Hrvatski šumarski institut
Croatian Forest Research Institute

Estimation of Effects of Drought Periods on Atmospheric Carbon Storage in Biomass of Young Pedunculate Oak Stands in Pokupski Basin

Authors:
Elvis PALADINIĆ, Dijana VULETIĆ,
Hrvoje MARJANOVIĆ, Krunoslav INDIR

Introduction

- During last 10 years - increasing frequency of drought periods in the growing season (extreme droughts in Croatia: 2000, 2003)
- Effects on forest ecosystem: reduced assimilation, decreased increment, i.e. atmospheric carbon storage reduced
- Scope of presentation - atmospheric carbon capture and storage by forest in order to emphasise the role of the forest as a dynamic and important 'carbon pool' concerning climate change mitigation issues

Objective

- To assess the atmospheric carbon quantity (and its CO_2 equivalent) which young forest could capture (assimilate) in the drought conditions and compare it with quantity of carbon captured by the same forest grown in *average* climate conditions
- Two climate-related scenarios were created
  Scenario 1 - two successive vegetation periods affected by drought
  Scenario 2 - two climatically average growing seasons
- Main assumption: annual radial increment of tree stem during growing season with extreme drough, will be reduced to a half of the radial increment value in climatically *average* growing season (Lukić et al 2001, Vajda 1980)

Research object

- Forest stand presenting young flooded lowland pedunculate oak forest (*Genisto elatae - Quercetum roboris* Ht. 1938) of Pokupski Basin

- Description:
  Forest sub-compartment of forest management unit
  The stand is even-aged and managed on the principles of sustainable forest management
  Coordinates of the research object: 45° 37' 16'' N & 15° 41' 24'' E
  Altitude : from 109 to 112 m a.s.l.
  The mean annual temperature is 10,4 °C (last 25 years)
  Annual rainfall about 734-1174 mm
  Age: 34 years old. Area of sub-compartment : 36,8 ha
  Rotation : 140 years


Jastrebarski lugovi
CRNA MLAKA
Draganički lugovi
Pisarovinski lugovi
Rečički lugovi
N
W
E
S
0
1
2
3
4
5
km

Methods I

- Field work activities (2007/08):
  - Establishing and measuring permanent sample plots (circular, r = 8,0 m) in selected forest stands
  - Measuring weekly diameter increment of tree stems using previously installed dendrometer bands (Ostrogović 2008)
  - Collecting samples from tree components (stem, branches, leaves) regarding tree species (C & N content)

Methods II

- In the office:
  - Filtering and processing of collected data (calculating the forest stand biomass and amount of carbon stored regarding main tree components, in the year of measurement - 2008)
  - Simulation of two climate-related forest growth scenarios using the CO2Fix model, comparing obtained simulation results, making conclusions

Model CO2Fix v.3.1

- CO2Fix (Mohren, Nabuurs et al) - simple carbon bookkeeping model made for assessing changes in carbon reserves and carbon flows through elements of a forest stand over a given time period
- Main properties:
  - user-friendly for applying on forest management & sylvicultural issues - input and output data adapted to forestry level
  - comprehensive in applicability (for simulation of monospecies or mixed stands, even- or uneven-aged stands)
  - tested and validated on numerous forest communities worldwide in different Case studies
  - modular structure - consisting of 6 modules
  - model inputs and outputs are fully compatible with the terminology of GPG LULUCF and Kyoto Protocol

CO2Fix - [Delnice_60a.co2]

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year [yr]	Osnovni Biomass Jela stems carbon [MgC/ha]	Osnovni Biomass Jela stems dry weight [MgDM/ha]	Osnovni Biomass Jela stems volume [m3/ha]	Osnovni Biomass Jela stems CAI [m3/ha/yr]	Osnovni Biomass Jela foliage carbon [MgC/ha]	Osnovni Biomass Jela foliage dry weight [MgDM/ha]	Osnovni Biomass Jela branches carbon [MgC/ha]	Osnovni Biomass Jela branches dry weight [MgDM/ha]	Osnovni Biomass Jela roots carbon [MgC/ha]	Osnovni Biomass Jela roots dry weight [MgDM/ha]	Osnovni Biomass Jela carbon [MgC/ha]	Osnovni Biomass Jela dry weight [MgDM/ha]	Osnovni Biomass Bukva stems carbon [MgC/ha]	Osnovni Biomass Bukva stems dry weight [MgDM/ha]	Osnovni Biomass Bukva stems volume [m3/ha]
0	89.85	179.69	449.24	0.00	0.22	0.44	14.50	29.00	41.35	82.70	145.92	291.83	19.16	38.31	55.53
1	90.43	180.86	452.16	2.92	0.22	0.45	14.45	28.90	41.00	82.00	146.10	292.21	20.15	40.30	58.40
2											120.55	241.09	16.32	32.64	47.30
3											120.88	241.76	17.31	34.62	50.18
4											121.21	242.43	18.30	36.61	53.05
5											121.55	243.11	19.29	38.59	55.93
6											121.90	243.79	20.29	40.57	58.80
7											120.59	241.18	21.28	42.56	61.67
8											120.95	241.90	22.27	44.54	64.55
9											121.31	242.62	23.26	46.52	67.42
10											121.67	243.34	24.25	48.50	70.30
11											122.04	244.07	25.24	50.49	73.17
12											100.67	201.34	20.08	40.16	58.21
13											101.51	203.03	20.92	41.83	60.63
14											102.36	204.71	21.75	43.50	63.05
15											103.20	206.39	22.59	45.17	65.47
16											104.03	208.07	23.42	46.84	67.89
17											103.56	207.13	24.26	48.51	70.31
18											104.46	208.92	25.09	50.18	72.73
19											105.36	210.72	25.93	51.86	75.15
20	71.27	142.54	356.36	4.19	0.28	0.55	9.62	19.23	25.09	50.18	106.25	212.51	26.76	53.53	77.57
21	72.11	144.22	360.55	4.19	0.28	0.57	9.66	19.31	25.10	50.19	107.15	214.29	27.60	55.20	79.99
22	59.36	118.71	296.79	3.61	0.23	0.47	7.89	15.77	20.42	40.84	87.89	175.79	22.36	44.73	64.83
23	60.08	120.16	300.39	3.61	0.24	0.48	7.92	15.85	20.44	40.89	88.69	177.37	23.26	46.51	67.41
24	60.80	121.60	304.00	3.61	0.25	0.49	7.96	15.92	20.47	40.94	89.48	178.95	24.15	48.30	70.00
25	61.52	123.04	307.60	3.61	0.25	0.50	8.00	15.99	20.49	40.99	90.26	180.53	25.04	50.08	72.58
26	62.24	124.48	311.21	3.61	0.26	0.51	8.03	16.07	20.52	41.04	91.05	182.10	25.93	51.86	75.17
27	62.11	124.22	310.55	3.75	0.26	0.52	7.96	15.92	20.27	40.54	90.60	181.20	26.90	53.80	77.97

Biomass

Stems | Foliage | Branches | Roots | Mortality | Competition | Management mortality | Thinning-Harvest

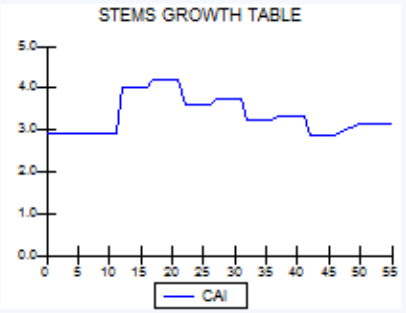
Scenario: Osnovni Cohort: Jela

Carbon content [MgC/MgDM]: 0.5

Wood density [MgDM/m3]: 0.40

Initial carbon [MgC/ha]: 89.8475

Age [yr]	CAI [m3/ha/yr]
0	2.923
7	2.923
11	2.923
12	4.020
16	4.020
17	4.190
21	4.190



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Results

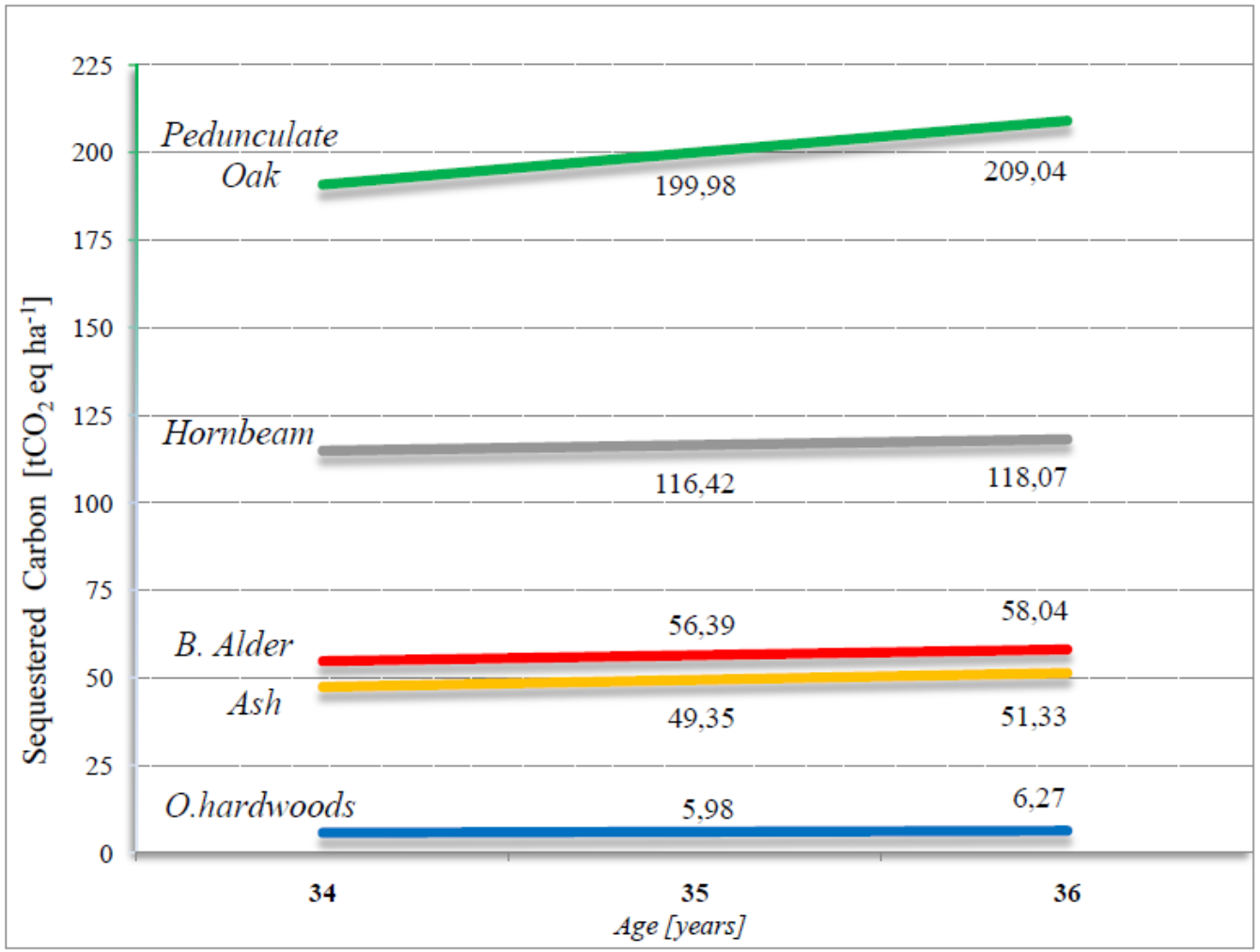
Tree species	Mean tree diameter [cm]	Number of trees [N/ha]	Basal area [m^2/ha]	Merchantable wood volume [m^3/ha]	Share in m.w. volume [%]
Pedunculate Oak (*Quercus robur* L.)	17,3	440,1	10,30	99,7	*48,82*
European Hornbeam (*Carpinus betulus* L.)	11,9	526,2	5,88	45,4	*22,22*
Black Alder (*Alnus glutinosa* L.)	14,3	264,1	4,24	32,8	*16,05*
Narrow-leaved Ash (*Fraxinus angustifolia* Vahl.)	13,2	220,1	2,99	22,0	*10,78*
Other Hardwoods	10,5	72,7	0,62	3,6	*2,13*
Sum		**1.523,2**	**24,03**	**203,5**	**100,00**

Simulation results

- Simulation prerequisites:
  - annual stem volume increment
  - actual wooden biomass of forest stand (concerning tree components)
  - carbon content of wood dry matter
  - several other parameters (basic wood density, correction factors of branches, roots and foliage growth etc.)
- Simulation results (quantity of carbon sequestered in tree biomass) are expressed in CO_2 equivalent units (per hectare)

Simulation results - forest woody biomass

Scenario - two climatically average growing seasons



Carbon in whole biomass of trees ≈ 442,75 tCO_2 eq ha^{-1} (with roots)

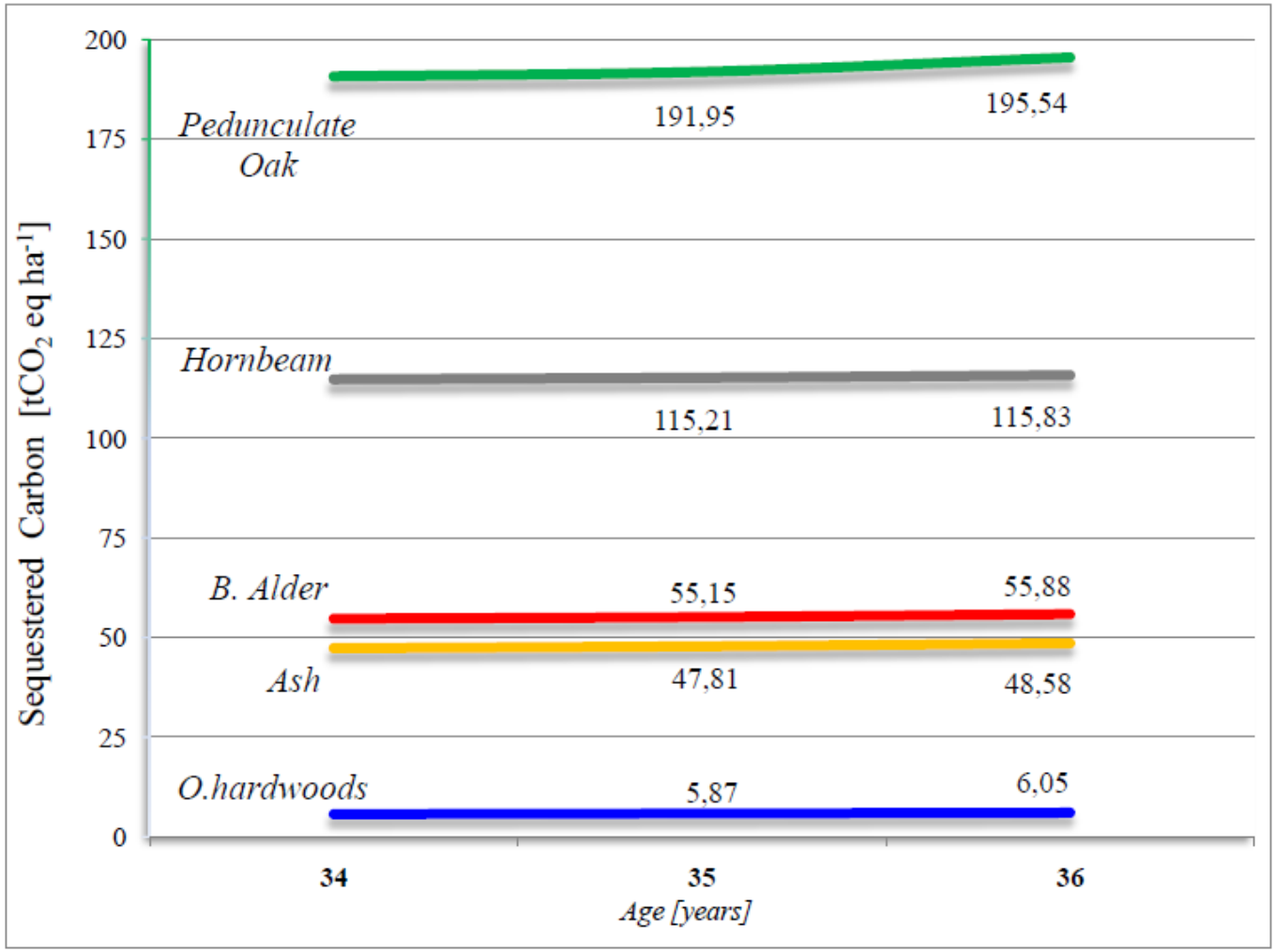
Average carbon sequestration ≈14,70 tCO_2 eq $ha^{-1}yr^{-1}$

≈ 6280 l of gasoline

≈ 5490 l of diesel

Simulation results - forest woody biomass

Scenario - two successive vegetation periods affected by drought



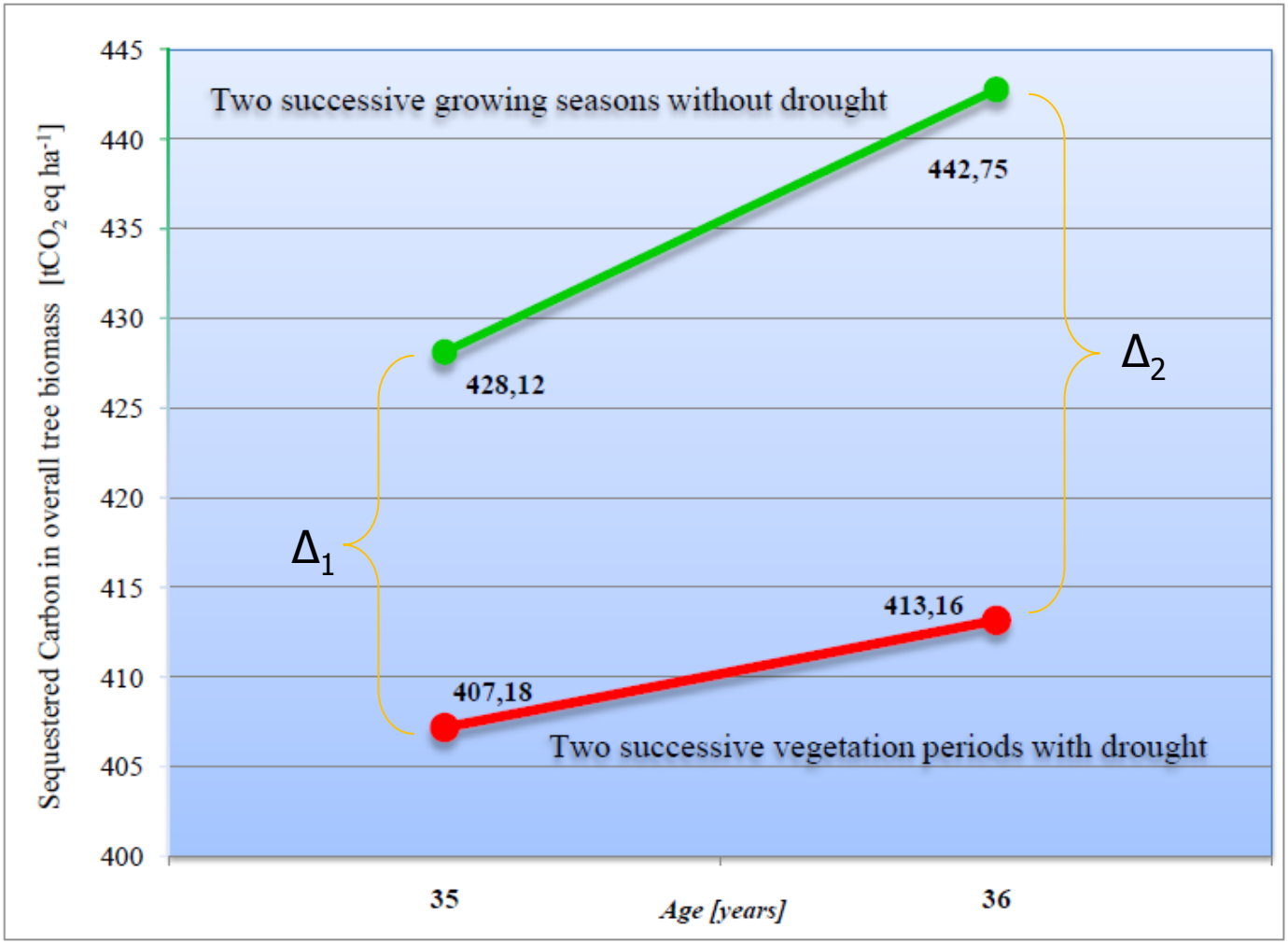
Carbon in whole biomass of trees ≈ 421,89 tCO_2 eq ha^{-1} (with roots)

Average carbon sequestration ≈ 6,0 tCO_2 eq ha^{-1} yr^{-1}

≈ 2560 l of gasoline

≈ 2240 l of diesel

Simulation results - forest wooden biomass in total



Δ_1= 20,94 tCO_2 ha^{-1}
≈ 8900 l ha^{-1}
gasoline

Δ_2= 29,59 tCO_2 ha^{-1}
≈ 12600 l ha^{-1}
gasoline

Conclusions

- Results obtained with simulation show, as expected, significant differences in carbon assimilation between two scenarios.
- Yearly 'Absorption capacity' of oak stand concerning atmospheric carbon, has been decreased in simulated drought conditions for 59 % regarding average climate conditions.
- The biggest difference regarding sequestered carbon in tree components, is between biomass of stems.

Conclusions

- Impotrant: soil raspiration and tree increased tree mortality are not included in the model!
- Even greater difference in carbon sequestration between two scenarios is likely.