Dynamic Life Cycle Assessment of the *Ribeiro* wine appellation (NW Spain) in the period 1989-2009

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Introduction

- Recent studies have identified the environmental profile of viticulture operations (Rugani et al., 2013).

- Most have focused on 1 year of operation, despite important yearly changes (Vázquez et al., 2012).

- Focus on operations has shaded other key issues, such as land use changes (LUCs).

Rugani, B., Vázquez-Rowe, I., et al. (2013). J. Clean. Prod. 54, 61-77.
Vázquez-Rowe, I., et al. (2012). J. Environ. Manage. 98, 73-83.

Aim of the study

Understand from a timeline approach how these changes are affecting the environmental profile of wine appellations through time:

- Inclusion of LUCs within the system boundaries, accounting for changes in vineyard distribution.

- Technological leaps in the viticulture sector (shift from small-holdings to industrial exports).

Ribeiro Appellation

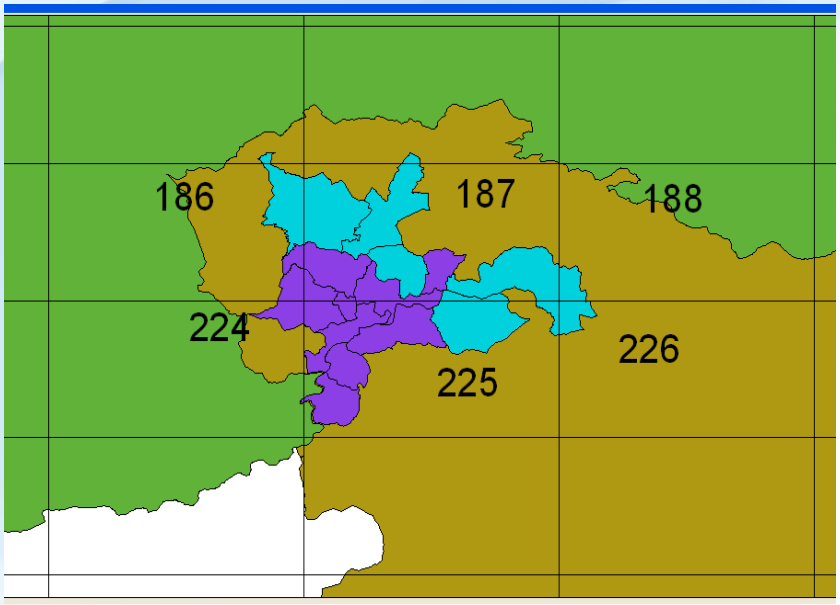
Location

- One of five appellations in the region of Galicia.
- Previous LCA studies analyzed:
  - Interannual variations in environmental profile (Vázquez et al., 2012).
  - Biodynamic vs. conventional production systems (Villanueva et al., 2013)

Villanueva-Rey, P., et al. (2013). J. Clean. Prod. 65, 330-341.

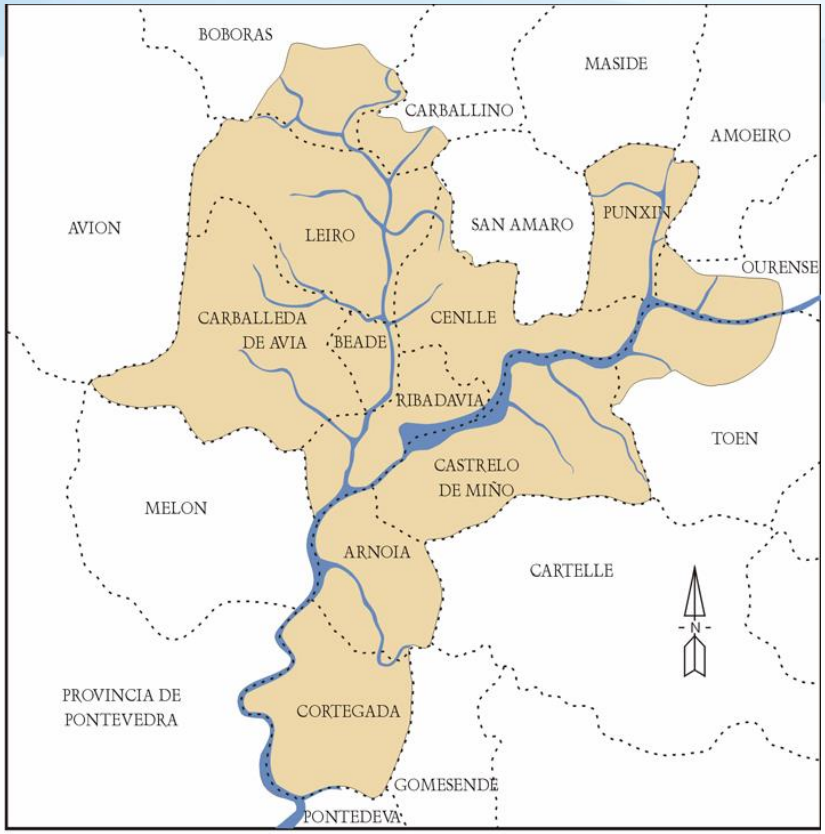
Materials and Methods (i)

Spanish government map grid



Studied area

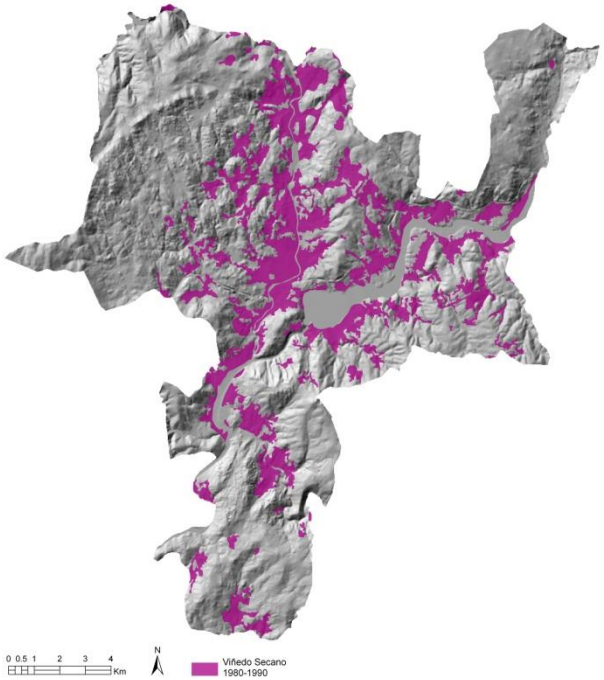
Ribeiro appellation



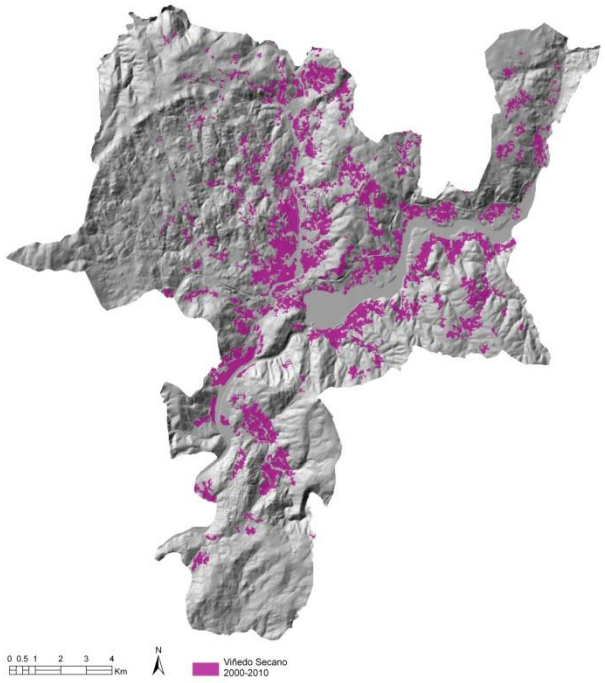
Materials and Methods (ii)

Vineyards reduction

1980-90 period



2000-10 period



Vineyards

Materials and Methods (iii)

IPCC guidelines for LUCs

- Adapted for a dynamic LCA study
- Tier 2 and 3 for almost every Land Use and compartment
- Specific factors and parameters for the area studied (forest, soil, etc) obtained from the Spanish GHG inventory

Specific data for Spain and Galicia:

- Forest type, forest fires, timber & firewood harvesting
- Other crops (surface, yield, etc.)
- Fertilization intensity*

Materials and Methods (iv)

Data acquisition

- Maps (Spanish Ministry for the Environment and Rural and Marine Affairs) covering Land Use periods 1980-1990 and 2000-2010 years. Maps were processed using GIS
- Interviews (farmers, wineries, EVEGAL)
  - Technology and trellis evolution
  - Field operations
  - Changes in planting density and frame

Materials and Methods (v)

Life Cycle Inventory

- Fuel
  - EMEP/EEA air pollutants guidelines
  - Different approaches depending on inventory year
  - Diesel and petrol two-stroke machinery
  - Fuel secondary data: S and Pb content adapted depending on year
- Spanish electricity mix adapted per inventory year

Results (i)

Land Use Changes (LUCs) matrix. Unit: ha (1989-2009)

Final \ Initial	F	G	C	W	S	O	Final surface
F	10475	2637	2036			154	**15302**
G	1845	1997	283			30	**4155**
C	654	318	2707			120	**3799**
W	73	10	69			777	**929**
S							**0**
O	245	90	402			104	**841**
Initial surface	**13292**	**5052**	**5497**	**0**	**0**	**1185**	**25026**
Net change	2010	-897	-1698	929	0	-344	0

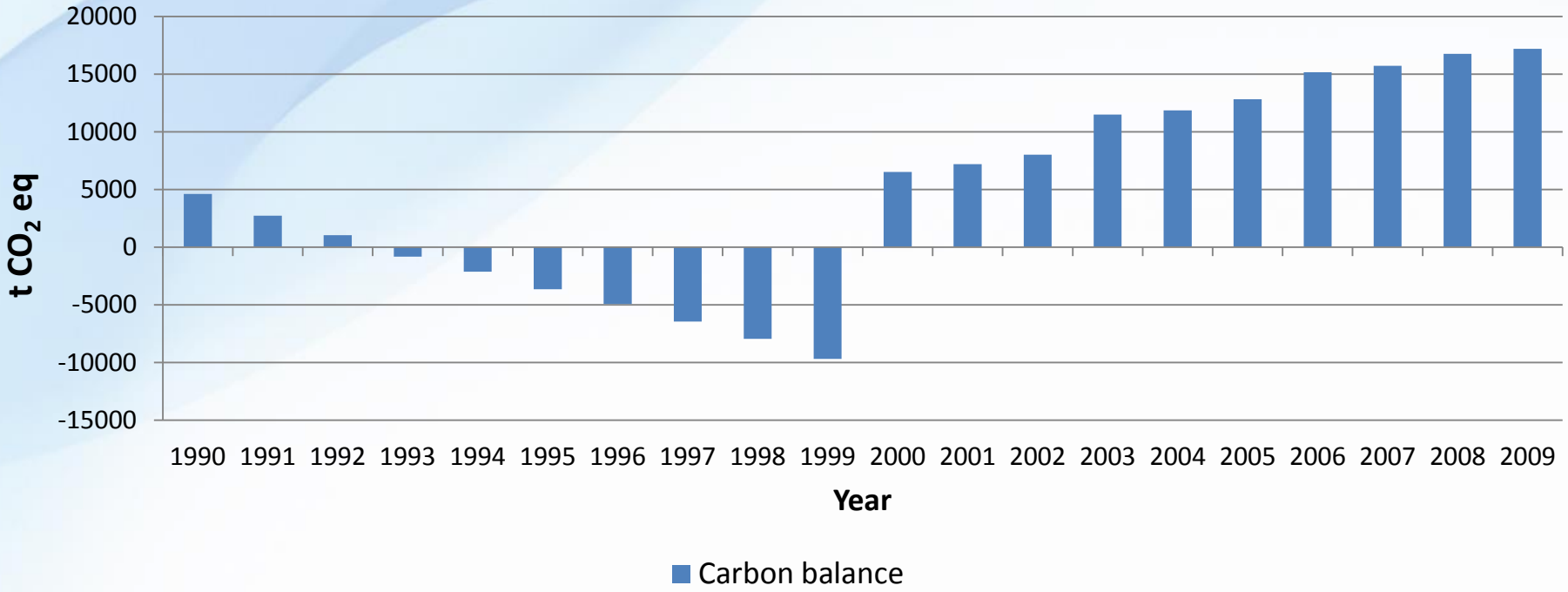
F: Forest land
G: Grassland
C: Crops
W: Wetlands
S: Settlements
O: Other lands

Results (ii)

	1989	1993	1997	2001	2005	2009
Forest land	535	535	535	428	214	0
Forest land (transition)	0	645	1290	1613	1613	1613
Vineyards-Forest	0	645	1290	1613	1613	1613
Vineyards	4448	3693	2938	2471	2291	2111
Vineyards (transition)	0	111	221	408	670	932
Forest - Vineyards	0	0	0	107	321	535
Grassland - Vineyards	0	16	32	49	65	81
Crops - Vineyards	0	62	125	156	156	156
Other land -Vineyards	0	32	64	96	128	160
Grassland	81	65	49	32	16	0
Grassland (trasition)	0	20	40	60	80	100
Vineyards - Grasland	0	20	40	60	80	100
Crops	156	94	31	0	0	0
Crops (transition)	0	0	0	35	105	175
Vineyards - Crops	0	0	0	35	105	175
Other land	160	128	96	64	32	0
Other land (tansition)	0	77	154	230	307	384
Vineyards -Other land	0	77	154	230	307	384
Wetlands	0	0	0	0	0	0
Wetlands (transition)	0	13	26	39	52	65
Vineyards - Wetlands	0	13	26	39	52	65
TOTAL	**5380**	**5380**	**5380**	**5380**	**5380**	**5380**

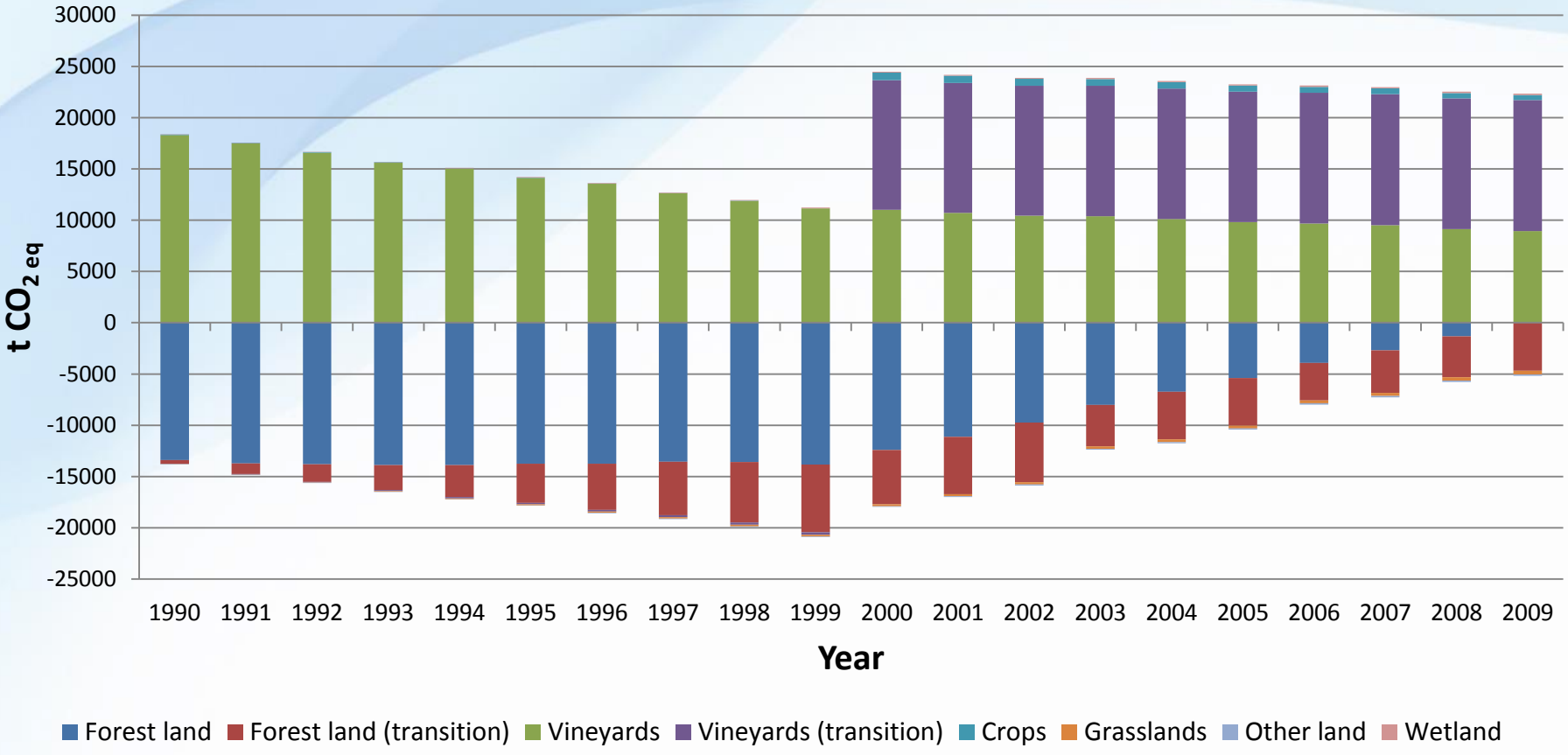
Results (iii)

GHG emissions balance related to LUCs



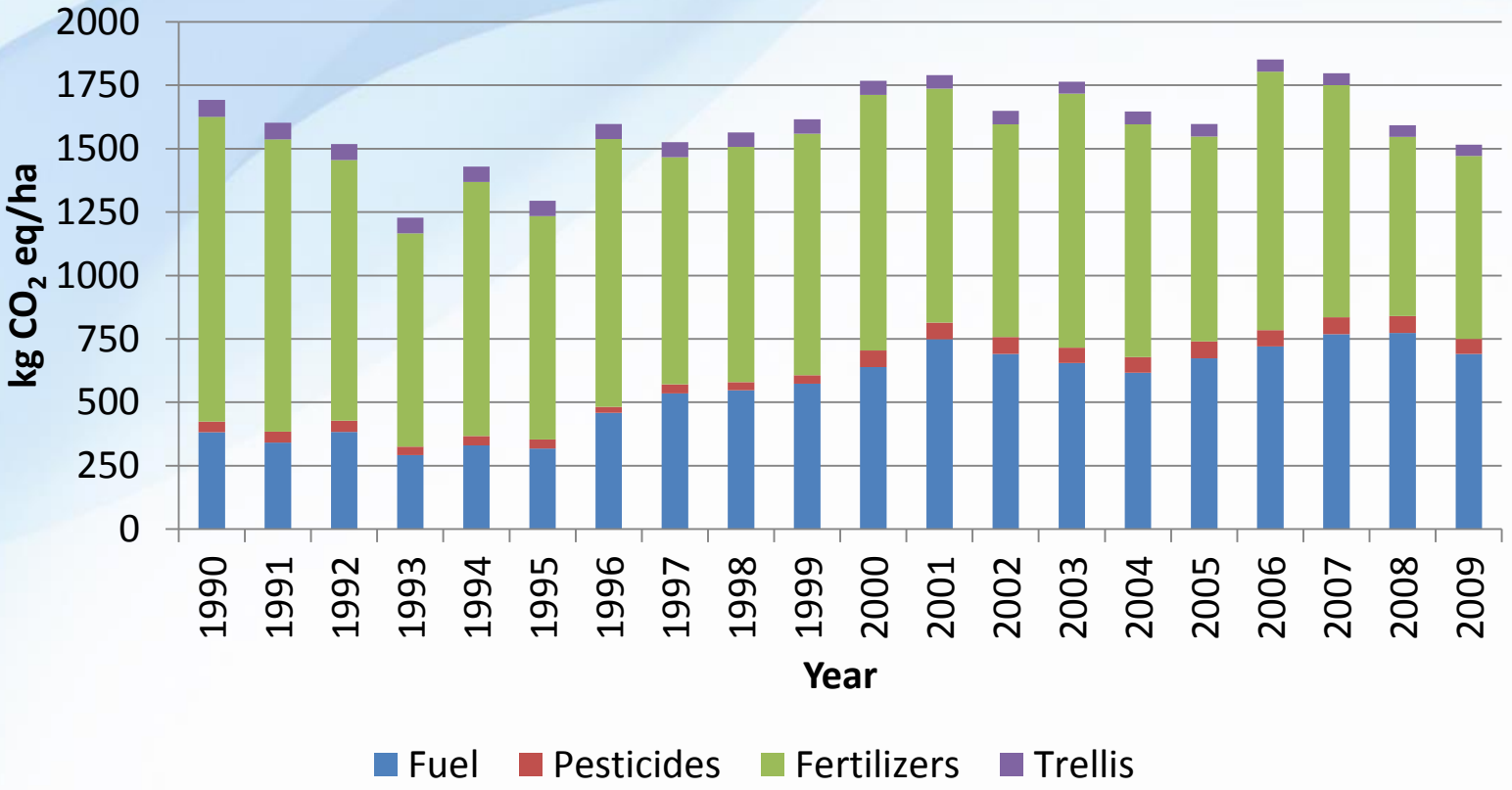
Results (iv)

GHG emissions and carbon storage potential



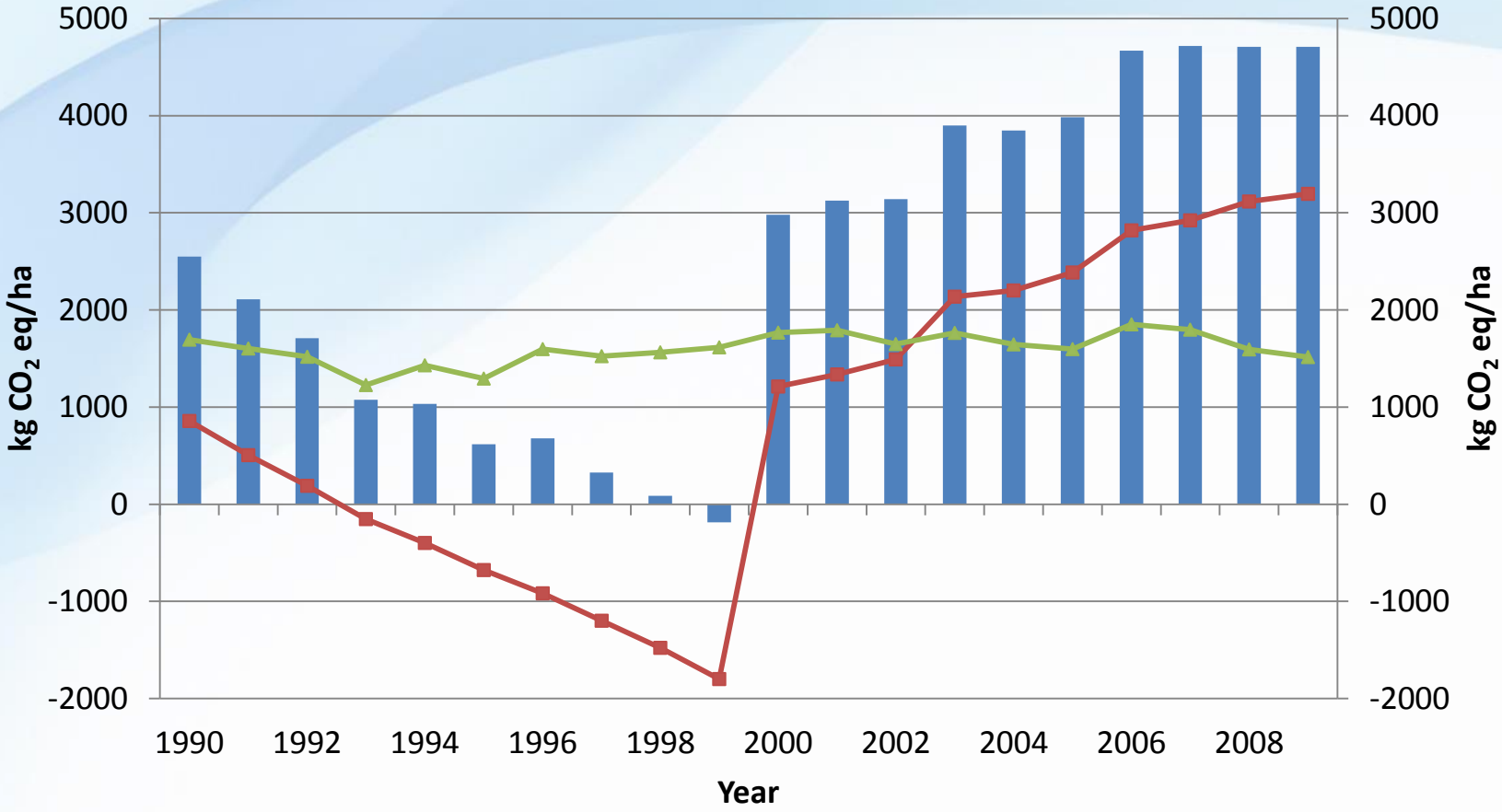
Results (v)

Dynamic LCA for viticulture operations



Results (vi)

Land Use Changes (LUCs) and dynamic LCA: Net Carbon Balance



Discussion (i)

✓Environmental profile of vineyard operations strongly influenced by changes in annual yield.

✓Minimal influence of technological improvements, including the shift from small-holdings to larger wineries.

✓Inorganic fertilizers and fuel use are the main contributors to GHG emissions throughout the period.

✓Changes in trellis materials have minimal impact on GHG emissions.

Discussion (ii)

✓Important differences in the carbon storage/emissions due to LUCs.

✓Two main trends identified:

a. 1990s → carbon storage due to strong reduction in vineyard surface.
b. 2000s → carbon emissions due to deforestation to plant new vineyards

On-going research

✓Improvement of specific inventory items (e.g., fertilizers).

✓Extension of the dynamic analysis to other impact categories (toxicity, eutrophication, water depletion, etc.).

✓Consequential – LCA, linking environmental impact changes to increase in exports (+500% since 1990).

✓Analogous analysis in appellations with different socioeconomic characteristics.

Time for questions…

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