

Berkeley Faculty Roundtable on Environmental Services in Rangeland Production Systems

Presentation and Discussion Notes from the Fifth Roundtable: November 13, 2009

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**CARBON SEQUESTRATION IN MEDITERRANEAN FORESTS
AS A NEW SOURCE OF INCOME FOR LANDOWNERS**

Berkeley Faculty Roundtable on Environmental Services in Rangeland Production Systems

Part I:
Powerpoint Presentation by Alejandro Caparrós

Carbon Sequestration in Mediterranean Forests as a New Source of Income for Landowners

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Outline



- Accounting for ecosystem services
- How important can climate policy be for land use?
- Mediterranean forests
- Carbon sequestration in Mediterranean forests
- Additional issues to be considered
- Conclusions

Accounting for ecosystem services

Total Economic Value (TEV)



- Commercial values
- Private amenity value (*as for self-occupied housing*)
- Ecosystem services (ES)
 - Biodiversity values
 - *Carbon sequestration*
 - Erosion control
 - Scenic values
 - Public recreation
 - ...

Commercial values



- Production account:
 - Revenues and costs of the year
 - Capital consumption
- Capital balance:
 - Fixed capital
 - Land
 - Infrastructure
 - Production in progress
 - Standing timber

Partial/total internalization of ES



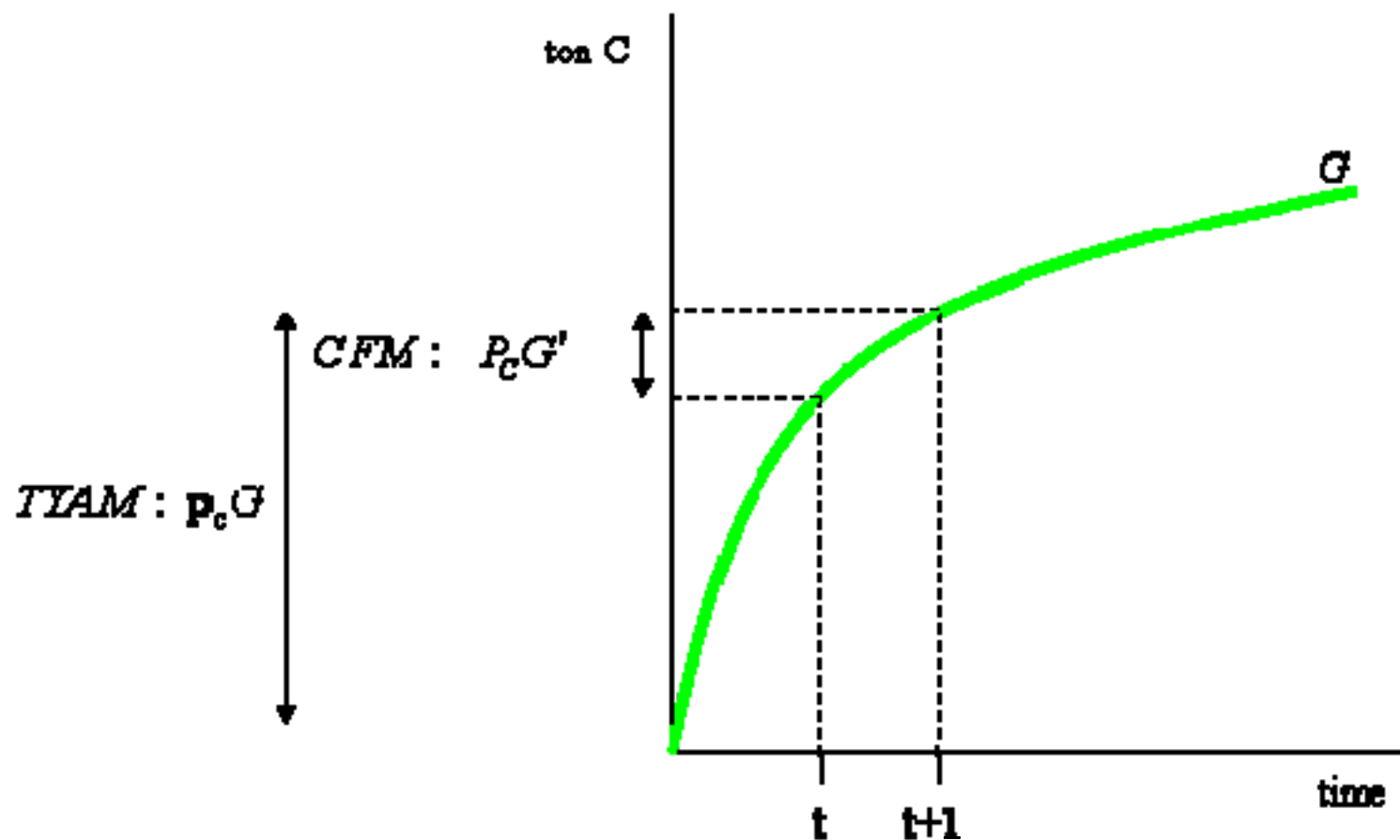
	Commercial (1)	Ecosystem services			Total economic value (5) = (1) + (4)
		Internalized (2)	Non-internalized (3)	Social (4)=(2) + (3)	
Cattle	X				X
Firewood					
Carbon		Z	Z	Z	
Biodiversity		X	Y	X+Y	X+Y
Erosion control					
Scenic values					
Public recreation					

Carbon accounting methods I



- *Carbon Flow Method (CFM)*
 - The forest owner gets paid when carbon sequestration takes place and pays when carbon is released.
- *Ton Year Accounting Method (TYAM)*
 - The forest owner gets paid each year (a smaller amount) as long as the carbon is sequestered.
- *Land Conversion Subsidy (LCS)*
 - A subsidy for the conversion of the land to forest and a tax on the conversion of land out of forest.

CFM, TYAM, LCS



Carbon accounting methods II



- Caparrós (2009) or Caparrós and Zilberman (2009) study carbon accounting methods that allow *perfect* internalization
 - *CFM* is always efficient
 - *TYAM* can be made efficient, even without knowing future carbon prices
 - LSC can only be efficient if future carbon prices are known.

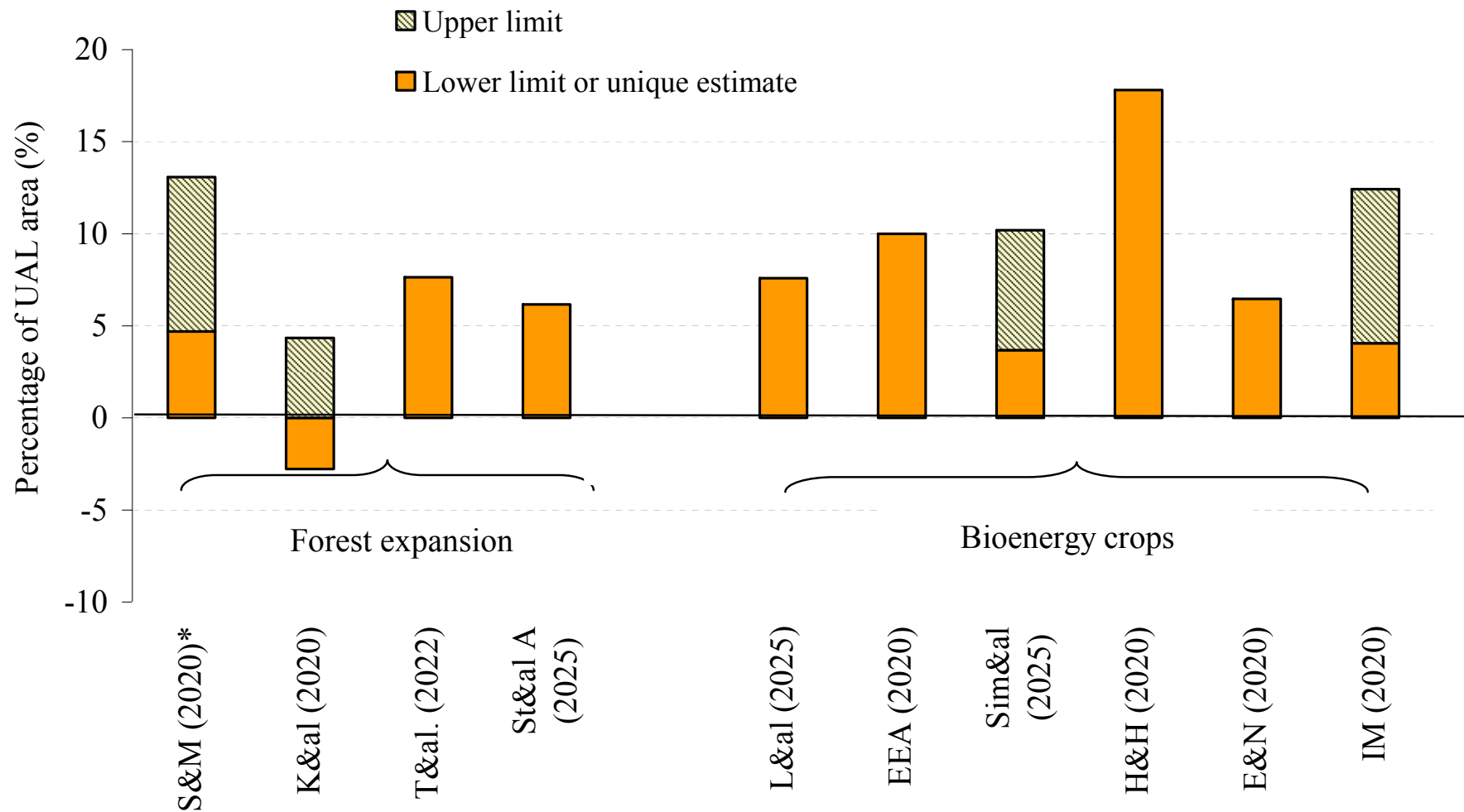
Carbon accounting methods III



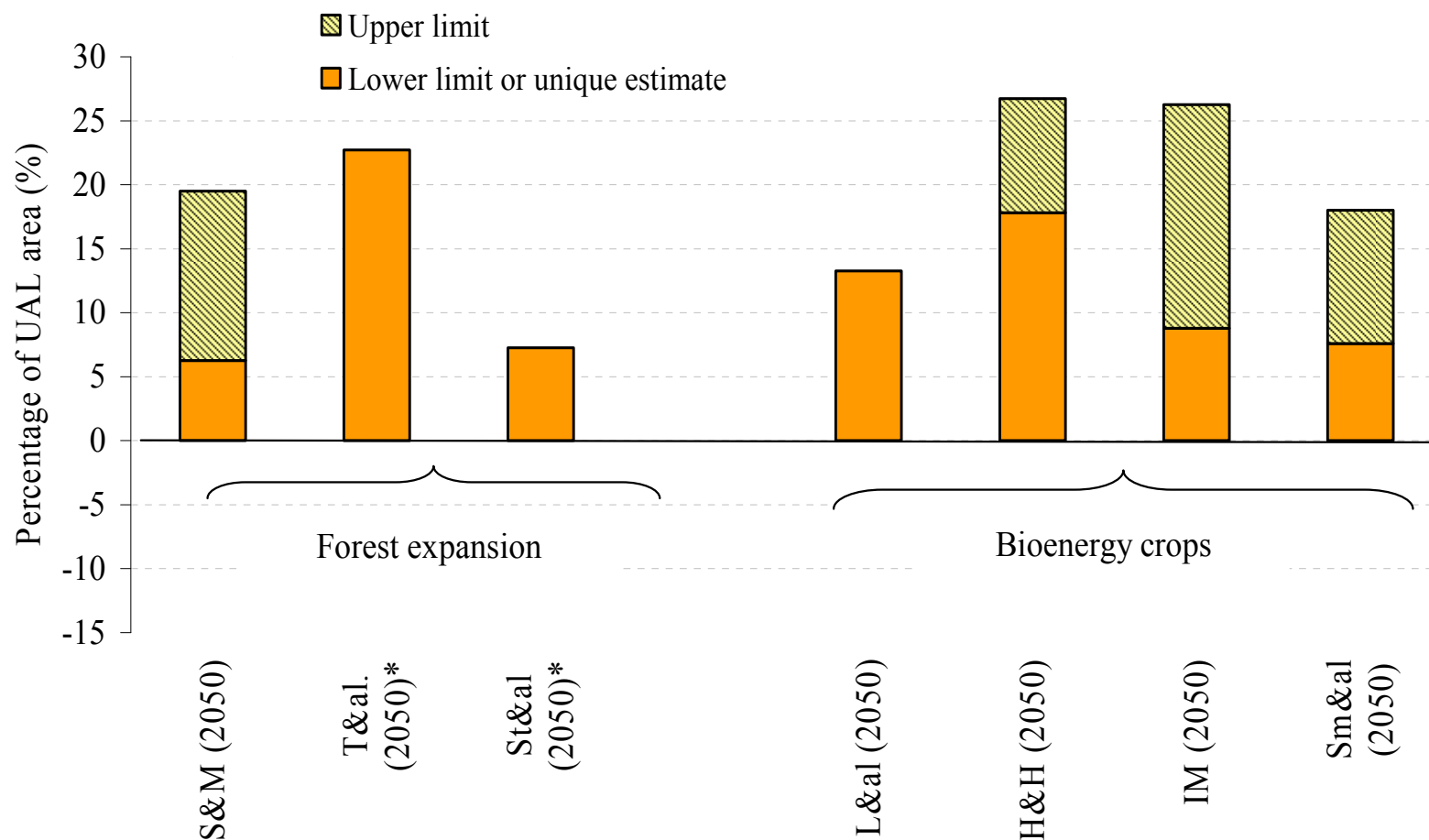
- Caparrós *et al.* (2009) analyze the impact of CFM / TYAM in terms of biodiversity-scenic values:
 - CFM favors fast growing species
 - *TYAM* favors species that sequester carbon for a long period of time (these species tend to have higher biodiversity-scenic values in Mediterranean forests)
- Our preliminary results of a Delphi to European land –owners shows that:
 - *TYAM* is preferred over CFM.

**How important can climate policy
be for land use?**

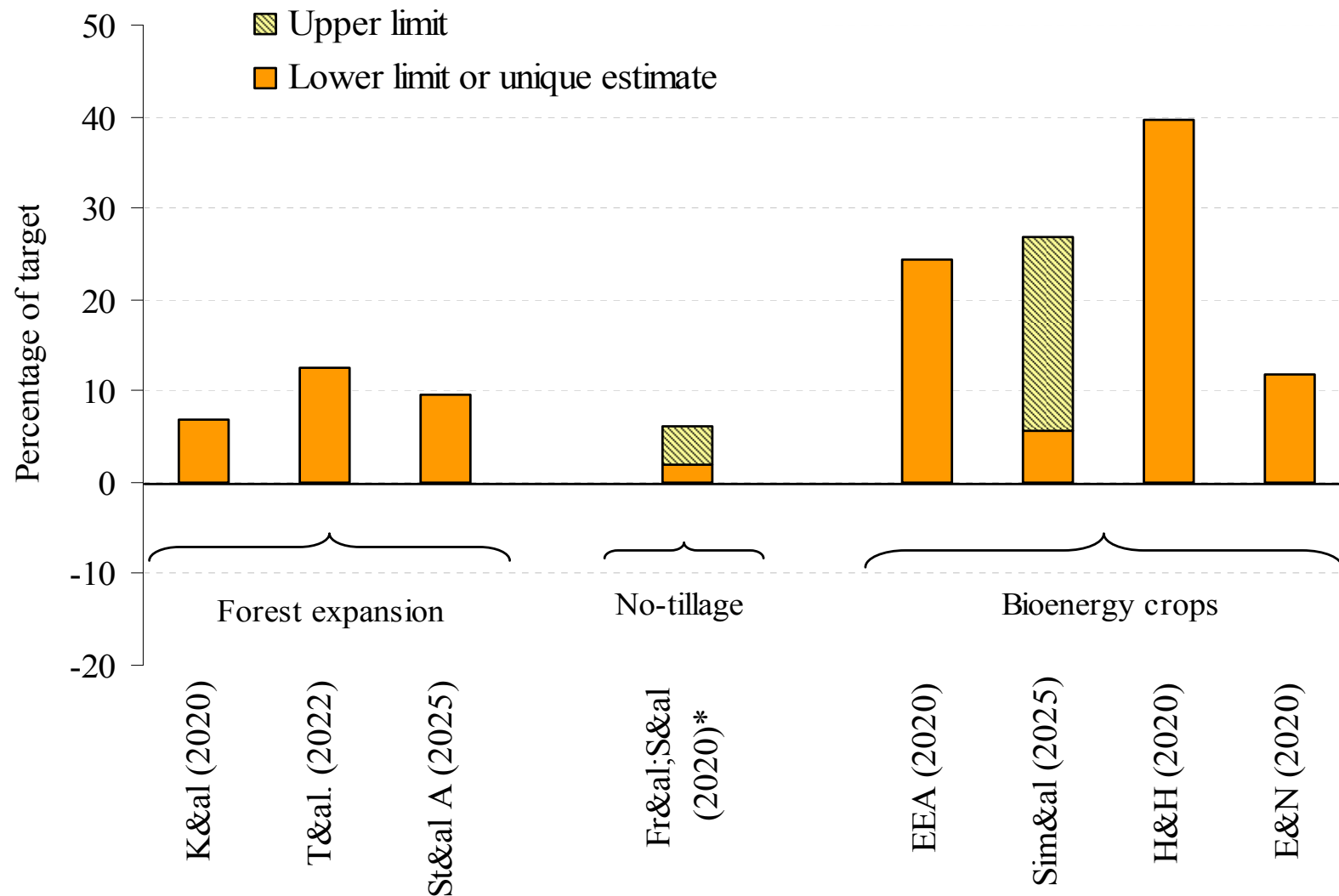
Land resources demand as percentage of available agricultural land in the EU-25 by 2020



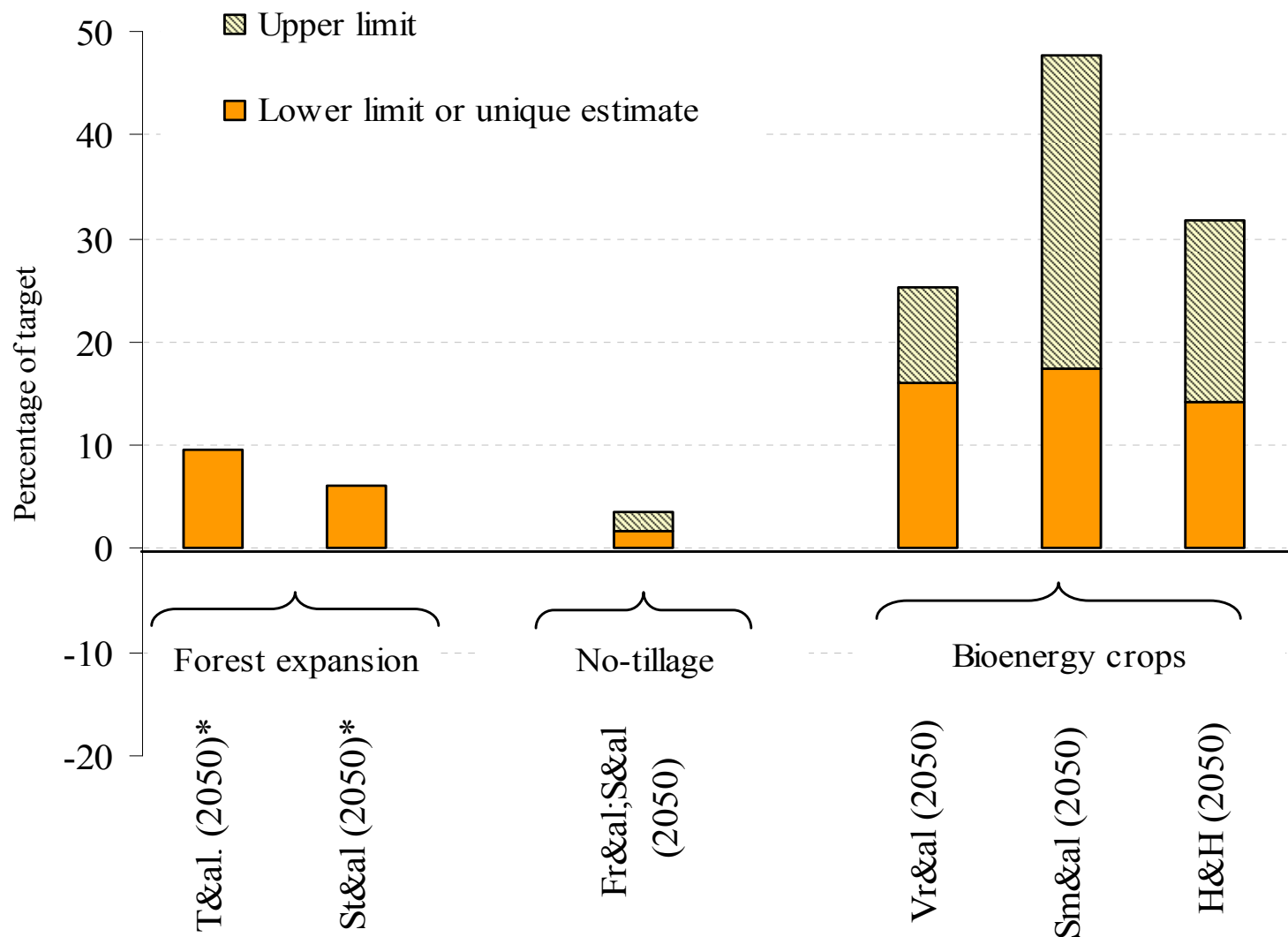
Land resources demand as percentage of available agricultural land in the EU-25 by 2050



Land use activities in the 2020 European emission reduction target (20% reduction compared to 1990)



Land use activities in the 2050 European emission reduction target (60% reduction compared to 1990)



Mediterranean Forests

Mediterranean forests



Research Group on Environmental Economic Analysis (GEA)



Multiple-use forests



- Spain:
 - Cork
 - Grazing
 - Recreation
 - *Firewood*
- Tunisia
 - *Cork*
 - Grazing
 - Firewood

Multiple use: Cork in Spain



Multiple use: Grazing in Spain



Multiple use: Grazing in Tunisia



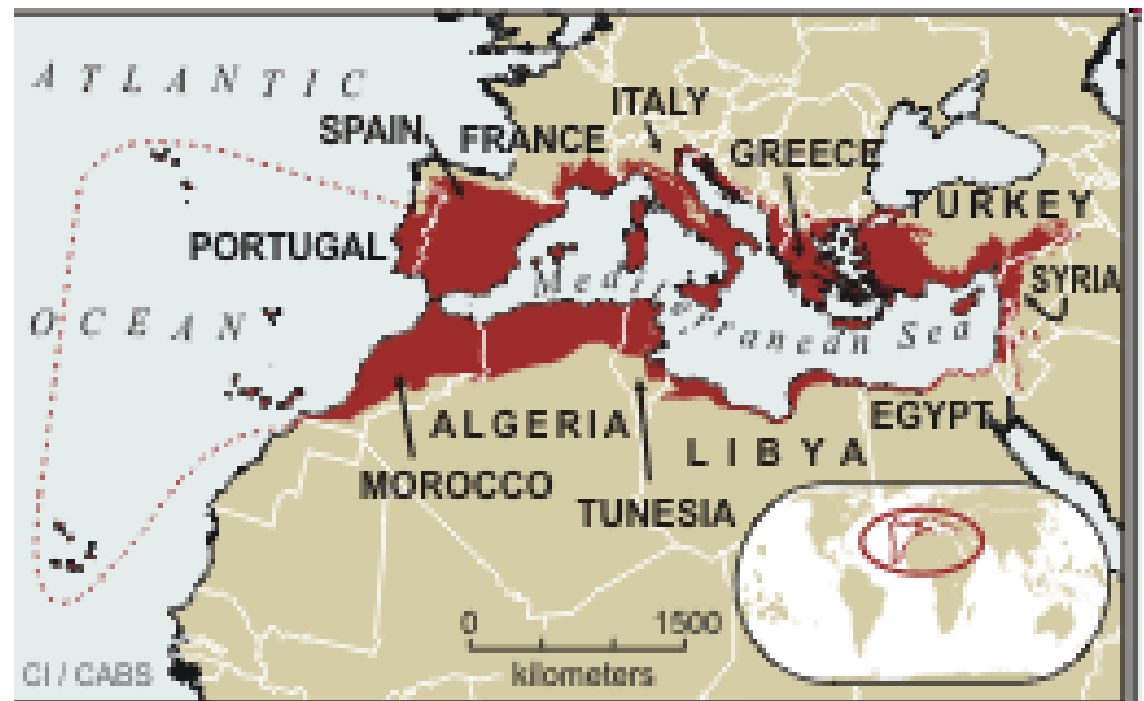
Multiple use: Cork and Firewood in Tunisia



Biodiversity



- Slow growing native species (*Quercus*)
- Up to 135 plant species per m²
- Habitat for endangered species such as the Iberian Lynx
- Part of the biodiversity hotspot *Mediterranean Basin*



Legal framework



	Spain	Tunisia
Property rights of land owner	Private owners exclusion rights.	State-owner has the exclusion rights on tree uses and hunting.
Property rights of local inhabitants	Access to public roads.	Free-use rights on grazing, firewood, charcoal and crops.
Labour market	Competitive labour market.	Mainly self-employed.
Management goals	Social and conservation for public lands Private incomes (commercial plus environmental) for private lands.	Maximizing commercial incomes.
Government intervention	Large subsidies for reforestations. Management subsidies. No program for avoid degradation.	Government cannot afford subsidies. Government obtains income from cork oak.

Deforestation-degradation: Spain



- Deforestation (cutting) is forbidden by law and enforced, but aging and lack of regeneration is leading to degradation and even to deforestation.
- From 1969 to 1996 cork-oaks have been reduced by 16% in Cádiz (ANP) and younger trees have been reduced up to 30%.

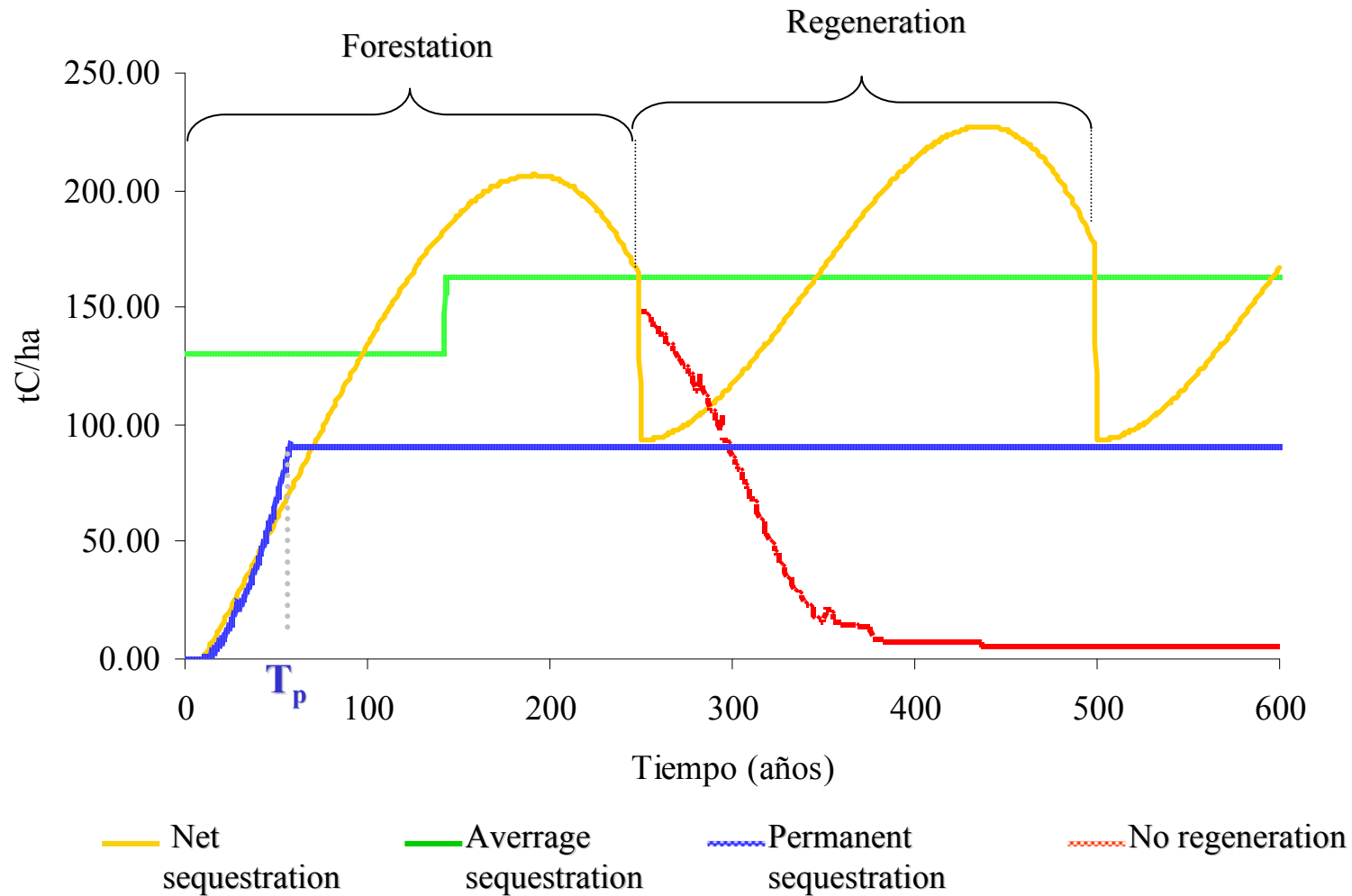
Deforestation-degradation: Maghreb



- In Tunisia, cork oak is one of the main tree species and its surface area has decreased from more than 127000 ha in 1950 to 70000 ha in 2003.
- In Algeria, it has been reduced from 425000 ha in 1955 to 229000 ha in 1984.
- In Morocco, it has been reduced from 367000 ha in 1948 to 348000 ha in 2002.
- Hence, in the Maghreb countries, one-third of cork oak forests have disappeared.

Carbon Sequestration in Mediterranean Forests

Carbon in reforestations - regeneration



T_p : permanent sequestration

Species: *Quercus ilex*

Break-even CO₂ prices (CFM and TYAM)



	Avoided degradation			Reforestation		
Carbon price increase (α):	0%	2%	4%	0%	2%	4%
CFM						
Quercus suber						
Aljibe (Spain)	183.8	72.9	25.4	565.9	137.4	26.4
Monfragüe (Spain)	1.517.3	82.5	20.2	85.8	45.5	11.2
Ain Snoussi (Tunisia)	9.1	8.0	9.1	na	na	na
Quercus ilex						
Monfragüe (Spain)	∞	28.0	4.0	38.5	18.3	5.3
TYAM						
Quercus suber						
Aljibe (Spain)	180.1	78.5	20.2	365.9	86.8	5.1
Monfragüe (Spain)	184.1	64.9	13.2	175.9	48.0	3.1
Ain Snoussi (Tunisia)	19.6	9.3	3.0	na	na	na
Quercus ilex						
Monfragüe (Spain)	56.2	13.8	1.1	80.5	19.3	0.9

Break-even CO₂ prices with current subsidies



	Avoided degradation			Reforestation		
Carbon price increase (α):	0%	2%	4%	0%	2%	4%
CFM						
Quercus suber						
Aljibe (Spain)	138.5	54.9	19.1	-17.0	-4.1	-0.8
Monfragüe (Spain)	817.9	44.5	10.9	-0.9	-0.5	-0.1
Ain Snoussi (Tunisia)	9.1	8.0	9.1	<i>na</i>	<i>na</i>	<i>na</i>
Quercus ilex						
Monfragüe (Spain)	∞	23.1	3.3	-24.5	-11.6	-3.4
TYAM						
Quercus suber						
Aljibe (Spain)	135.6	59.2	15.2	-11.0	-2.6	-0.2
Monfragüe (Spain)	99.3	35.0	7.1	-1.8	-0.5	0.0
Ain Snoussi (Tunisia)	19.6	9.3	3.0	<i>na</i>	<i>na</i>	<i>na</i>
Quercus ilex						
Monfragüe (Spain)	68.1	16.7	1.3	-51.2	-12.3	-0.6

Present values (- BEP for LCS)



	Avoided degradation		Reforestation	
	Without subsidies	With subsidies	Without subsidies	With subsidies
Quercus suber				
Aljibe (Spain)	-5.994,1	-4.515,8	-9.066,1	272,2
Monfragüe (Spain)	-5.094,7	-2.746,2	-5.061,6	52,4
Ain Snoussi (Tunisia)	-1.184,4	-1.184,4	na	na
Quercus ilex				
Monfragüe (Spain)	-1.558,9	-1.285,8	-2.857,2	1.818,1

Additional issues to be considered



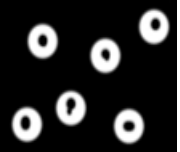
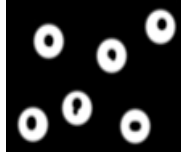
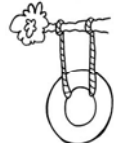


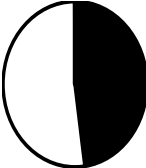
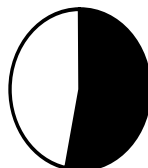
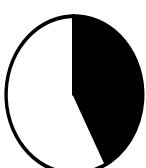
Spain: Recreation-conservation



- In Spain, recreational values by the forest owner and by free-access visitors are relevant.
- Conservation preferences of the population are also relevant.
- According to our survey to about 1000 visitors:
 - reforestations are seen as positive
 - but regeneration is preferred.

Spain: choice set example



Characteristics	CHOICE 1 (Code 72)		
Biodiversity (tree species employed, including cork oak)	1 autochthonous specie 	1 autochthonous specie 	No reforestation
Technique employed	Natural regeneration 	Natural Regeneration 	None
Recreational areas created	None	2 recreational areas 	None
Additional employees generated (equivalent fixed employees)	20 employees 	60 employees 	None
Forestry surface ensured (forestry surface in black)	90% current (reduction 10%) 	100% current (maintain the same) 	80% current (reduction 20%) 
Increase in the taxes of this year	6 EUROS (1,000 pesetas)	48 EUROS (8,000 pesetas)	0 EUROS
Mark ONLY ONE OPTION (A, B or C)	Option A <input type="checkbox"/>	Option B <input type="checkbox"/>	Option C <input type="checkbox"/>

Spain: Random parameters logit



Attribute parameters	Model I	Model II	Model III
...			
<i>TEC</i>	1.262*** (0.318)	0.810*** (0.207)	0.711*** (0.170)
<i>TEC*REA</i>		0.529*** (0.177)	0.470*** (0.158)
...			
Standard deviation parameters			
...			
<i>TEC</i>	2.291*** (0.761)	1.709*** (0.523)	1.465*** (0.411)
...			
N	7,194	7,194	6,180
LogL (β)	-5,188.59	-5,174.72	-4,912.02
LogL (0)	-7,903.42	-7,903.42	-7,481.550
ρ^2	0.34	0.34	0.34

Tunisia: Don't forget herders!



Compensation to different agents to avoid degradation (2002 €)

Discount rate:	4%	10%
Total	1184	788
<i>Forest owner</i>	730	137
<i>Herders</i>	455	651

Conclusions

Conclusions I



- Mediterranean forests are suffering a degradation-deforestation process.
- Reforestations are more supported by EU policy but avoided degradation is better in:
 - Commercial terms (*sometimes*)
 - Environmental terms (*always*)

Conclusions II



- Paying for the standing carbon (TYAM) is probably the best alternative to internalize carbon:
 - Efficient, even without knowing future carbon prices
 - Better for biodiversity-scenic values
 - Slightly more favorable for avoided degradation
 - Does not preclude reforestations
 - Preferred by land-owners



Thank you for your attention

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Part II: Discussion

Notes and synthesis by Kayje Booker

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BACKGROUND

The subsidies that Europe has in place for their forests are not based on carbon sequestration but on other values like biodiversity and cultural heritage. In the climate treaty negotiations, Europe has been very against carbon sequestration for mitigation, so-called “sinks.” The US position was to include sinks in Kyoto Protocol, and that position eventually won out even though the US pulled out of the negotiation. Now Europe must account for all of its greenhouse gas sinks as well as its sources, so even though the subsidies and forestry policies were not put in place with carbon in mind, now they are being reexamined for how they may affect carbon sequestration.

PRESENTATION COMMENTS AND Q&A :

Why does the international climate treaty have a different way of treating forestry emissions from industrial and developing countries?

Only the industrialized countries have greenhouse gas emissions reduction targets. So those countries have national accounting systems that takes all carbon fluxes into account. That is not the case for developing countries: they have neither targets nor systems to account for all positive and negative fluxes. Instead, developing countries have a project-based process for emissions reductions – The Clean Development Mechanism. Because it is project-based without a national accounting system, there is a risk that emissions saved in one place might be emitted somewhere else without giving a net savings. Fear of this issue, “leakage,” has kept avoided deforestation from being included in the allowable projects for developing countries because, if you promised not to cut down a forest in order to get emissions credits, you could just cut down another forest instead. It is very hard to keep track of. Reforestation is included because it is easier to show that you are actually saving carbon.

Why was Europe against including sequestration?

Europe was against carbon sequestration for two reasons. One was that avoided deforestation was included under that, and they were very against avoided deforestation which would have been a cheap way to meet targets but has issues with leakage (as described above). There wasn't enough time during negotiations to get the rules written up in a way that made avoided deforestation seem robust enough to support. Even now it will be hard to get support for these policies. Also, in Europe, the Green Party was a strong part of Germany position, and Germany was strong part of EU position, and the Greens wanted reductions to be done at home and focused on reducing fossil fuel emissions.

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What role could forests play in climate mitigation? In a world with a lot of volatility in carbon prices, how does forest mitigation stack up against other strategies?

Bioenergy estimates and forest expansion opportunities show significant possible impact towards reduction target, but it is likely that much of this is double counted between these two uses. No studies compare them both, so it is likely counting the same land.

However, as we show in our paper, if you are going to increase the amount of forests for carbon sequestration, you need some payment in addition to carbon sequestration. Subsidies for other ecosystem services may pay a large amount of what you need to pay landowners to get them to maximize carbon sequestration. The issue with forests is that, because they take so long to grow and must be maintained long-term, you must focus very long-term on the carbon price, much longer than for other mitigation options. This is a problem for determining carbon sequestration values for forests. On the other hand, the advantage of forests, is that forest preservation is not just about carbon. Nobody would produce slow-growing species just for carbon, but they have lots of other benefits that people are willing to pay for.

In terms of comparison with other mitigation strategies, wind and bioenergy make sense without too many subsidies, especially second generation biofuels from cellulosic. You will see these develop even if carbon prices are low. But for land use, carbon is just one additional benefit, so even if carbon prices are low, if there are subsidies for other ecosystem services provided by forests, you will still see the development of forest carbon sequestration.

You are discussing the climate change mitigation potential of biofuels and forests: does that mean that the EU is counting transportation in their cap-and-trade program?

No – the EU cap and trade system does not include transportation. But they are using many different mechanisms to meet their emission reduction targets. Activities that are outside the cap and trade can be used to meet the target – they just don't go into the emission trading system. That would be the case with bioenergy. Carbon trading under cap and trade covers about 50% of the emissions.

Three Policy Methods to Pay for Carbon Sequestration:

First, it is important to note that if you want to see what a landowner is going to do, you have to consider both commercial value and the owner's amenity values. Subsidy design and pricing should take into account the owner's private preferences and values as well as commercial value.

Carbon sequestration is one of the values of the forest whether it is the target of the policy or not. Carbon sequestration is a positive externality with societal benefits. The policy question is how to internalize that value to make the owner act in the way we

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want him/her to do to get maximum societal value. For carbon sequestration, if the policy is designed correctly, you may be able to get a perfect internalization of the value of carbon sequestration for society in such a way that the payments to the landowner cause him/her to maximize the carbon sequestration.

Carbon Flow Method – Pay for the flows of carbon, in and out. CFM is the easiest method to make a perfect internalization in theory but hardest to put in practice because if a landowner lost all of the stored carbon, through fire, for example, he/she would have to pay for it. That could be a large sum of money and would certainly be politically unpopular. This mechanism is also most compatible with Clean Development Mechanism.

Tonne Year Accounting Method – Pay for the stock, smaller amount than CFM and pay every year for as long as it is there. If there is a fire, you don't get additional money but you don't have to pay the money back. May get good internalization, but need more information.

Land Conversion Subsidy – hardest to make perfect internalization but easiest to implement. Pay landowner when convert from pasture or another use to forest. Similar to conservation reserve program. Impossible to get perfect internalization unless you know future carbon prices and how trees will grow. Forest carbon stock accumulation is not necessarily equilibrium. There are models drawn of carbon uptake for every species. But tree growth and sequestration will vary based on all kinds of factors (soil, rainfall, climate, etc.) that are hard or impossible to control and make it hard to predict future growth very well.

With carbon flow method seems problematic because as the forest is growing, carbon prices are rising, so when there is a fire and carbon is released, you are paying for it at a higher price than you were paid to store it.

That is true, but with time value of money and the discount rate, the money that landowners were paid to begin with was worth more (because they could do things with it like investing) than payments they have to make back later. So it depends on how carbon prices over that time compare to interest rates.

Carbon Flow Method (TFM) v Tonne Year Accounting Method (TYAM)

CFM gives landowners the incentive to plant fast-growing species (like eucalyptus). TYAM, on the other hand, favors trees that grow slowly but stay for a long time. So, TYAM favors management that supports biodiversity and scenic values more than CFM. Landowners have stated that they prefer payments based on TYAM (smaller payments but with no circumstance under which they would have to pay back). All three methods are compatible with what we think will happen w/ international carbon policies.

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CASE STUDIES

Does stripping the cork count as release as carbon?

In the calculations there is a decay rate for the gradual GHG release from cork removed from trees. Kyoto assumes as soon as biomass is removed from system it decays immediately. Our way is more realistic – the cork decays over time.

The main product from cork oak is high quality wine stoppers. Taking cork off doesn't kill the tree. After about 10 years, it has grown back, and you strip again. It takes about 30 years for first cork layer to grow, and that is low quality. 40 years for high quality cork. This makes it difficult to get landowners to plant –they must wait a long time to get any profit. This makes regeneration hard, and it is a big problem in Spain right now.

What do you include in your boundary of the land use decision? If a reforestation action decreases meat production in one place, leading to increasing meat production in other places, do you include that carbon impact when you are assessing the reforestation action? We don't know what that impact would be. However, these are extensive systems, that do not produce that much, so a decrease in some grazing land probably won't decrease production that much.

If you didn't take cork off, and tree didn't have to regrow skin every time, would they be bigger? In that case, doesn't stripping the tree result in some foregone opportunity for growth that would have sequestered carbon, and shouldn't that be counted?

Trees under cork production still live for a long time (up to 200 years) but would be bigger without expending the energy to regrow cork after it is stripped. We don't know how much bigger, and, therefore don't know what the foregone growth and sequestration potential would be because all of the trees in the area are harvested for cork (it is a very profitable enterprise). There are no comparisons. However, we think that you don't really have to account very much for this lost potential in the carbon calculations because the change in the overall numbers would be very, very small.

About how much is per head subsidy on cattle?

It is a significant amount and makes the difference between making and losing money. It is a lot of money by US standards. There is a number limit on the cattle for the subsidy, and nobody has more cattle than the subsidy supports. However, the EU is reducing direct production subsidies on agriculture now in favor of payments for ecosystem services.

Degradation v Deforestation

Both areas have deforestation (Tunisia) and degradation (Spain). In Spain, there is a lack of regeneration. A landowner must exclude grazing for about 10 years to ensure regeneration, and this is not happening. Trees are aging and not regenerating new ones.

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Does the permanent sequestration line refer to below-ground sequestration? (Slide 28)

No, that is just the minimum amount of carbon (above and below ground) that is always sequestered in the forest. Even when you cut some trees or some trees die off, the whole forest still has a base amount, so that line is the bottom or lowest amount of carbon stored in the forest when it is in decline. Originally we wanted to have different prices for the permanent and the temporary storage, which is a perfect theoretical way to do it, but it is too difficult practically b/c you need to know the point where it transitions from permanent to temporary, and it is too hard to figure that out especially on a national scale. We proposed it but then changed our mind.

The point from 0 to T_p (on slide 28) seems pretty similar to what you have in the NE of the U.S. with rapid regrowth of forests. Would you want to treat that differently than a forest that has reached a more equilibrium condition, perhaps separate temporary and permanent sequestration?

This question relates to the same issues as the prior one. It makes sense theoretically to separate permanent from temporary sequestration, but on a national scale, it becomes very complicated. Plus there are reasonable methods, like the ones mentioned before, which can compensate. Usually, you have much more land in the equilibrium condition, so you can just use that for your calculations.

Is there a way to continue to graze and still get reforestation? Perhaps do select plantings, protect the individual trees, and graze around that area?

There have been attempts to do this, but it is more expensive with all the fencing, and it is less successful. Cattle often are able to break down the fencing. It has not been proven to work very well in Spain. It is cheaper for them to just close a bigger area.

Also, landowners in Spain never reforest much at one time, no more than 20 acres. So you have multi-use on the landscape, just not on that parcel. It goes back into multifunctional use after the trees have been allowed to grow, after around 20 years.

Slides 29

The carbon prices we expect about are about 20 euros per tonne. You can see on these charts that using either method, the carbon price would have to be much more than 20 euros to make a difference in land management. Only in Tunisia would you see avoided degradation (although right now you can't count avoided degradation in Kyoto, only reforestation) because, as a poor country, prices are lower and labor is so much cheaper. The main point of slide 29 is that the price you would need to encourage landowners to undertake these activities is way above what you would get for the carbon. You would need additional subsidies. The other thing to note is that CFM and TYAM prices are more or less the same – the choice between these methods doesn't really matter. You could do it either way and get similar results.

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Slide 30

This slide does have subsidies, and they are paying for things like biodiversity, erosion control, and production, not carbon. Because of current high subsidies in Spain for reforestation, you can see that it makes sense to do it already (as shown by the negative numbers). Any carbon payment would just be a bonus. But the avoided degradation figures haven't changed much from the last slide, which shows that current subsidies do not pay for avoided degradation even though avoided degradation is better than reforestation for a lot of reasons (e.g. working landscapes and biodiversity). The EU subsidizes only reforestation, so landowners have much more incentive to reforest than to do programs for avoided degradation. The main point on this slide is that the market does not favor reforestation – only with the subsidies do you favor reforestation. Furthermore, there is no particular reason to favor reforestation – it is not better ecologically or for carbon sequestration. As you will see later, it is also not preferred by the population.

It is true that there are some options (as you see on the slides) that would be paid for by carbon – break-even price is below 20 euros. Some of these options (e.g. quercus ilex) would make sense under carbon accounting. But even these avoided degradation options that look good under carbon payment system without subsidies get worse when subsidies and taxes are considered on the next slide. Current EU policies are making those choices less favorable.

Slide 31

This slide shows the net present value for different actions (e.g. avoid degradation of cork oaks). If the amount is negative, it means that you would have to pay someone that amount to make them take that action. If it is positive, it means that they do have economic incentive to do it. You see that only with the subsidies does reforestation have a positive NPV, and even with subsidies, avoided degradation has negative NPV. The main subsidy here is for reforestation of slow-growing species.

Slide 36

In Tunisia, you should not forget the herders when you are making carbon policies. Both the landowner and the herders could lose a lot of money from firewood and grazing restrictions, so both should be compensated. Herders don't have official right, so it is tempting to set up a system to pay only official landowners, but the system is likely to fail if you don't pay those that use the system – the herders will likely not abide by the system if they are losing money and not getting reimbursed as well.

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DISCUSSION

Reforestation v Deforestation v Avoided Degradation:

Deforestation is illegal in Spain right now. You cannot cut down trees, so deforestation is impossible, but you can just let the trees die, which is what we call “degradation.”

Avoiding degradation, therefore, means replanting and protecting young trees from grazing. Reforestation, in contrast, refers to areas where there are not trees initially. At the international level, afforestation is putting forest on land that wasn't forest for the last 50 years, while reforestation is foresting land that has been forested at some point within the last 50 years. Degradation is possible.

Role of Subsidies

If subsidies for livestock were removed and people stopped wanting livestock in these forests, then it would no longer be avoided degradation because trees would come back on their own?

Without the subsidies you would have much less grazing, but the trees wouldn't necessarily come back on their own. In some areas they would and in some they wouldn't. You would lose the pasture, but some would become scrubland. Subsidies do play an important role in causing the situation of degradation. There are also subsidies for oak reforestation. Landowners get large amount up front for planting costs. Then for 5 years they get nursery money to come back to take care of them. In years 5-20, they get compensation for grazing losses. At the end it adds up to a very substantial amount of money.

Subsidies are also changing from production subsidies to green subsidies that might lead to a lower level of livestock production in Spain, but the production level will probably not drop below the level of consumption or subsidies would be increased again.

Policies for avoided degradation or avoided conversion

In California, we do have protocols and policies for avoided deforestation or avoided conversion. Some people seem to be selling this kind of project on the voluntary markets. To do so, they are building buffers into the fees landowners get paid up front so if something happens to the carbon, you can take it out of that money instead of charging landowners. That allows these projects to go forward. However, when you put in these kind of buffers, you are not getting the same perfect internalization because it makes the prices are too low (because the buffer is subtracted out).

Still a system with buffers at least enables these projects to be created, and the imperfect internalization may not be too important because people are usually doing this for other reasons. They already want to conserve the land for habitat or something else. This type of program is similar to the land conversion payment discussed earlier, and it does work pretty well. You still have to include private amenity values, such as those

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mentioned – habitat etc. – to get as perfect an internalization possible. You will never get as perfect internalization as you will in the other methods, but you will get a reasonable one, and it is a relatively simple method because you don't have to take the carbon into account, just pay people to keep it or convert it into forest. That's why in the US it was used for the conservation reserve program, and it could make sense to use it for carbon as well. In Spain it is being used for reforestation, and it would be reasonable to use it for carbon.

Connecting this talk to broader roundtable themes

All of this work has direct implications for things that are happening in California – in some ways Spain is just a more advanced case. Previous roundtable talks have indicated that carbon sequestration opportunities on California rangelands are quite low except for woody vegetation, so many of these techniques for encouraging people to grow trees could be good tools for California landowners to take advantage of carbon sequestration.

Also, the approach of total economic value would apply directly to CA and give us better answers on the likely kinds of activities that would be employed on these lands and where there should or shouldn't be subsidies and government intervention. Bringing in these non-economic values as well as commercial values gives a good framework for understanding landowner decision-making. It could provide a good model for analyzing and interpreting why people do things on California rangelands, especially hardwood dominated rangelands. For carbon sequestration and other environmental service provision, we will have to go further with the hardwood work than we have in the past. In addition to getting back to a savannah-like standard, as we have been trying to do, we may need to aim for a higher amount of tree cover. This gives us a way to do that and provide rational analyses to support these kinds of activities.

Another theme of this talk that has come up in our other discussions and in other talks about global carbon sequestration is that it is only part of picture. On the one hand, carbon sequestration is only a piece of the solution to global warming and, on the other hand, carbon payments are also just one piece of land management and landowner decision-making. Carbon payments by themselves are never going to make the entire difference for a landowner, in even the most optimistic carbon prices, and rangeland carbon sequestration alone is never going to solve global warming.