# 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

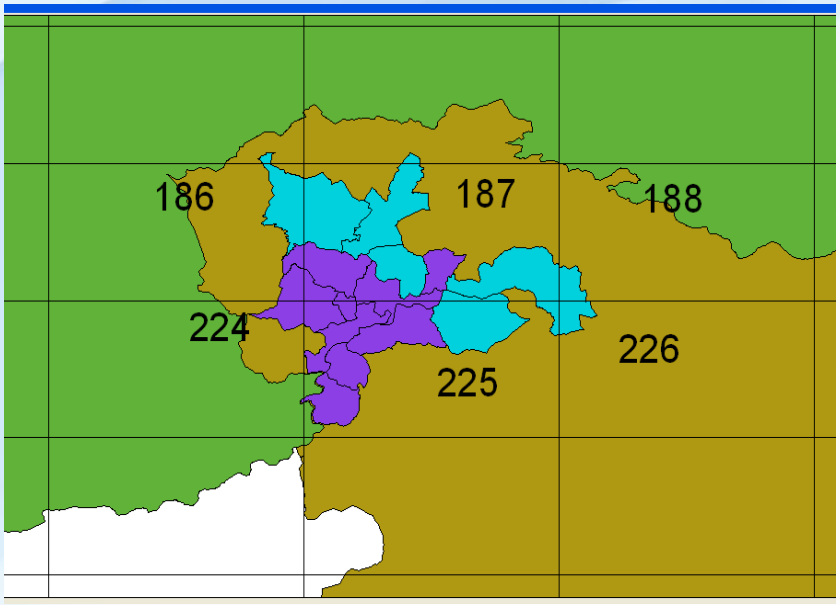
## Location


- 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.

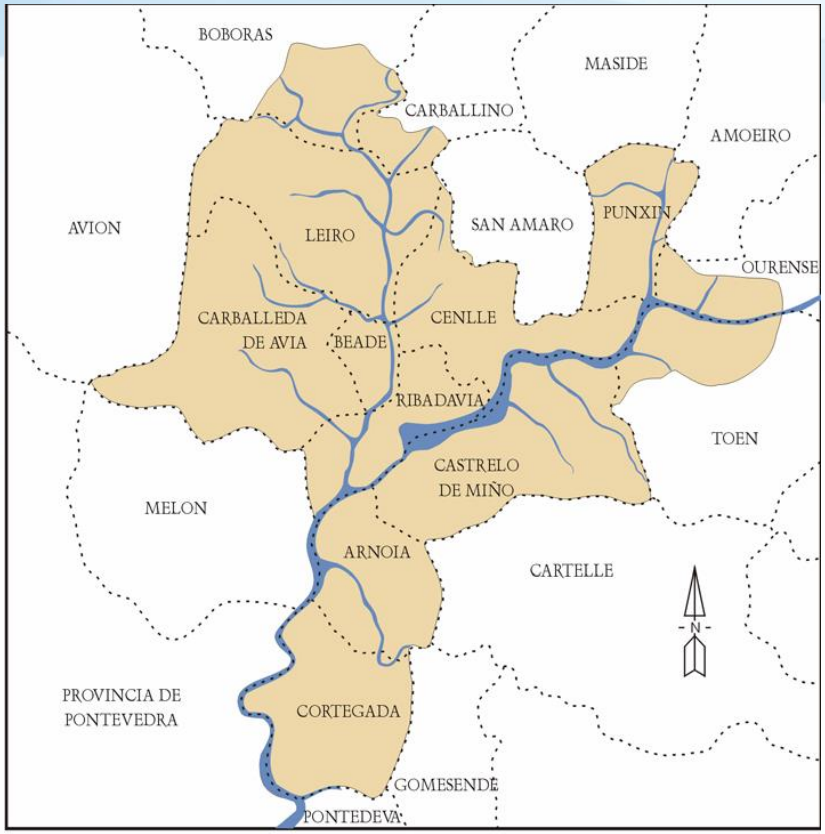
# Materials and Methods (i)

Spanish government map grid




Studied area

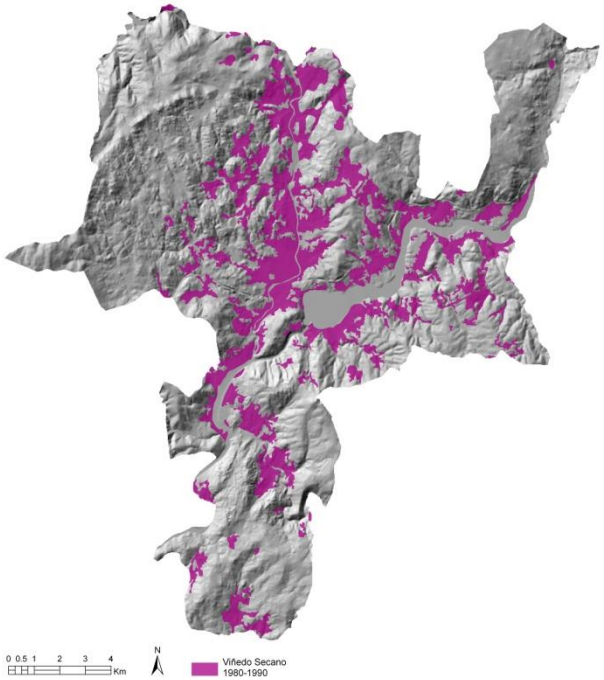
Ribeiro appellation



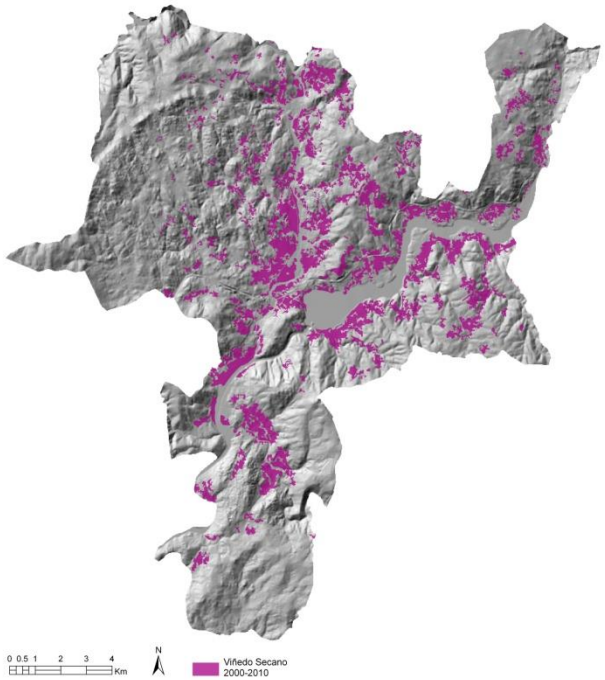
# Materials and Methods (ii)

## 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 |

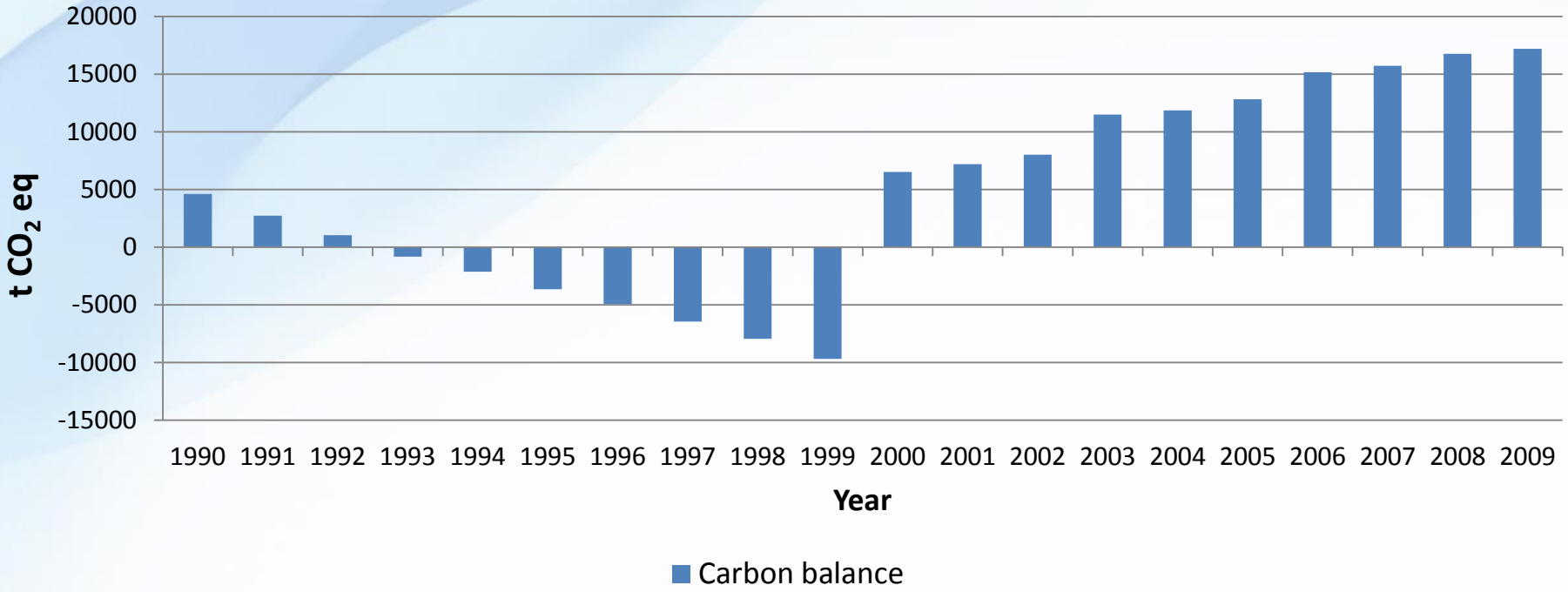
F: Forest land
G: Grassland
C: Crops
W: Wetlands
S: Settlements
O: Other lands

# 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** |

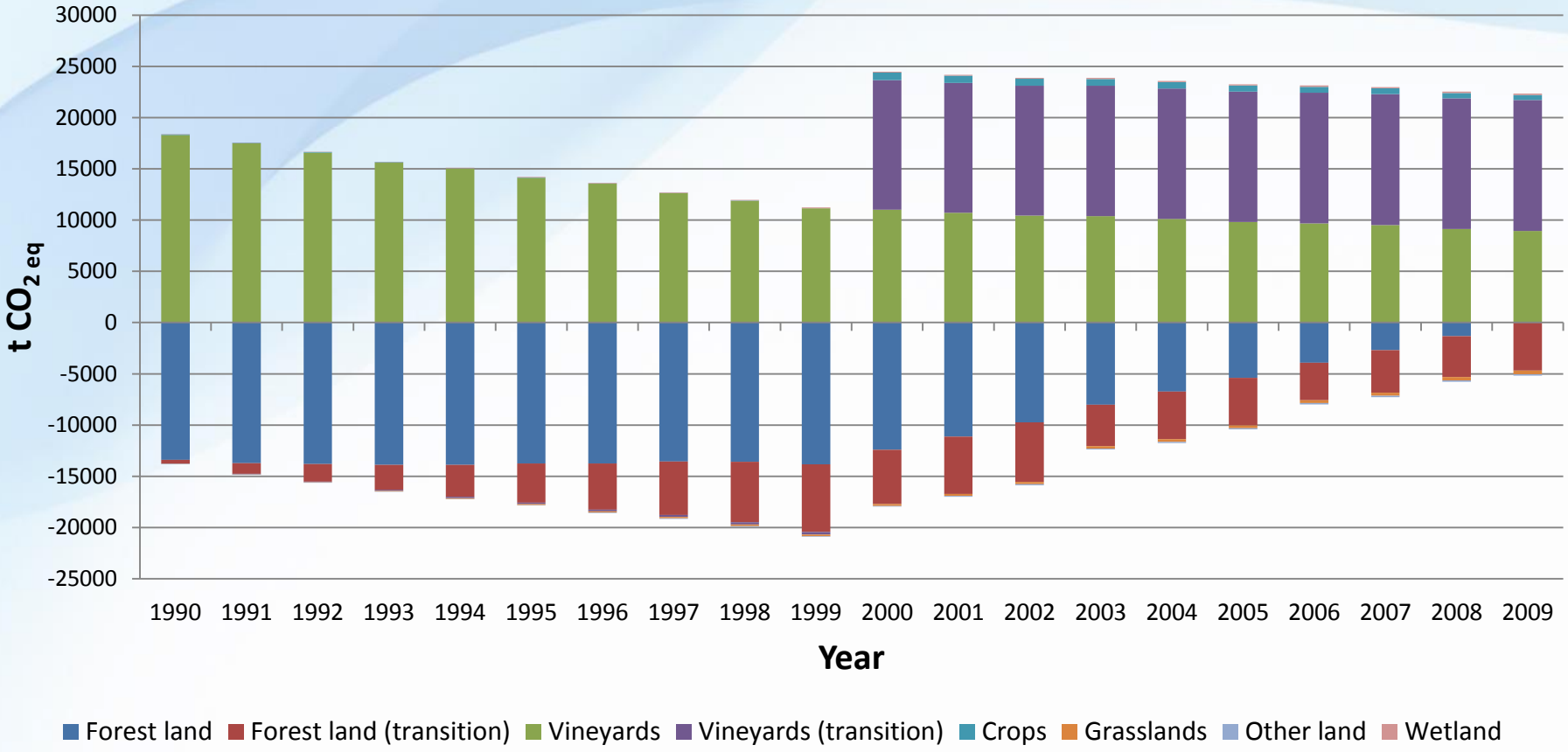
# Results (iii)

## GHG emissions balance related to LUCs



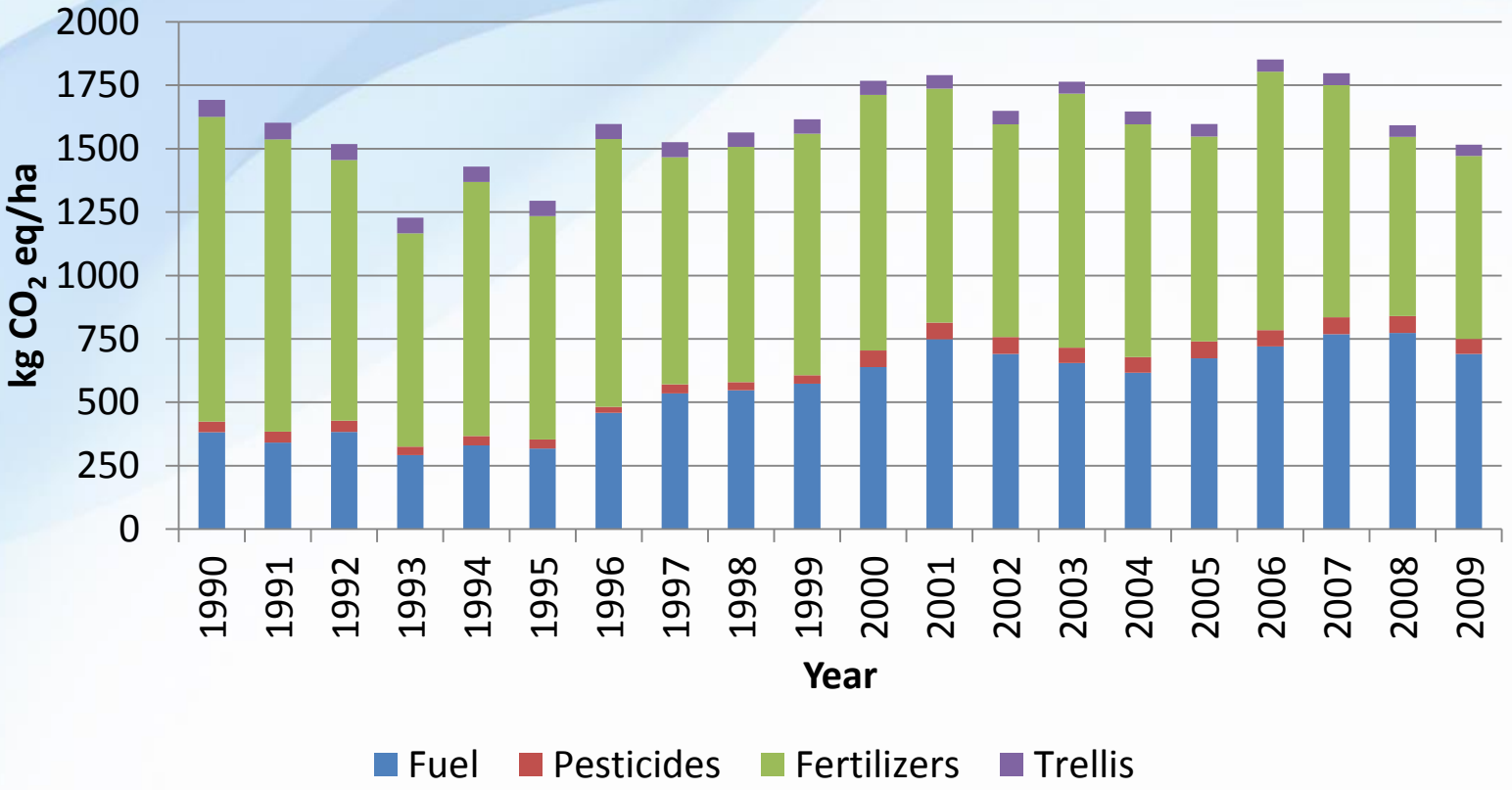
# Results (iv)

## GHG emissions and carbon storage potential



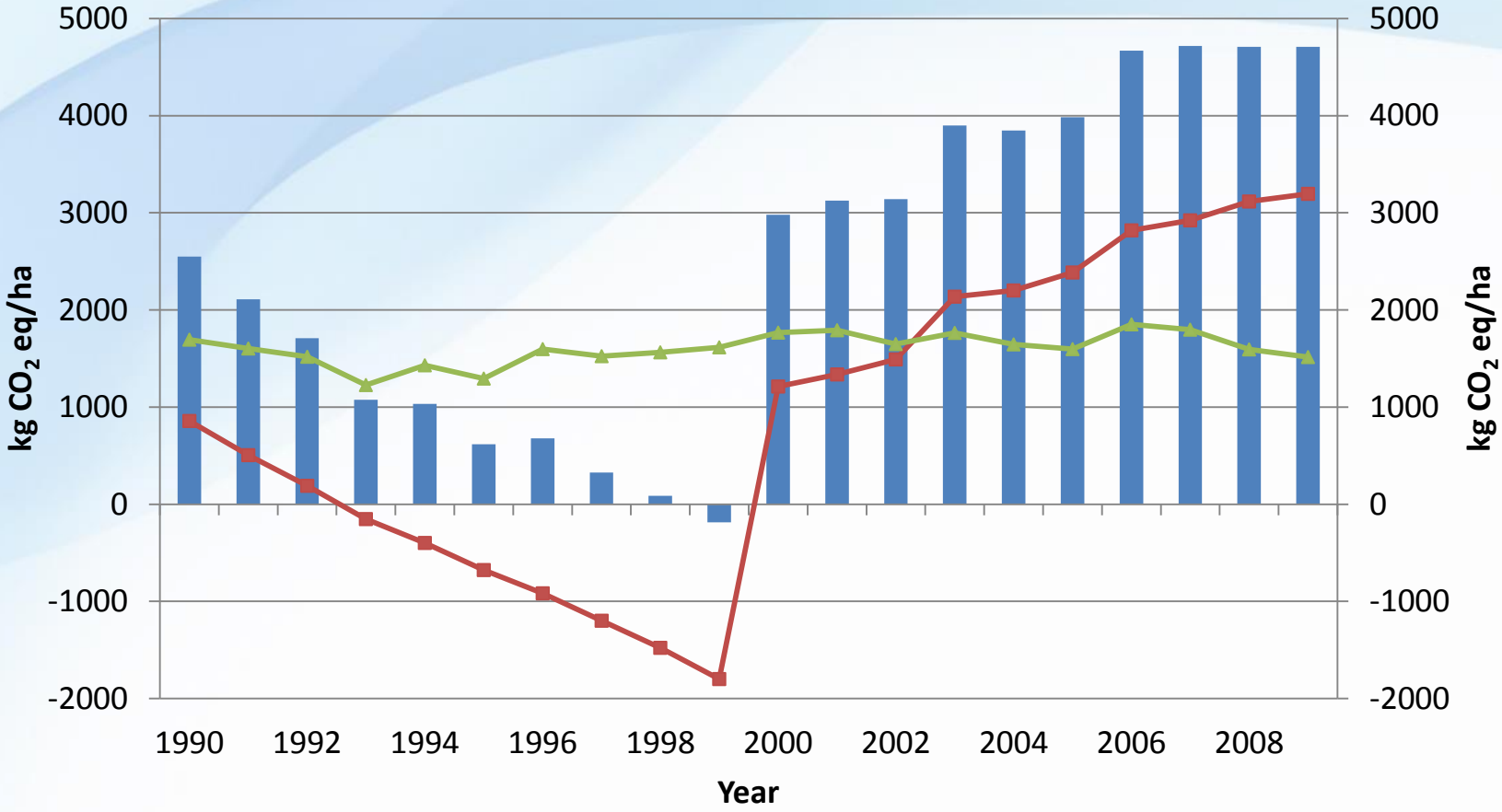
# Results (v)

## 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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