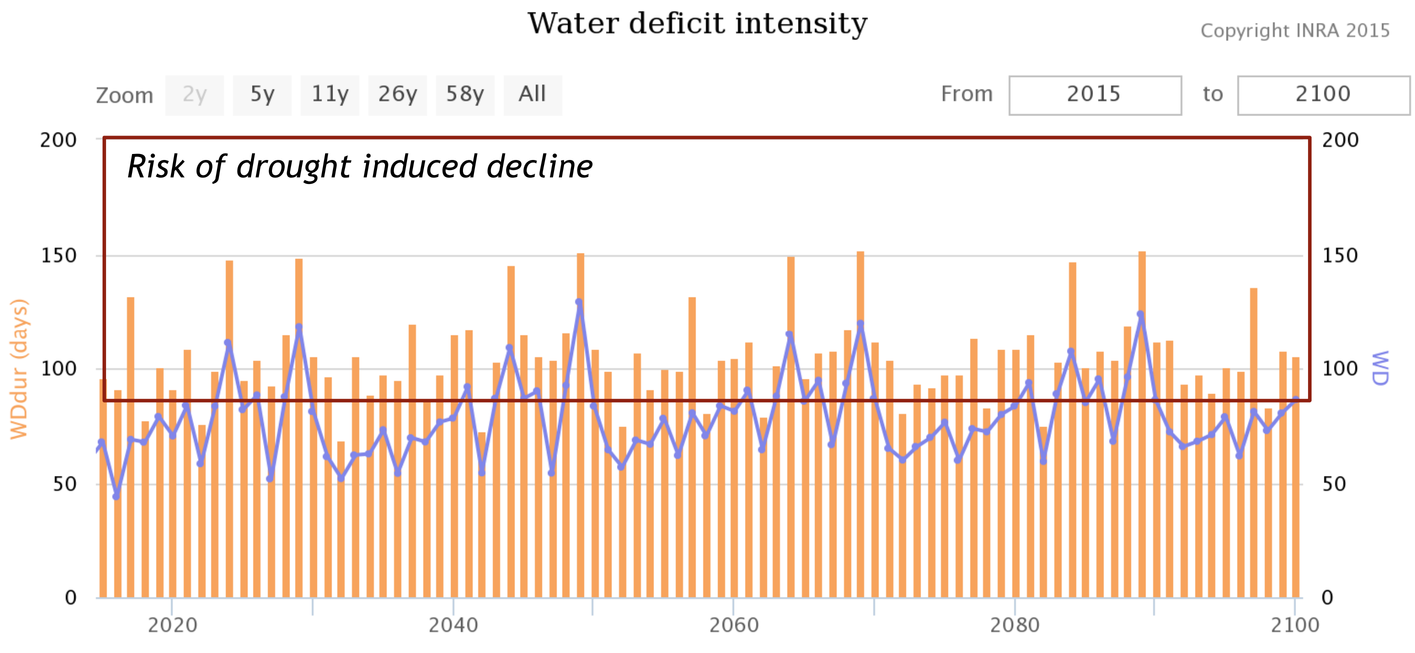
Step 4: Testing hard adaptation options: transformation from coniferous to deciduous species

- Simulation condition:
  - Keep observed soil properties
  - <u>Change from sempervirent canopy to deciduous canopy</u>
  - Keep daily future climatic data from climatic scenario



Future risk of drought induced decline with transformation: 37%

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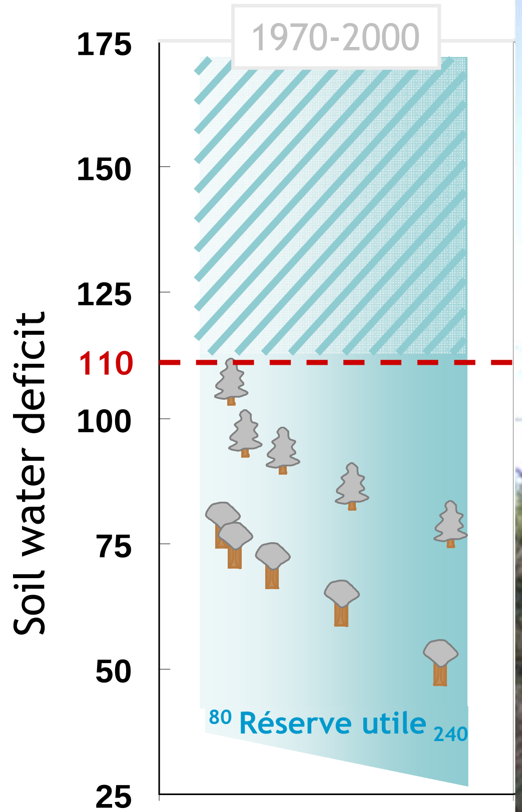
To sum up adaptations options to cope with future soil water deficit



Modèle BILJOU

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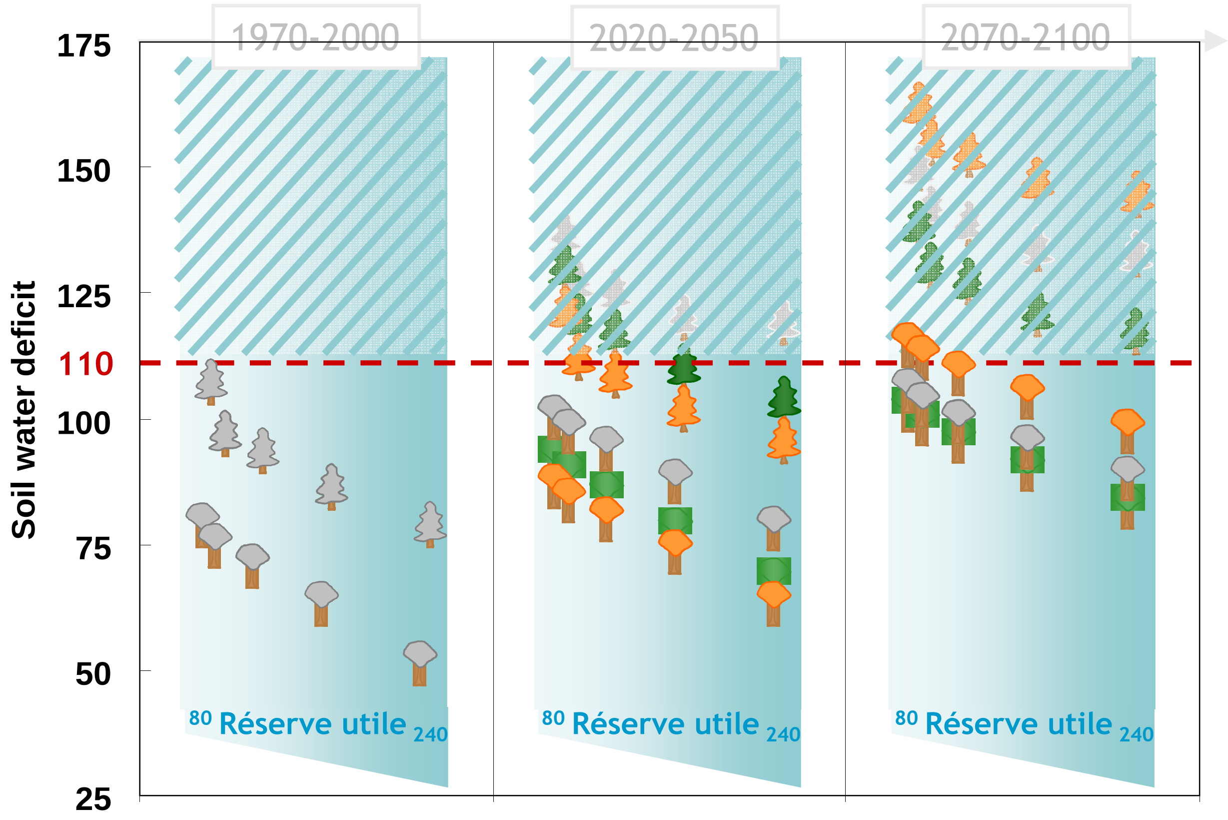
To sum up adaptations options to cope with future soil water deficit



Adaptation options:

1. Limiter aux sols à forte RU
2. Couvert décidu sur même gamme de sol
3. Itinéraires à LAI réduit
4. Relocation

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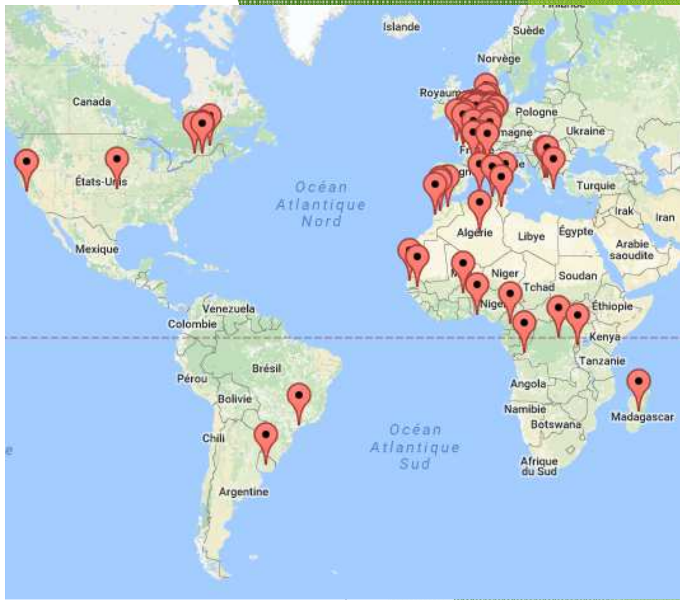
Modèle BILJOU



February 2017: 160 users for the calculation tool, 6910 runs

Join the Biljou© user community !

https://appgeodb.nancy.inra.fr/biljou/

Contact: nathalie.breda@inra.fr

Live demo on request during the workshop

Some papers that used Biljou© soil water balance calculations

- Gandois, L., M. Nicolas, G. VanderHeijden and A. Probst (2010). "The importance of biomass net uptake for a trace metal budget in a forest stand in north-eastern France." Science of The Total Environment **408**(23): 5870-5877.
- Boulard, D., T. Castel, P. Camberlin, A.-S. Sergent, N. Bréda, V. Badeau, A. Rossi and B. Pohl (2015). "Capability of a regional climate model to simulate climate variables requested for water balance computation: a case study over northeastern France." Climate Dynamics.
- Sergent, A.-S., P. Rozenberg and N. Bréda (2014). "Douglas-fir is vulnerable to exceptional and recurrent drought episodes and recovers less well on less fertile sites." Annals of Forest Science **71**(6): 697-708.
- Michelot, A., N. Bréda, C. Damesin and E. Dufrêne (2012). "Differing growth responses to climatic variations and soil water deficits of *Fagus sylvatica*, *Quercus petraea* and *Pinus sylvestris* in a temperate forest." Forest Ecology and Management **265**: 161-171.
- Granier, A., M. Reichstein, N. Bréda, I. A. Janssens, E. Falge, P. Ciais, et al. (2007). "Evidence for soil water control on carbon and water dynamics in European forests during the extremely dry year: 2003." Agricultural and Forest Meteorology **143**(1-2): 123-145.
- Olivar, J., S. Bogino, C. Rathgeber, V. Bonnesoeur and F. Bravo (2014). "Thinning has a positive effect on growth dynamics and growth-climate relationships in Aleppo pine (*Pinus halepensis*) trees of different crown classes." Annals of Forest Science **71**(3): 395-404.