Drought impact on growth and wood properties of larch

Luc Pâques

IUFRO

IUFRO Unit 2.02.07

Larch breeding and genetic resources

1976 - 2012

Fulda, 1987

IUFRO Centennial
Meeting of the
IUFRO Working Party S2.02-07

IUFRO

Berlin, September 5 - 12, 1992

Berlin, 1992

Larix

Montana, 1992

IUFRO

IUFRO WORKING PARTY S2.02-07
July 31 - August 4, 1995
Remningstorp and Siljansfors, Sweden

Remmingstorp, 1995

Larix-98:

Krasnoyarsk, 1998

Larix 2002
International symposium
France, 16-21/09/2002

Gap, 2002

Larix 2004
International Symposium Larix 2004

Kyoto-Nagano, 2004

LARIX 2007

Québec, 2007

LARIX 2010

Syktyvkar, 2010

LARIX 2012

Hallormsstadur, 2012

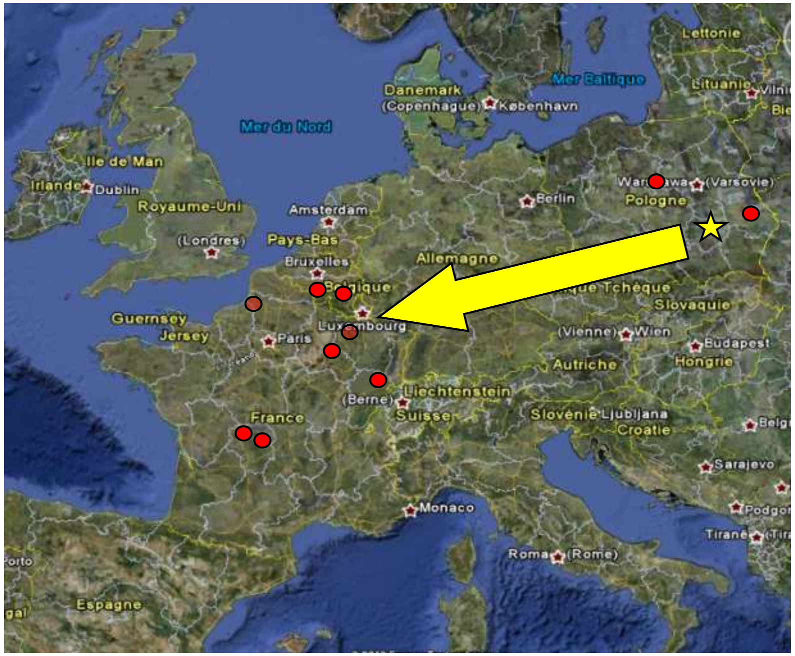
Drought impact on growth and wood properties of larch

By L.E.Pâques

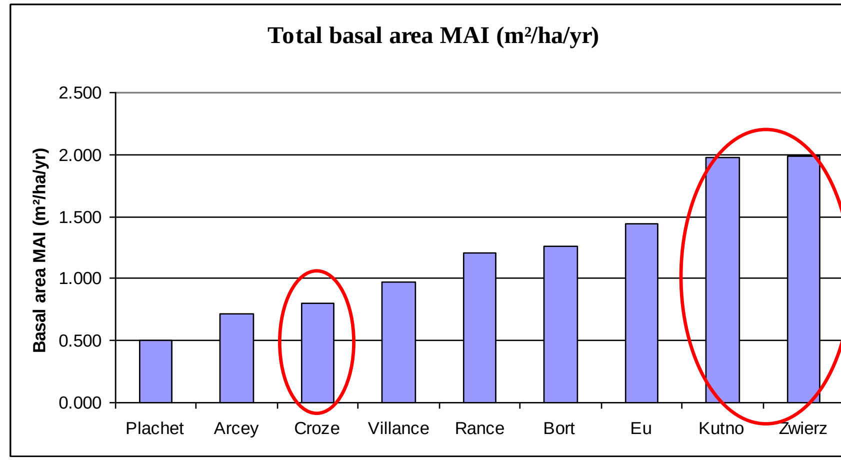
INRA- Unit AGPF- Orléans (France)

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?



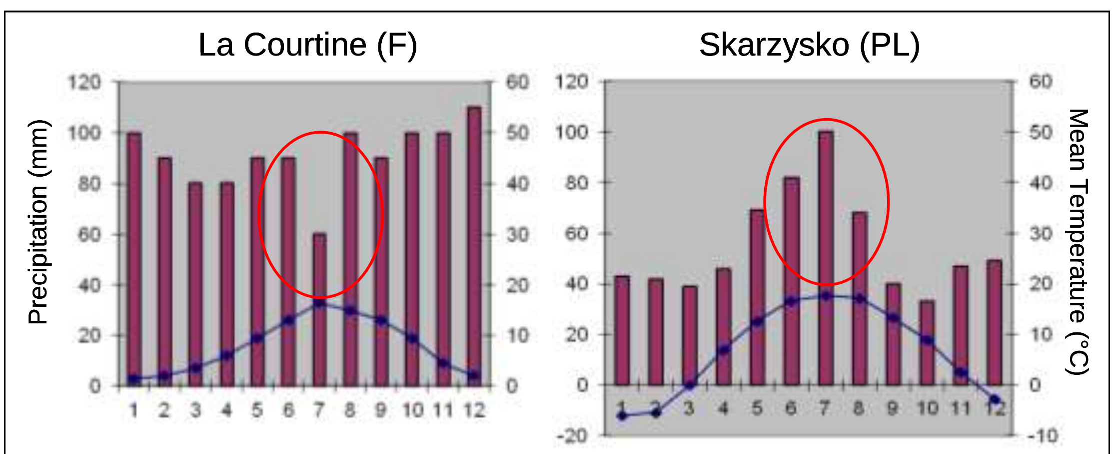
157 EL progenies collected in Central Poland
(*INRA-IBL collection 1987*)



Is it a climate thing?

R: 1090 mm

Tm: 8° C

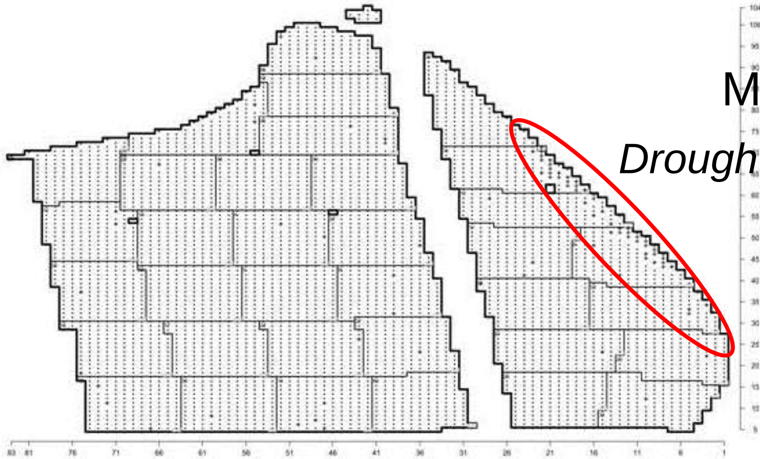


R: 605 mm

Tm: 6.8°C

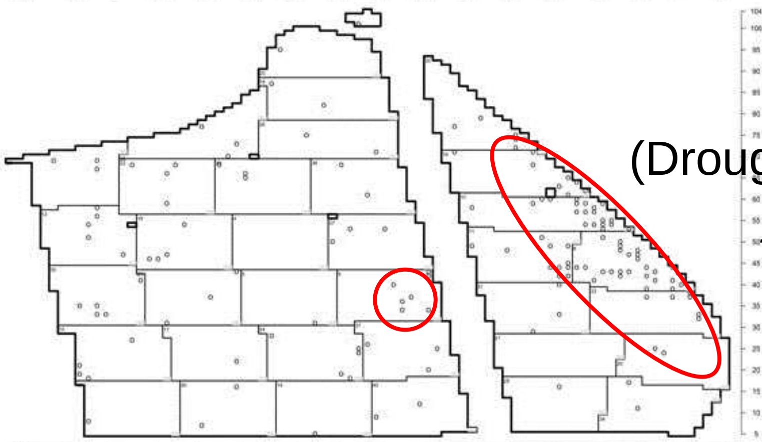
EL Progeny trial

Bort (*polonica*)



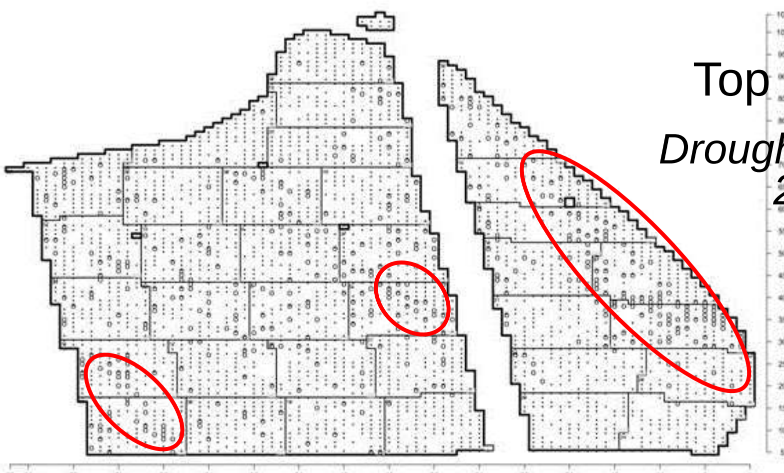
Mortality

Drought spring 1995



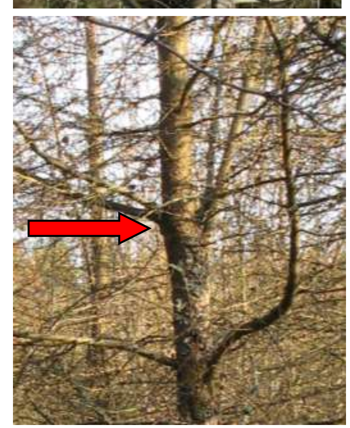
(Drought) cracks

1999



Top dieback

Drought Summer 2003

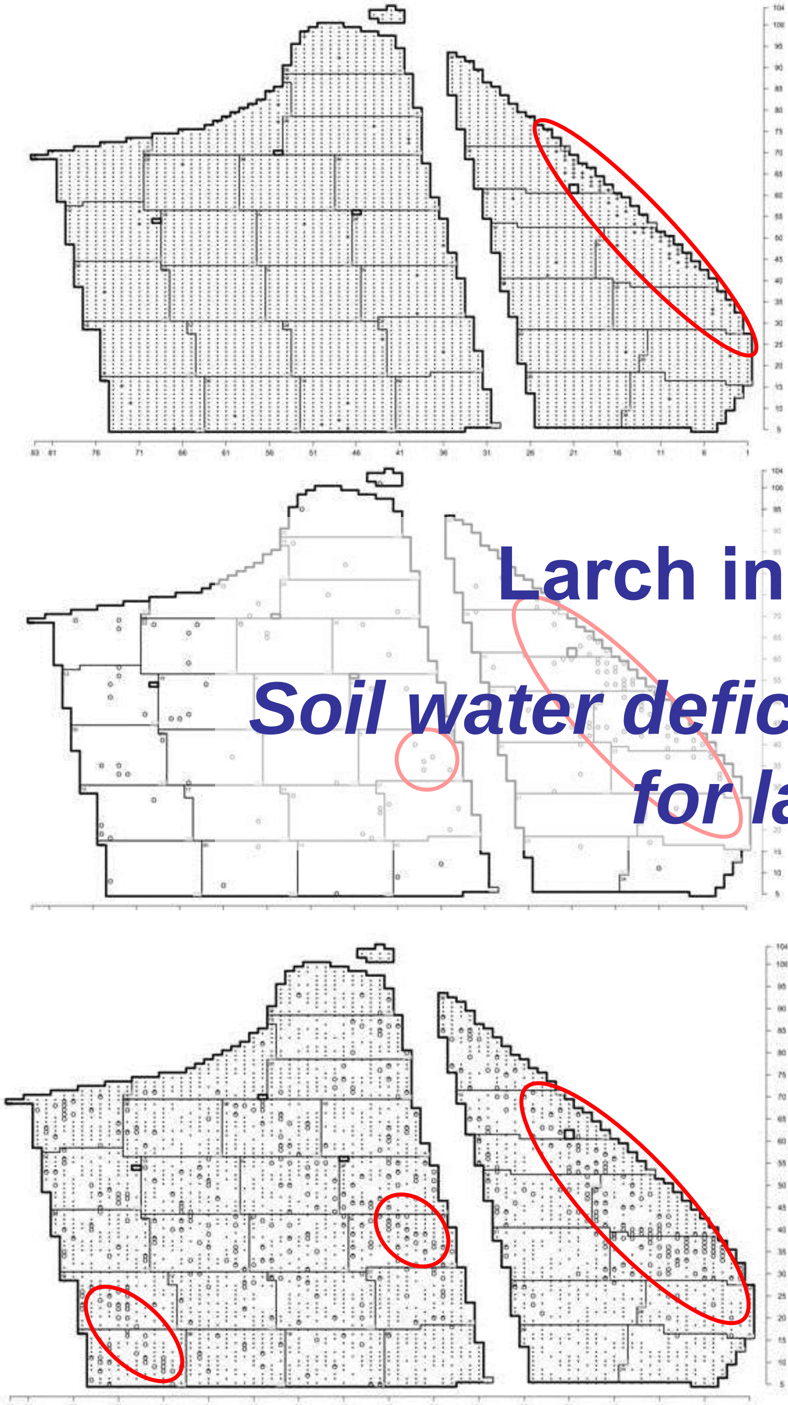


+

Meria laricis

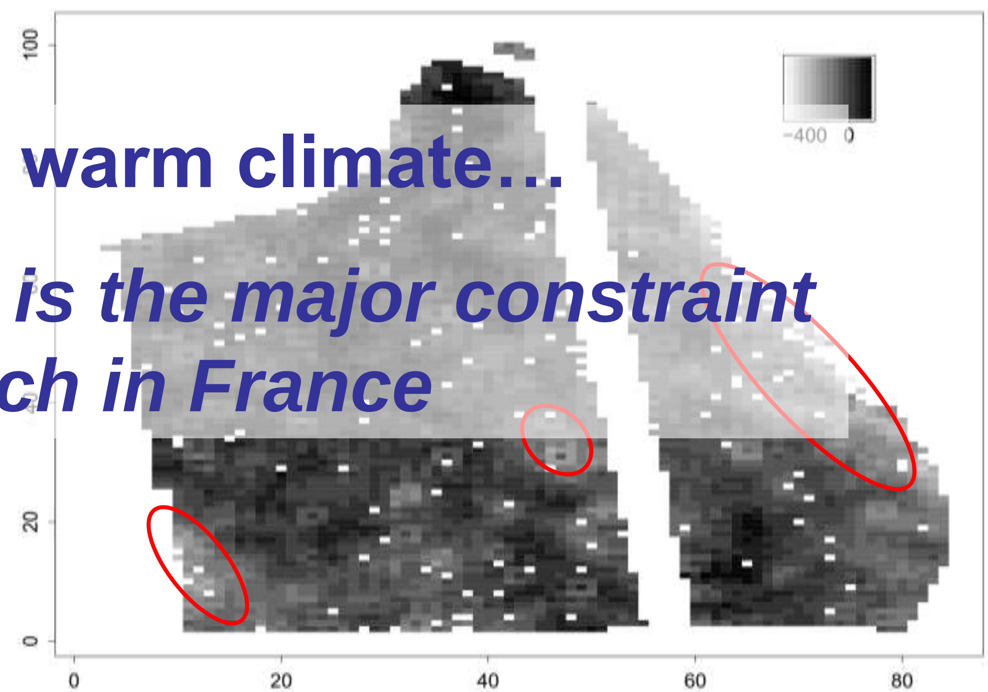
EL Progeny trial

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 deficiences in P,K, Mg

INRA-Orléans, nursery

Material

• **EL**: 20 HS progenies *Larix ‘polonica’* (Swinia Gora)

• **HL**: 1 open-pollinated progeny (~FP201DK)

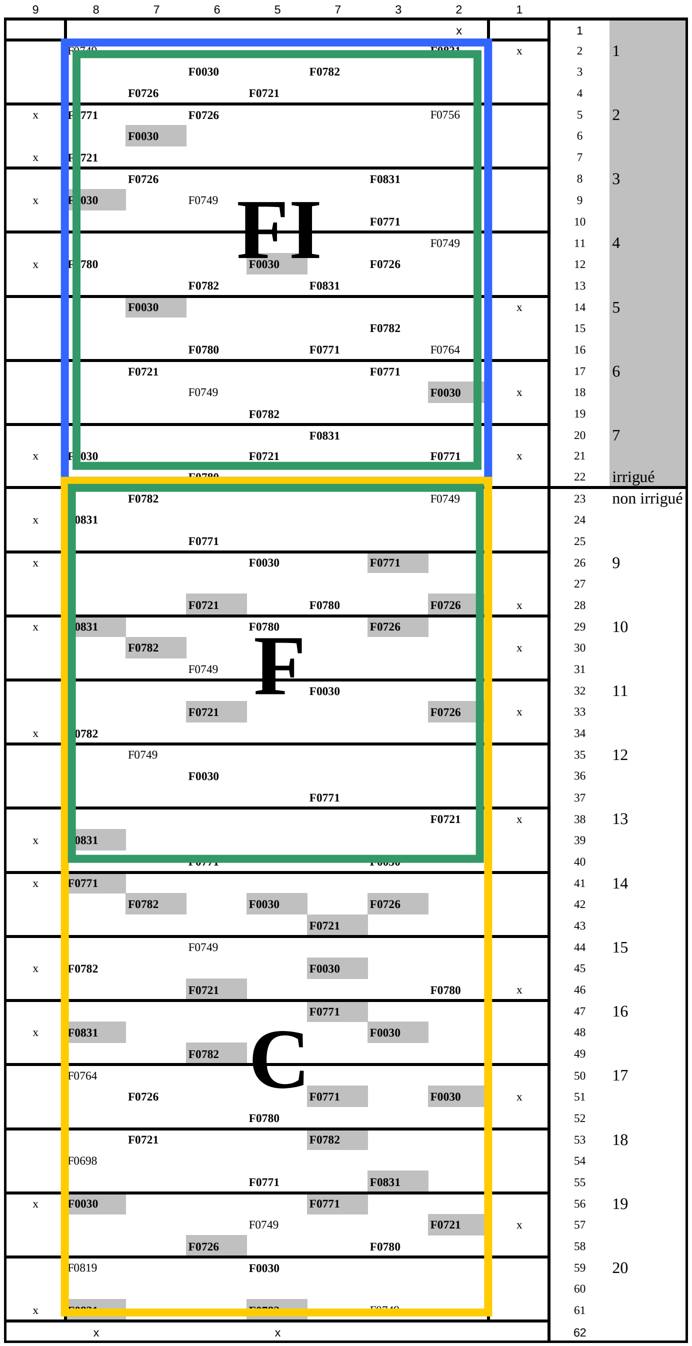
Design

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 → **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)

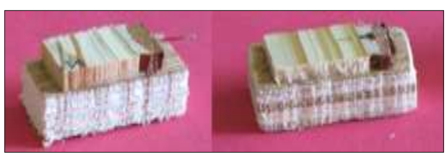
- *FI & F: 2 fertilisations in 2000: P, K, N + oligo-elements*
- ***FI: Drop-irrigation: from 2000 to 2006 [04-09]***

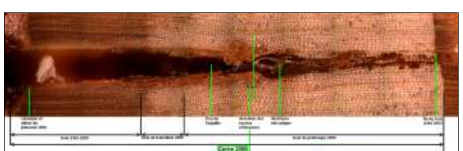
	Temperature (°C)	Precipitation (mm)	Water supply 1) (mm)	Cumulated soil water deficit 2) (mm)
2000	12.2 (17.8)	987 (389)	1031	48.4
2001	11.8 (17.6)	1053 (475)	802	69.3
2002	12.2 (17.0)	786 (293)	0	92.3
2003	12.5 (19.7)	685 (227)	836	187.7
2004	11.8 (18.0)	744 (272)	2235	134.1
2005	12.0 (18.5)	672 (271)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

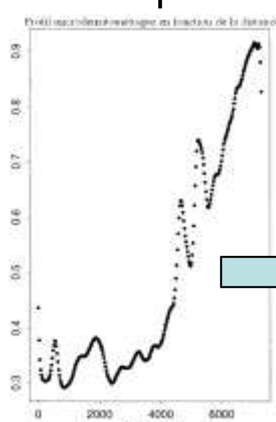
April-October 2006, once a week

HL: 5 irrigated / 5 non-irrigated

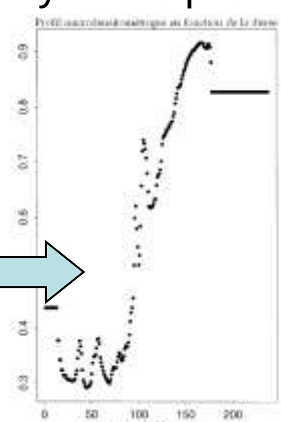
Dynamics of ring formation

EW, TW, LW

Static profile

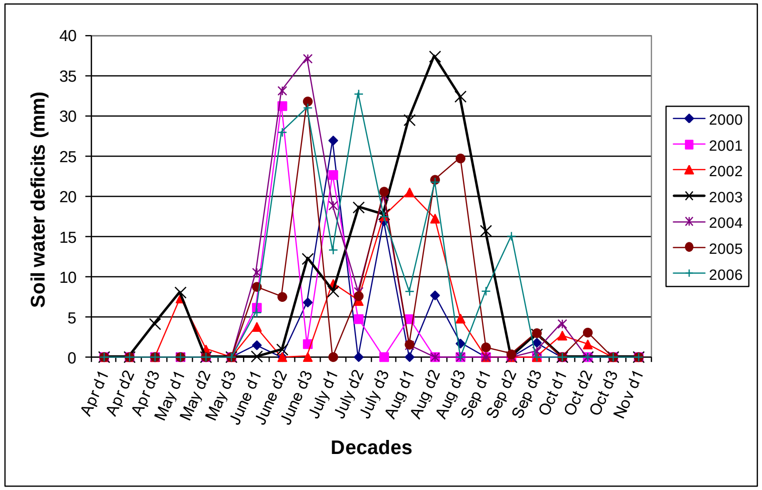


Dynamic profile

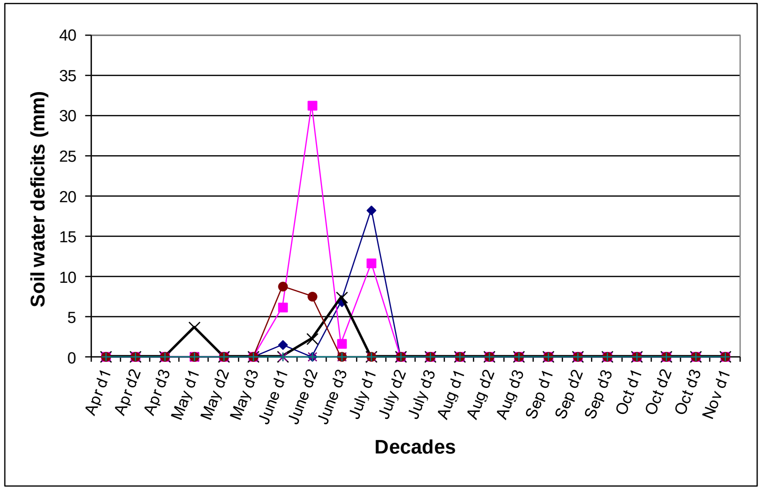


Evaluation of drought stress

Non-irrigated

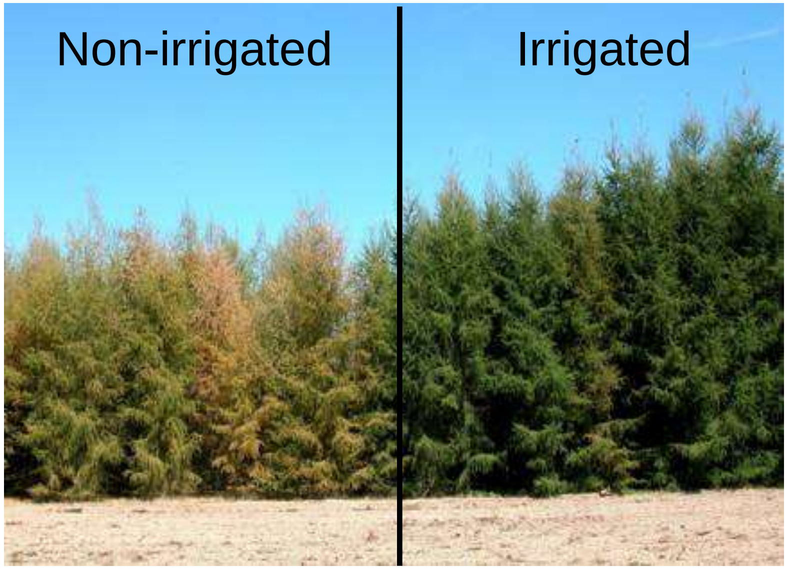


Irrigated

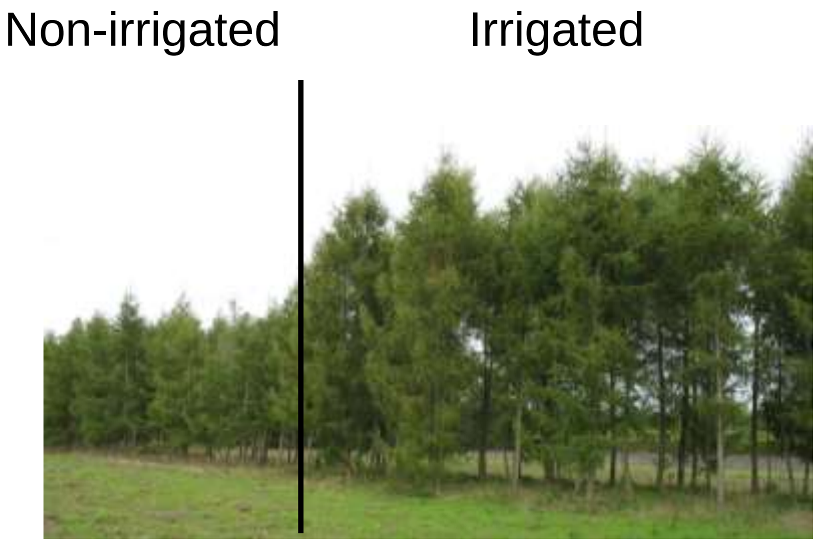


- Recurrent water deficits from June (1st decade) up to September (2nd decade)
- Usually severe but short-period of stress: e.g. 2004 (3rd decade June), 2002 (1st decade August)
- 2003 & 2006: exceptionally long (2nd decade of June up to 1st decade of September) and intense !

Results



M.Verger, August 2003



L.Pâques, October 2006

Results

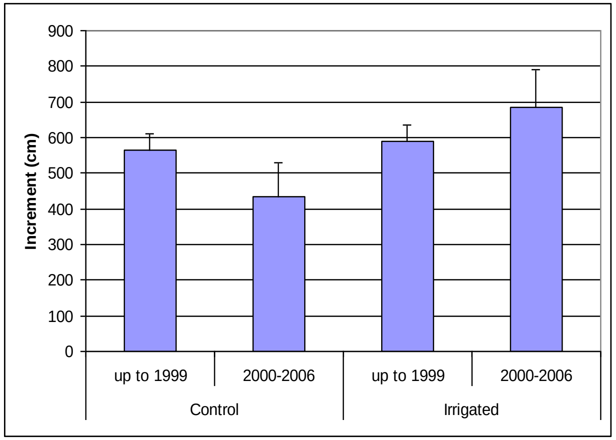
➢ *Highly significant differences are observed between irrigated and non-irrigated trees for*:

	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%

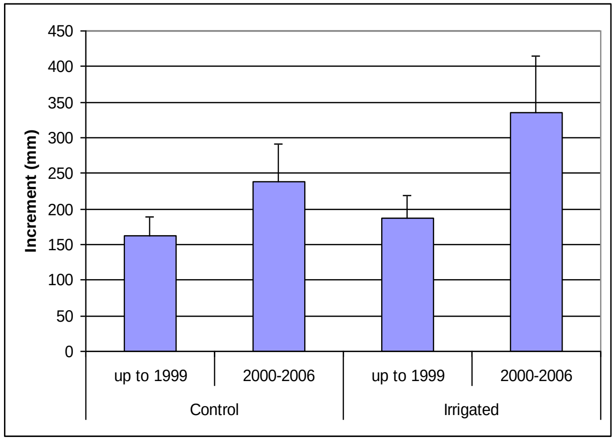
➢ *No differences for:*

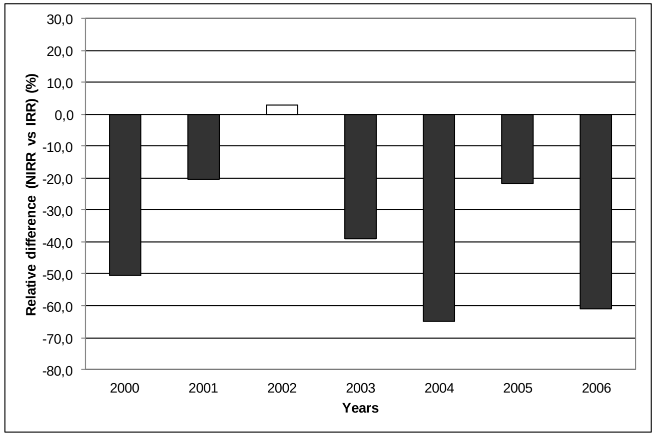
- Latewood proportion
- Heartwood proportion/ HW extension
- Ring density (EW, LW, R)

Height



Girth



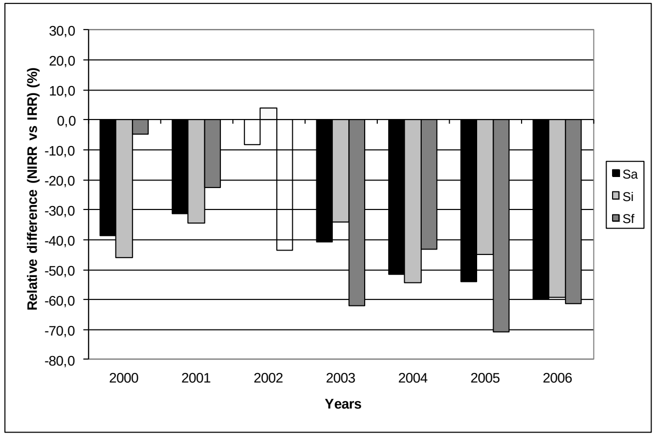


APICAL GROWTH

Strong negative impact all years

From -20 to -65%

Worse years: 2004 – 2006 – (2000)



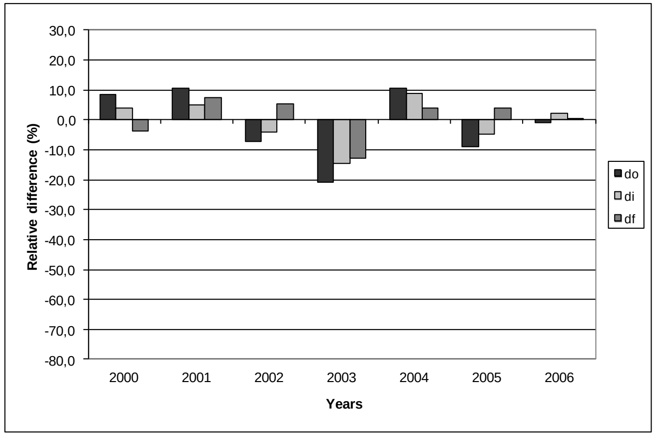
RADIAL GROWTH

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

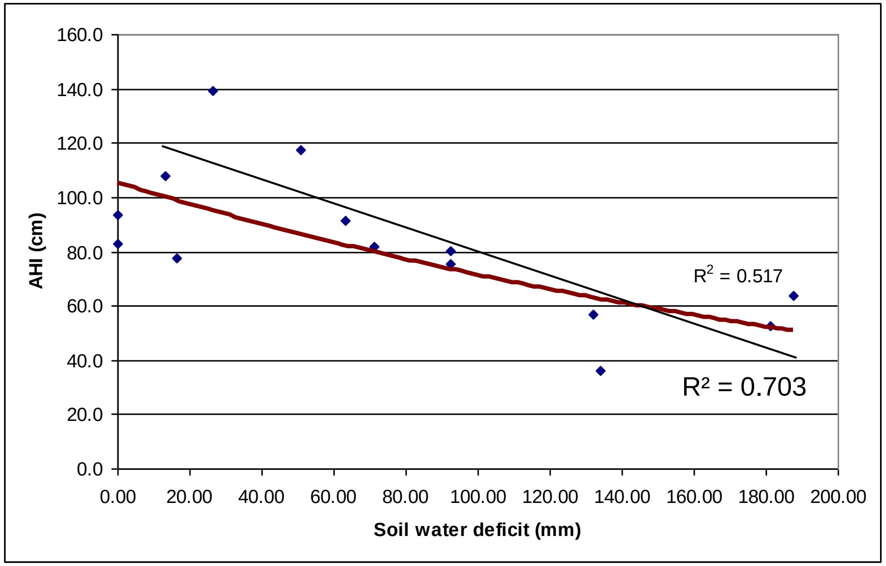
Weak effects (positive or negative)

for overall, EW and LW density

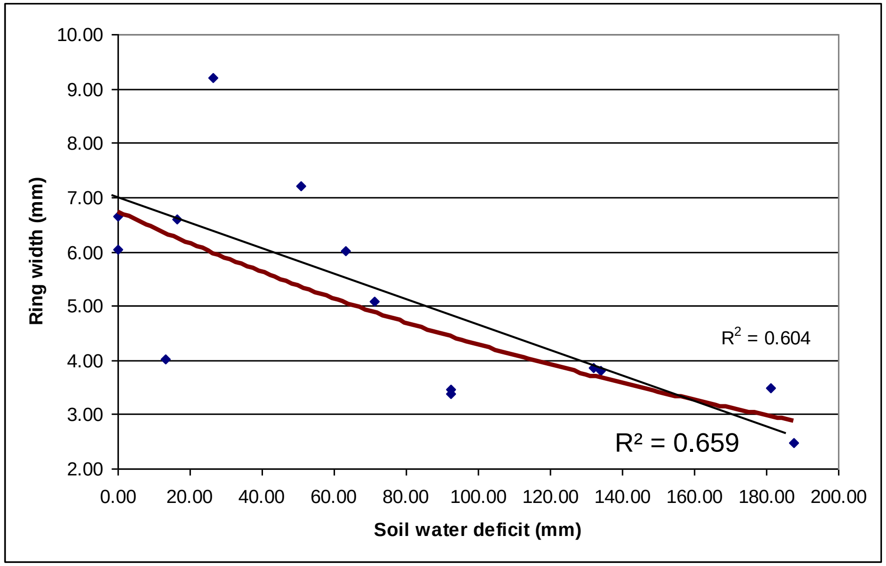
Results

Soil water deficit has a strong negative impact on growth

Height increment

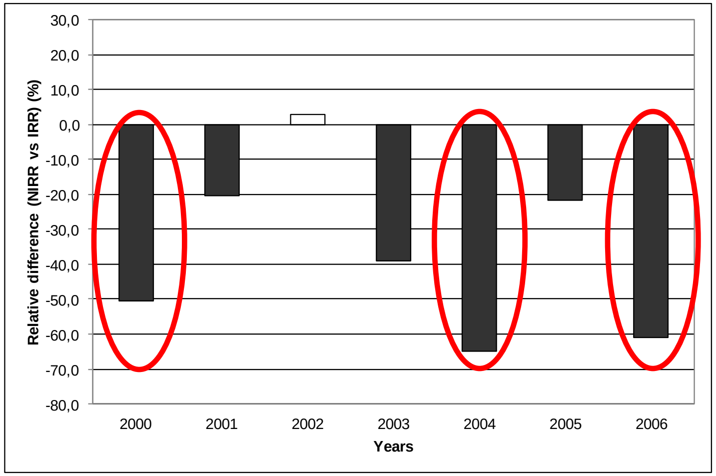


Ring width

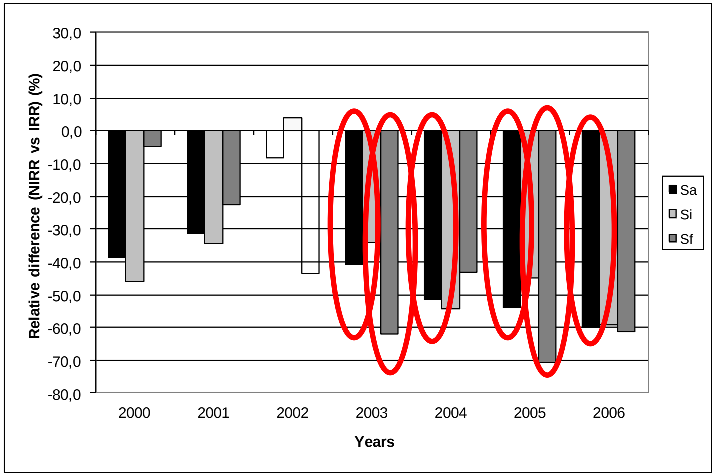


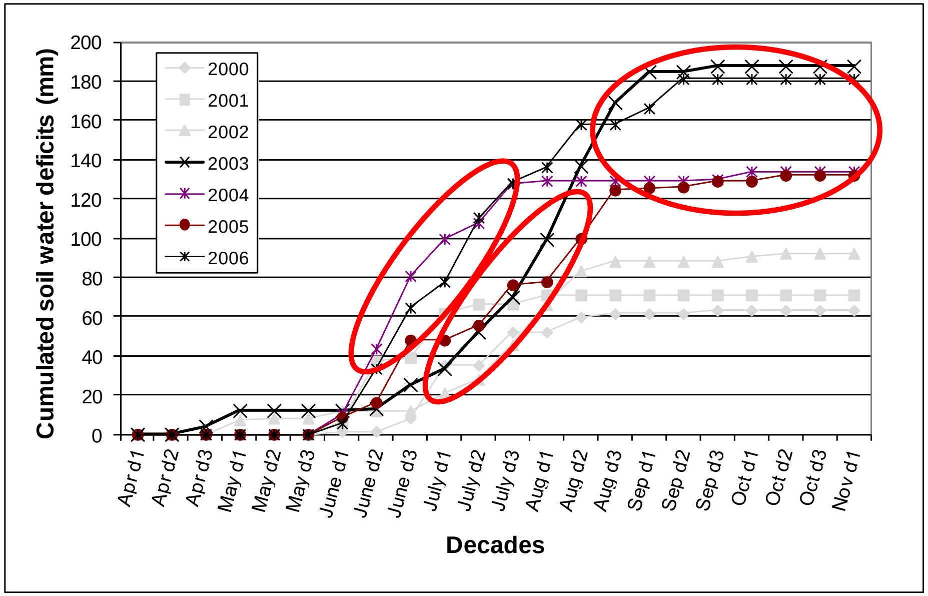
Results

APICAL GROWTH



RADIAL GROWTH





~ accumulated water stress

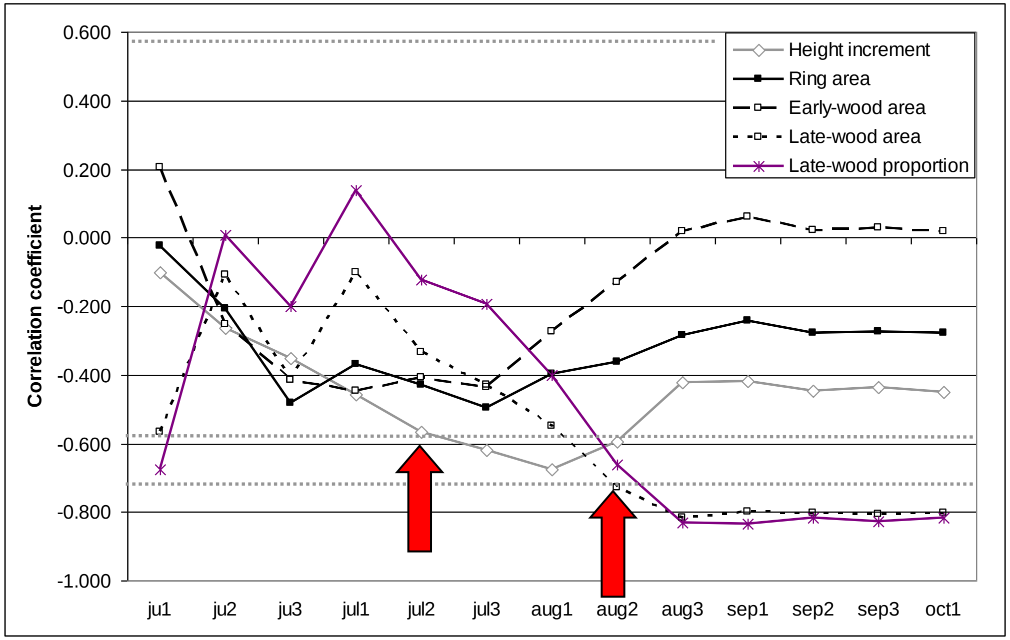
Results

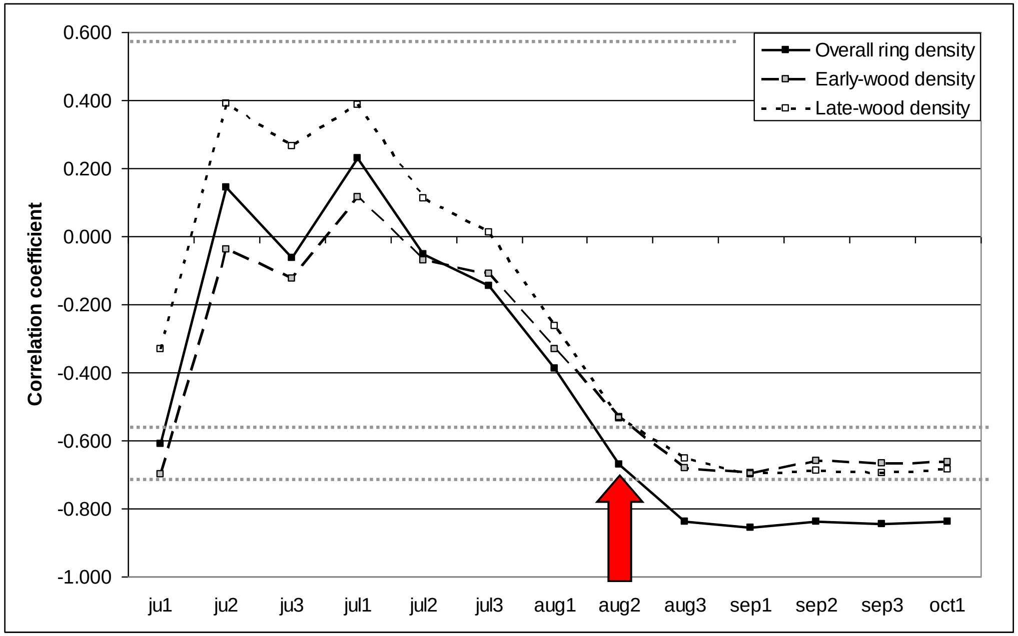
Link between cumulated water deficits along the growing season and their impacts on traits

Significant negative link between impacts and water deficits are observed

- not before 2nd decade of July for height growth

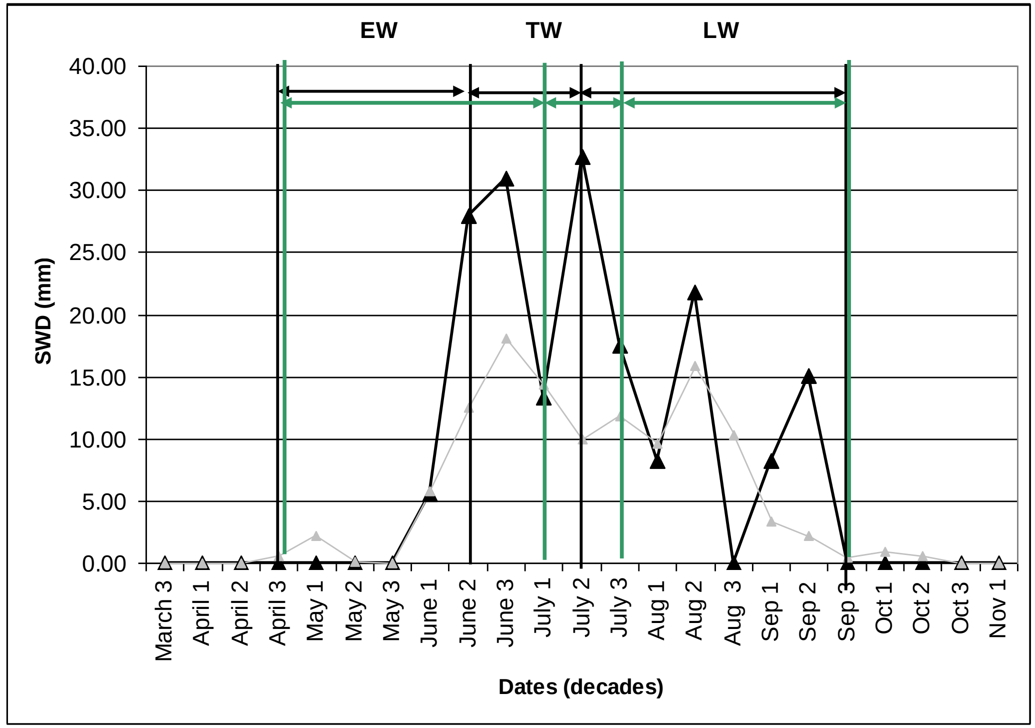
- and one month later for radial growth and wood density





Results

Hybrid Larch - Growing season 2006

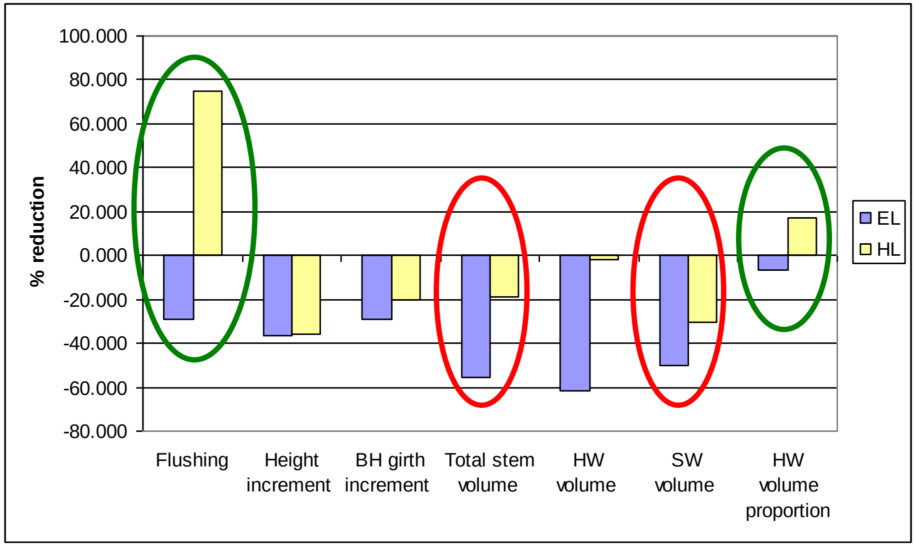


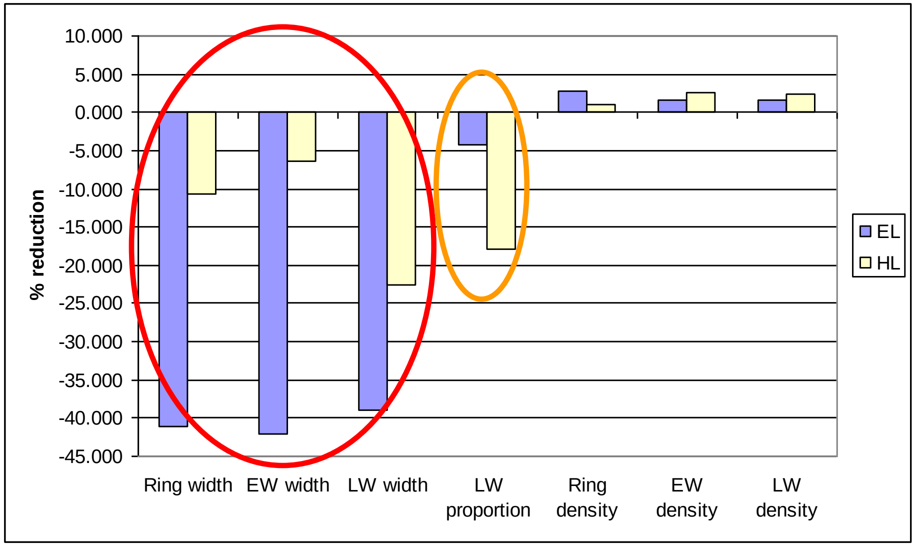
Ring width	*EW duration*	*EW speed*	*TW duration*	*TW speed*	*LW duration*	*LW speed*
Irrigated	**71**	0.036	25.3	**0.046**	68.8	**0.018**
Non irrigated	**60.6**	0.028	22.6	**0.019**	74.0	**0.005**

HL	Irrigated	Non irrigated
2006		
RW (mm)		2.5
LW (%)		24.0

Results

Comparison of impacts on EL vs HL





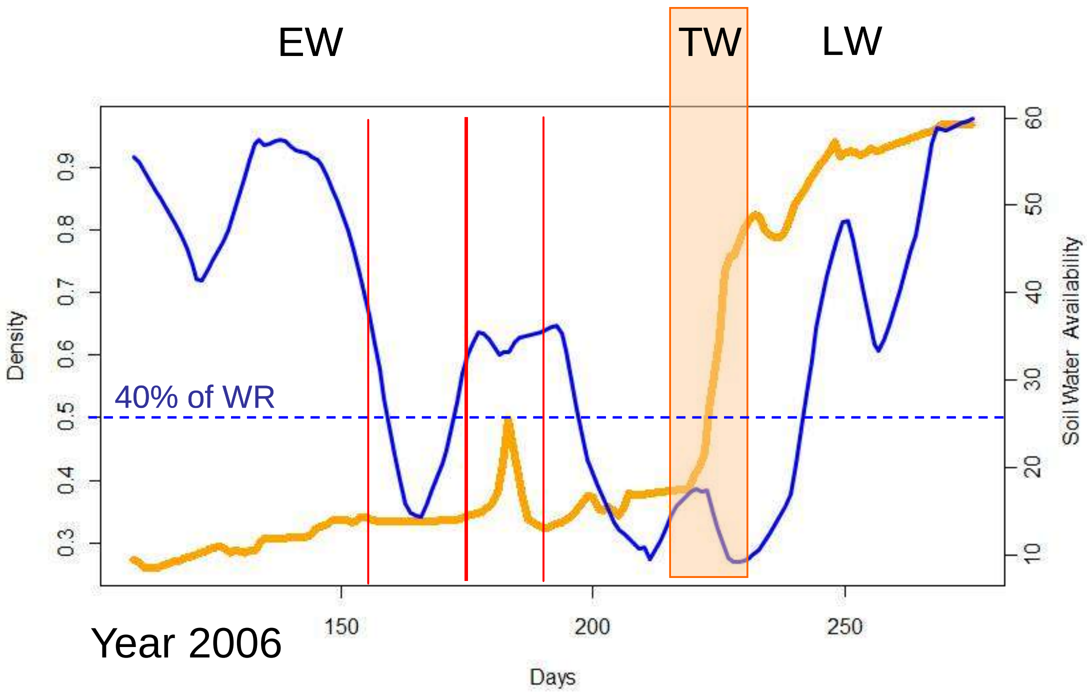
- Opposite impact on EL/HL: flushing, HW proportion…HW volume
- Similar impact in EL/HL: height
- Stronger negative impact on EL: volume (total, HW, SW)
- Stronger negative impact on HL: %LW

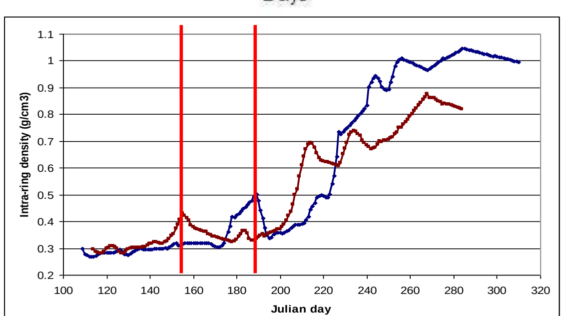
Conclusions

- ✓ 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

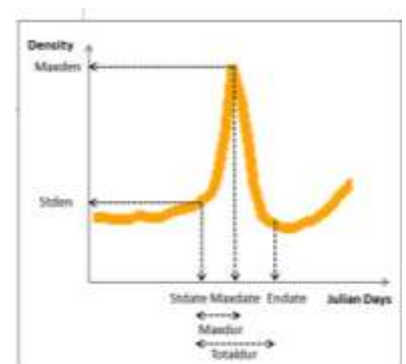
Perspectives

- 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 ?

	father														
mother	106	109	166	214	221	222	242	284	3190	3193	3194	3200	3203	3217	Total
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							10	10	10	10	10	9		1	60
222							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													10	10	20
3203														10	10
Total	10	20	10	10	29	19	30	29	65	80	79	79	40	51	551

EL HL JL

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