The type of forest matters in reforestations for carbon sequestration

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Transust.Scan results

1. How important will LULUCF be in Europe?

   Ovando, P. and Caparrós, A., 2007. Land Use and Carbon Mitigation in Europe: A Survey of the Potential of Different Alternatives.

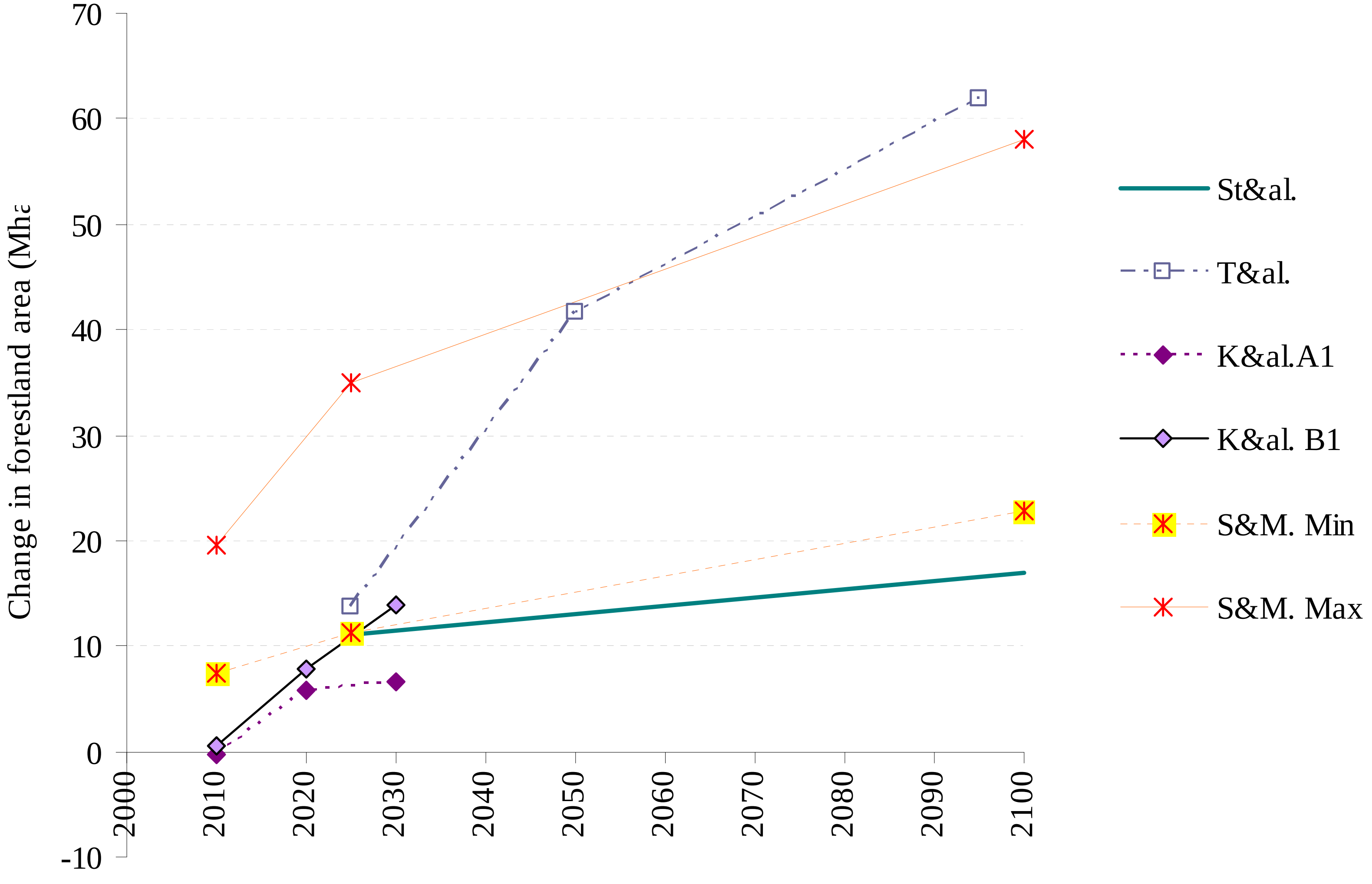
2. Biodiversity-scenic values and the selection of the type of forest

   Caparrós, A, Cerdá, E., Ovando, P. and Campos, P., 2007. Carbon Sequestration with reforestations and biodiversity-scenic values. FEEM Working Paper 28.2007, Milan.

3. Growth patterns and the selection of the type of forest

   Caparrós, A. and Zilberman, D., 2007. The effect of different biological or physical sequestration functions on the time path and implementation of carbon sequestration

Forest area expansion in the EU-25 from 2010 to 2100 (Mha)



Source: Ovando and Caparrós (2007).

Bioenergy crops/plantation in EU-25 from 2000 to 2100 (Mha)

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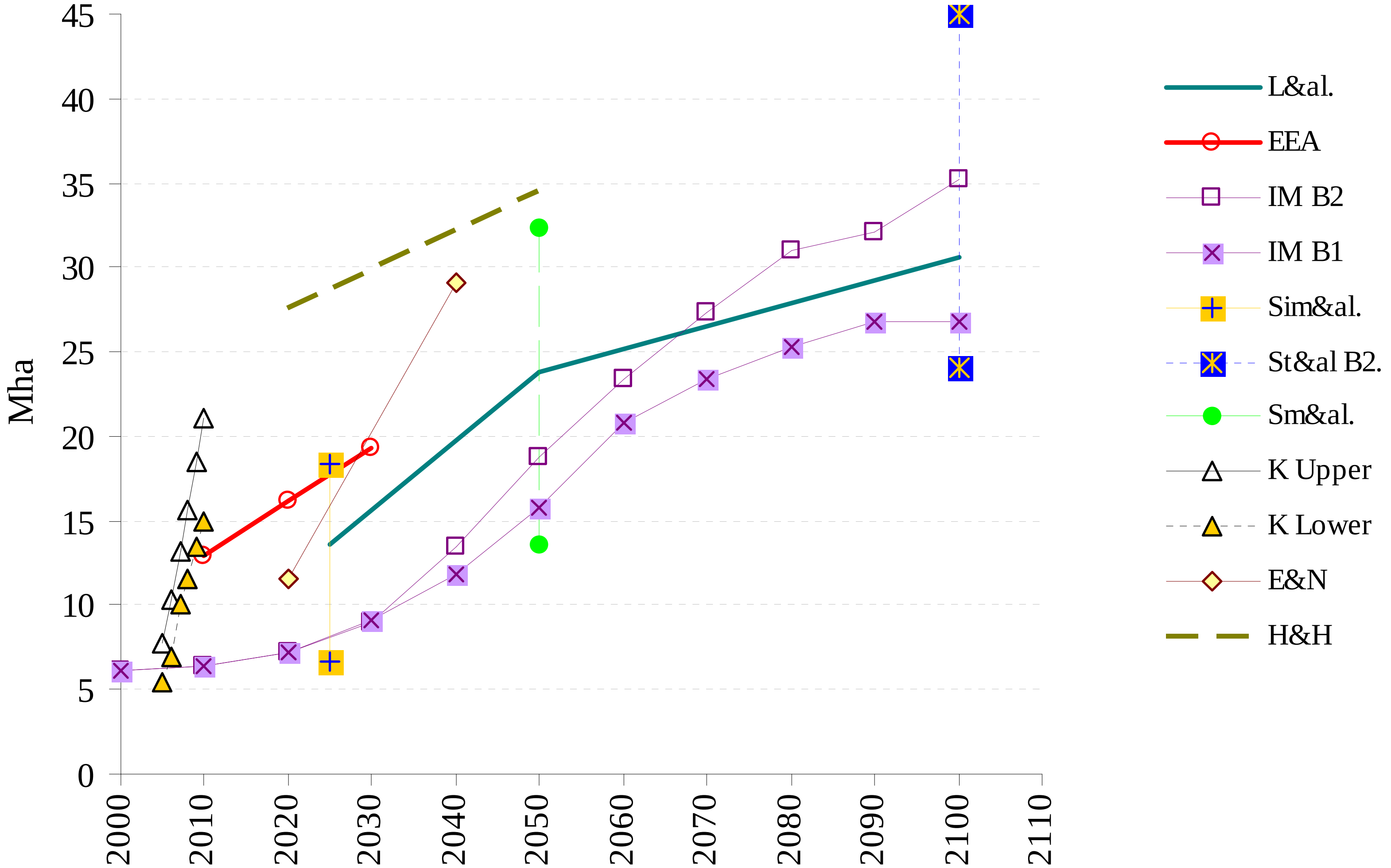
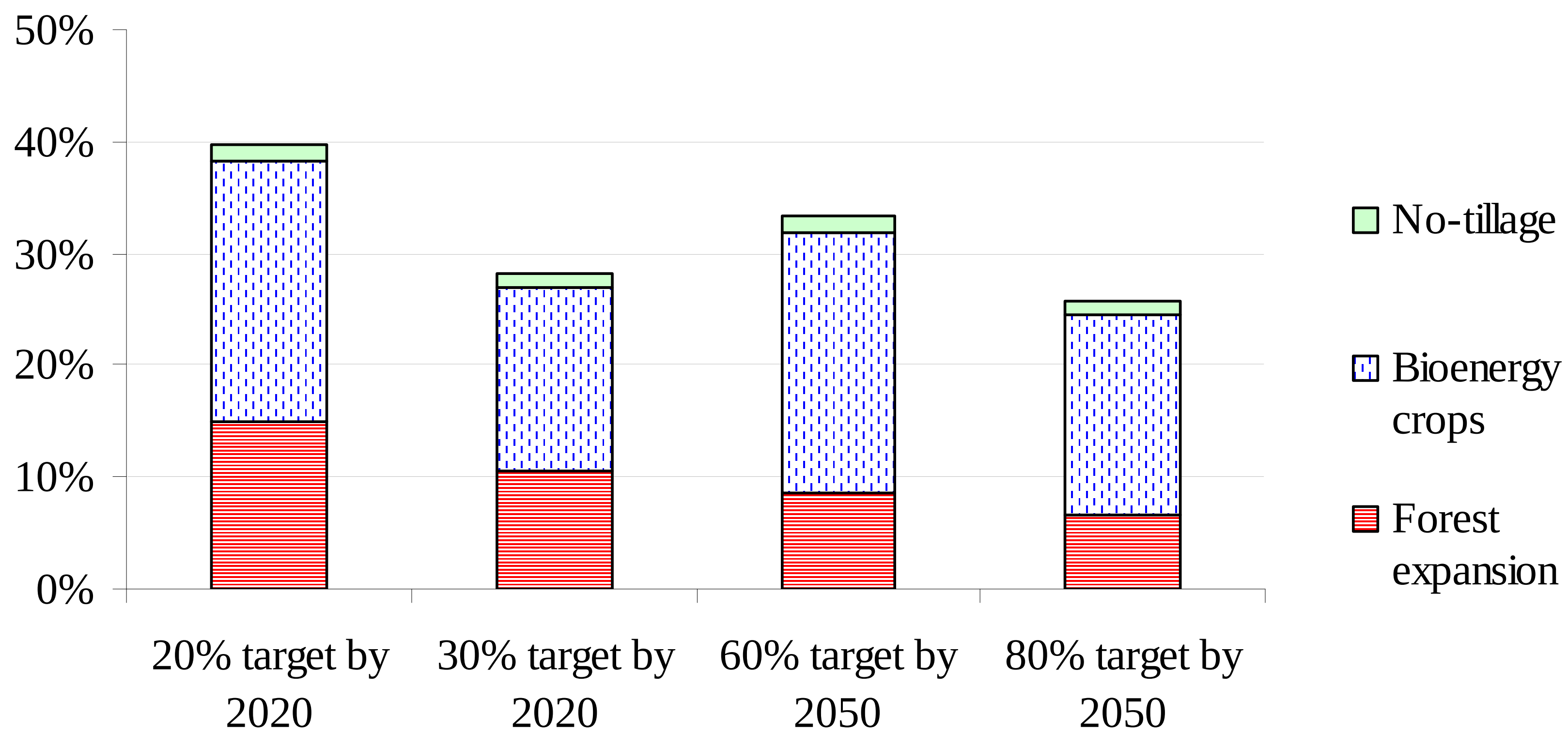


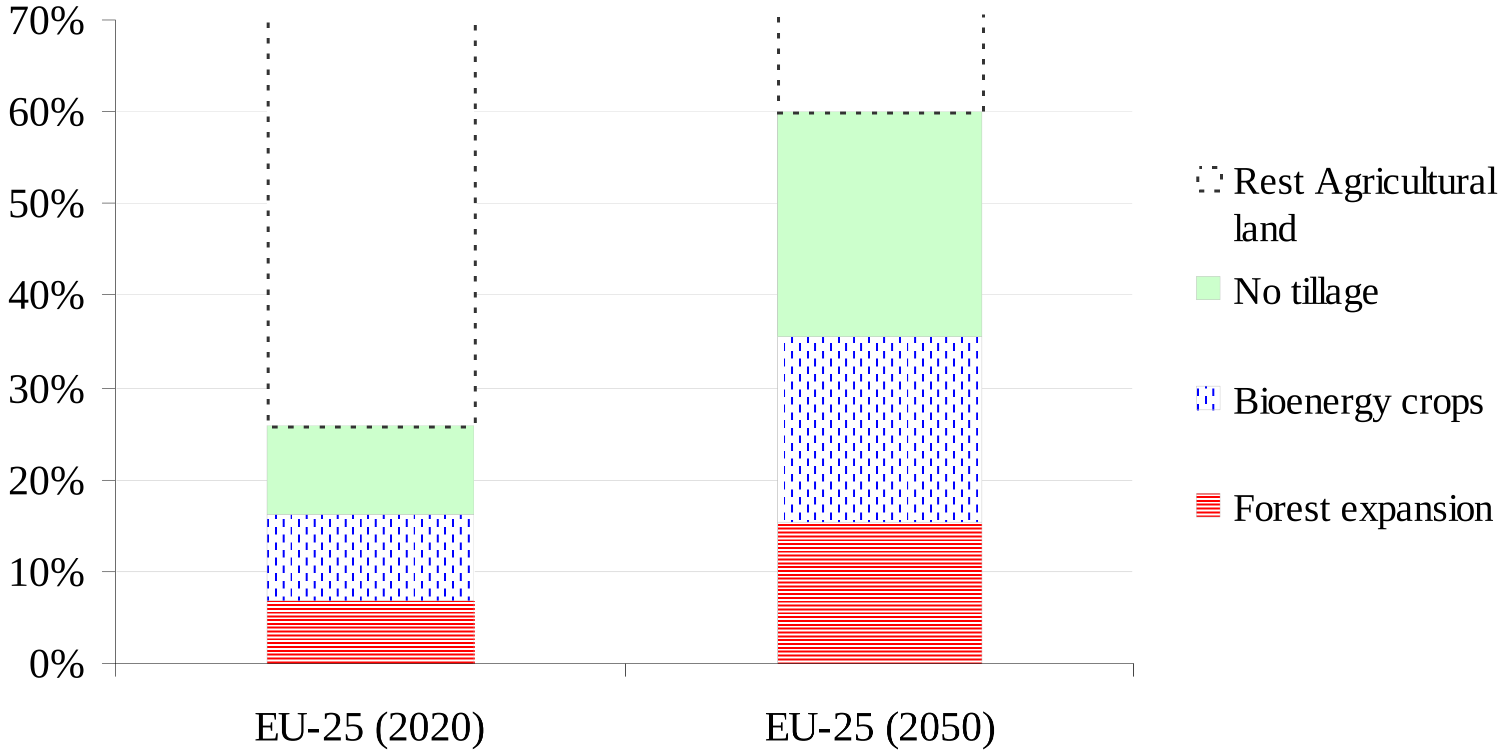
Source: Ovando and Caparrós (2007).

Contribution of carbon plantations, non-tillage systems and bioenergy crops to post-2012 GHG emission reduction targets



Source: Ovando and Caparrós (2007).

Land resources demand for AR, no-tillage farming and bioenergy crops respect to available agriculture land



Source: Ovando and Caparrós (2007).

The effect of different biological or physical sequestration functions on the time path and implementation of carbon sequestration

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Motivation

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- Carbon sequestration is widely seen as a means to “buy time” and should be analyzed within a dynamic general equilibrium model.

- Biomass and soil sequestration in “afforestations and reforestations” or soil sequestration in “cropland management” or “grazing land management” tend to be non-linear, with higher initial sequestration rates until a saturation point is reached.

- Trees need (a lot of) time to reach maturity (soil carbon needs also a substantial amount of time to reach the saturation point).

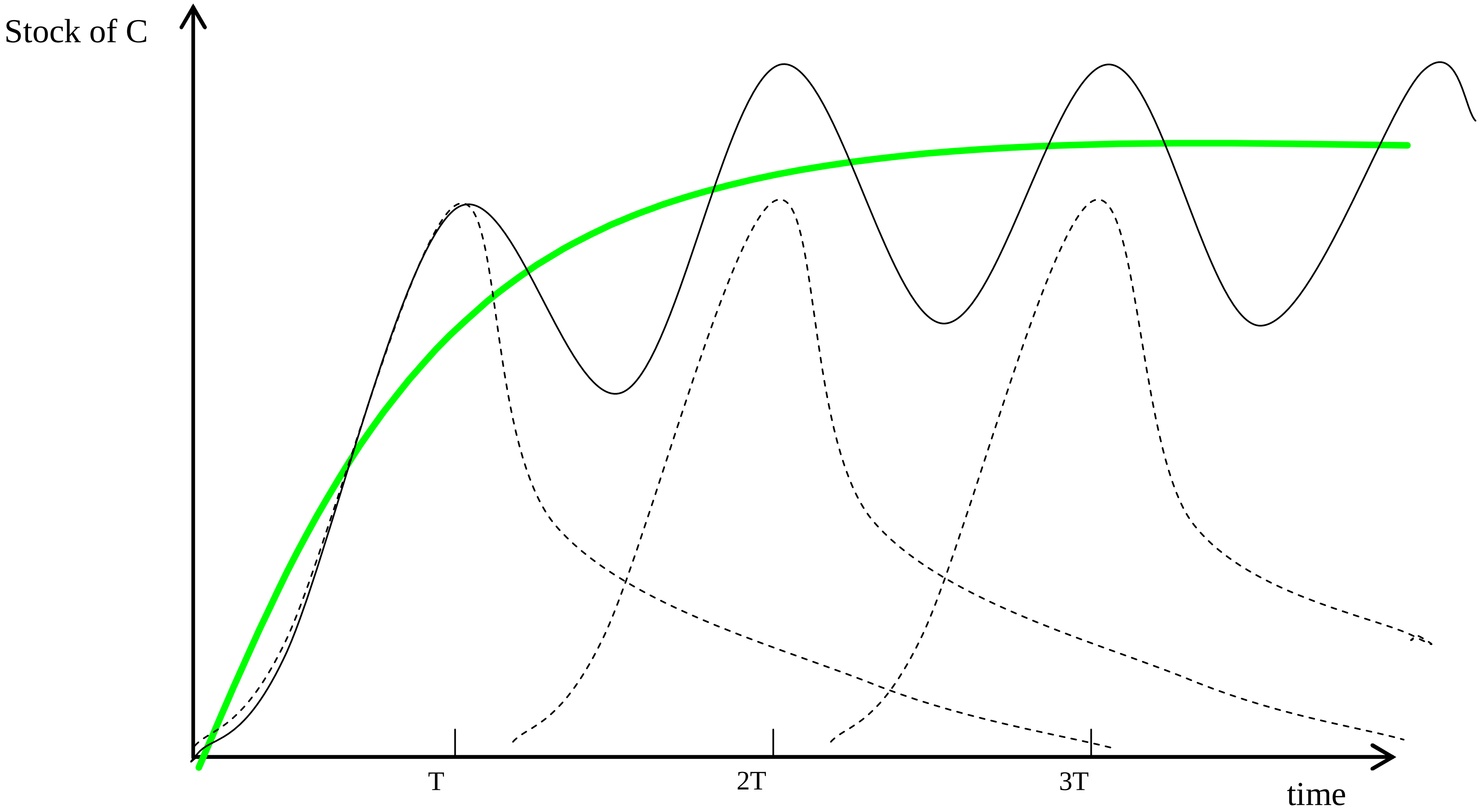
- Different tree species grow differently.

Motivation

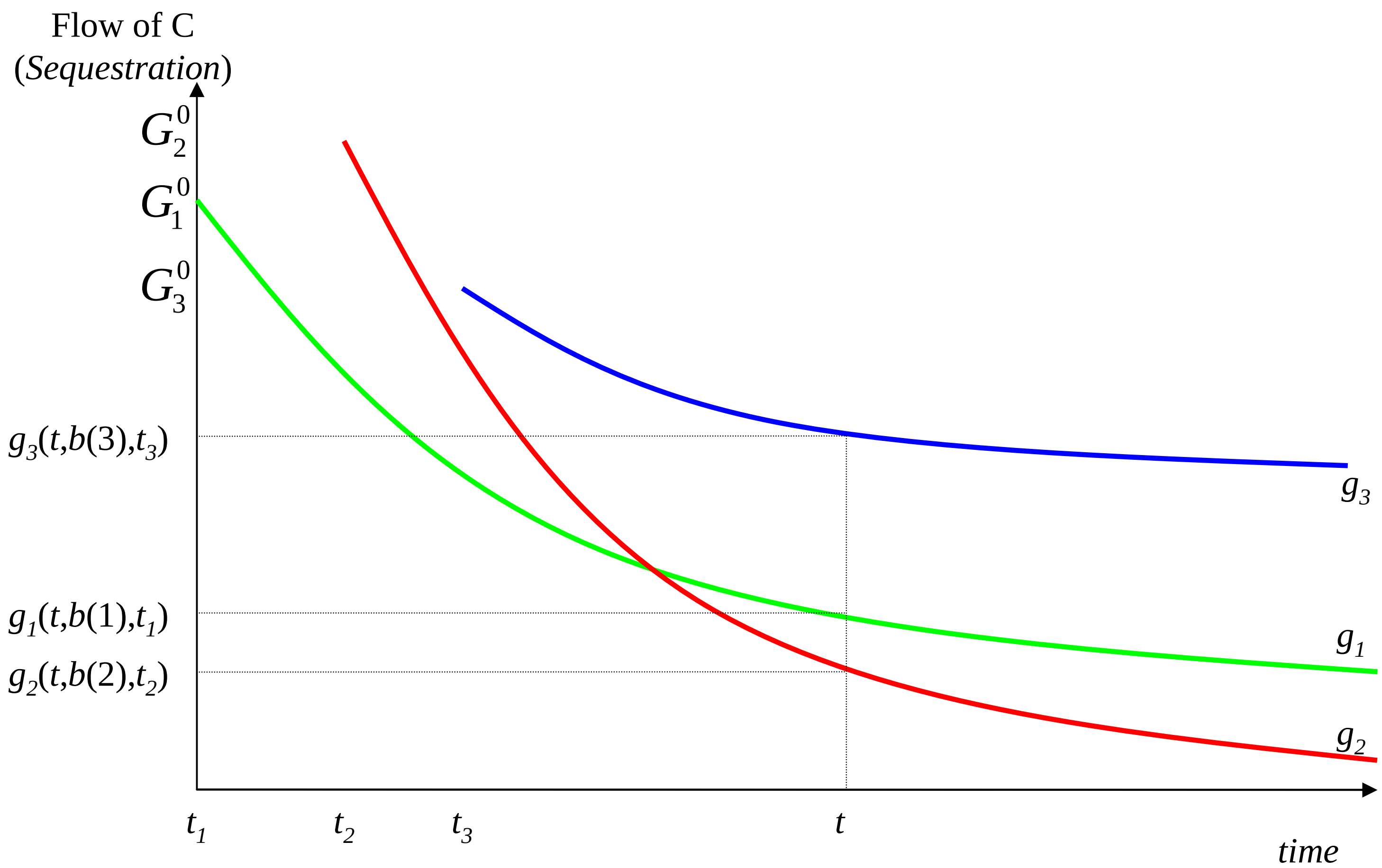
- Existing theoretical analysis of the optimal path of sequestration, within a dynamic general equilibrium model (Feng et al., 2002), assume:
  - Growth is instantaneous
  - Only one type of tree-species (or soil practice)

- Partial equilibrium models (e.g. Veld and Plantinga, 2005) also tend to assume that only one type of species is available.

(Un-)managed forest



Different species, different growth



$$G(t) = \sum_{s=1}^{3} a(s) g(t, b(s), s) = \sum_{s=1}^{3} a(s) G^0 (b(s)) e^{-b(s)(t-s)}$$

Feng, Zhao and Kling (2002)

$$\max_{e(t),a(t)} \int_0^T e^{-rt}[B(e(t)-D(C(t))-Q(A(t))]$$

$$\dot{C} = e(t) - \sigma C(t) - a(t)$$

$$\dot{A} = a(t)$$

a(t) is simultaneously land conversion and immediate sequestration of the maximum carbon capacity of the land (1 ton C).

General model

$$\max_{e(t),a(t),b(t)} \int_0^T e^{-rt}[B(e(t)-D(C(t))-Q(A(t)-R(a(t),b(t))]$$

$$\dot{C}=e(t)-\sigma C(t)-G(t)$$

$$\dot{A}=a(t)$$

$$G(t)=\int_0^t a(s)g(t,b(s),s)ds$$

- Each unit of forest planted is allowed to grow following a growth function *g(t,b(s),s)* that depends on the type of forest chosen for reforestation at period *s*: *b*(*s*).

- Since *b(s)* is not constant *G* is of the Volterra type.

Steady-state

- No new reforestations ($a^*=0$)
- Hence, when $t \rightarrow \infty$ no growth takes place either (although growth is positive long after $a^*=0$)
- This implies that species selection at the steady-state is irrelevant
- Thus, focusing on the steady-state as is standard in vintage models is of limited interest

Efficient implementation mechanisms

- Feng et al. (2002) define an efficient implementation mechanism as one that ensures that the landowner and the Social Planner will follow exactly the same reforestation path.

- We add that both agents have to choose exactly the same species.

Efficient implementation mechanisms

- Feng et al. (2002) show that:
  - The CFM is efficient
  - The CAA is efficient
  - The VLC is efficient if $q(t, \tau)=P(t)-e^{-rt}P(t+\tau)$
- In our framework:
  - The CFM and the CAA are efficient
  - The VLCC and the LCE are not efficient under the condition shown. VLC= VLCC=LCE in Feng et al. (2002)

Nested model

- Since we show that the Carbon Flow Method (CFM) is efficient,

- assuming that the CFM and an efficient emission trading scheme are in place ($P(t)=B_e(e(t))$), by analyzing the problem of the landowner we find the optimal path for the carbon sequestration related variables in the general model, for a given path of carbon prices.

Nested model II

$$\max_{a(t),b(t)} \int_0^T e^{-rt}[P(t)G(t) - D(C(t)) - Q(A(t) - R(a(t),b(t))]$$

$$\dot{A} = a(t)$$

$$G(t) = \int_0^t a(s)g(t,b(s),s)ds$$

$$R_a(a(t),b(t)) = \int_t^T e^{-r(s-t)}g(s,b(t),t)P(s)ds - \int_t^T e^{-r(s-t)}Q_A(A(s))ds$$

$$R_b(a(t),b(t)) = \int_t^T e^{-r(s-t)}a(t)g_b(s,b(t),t)P(s)ds$$

Path of sequestration

$$\dot{a}(t) = [X_1 H_{bb} - X_2 H_{ab}][H_{aa} H_{bb} - (H_{ab})^2]^{-1}$$
$$\dot{b}(t) = [X_2 H_{aa} - X_1 H_{ab}][H_{aa} H_{bb} - (H_{ab})^2]^{-1}$$

Assuming that an interior solution exist, if

$$g_b(t, b(t), t) > 0 \text{ and } \int_0^T g_b(s, b(t), t) e^{-rs} P(s) ds > 0$$

then $\dot{a}(t)$ is negative and $\dot{b}(t)$ is negative.

That is, the reforestation rate will decline

and slower and slower growing species will be chosen.

Other issues in the paper

- Conditions for the steady-state to be a saddle-point.

- Two special cases:
  1. Extending FZK to non-instantaneous growth
  2. Only one species and exponential growth

Summary

- Reforestations will be positive for a finite amount of time.
- The reforestation rate will decline over time and the species chosen will grow slower and slower.
- When the steady-state is reached, no additional reforestations will take place, although growth will be positive for a long period. Ultimately, no additional growth will occur.
- The steady-state point will be a saddle-point if the conditions provided are met.

Overall policy implications

- (Sinks + biofuels) may relatively soon use most available land in Europe.
- A long term ***optimal*** policy will move toward the use of tree species with long rotations.
- Trees with long rotations tend to have larger biodiversity – scenic values.
- **Short-term policies should not favor reforestations with short-rotation trees to meet immediate targets**

Thank you for your attention

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