Modelling Carbon Uptake and Analysing Economics of Planting Trees to Mitigate Climate Change

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Problem definition

- Impact of GHG results in CC and Global warming. Forests remove CO_2 from the atmosphere and store C in terrestrial ecosystems, playing role in climate stabilisation. Planting trees may therefore be an attractive economic alternative of C emissions reduction.

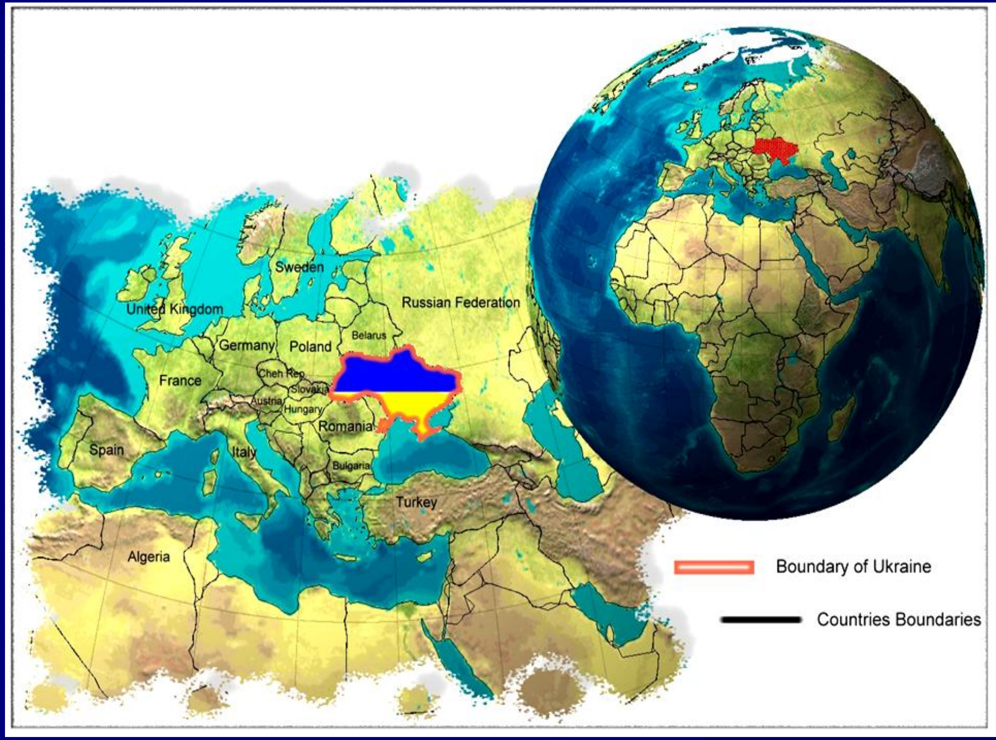
If C sink is on par with the emissions reduction, a country could receive credits for planting trees.

Research objectives

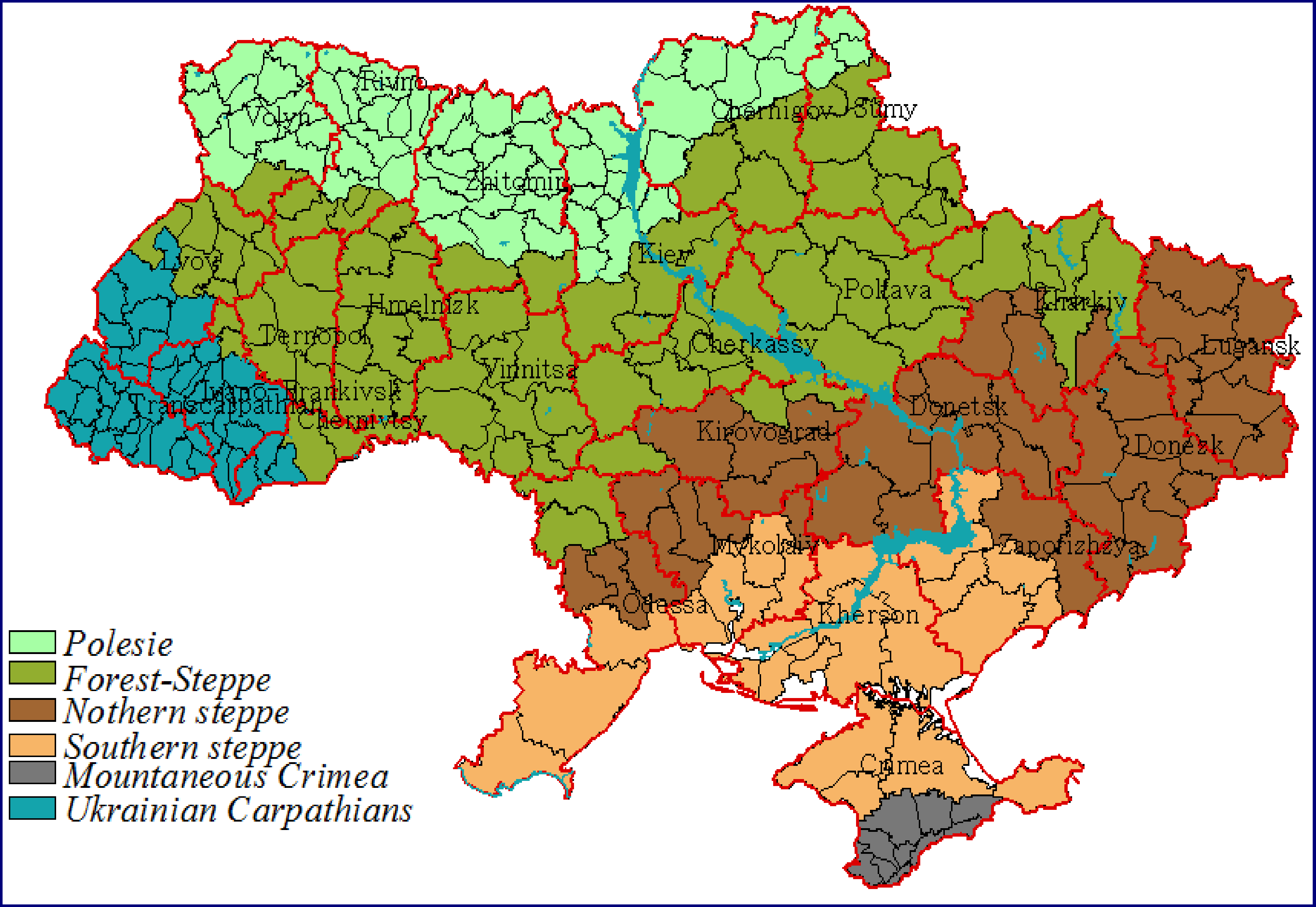
- assess the potential of planting trees on marginal land;
- estimate benefits in terms of physical C;
- estimate costs , provide benchmarks for comparing policy alternatives and indicate whether tree-planting is an economically efficient way of removing C and where?

- storage policy scenario;
- wood-for-fuel substitution;
- wood products scenario

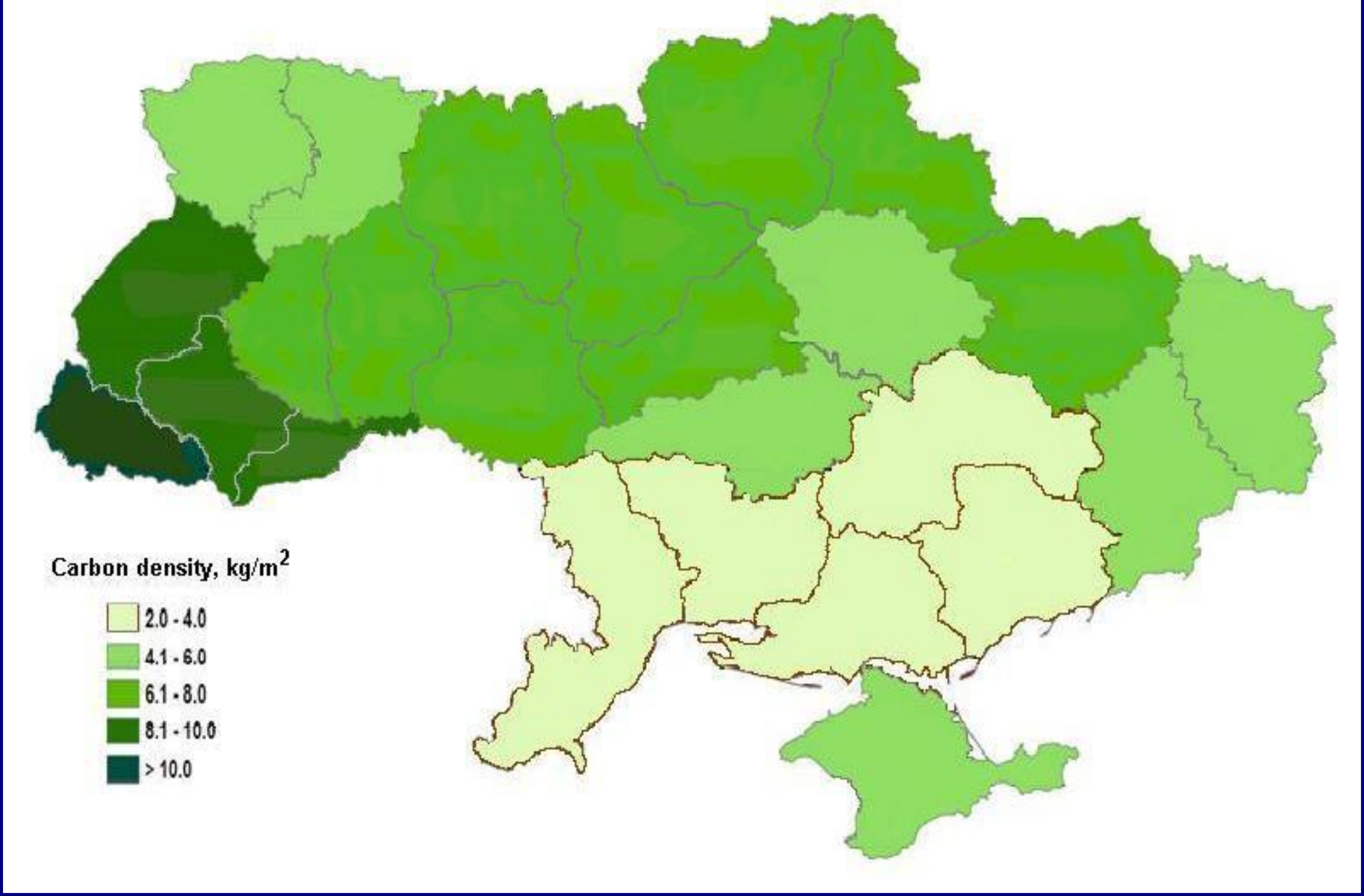
- **The case of Ukraine**



Natural vegetation zones

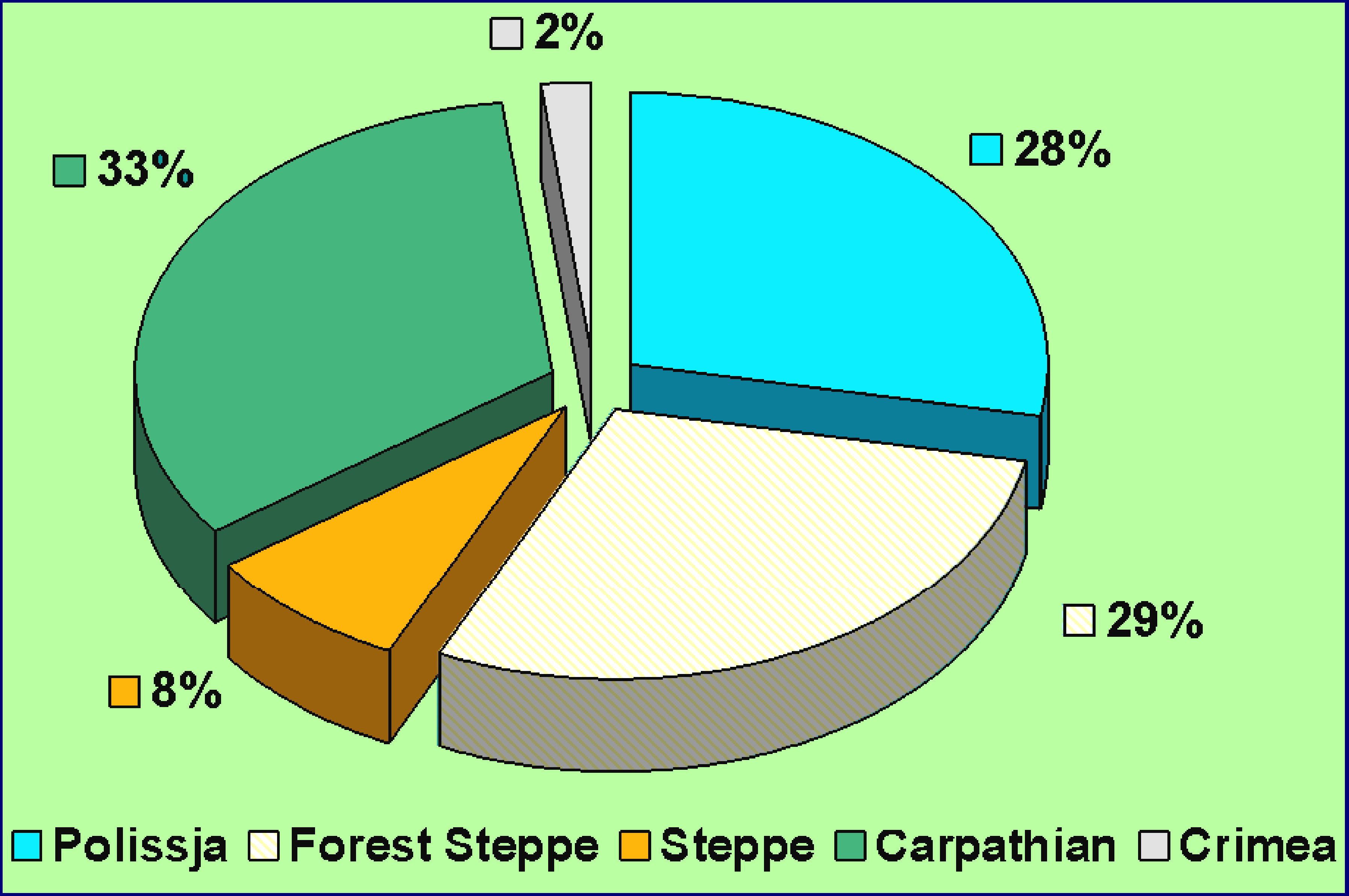


Forest carbon density across zones

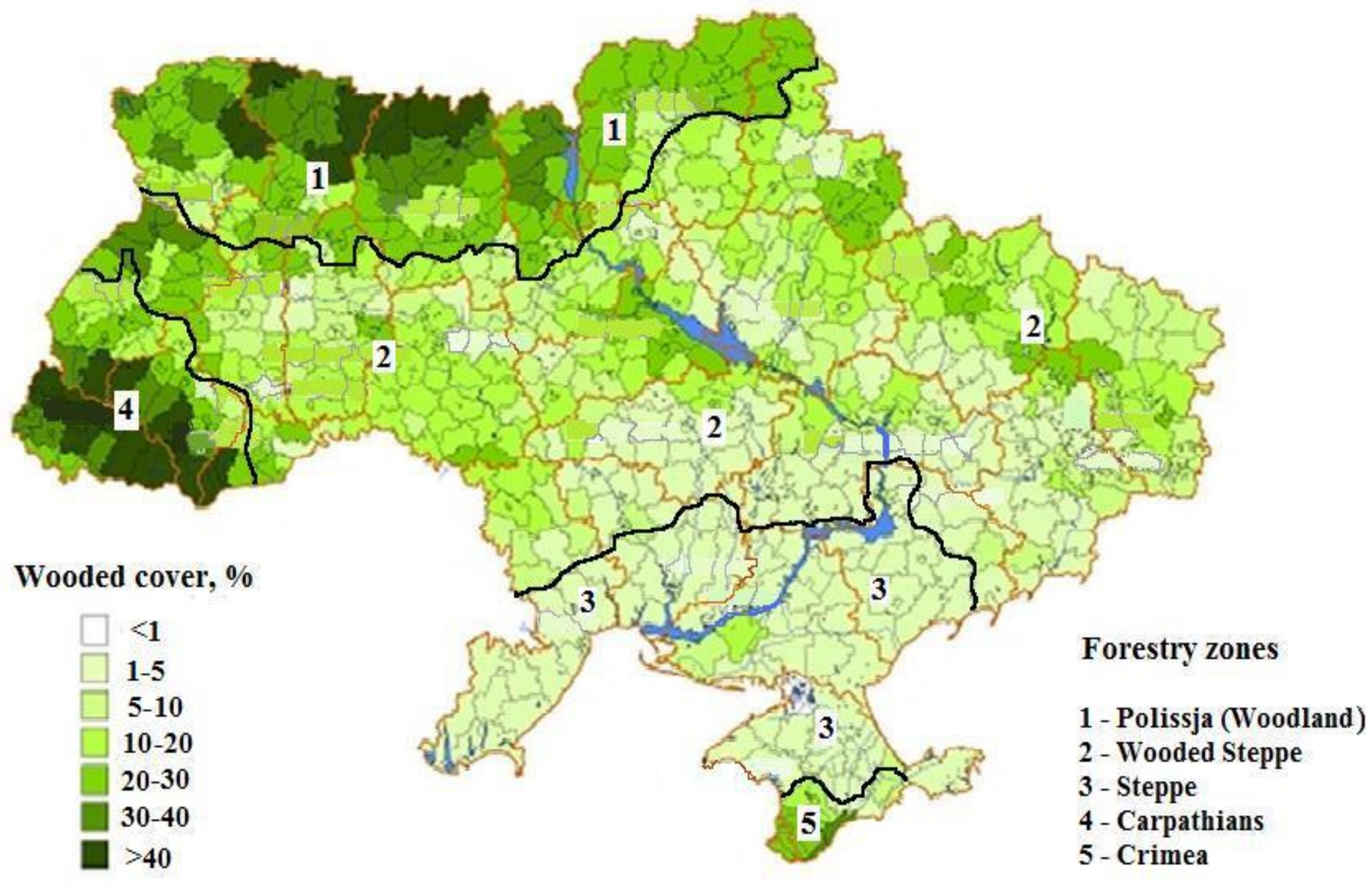


Source: Lakyda (2002)

Carbon content in forests across zones



Wooded cover, 2002 (%)



Source: Forestry Committee (2002)

Land considered for afforestation

- previously productive lands in the Wooded Steppe that have been converted into marginal and bare lands;
- marginal agricultural lands in the Polissja;
- some highlands not covered with forests in the Carpathian mountains;
- eroded and contaminated areas in various forestry zones;
- lands on sands, slopes, along roads, around water basins etc. where it is wise to create nature protective belts;
- zones around industrial agglomerations and lands that have been used in mining industry and which today are under recultivation.

Afforestation costs

Lands of the Forest Fund have no other use than growing trees, and the costs of afforestation comprise:

- tree-planting costs;
- silvicultural expenses.

Agricultural lands considered for afforestation, are bare lands and marginal lands used for forage, pasture and wheat production.

For each agricultural activity the costs of afforestation comprise:

- direct costs of tree-planting;
- silvicultural expenses;
- net returns associated with current land use (opportunity costs).

The costs differ per forestry zones, but are low in the Ukraine.

Planting trees to sequester carbon

Functional forms for stand growth of tree species proposed for planting were estimated. The statistical analysis shows that the best fit is achieved by an exponential functional form of tree growth $y = a_0\, t^{a1} e^{a2t}$ (m^3) in all forestry zones.

In the Carpathians, for spruce recommended for planting growth function is:

$$V(t) = 0.159\, t^{2.240}\, e^{-0.018t}$$

Growth function of pine in the Crimea is:

$$V(t) = 0.704\, t^{1.648} e^{-0.010t}$$

Growth of poplar in the Wooded Steppe is:

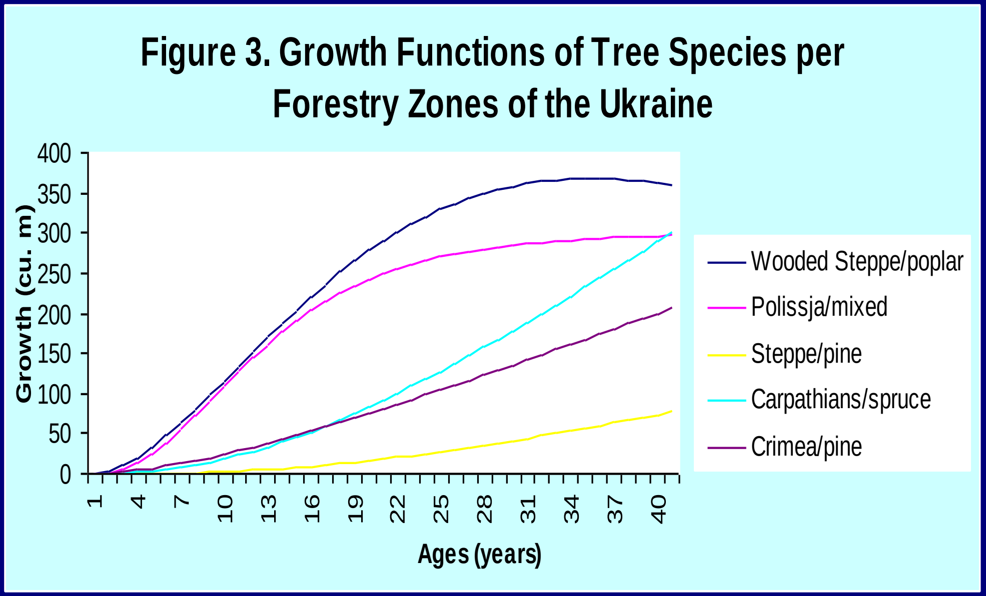
$$V(t) = 2.939\, t^{1.933} e^{-0.055t}$$

Growth function of pine in the Steppe is:

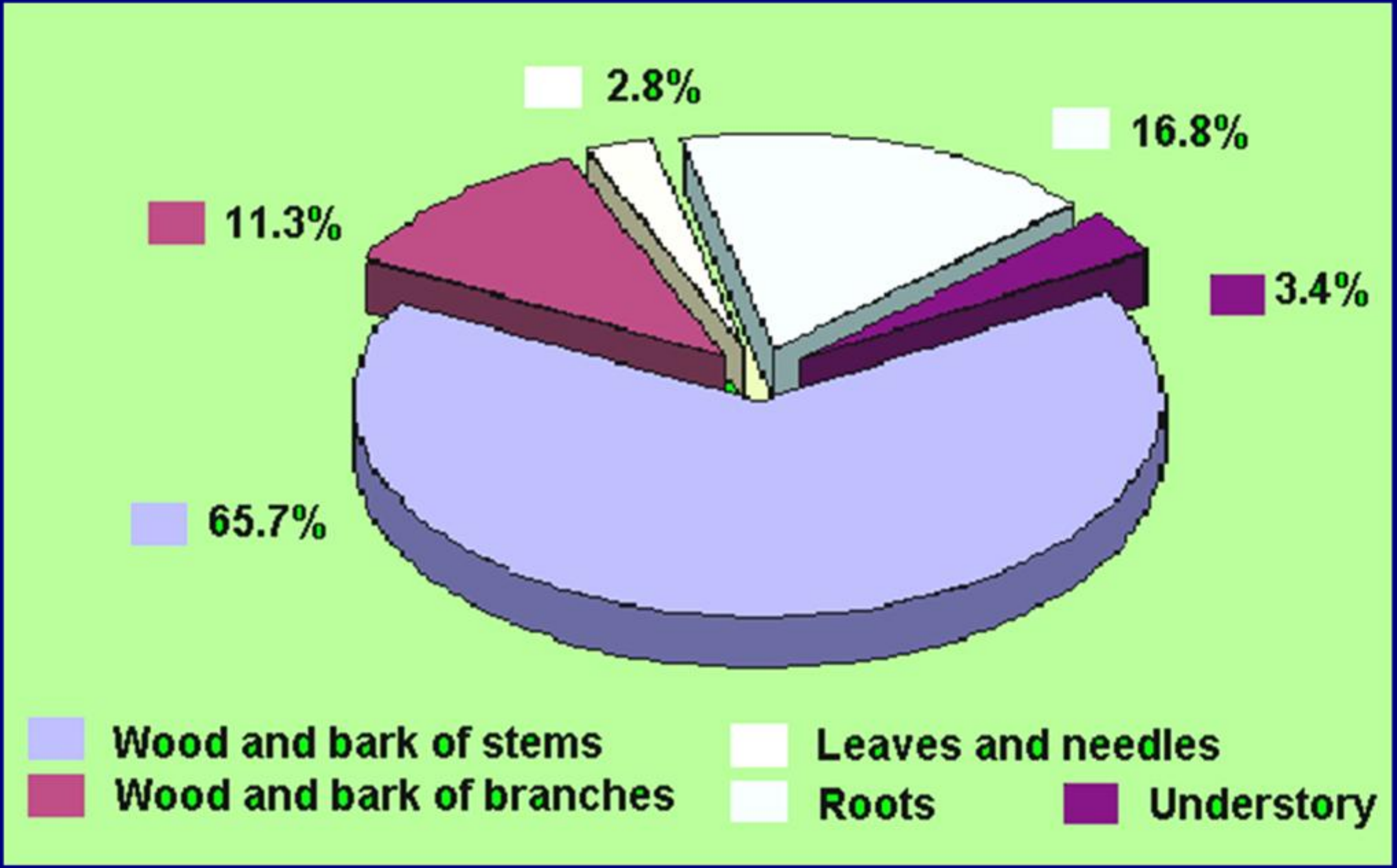
$$V(t) = 0.006\, t^{2.847} e^{-0.026t}$$

In the Polissja, for mixed stands:

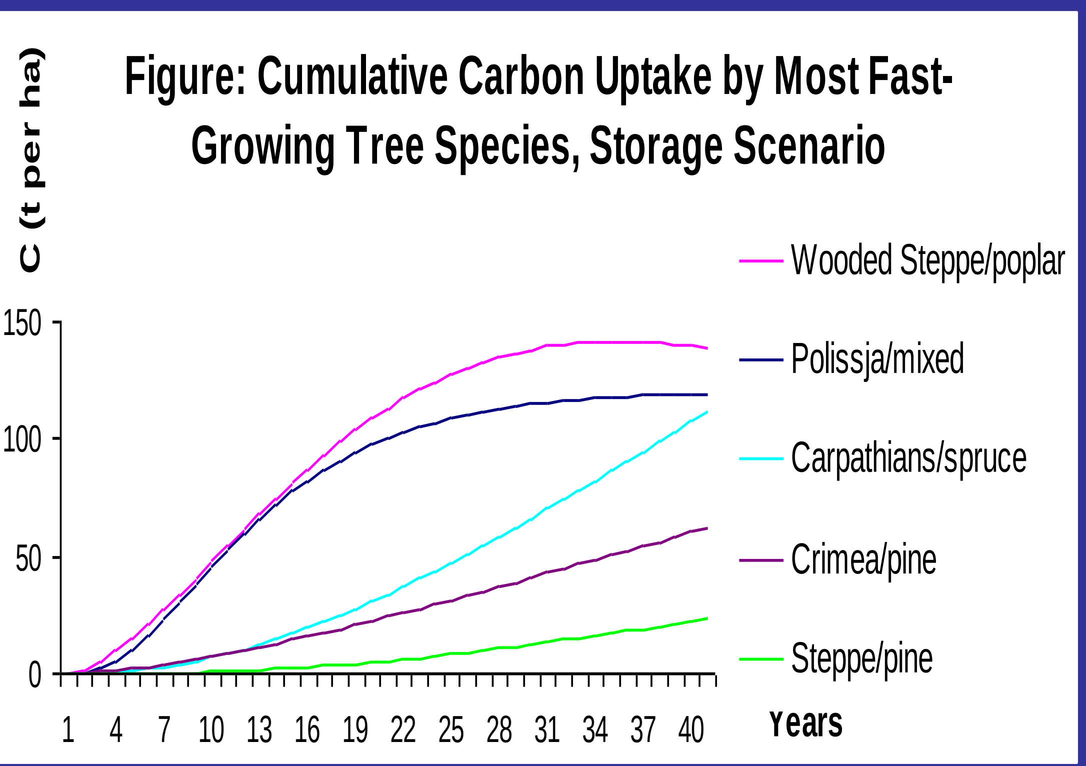
$$V(t) = 300\, (1 - e^{-0.14\, t})^3$$



Carbon content in forest biomass



Carbon sequestration



Cumulative and permanent amounts of sequestered C were computed:

$$C_{t\text{-}ys} = \left[\sum_{t=1}^{40} \frac{(C_t - C_{(t-1)}) \times (40 - t + 1)}{(1+r)^t} \right]$$

$C_{t\text{-}ys}$ is total ton-years of C per ha;

C_t is C uptake in the year t, t/ha;

C_{t-1} is C uptake one year earlier, t/ha;

r is a discount rate

$$C_{perm.\ t} = C_{t\text{-}ys} / 50$$

50 - a conversion factor (IPCC, 2000)

Carbon uptake benefits

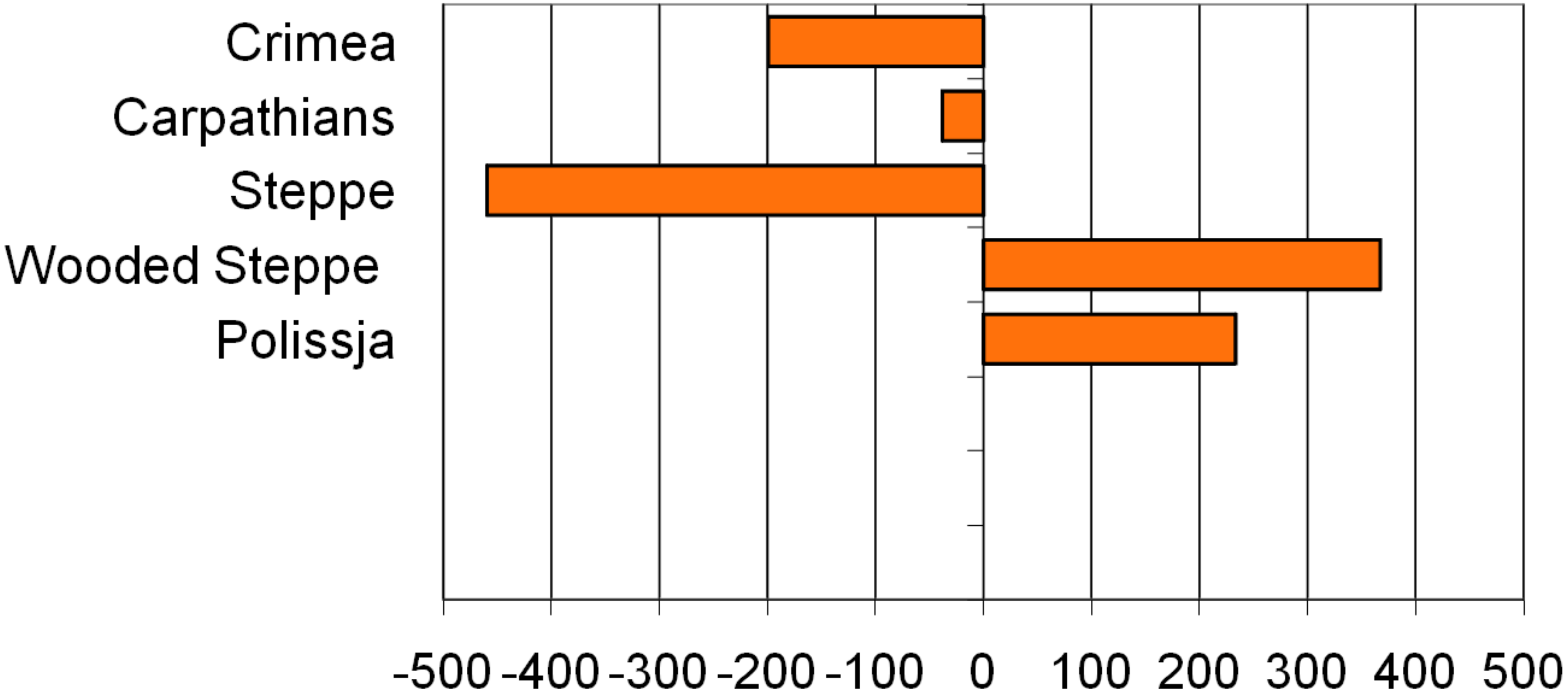
Table: C Upake in permanent tons and its Value per ha of the zones for the Storage option, at 4% discount

	Polissja	Wooded Steppe	Steppe	Carpathians	Crimea
Total ton-years of C	1846.2	2372.5	143.0	676.7	584.3
Permanent tons	36.9	47.5	2.9	13.5	11.7
Value of C uptake, €/ha	553.9	711.8	40.1	203.0	175.3

The C uptake benefits appeared to be high, especially for hybrid poplar in the Wooded Steppe zone and in the Polissja.

NPVB of C storage, AF scenario

Ukraine



€/ha, at 4% discount rate, C in permanent tons

Economics of carbon sequestration

Table: PV C Uptake Costs across Zones,

Forestry zones	€/t when C is discounted at	
	0%	4%
Polissja	5.8	8.7
Wooded Steppe	4.6	7.2
Steppe	78.5	173.3
Carpathians	8.7	17.9
Crimea	16.2	32.0
The Ukraine	9.5	18.1

The costs per ton of C are low. The storage option is the most viable. Under alternative scenarios, only poplar plantations in the Wooded Steppe are economically efficient.

Observations

- The policy of emissions reduction is to be a priority, yet forests must/can contribute to CCM.
- Compared to not emitting CO_2, C uptake in trees is overall temporary. Yet, it postpones CC, buys time for innovations, learning, and for adaptation to CC.
- Eventually, through wood decay, C is released to the air. Using wood for fossil fuel substitution and in wood products is then a more sustainable means of C management, in the long-run.
- Important is to find out which forests and forestry projects can best contribute to CCM, and how to achieve that at lower costs and with high social acceptability.

Conclusions

- Lands that fit for afforestation are available: 2.2 Mha.
- The potential of CS is high, C-S capacities depend on tree growth.
- The costs of afforestation are low (on average 9.5 € per ton C, rc = 0%, a storage scenario). C offset in trees is competitive with other means of C remove from the air
- An important factor that influences the simulations' results is r. The benefits of C uptake are not certain, and because of time preference, the future C reductions decrease in value rapidly. At high r, the value of any amount of C sequestered in t ≥ 40 years sharply approaches 0. Thus, if timing of C uptake is important, forests that capture C quickly, as poplar in the Wooded Steppe and the Polissja have advantage over spruce forests, in the Carpathians.
- The storage option is economically efficient strategy of offsetting CO_2 emissions in the Wooded Steppe and the Polissja (rc=0% through 4%).
- Under the alternative scenarios, when rc=4% the project's NPV>1 in the Wooded Steppe.