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Drought impact on growth and wood properties of larch

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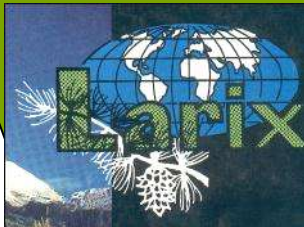
HAL Authorization



Fulda, 1987



Berlin, 1992



Montana, 1992



Remmingstorp, 1995



Krasnoyarsk, 1998



IUFRO Unit 2.02.07

Larch breeding and genetic resources

1976 - 2012



Gap, 2002



Kyoto-Nagano, 2004



Québec, 2007



Syktyvkar, 2010



Hallormsstadur, 2012



Drought impact on growth and wood properties of larch

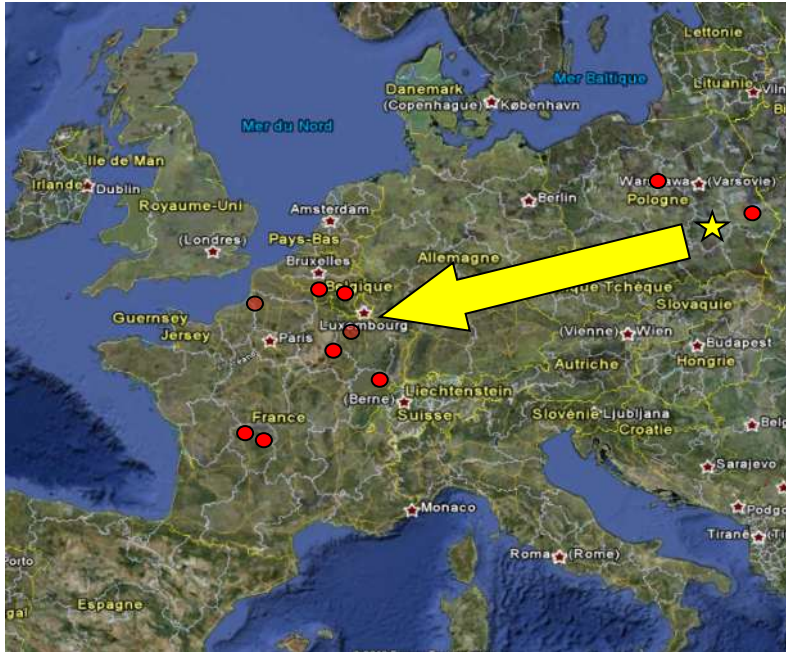
By L.E.Pâques

INRA- Unit AGPF- Orléans (France)

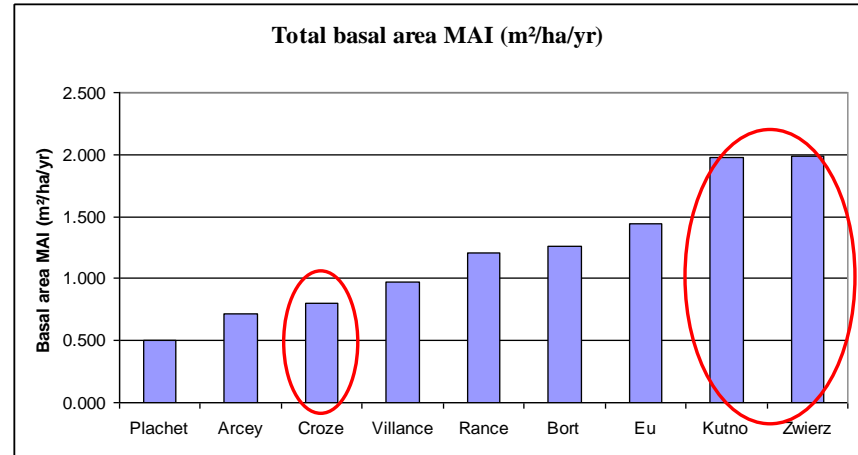
IUFRO Working Group S2.02.07
Larch Breeding and Genetic Resources
LARIX 2012 Conference
Hallormsstad National Forest, Iceland
11 - 13 September 2012.



Long-distance seed transfer & climate change?



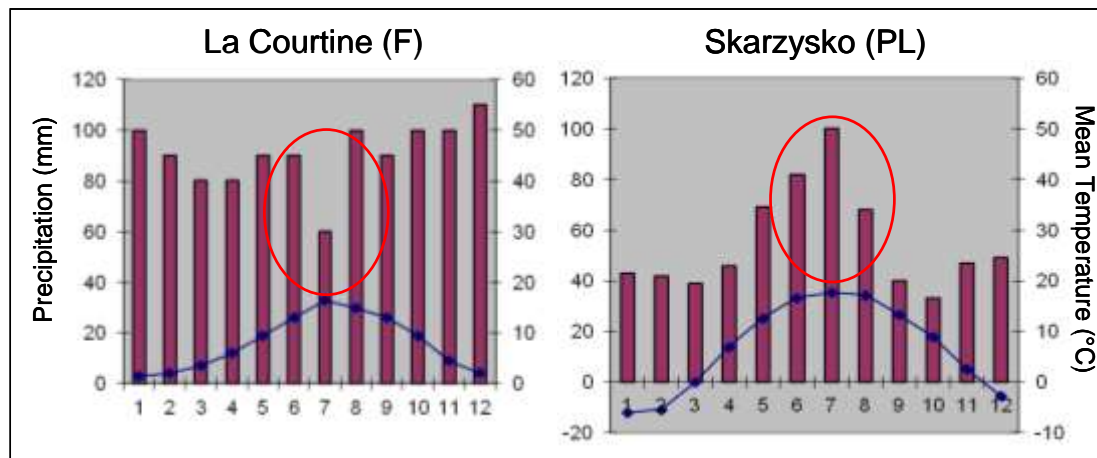
157 EL progenies collected in Central Poland
(INRA-IBL collection 1987)



Is it a climate thing?

R: 1090 mm

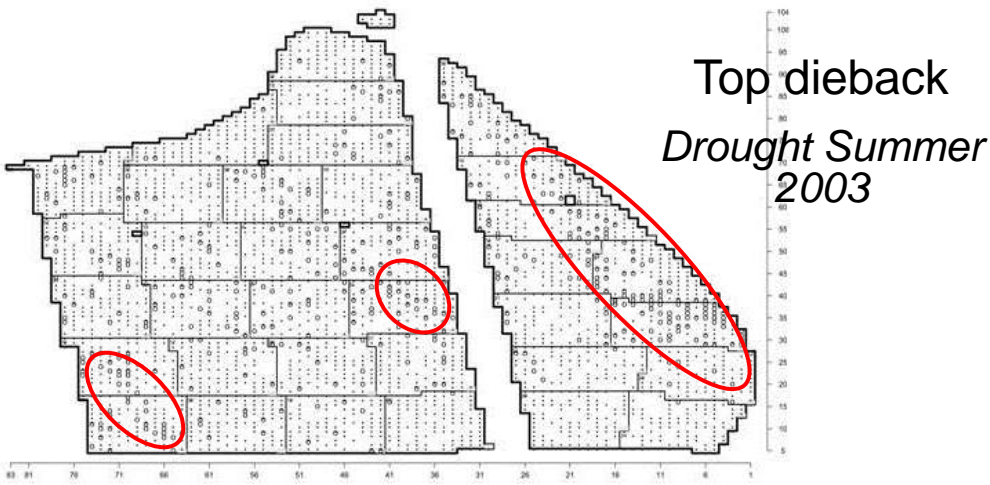
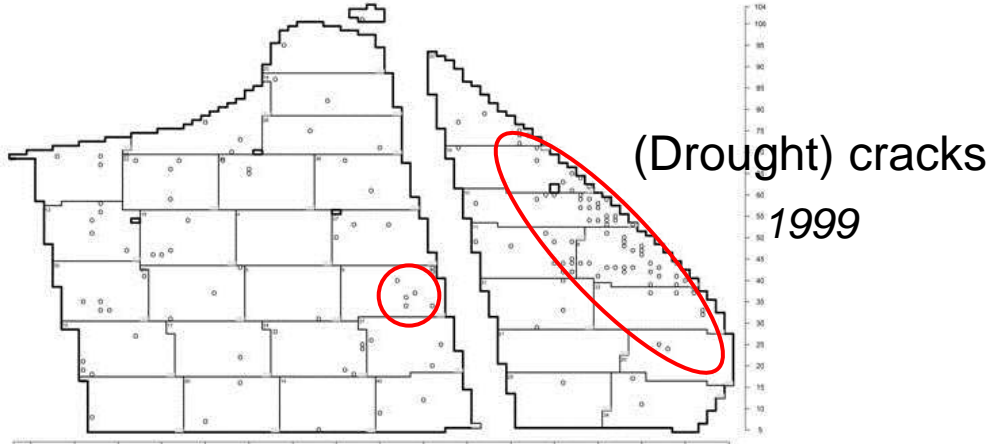
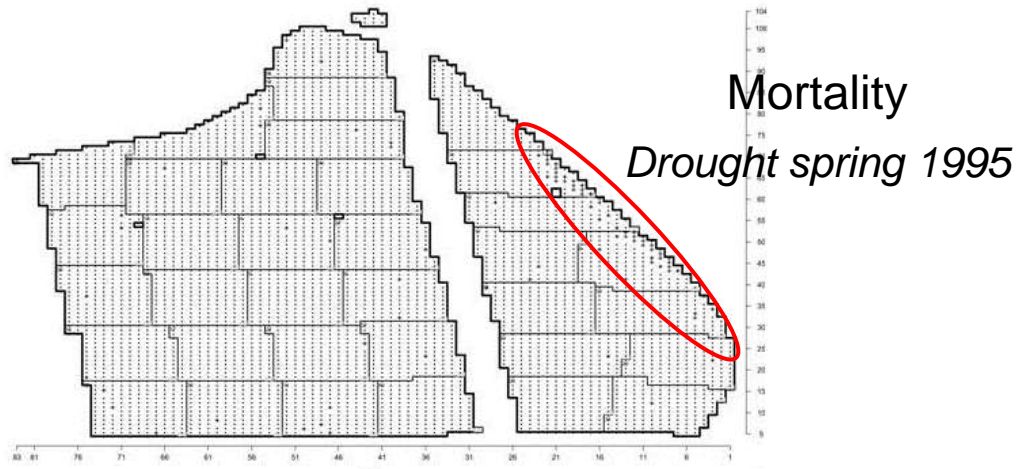
Tm: 8°C



R: 605 mm

Tm: 6.8°C

EL Progeny trial Bort (*polonica*)



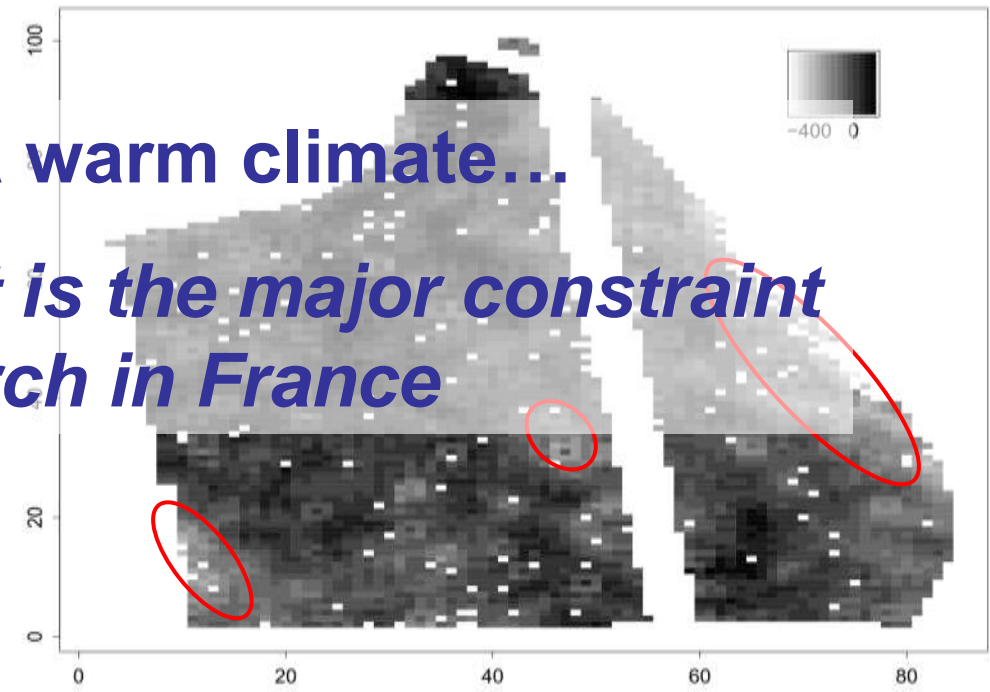
+



Meria laricis

EL Progeny trial
Bort (*polonica*)

Micro-environmental effects (Papadakis)
(based on total height 1999)

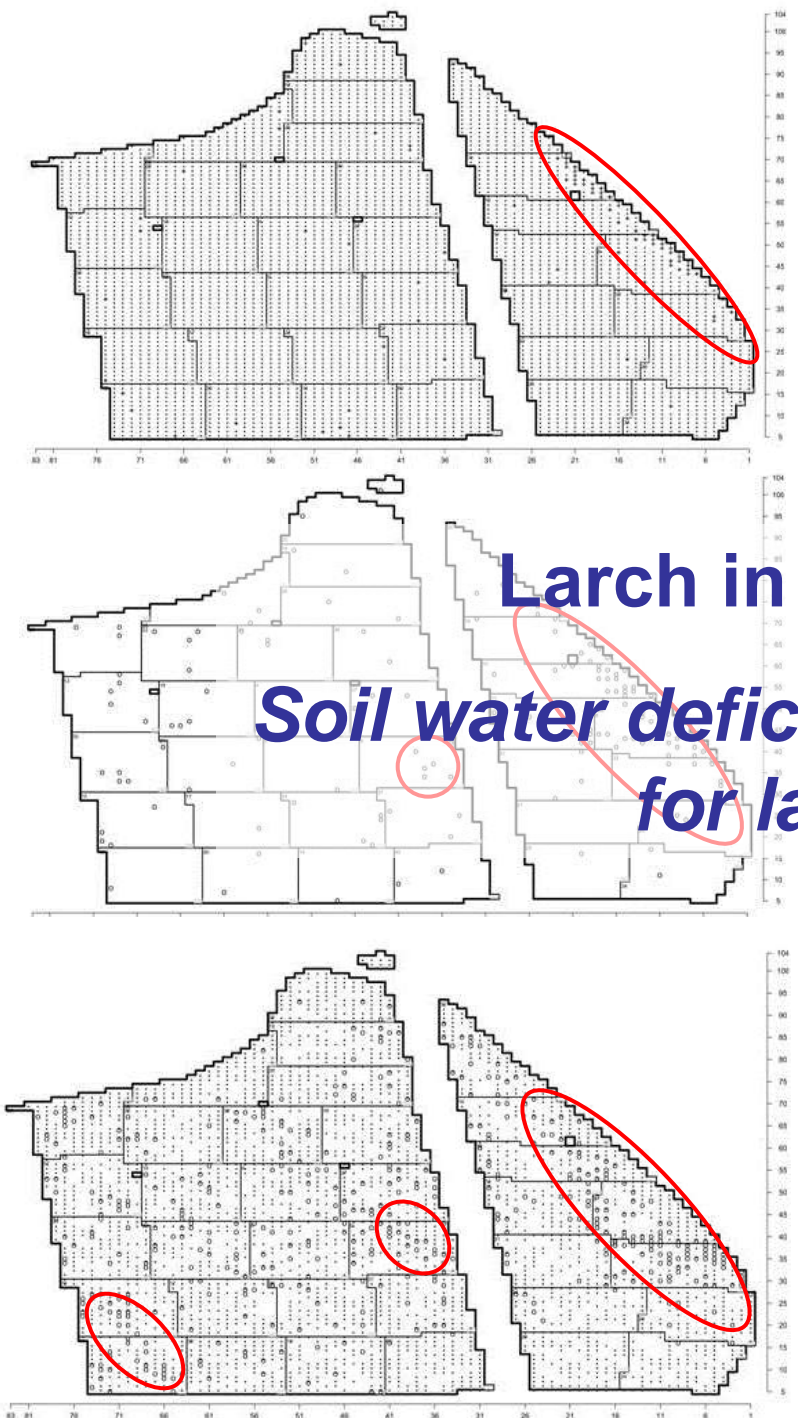


Exp.2.301.5: Bort

Larch in a warm climate...

**Soil water deficit is the major constraint
for larch in France**

Zones of low soil water availability



Objectives

- To test the influence of limiting vs non-limiting soil water availability on primary and secondary growth and on major economical traits
- To compare EL and HL behaviour

*All other environmental [temperature/
photoperiod/silviculture] and genetic [origin]
parameters being constant*

Material & Methods

Site

INRA-Orléans nursery: 'Farm-field' test

- Oceanic influence
- Coarse sandy soil with a low water capacity
- Soil deficiencies in P,K, Mg

Material

- **EL**: 20 HS progenies *Larix 'polonica'* (Swinia Gora)
- **HL**: 1 open-pollinated progeny (~FP201DK)

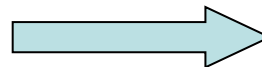
Design

CRB design, 20 blocks, single tree-plot

1993: sowing

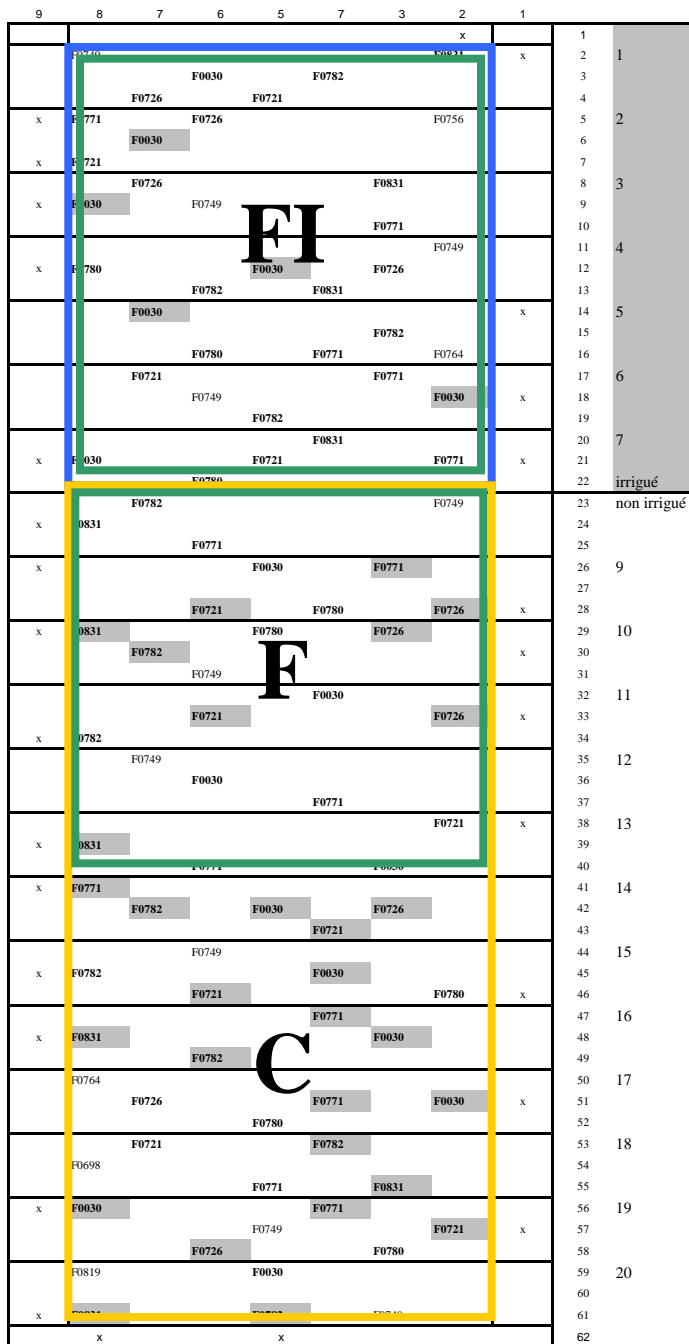
1995: Plantation : 1.2 x 1.2 m (6900 trees/ha)

2000: Thinning: down to 1500 trees/ha



INRA-Orléans, nursery

Start of the experiment



Treatments

- 1) FI: fertilisation-irrigation (7 blocks)
- 2) F: fertilisation (6 blocks)
- 3) C: control (no fertilisation, no irrigation) (7 blocks)

➤ *FI & F: 2 fertilisations in 2000: P, K, N + oligo-elements*

➤ *FI: Drop-irrigation: from 2000 to 2006 [04-09]*

	Temperature (°C)	Precipitation (mm)	Water supply ¹⁾ (mm)	Cumulated soil water deficit ²⁾ (mm)
2000	12.2 (17.8)	987 (389)	1031	48.4
2001	11.8 (17.6)	1053 (475)	802	69.3
2002	12.2 (17.0)	786 (293)	0	92.3
2003	12.5 (19.7)	685 (227)	836	187.7
2004	11.8 (18.0)	744 (272)	2235	134.1
2005	12.0 (18.5)	672 (271)	1784	119.6
2006	11.5 (18.2)	763 (212)	2540	181.2

Measurements & observations

- (1995) – 2000-2006:
 - Growth: BH girth & Total height (volume)
 - Phenology: bud burst & bud set
 - (branching, cracks, top-dieback, etc)
- 2007: from wood samples (disks)
 - Heartwood/sapwood radial & height size (volume)
 - Wood density (EW, LW, mean)
- +

Radial growth dynamics



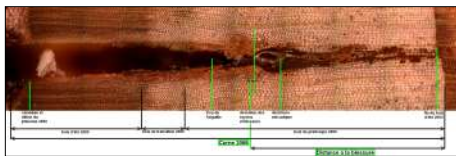
Pinning method

April-October 2006, once a week

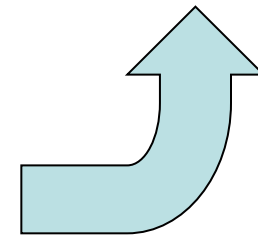
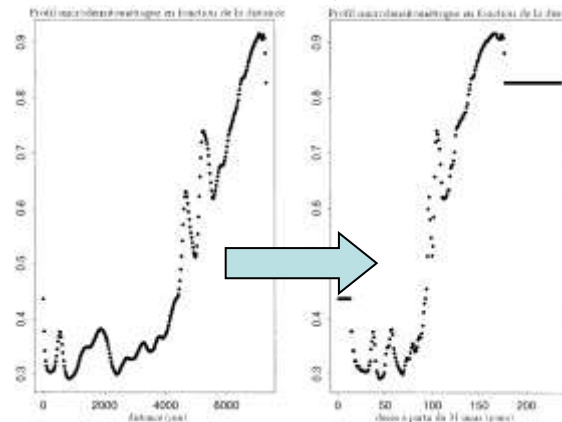
HL: 5 irrigated / 5 non-irrigated

Dynamics of ring formation

EW, TW, LW

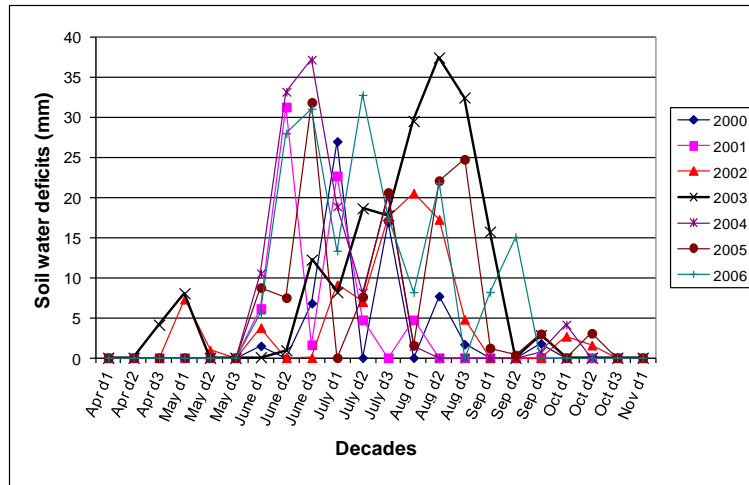


Static profile Dynamic profile

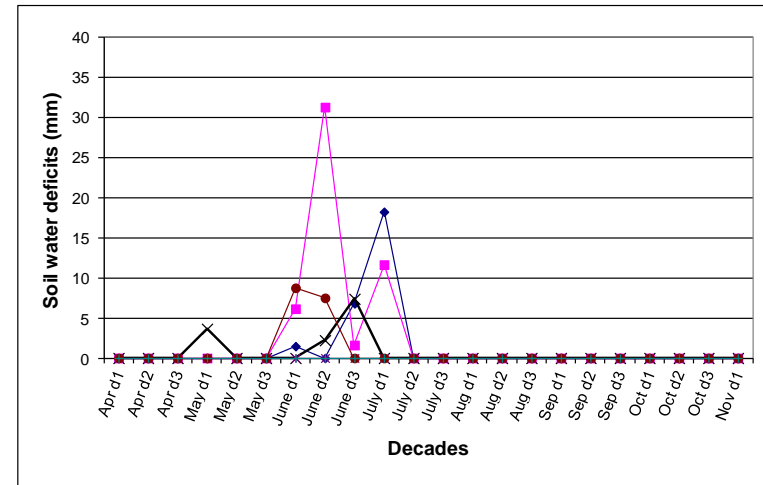


Evaluation of drought stress

Non-irrigated



Irrigated



- Recurrent water deficits from June (1st decade) up to September (2nd decade)
- Usually severe but short-period of stress: e.g. 2004 (3rd decade June), 2002 (1st decade August)
- 2003 & 2006: exceptionally long (2nd decade of June up to 1st decade of September) and intense !

Results



M.Verger, August 2003



L.Pâques, October 2006

Results

➤ *Highly significant differences are observed between irrigated and non-irrigated trees for:*

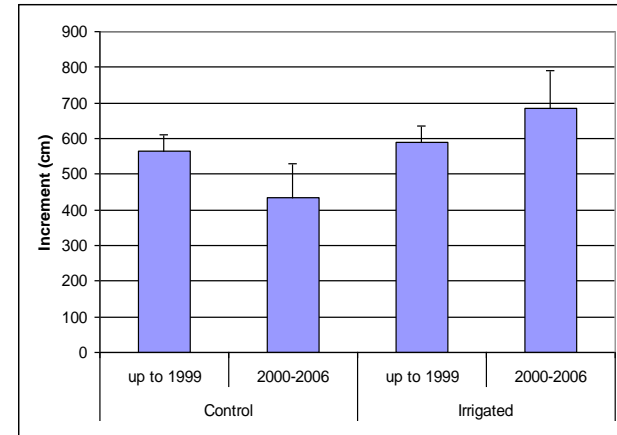
Total loss 2000-2006

Total height incr. :	-36.4%
Total girth incr. :	-29.0%
RW	-37.6%
EW	-38.4%
LW	-34.6%
Total volume:	-42.9%
HW	-39.7%
SW	-44.9%

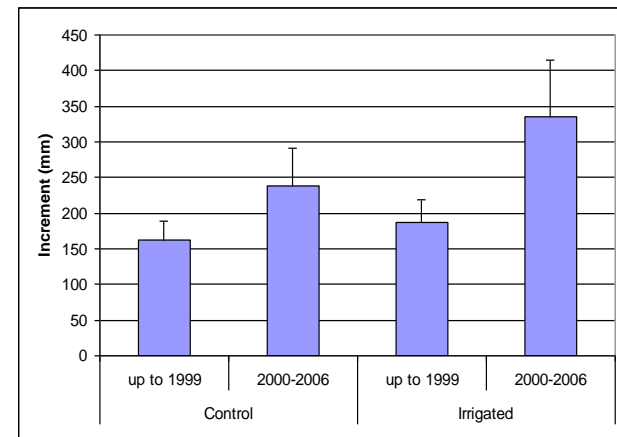
➤ *No differences for:*

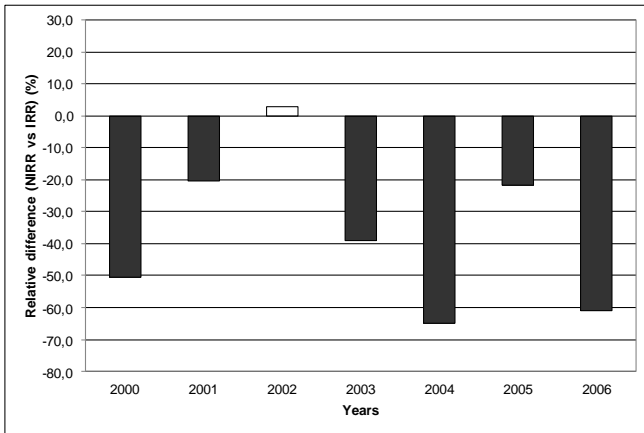
- Latewood proportion
- Heartwood proportion/ HW extension
- Ring density (EW, LW, R)

Height



Girth



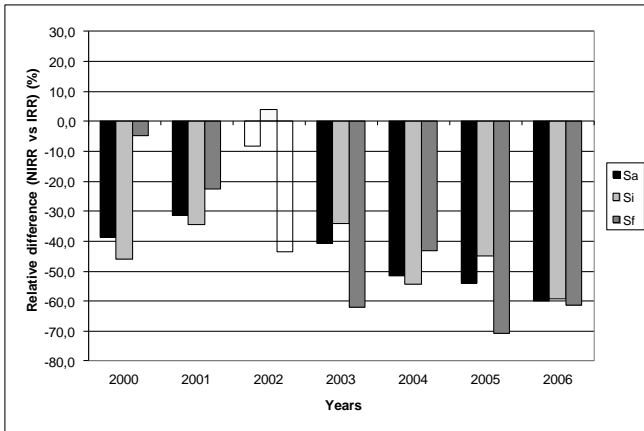


APICAL GROWTH

Strong negative impact all years

From -20 to -65%

Worse years: 2004 – 2006 – (2000)



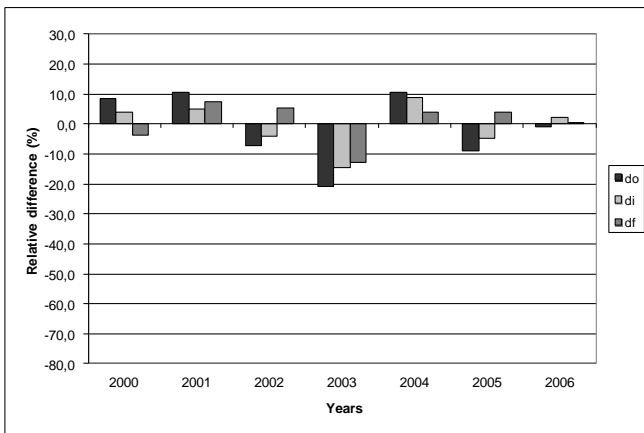
RADIAL GROWTH

Strong negative impact all years

From -31 to -60%

Worse years: 2006 – 2005 – 2004 – (2003)

EW = RW / LW: strong effect in 2003 – 2005



RING DENSITY

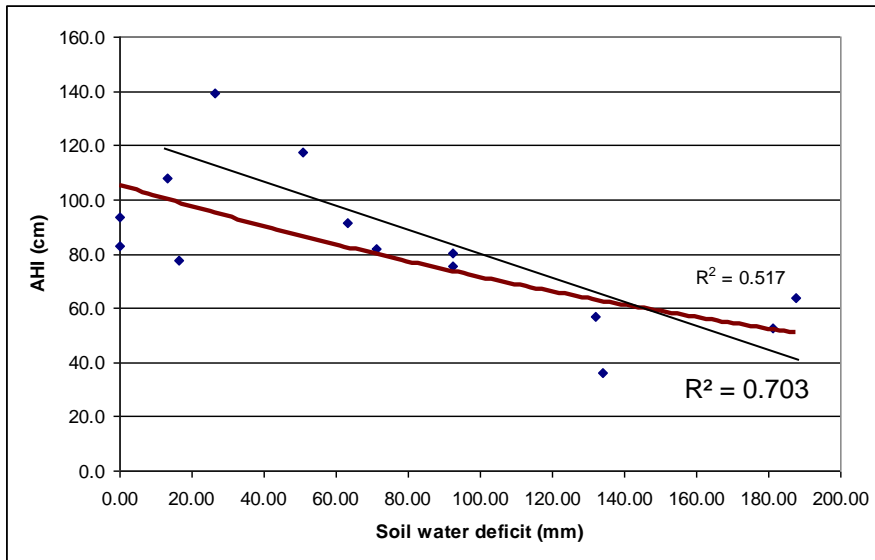
Weak effects (positive or negative)

for overall, EW and LW density

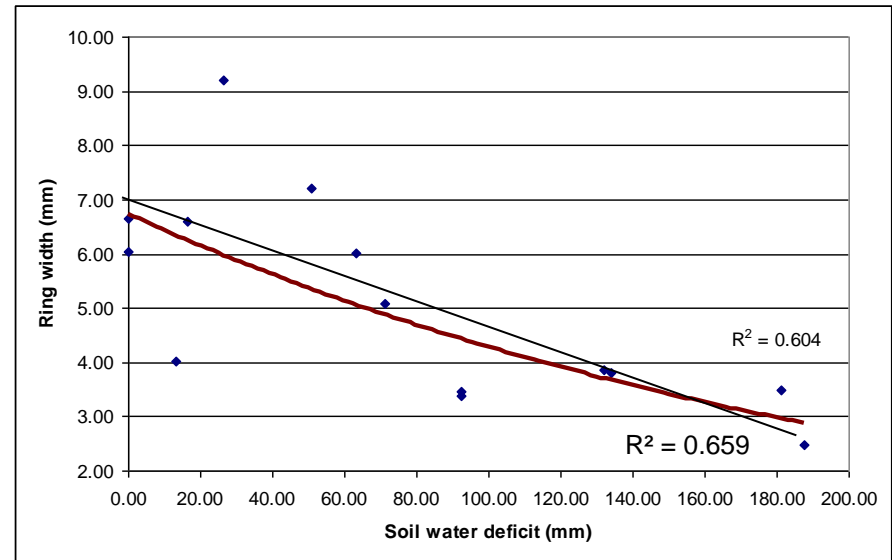
Results

Soil water deficit has a strong negative impact on growth

Height increment

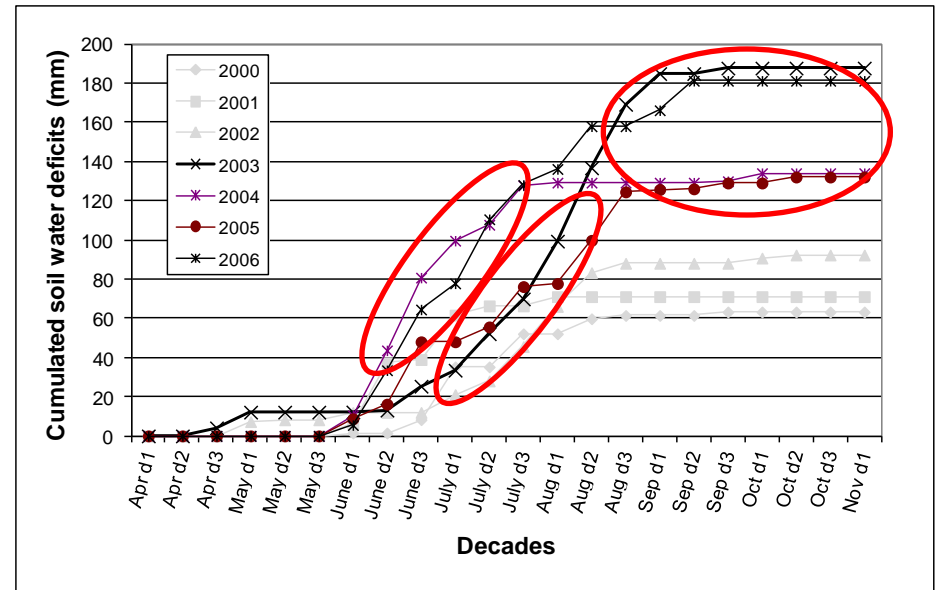
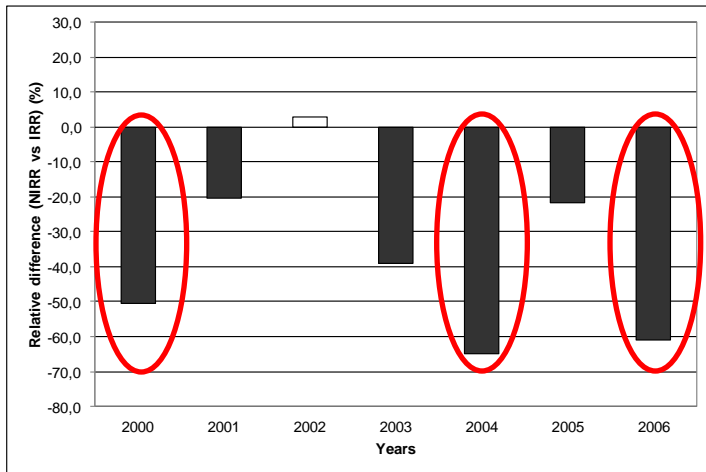


Ring width

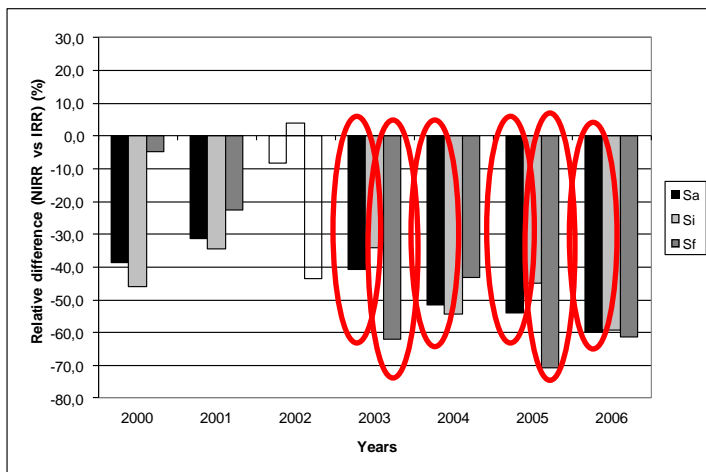


Results

APICAL GROWTH



RADIAL GROWTH



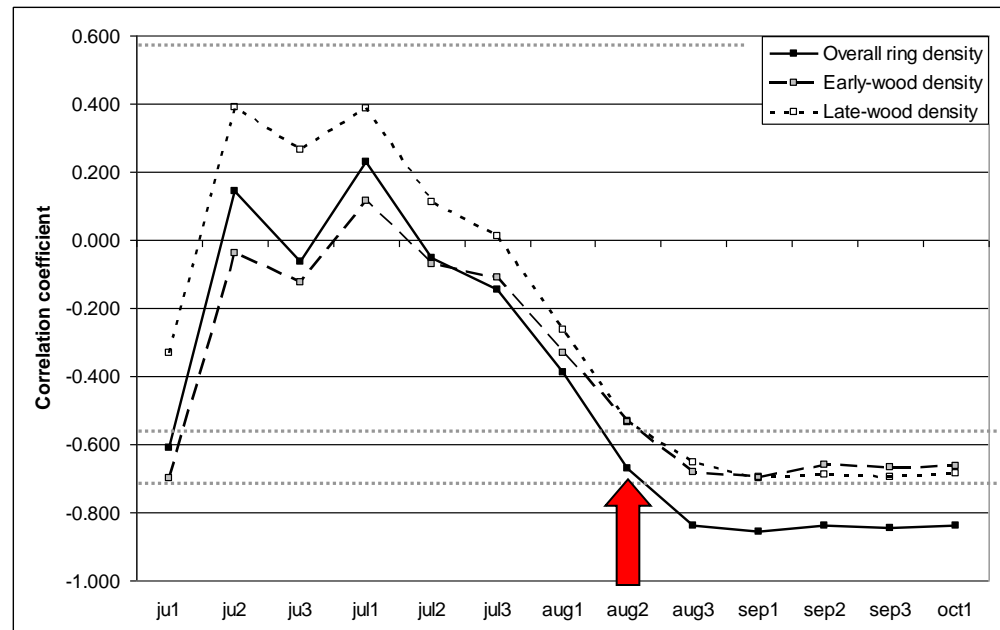
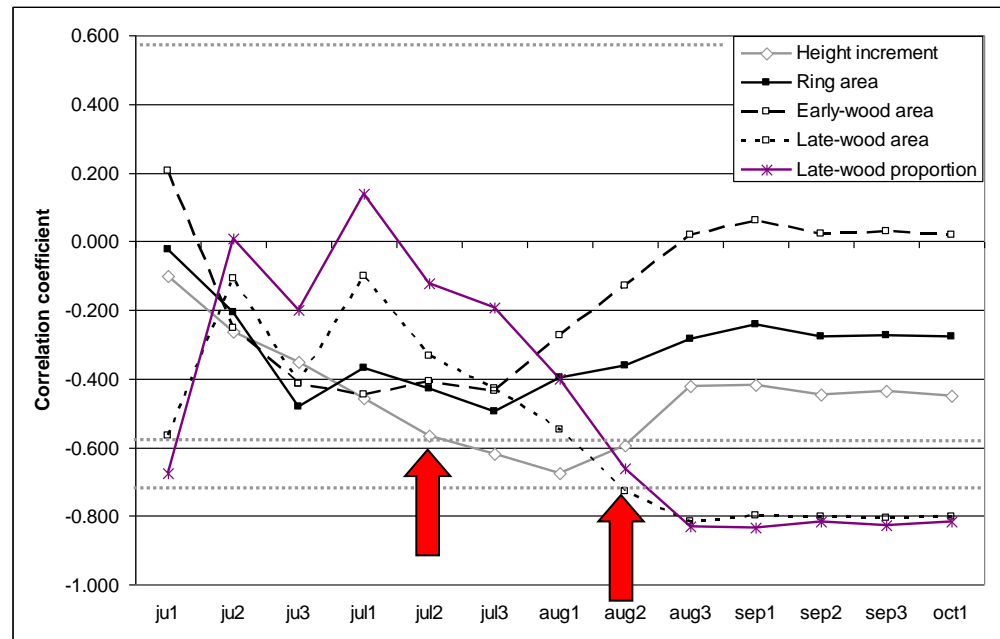
~ ~~strongly~~ *strongly* increased water stress

Results

Link between cumulated water deficits along the growing season and their impacts on traits

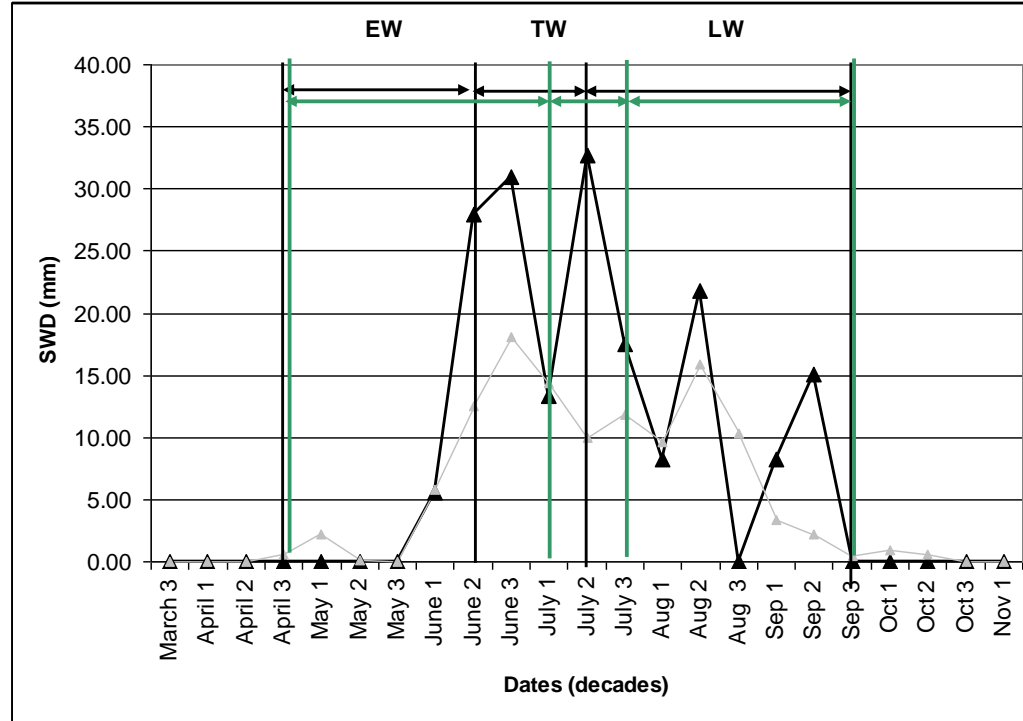
Significant negative link between impacts and water deficits are observed

- not before 2nd decade of July for height growth
- and one month later for radial growth and wood density



Results

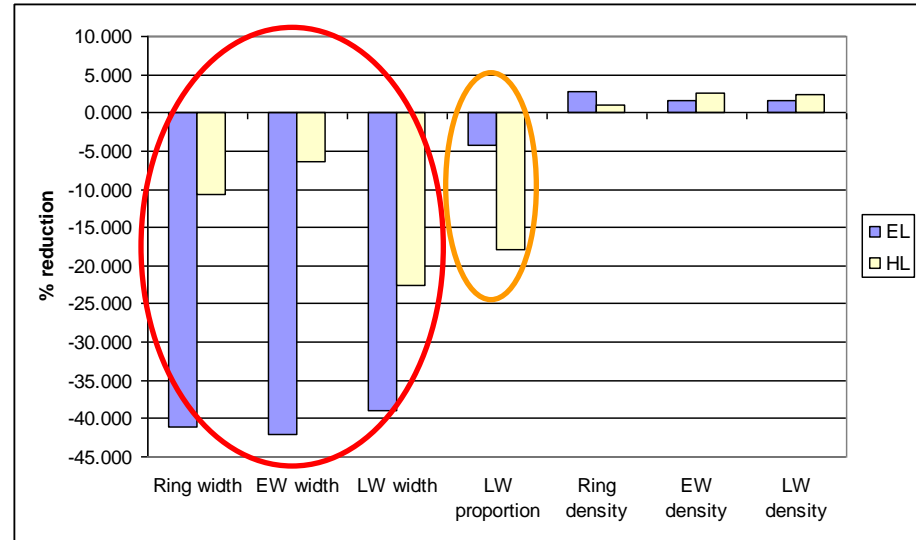
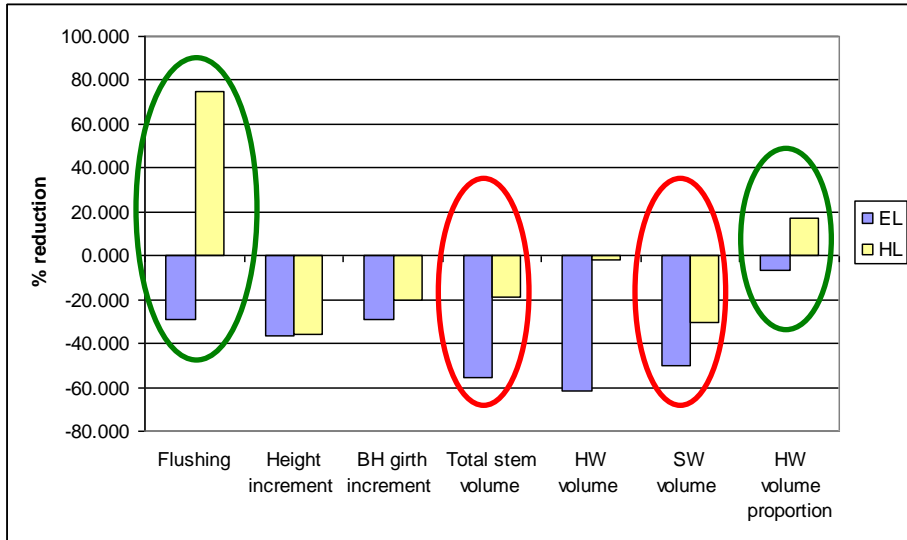
Hybrid Larch - Growing season 2006



Ring width	<i>EW</i> <i>duration</i>	<i>EW</i> <i>HL</i> <i>speed</i>	<i>TW</i> <i>duration</i>	<i>Irrigated TW</i> <i>speed</i>	<i>Non</i> <i>irrigated</i> <i>duration</i>	<i>LW</i> <i>speed</i>
<i>Irrigated</i>	71	2006 0.036	RW (mm) 25.3	0.046	25 68.8	0.018
<i>Non irrigated</i>	60.6	0.028	LW (%) 22.6	0.019	24.0 74.0	0.005

Results

Comparison of impacts on EL vs HL



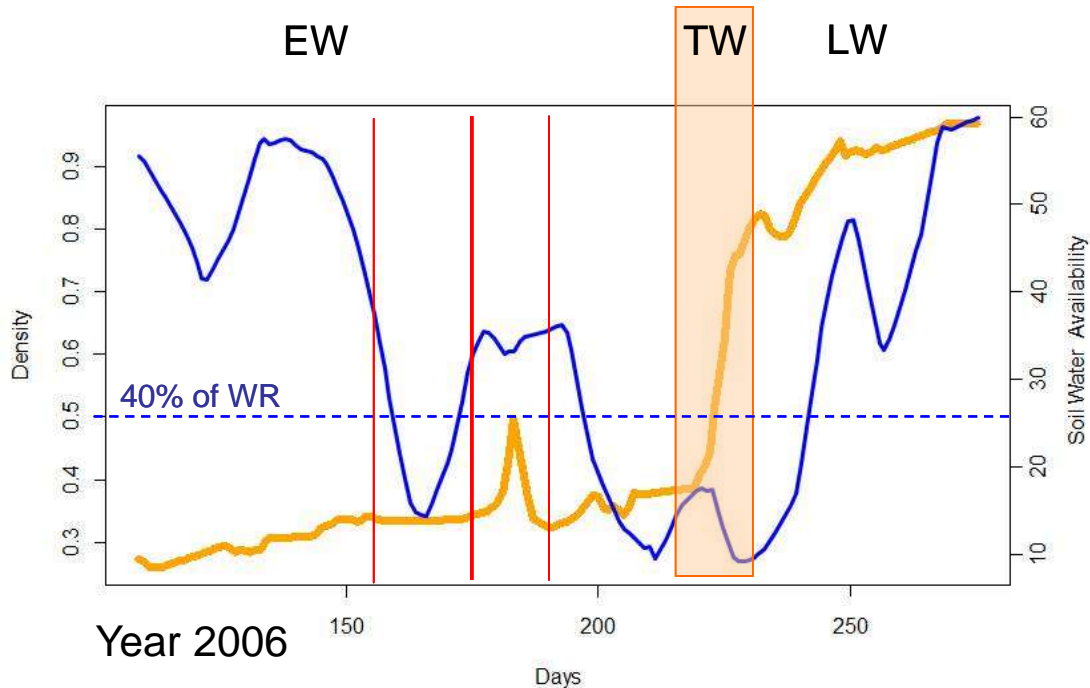
- Opposite impact on EL/HL: flushing, HW proportion...HW volume
- Similar impact in EL/HL: height
- Stronger negative impact on EL: volume (total, HW, SW)
- Stronger negative impact on HL: %LW

Conclusions

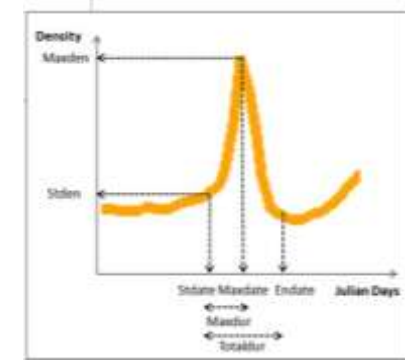
- ✓ Soil water deficit has a strong negative impact on apical and radial growth, including heartwood/sapwood size
- ✓ + timing of ring formation
- ✓ But not much influence latewood proportion, heartwood proportion and ring density
- ✓ Even weak deficits have an impact
- ✓ The timing and intensity of water stress influence differently apical and radial growth
- ✓ EL is globally more impacted than HL

Perspectives

➤ To explore the relationship between water deficit and ring formation

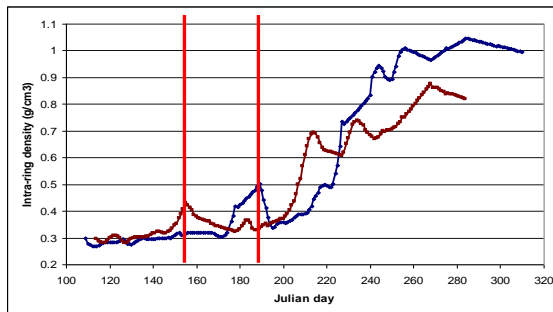


False ring



Transition wood

(date, duration, intensity, speed...)



Perspectives

- To study genetic variation
- To interpret genotypes reaction – adaptive behaviour

Will be used in the study of hybrid vigour: why HL is better than EL / JL ?

mother	father																Total
	106	109	166	214	221	222	242	284	3190	3193	3194	3200	3203	3217			
104	10	10		10	10			10	10	10	10	10				90	
106		10	10		9	10	10	9	10	10	10	10				98	
109					10	9										19	
221				EL			10	10	10	10	10	9			1	60	
222							10	10	10	10	9	10				49	
3179									10	10	10	10				40	
3180									5	10	10	10				35	
3183									10	10	10	10				40	
3190									10					10	10	30	
3193											10	10		10	10	40	
3194													10	10		20	
3200									JL				10	10		20	
3203														10		10	
Total	10	20	10	10	29	19	30	29	65	80	79	79	40	51		551	

Farm-field progeny test (INRA-Orléans nursery) – 2 environments