Yield gap analysis of feed crop-livestock systems: the case of grass-based beef production in France

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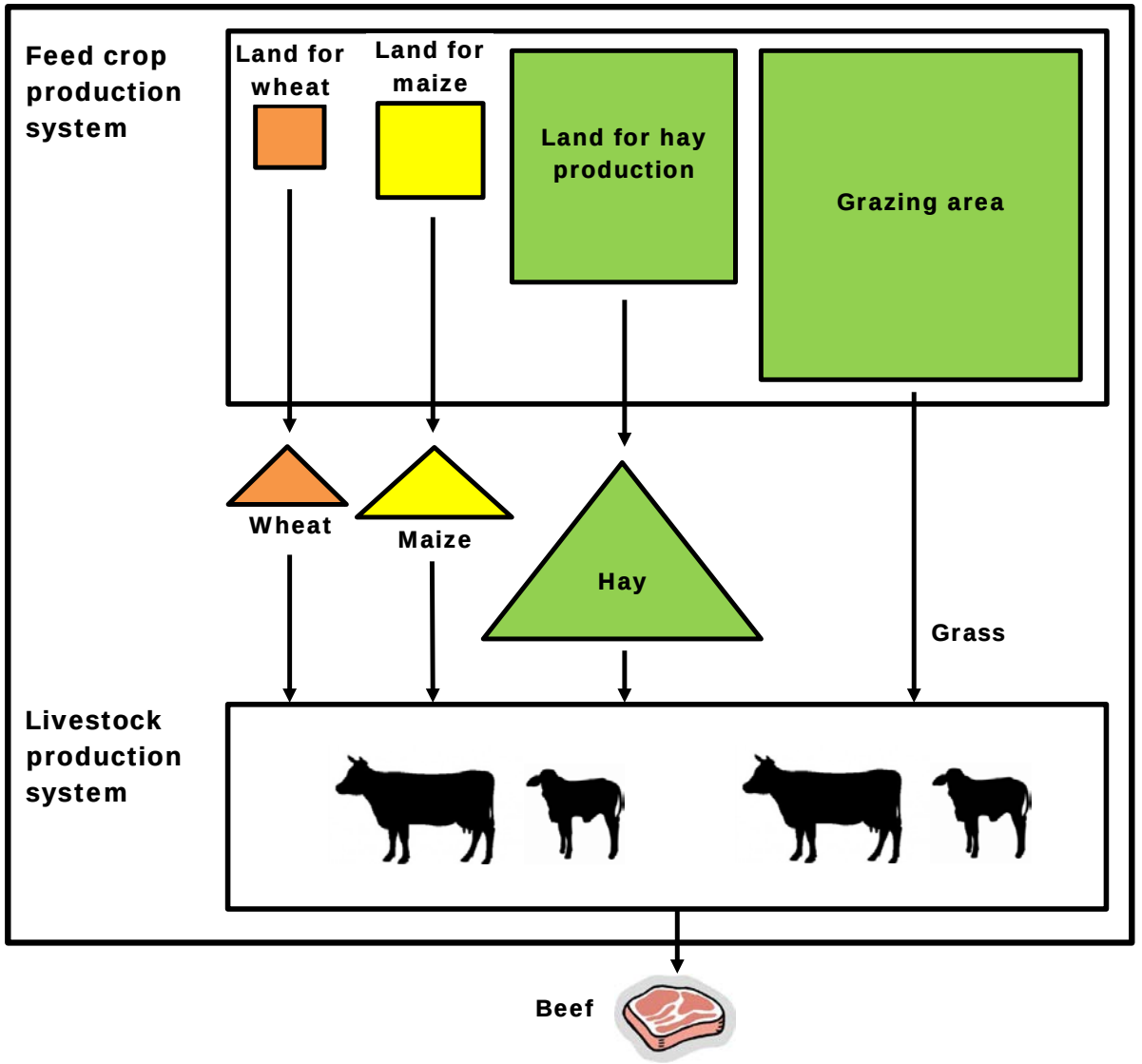
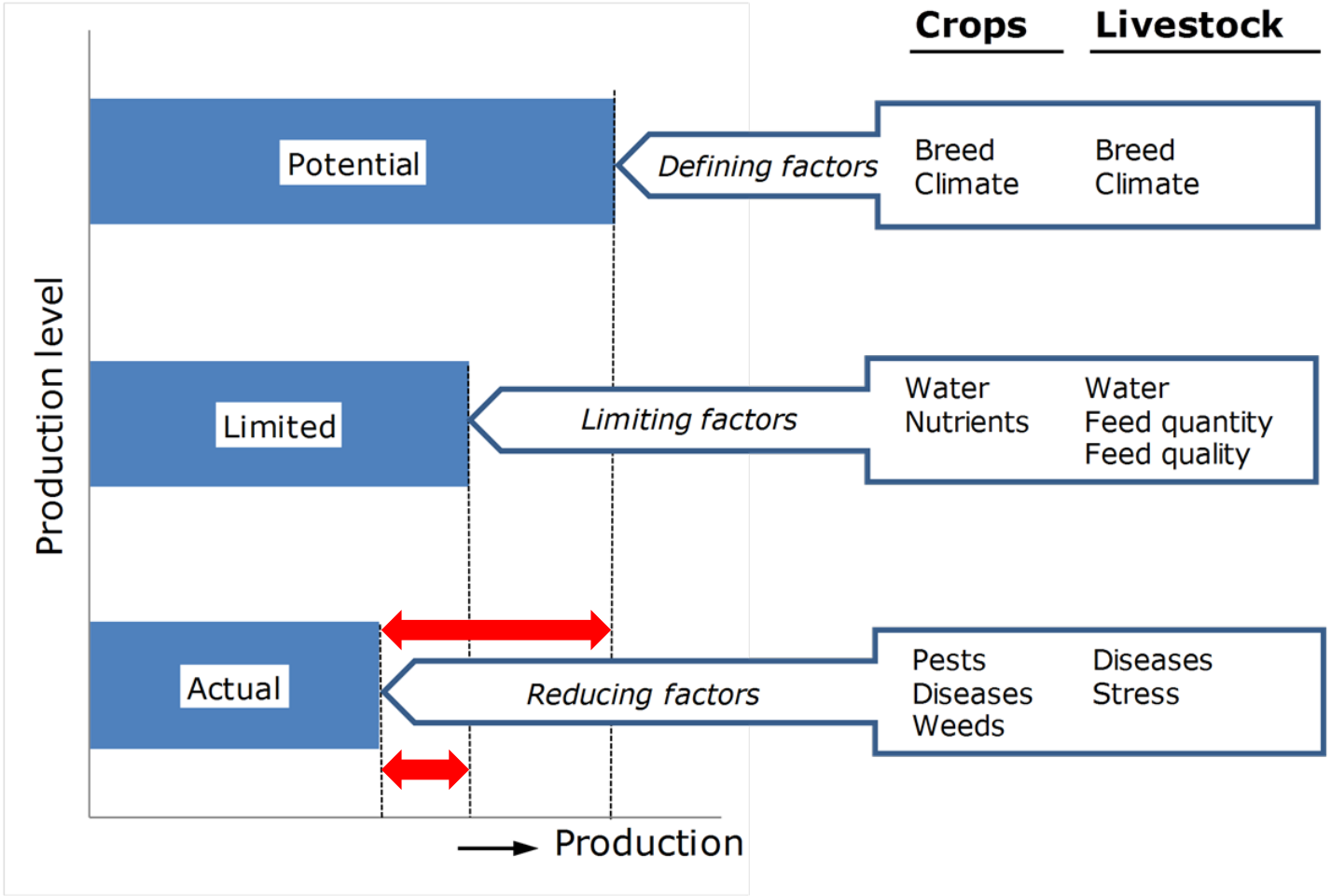
Introduction

Feed-crop livestock system



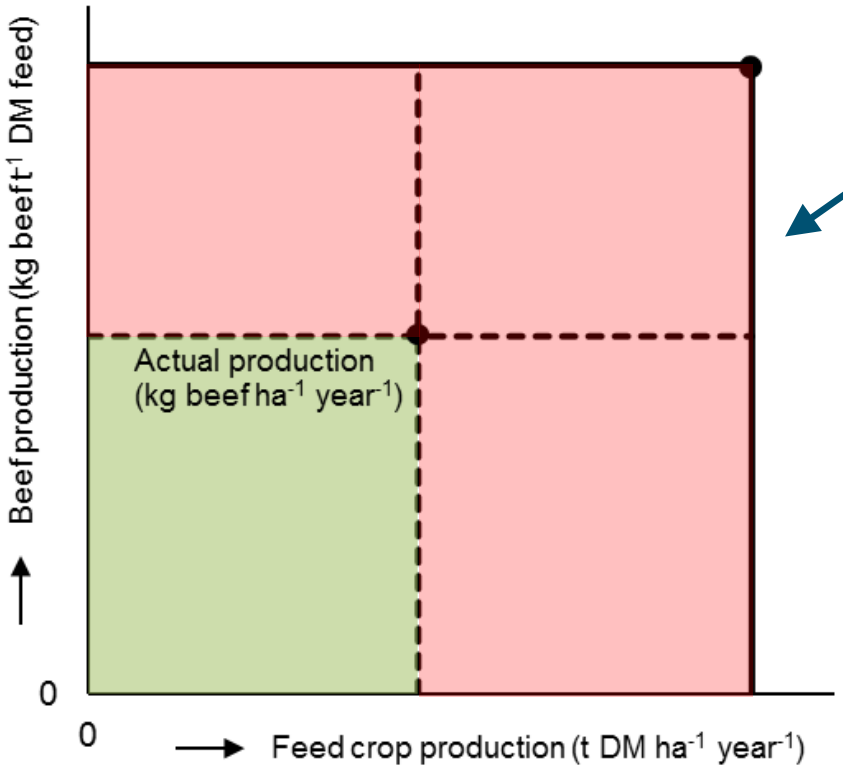
Introduction

Concepts of production ecology



Van Ittersum and Rabbinge, 1997; Van de Ven *et al*., 2003

Introduction



$$\text{kg beef t}^{-1}\text{ DM} \times \text{t DM ha}^{-1}\text{ year}^{-1} = \text{kg beef ha}^{-1}\text{ year}^{-1}$$

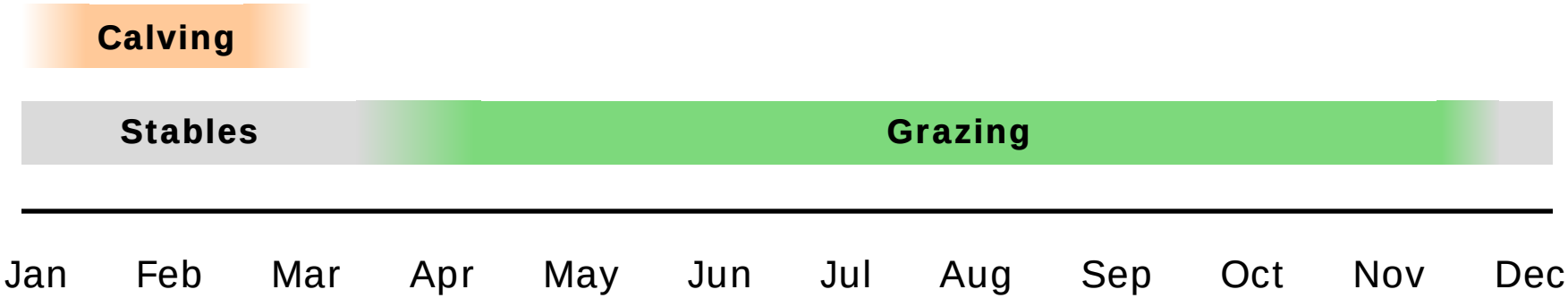
Objectives

- Quantify yield gaps in feed-crop livestock systems
- Analyse yield gaps in feed-crop livestock systems
- Identify improvement options to mitigate yield gaps

for beef production systems in the Charolais area of France

Materials and methods

Beef production systems in the Charolais area of France



Two main types

- Cow-calf systems (calves sold at 300-420 kg)
- Cow-calf-fattener systems (calves sold at 690-720 kg)

Materials and methods

12 farm types with Charolais cattle

Diets

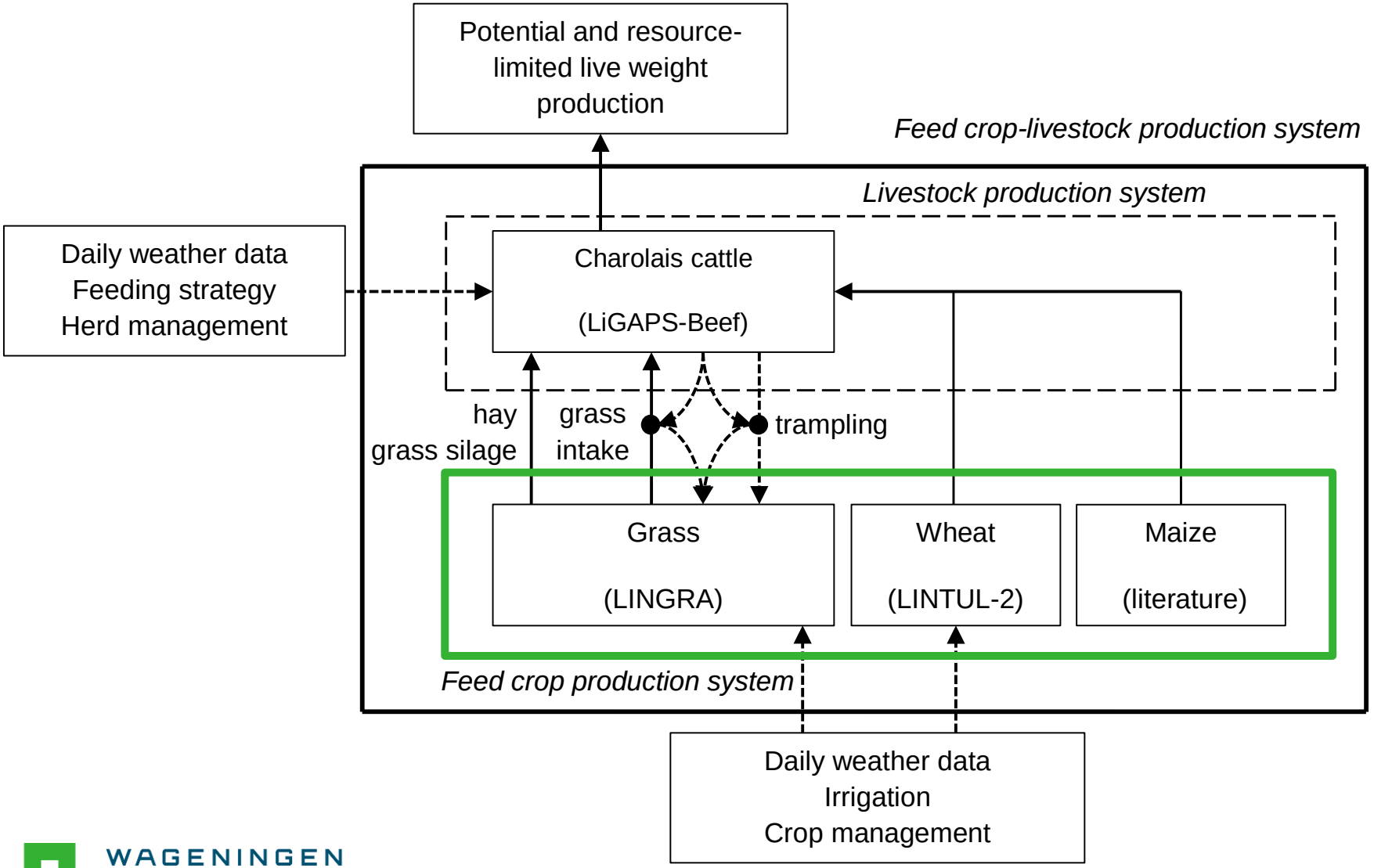
- Fresh grass: 44-66%
- Hay: 28-37%
- Cereals: 4-19%

Area feed production: 76-295 ha

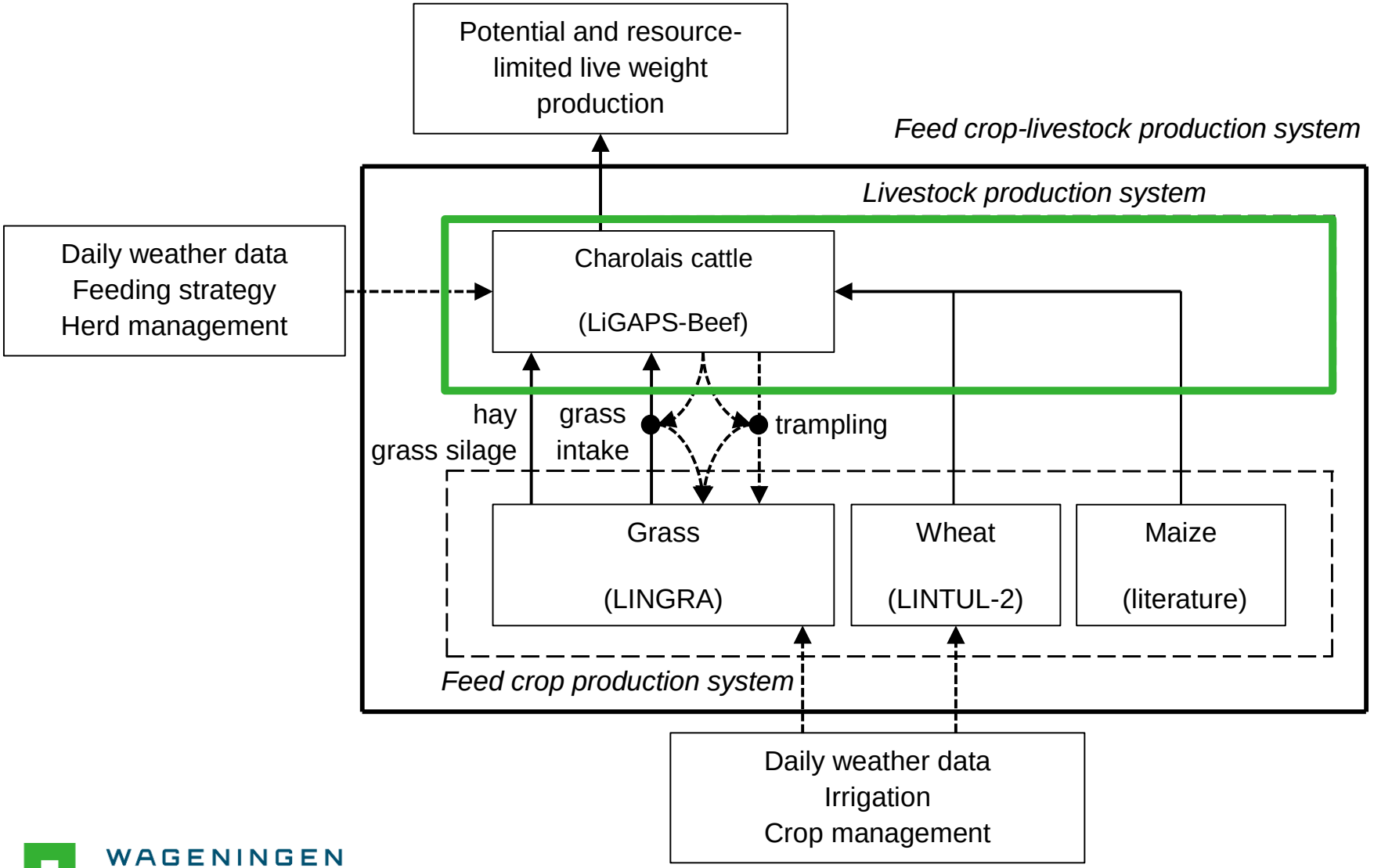
Stocking density: 1.21-1.81 livestock units per ha

Economic data

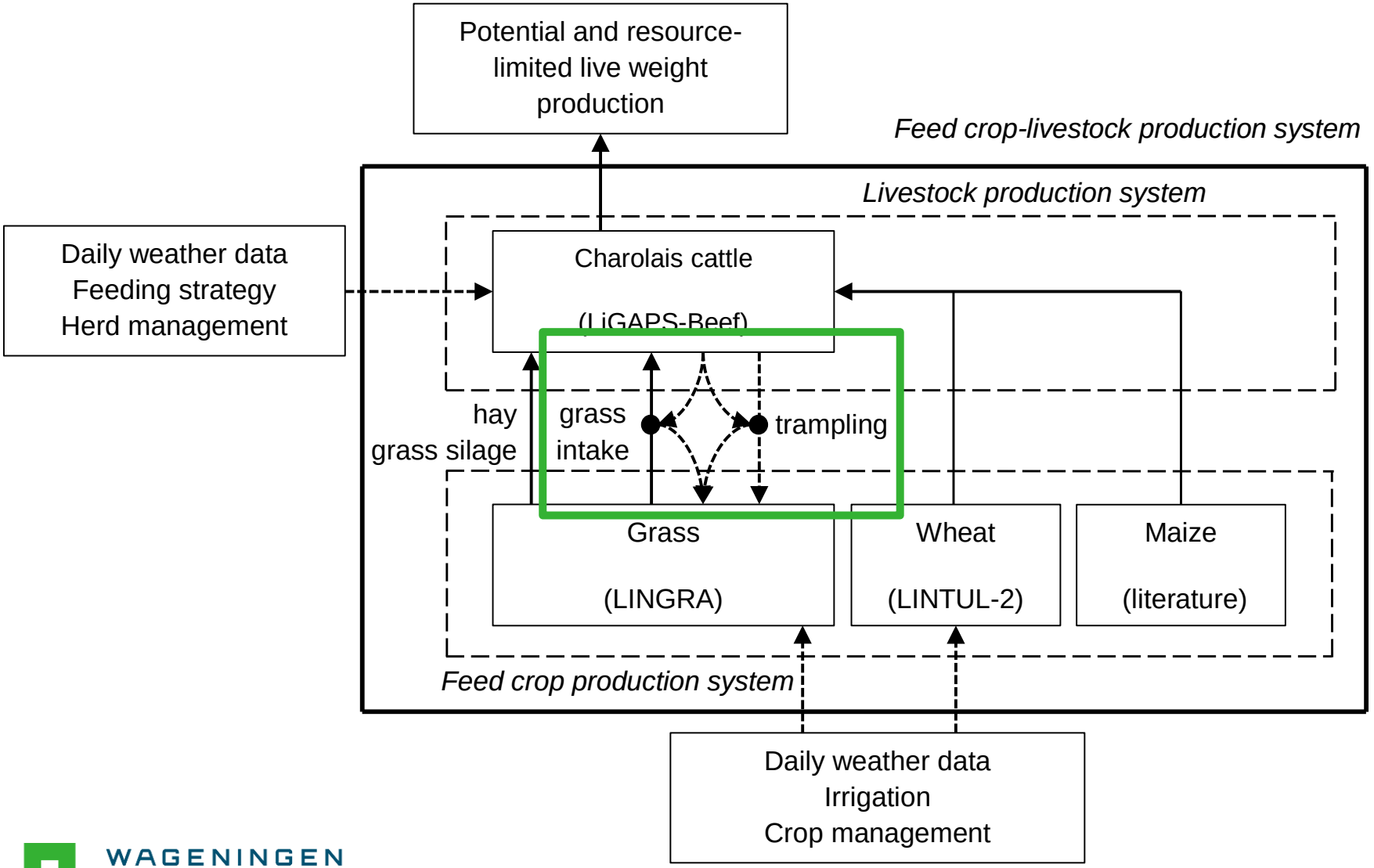
Materials and methods



Materials and methods



Materials and methods



Materials and methods

Simulated production levels (kg live weight ha^{-1} $year^{-1}$)

- Potential production → maximum production per hectare, 100% grass silage, potential grass yields
- Resource-limited production → water-limited crop production and feed-limited cattle production

Measured: actual production realized on farms

Additional production levels simulated

- Feed-limited cattle production and potential crop production
- Resource-limited production with sub-optimal cattle management
- Resource-limited production with sub-optimal cattle management, calf mortality, and prolonged calving intervals

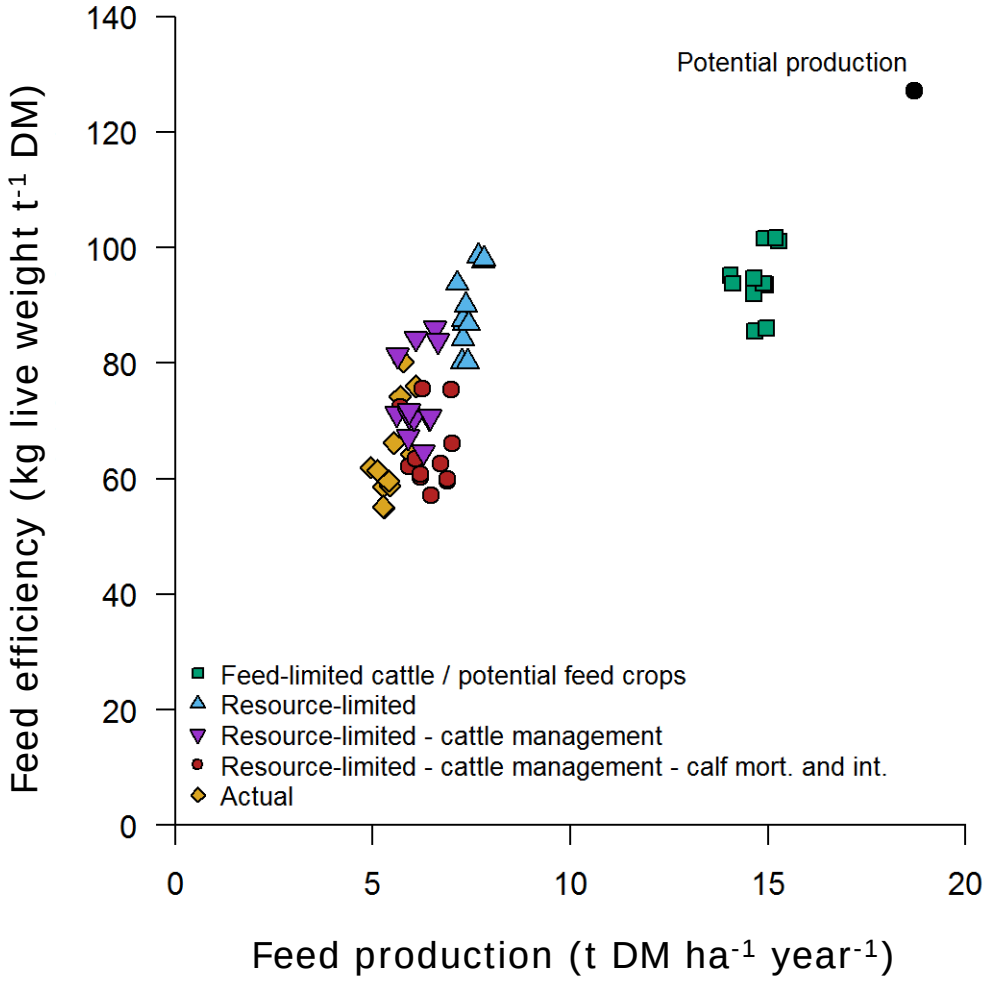
Results & discussion

Yield gaps in feed crops

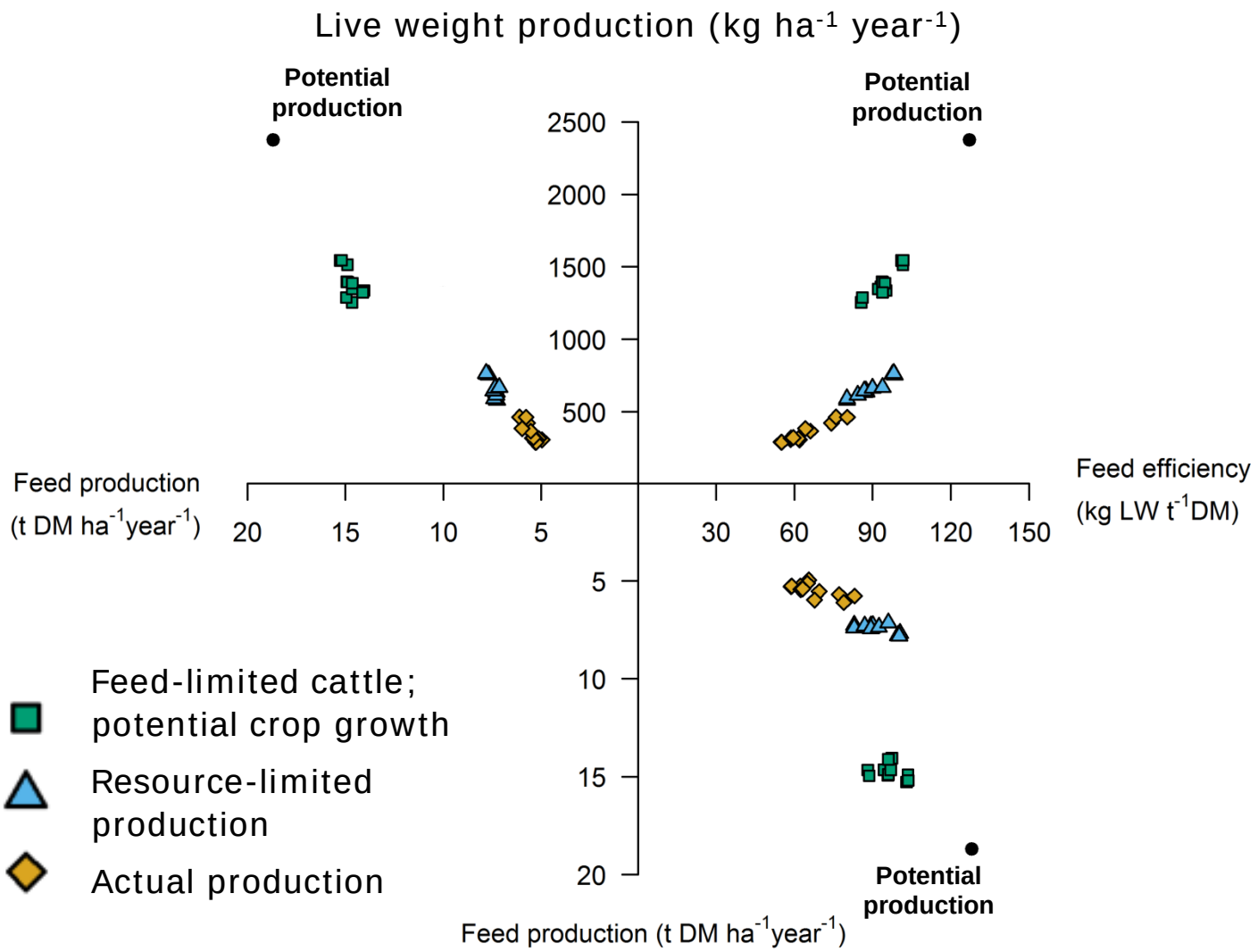
Production level or relative yield gap	Unit	Grass	Hay	Grass silage	Maize silage	Wheat
Potential production (Y_P)	kg DM ha^{-1} $year^{-1}$	14.4	16.6	18.7	25.2	8.3
Water-limited production (Y_L)	kg DM ha^{-1} $year^{-1}$	7.2	7.5	-	19.6	7.2
Actual production (Y_A)	kg DM ha^{-1} $year^{-1}$	4.8	3.2-5.7	-	10.0-10.5	5.0-5.6
Relative yield gap, $(Y_P - Y_A) / Y_P$		67%	66-81%	-	58-60%	33-40%
Relative yield gap, $(Y_L - Y_A) / Y_L$		33%	24-57%	-	46-49%	23-32%

Grazing
(average farm types)

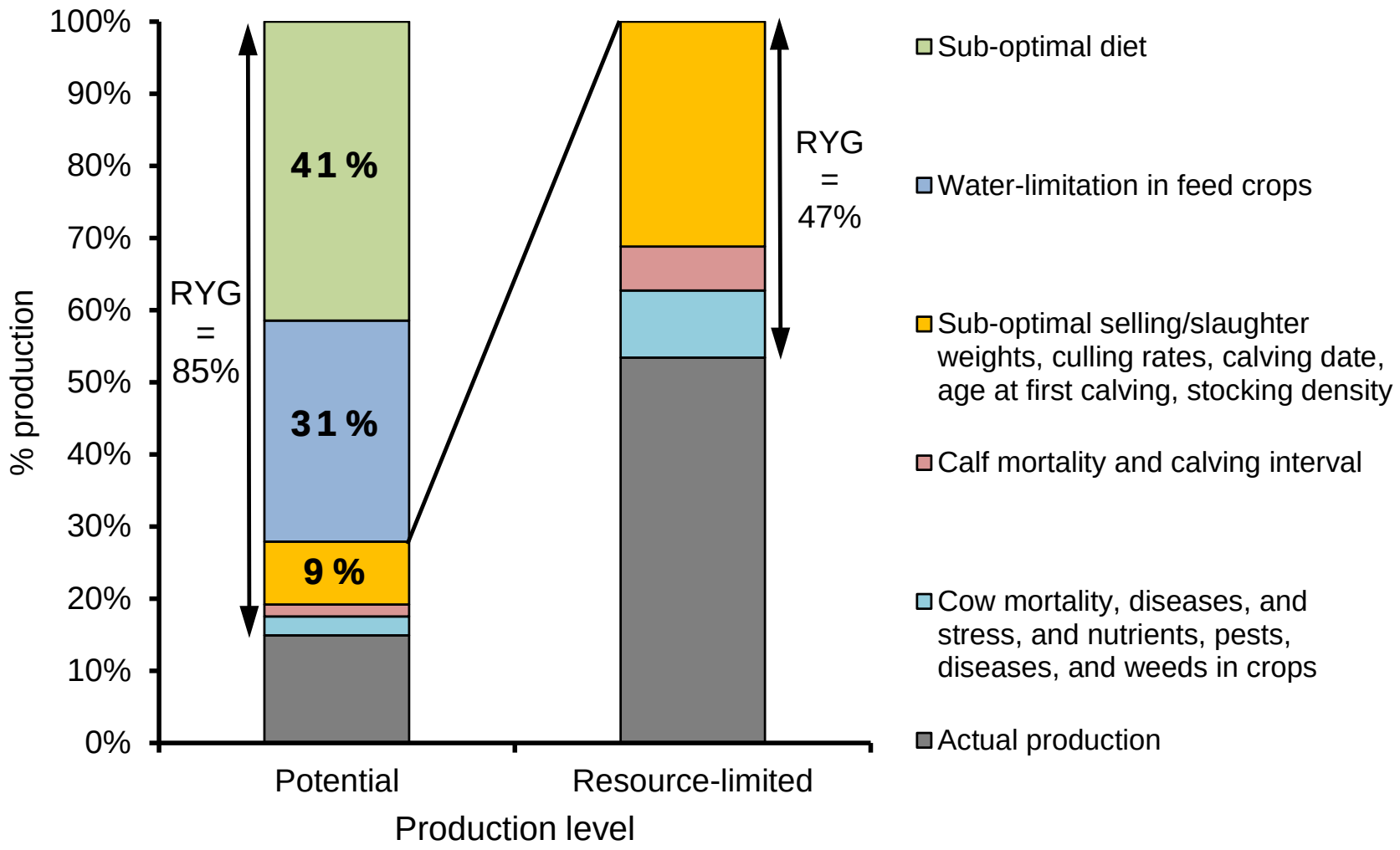
Results and discussion



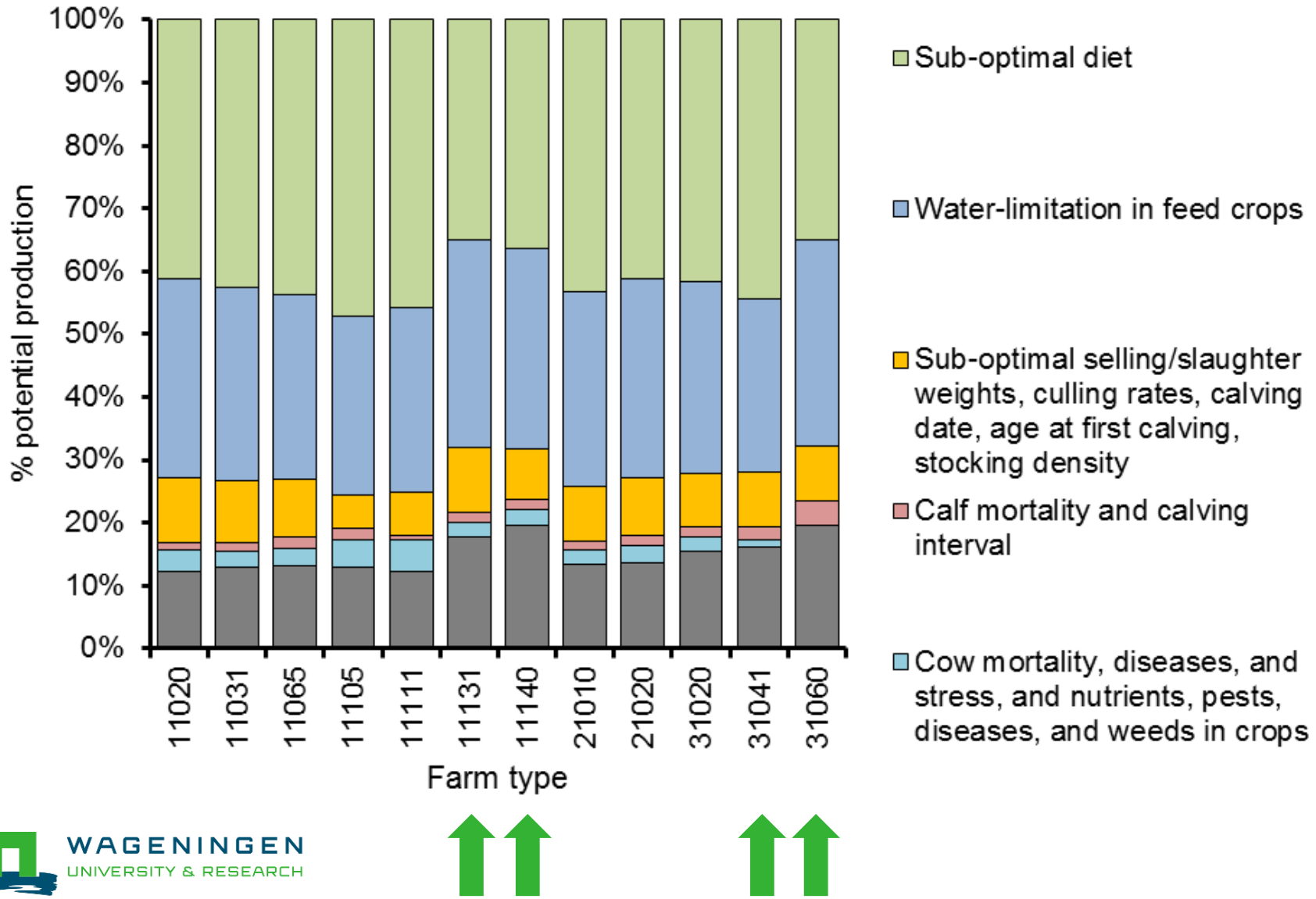
Results and discussion



Results


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% production
RYG = 85%
41 %
31 %
9 %
RYG = 47%
Potential
Resource-limited
Production level
Sub-optimal diet
Water-limitation in feed crops
Sub-optimal selling/slaughter weights, culling rates, calving date, age at first calving, stocking density
Calf mortality and calving interval
Cow mortality, diseases, and stress, and nutrients, pests, diseases, and weeds in crops
Actual production

Results



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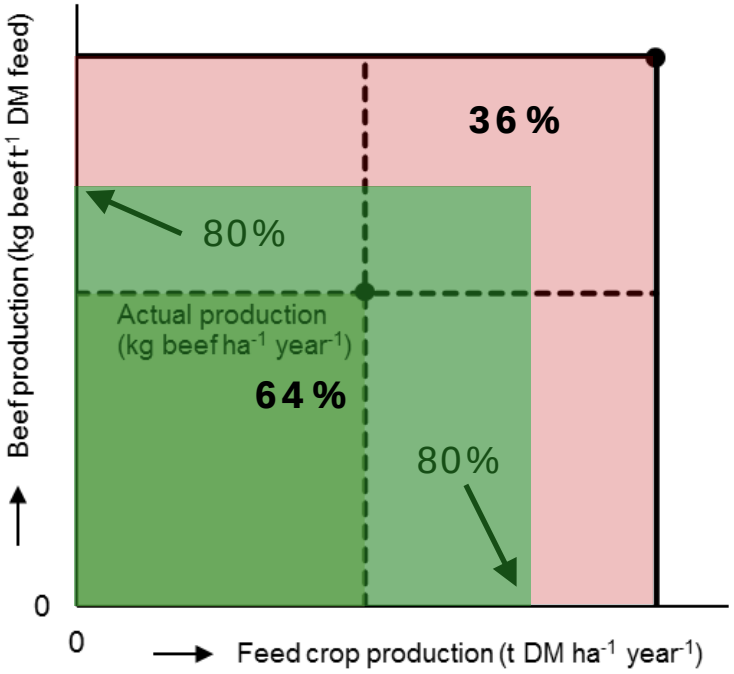
Results & discussion

Explanations for yield gaps

- Socio-economic and environmental constraints → exploitable yield gaps



Exploitable yield gap under resource-limited production:

47% - 36% = 11% of the resource-limited production

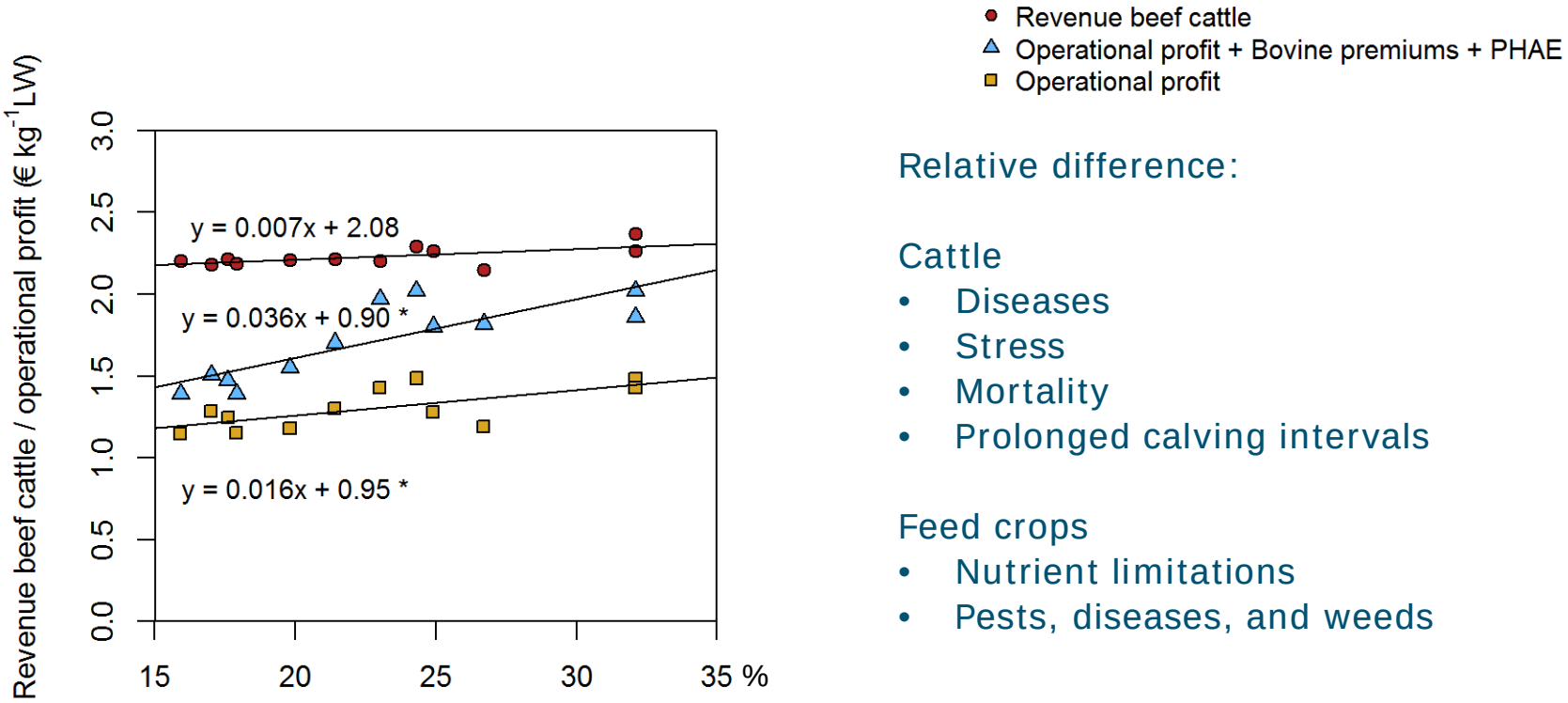
Results & discussion

Explanations for yield gaps

- Socio-economic and environmental constraints → exploitable yield gaps
- Farmers are eligible for grassland premiums if:
  - stocking densities < 1.4 livestock units per ha
  - more than 75% of the farmland is grassland
  - low N fertilization rates (max. 125 kg N ha^{-1})
- Cattle premiums are paid per cow
- Prices of farmland are € 2,800-4,000 per ha

Results and discussion

Yield gap mitigation → not attractive from an economic perspective



Relative difference:

Cattle
- Diseases
- Stress
- Mortality
- Prolonged calving intervals

Feed crops
- Nutrient limitations
- Pests, diseases, and weeds

$$\frac{\text{(Resource-limited / manag. – Actual)}}{\text{Resource-limited / manag.}} \times 100\%$$

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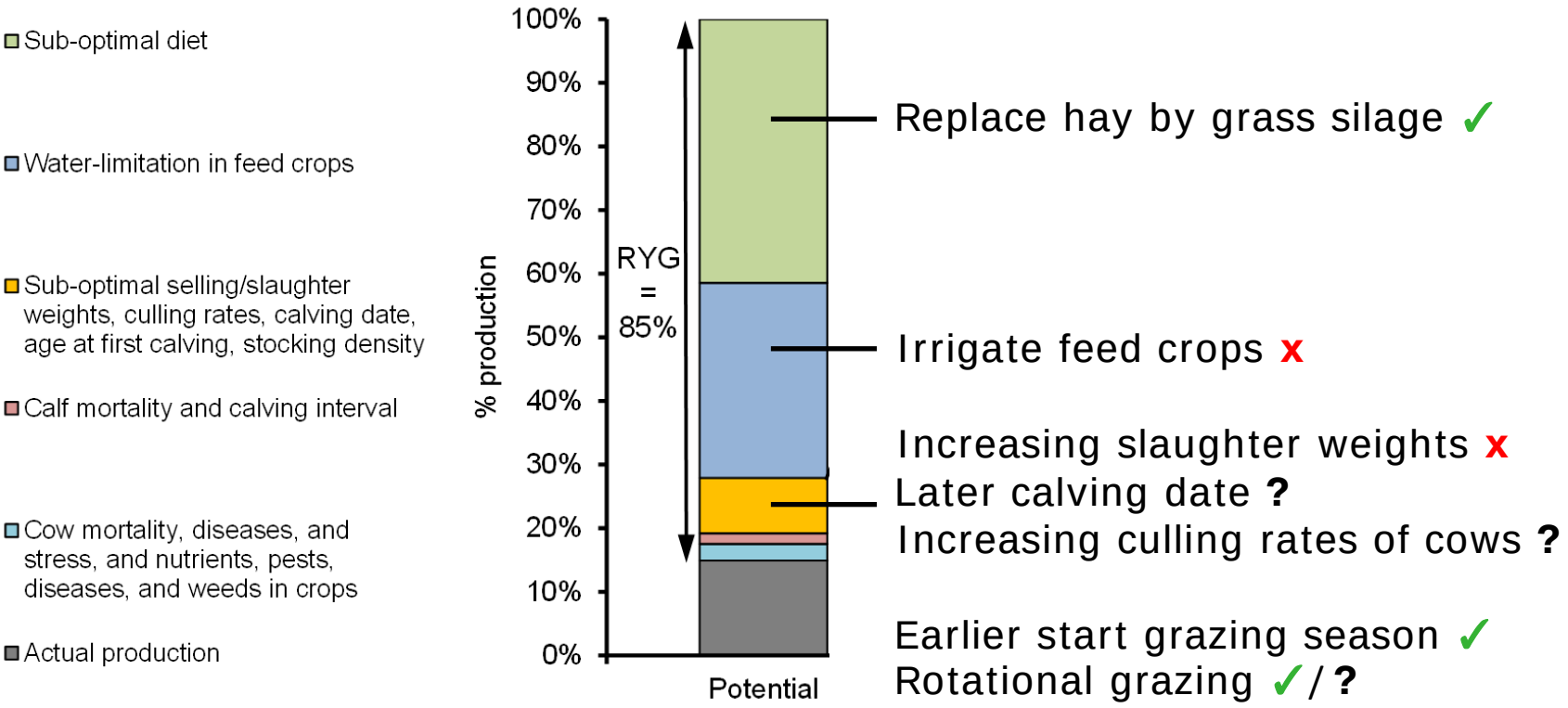
Results and discussion

How to mitigate yield gaps after the change in common agricultural policy (CAP) of the EU in 2015?



Conclusions

A generic framework and modelling method is now available to assess yield gaps in feed-crop livestock systems.

Its application to beef production systems in France shows that:

- Yield gaps were 85% of potential live weight production and 47% of resource-limited live weight production
- The main factors attributing to yield gaps were identified (feed quality and quantity limitations, water-limitation in feed crops, cattle management)
- The approach allows to identify improvement options for yield gap mitigation (grazing management, feeding silage)

Thank you for your attention!

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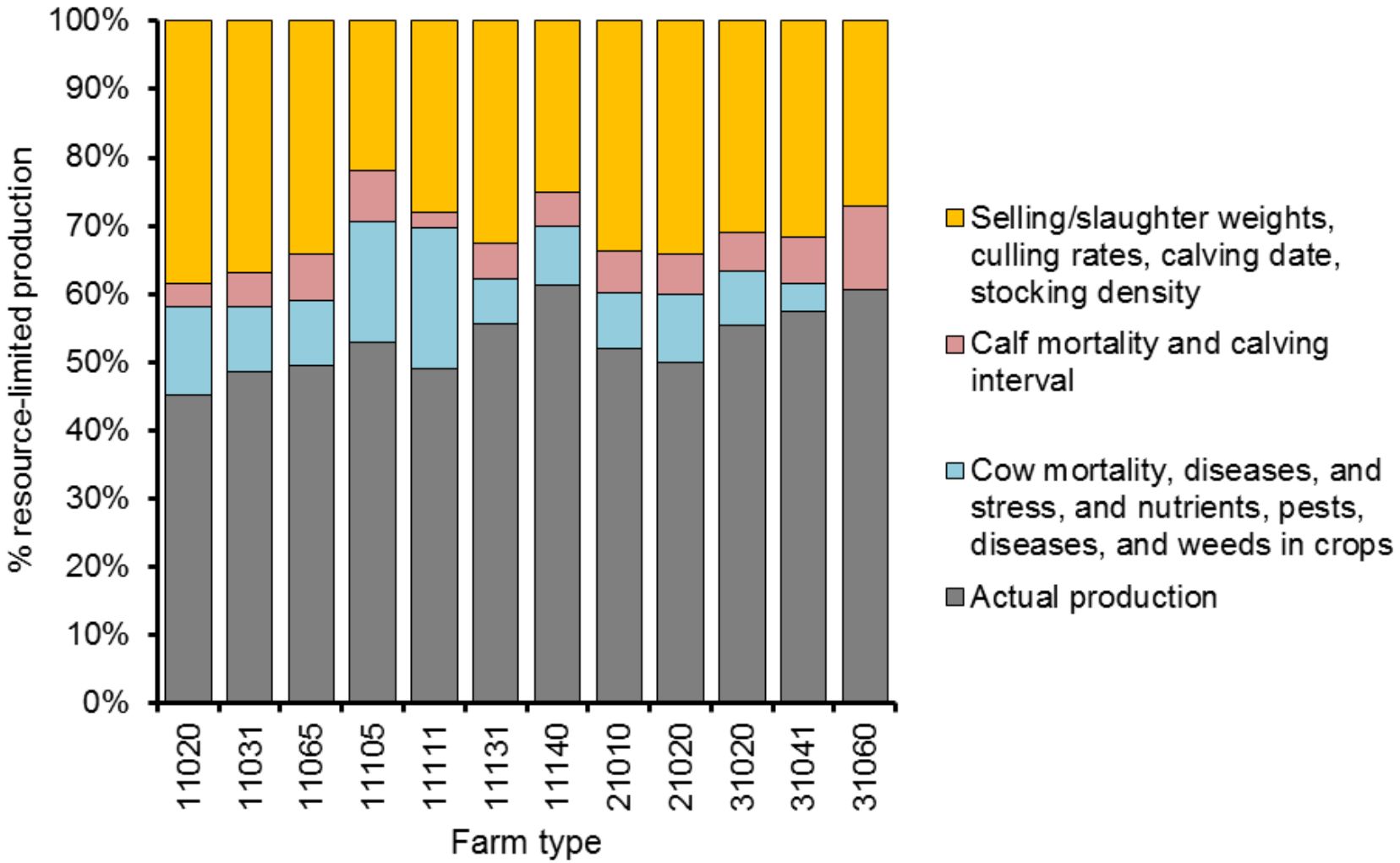
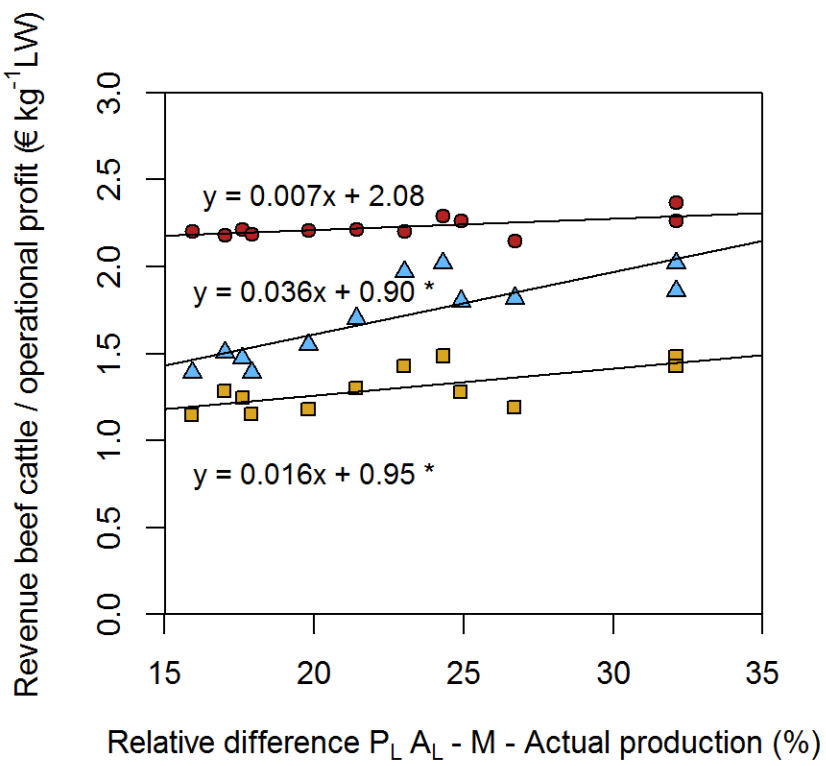
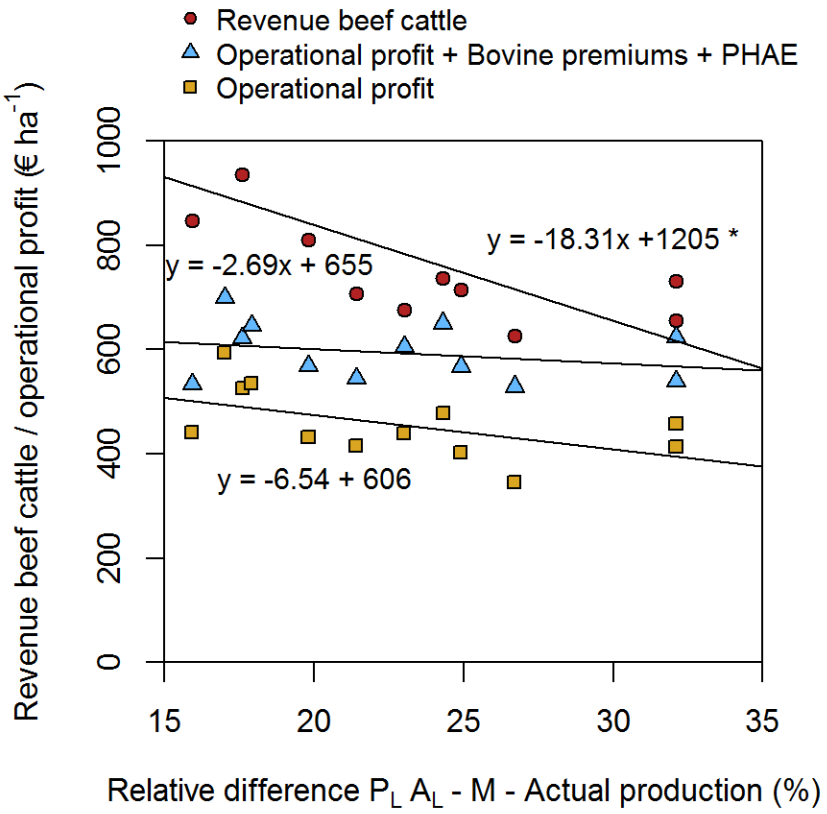
Results

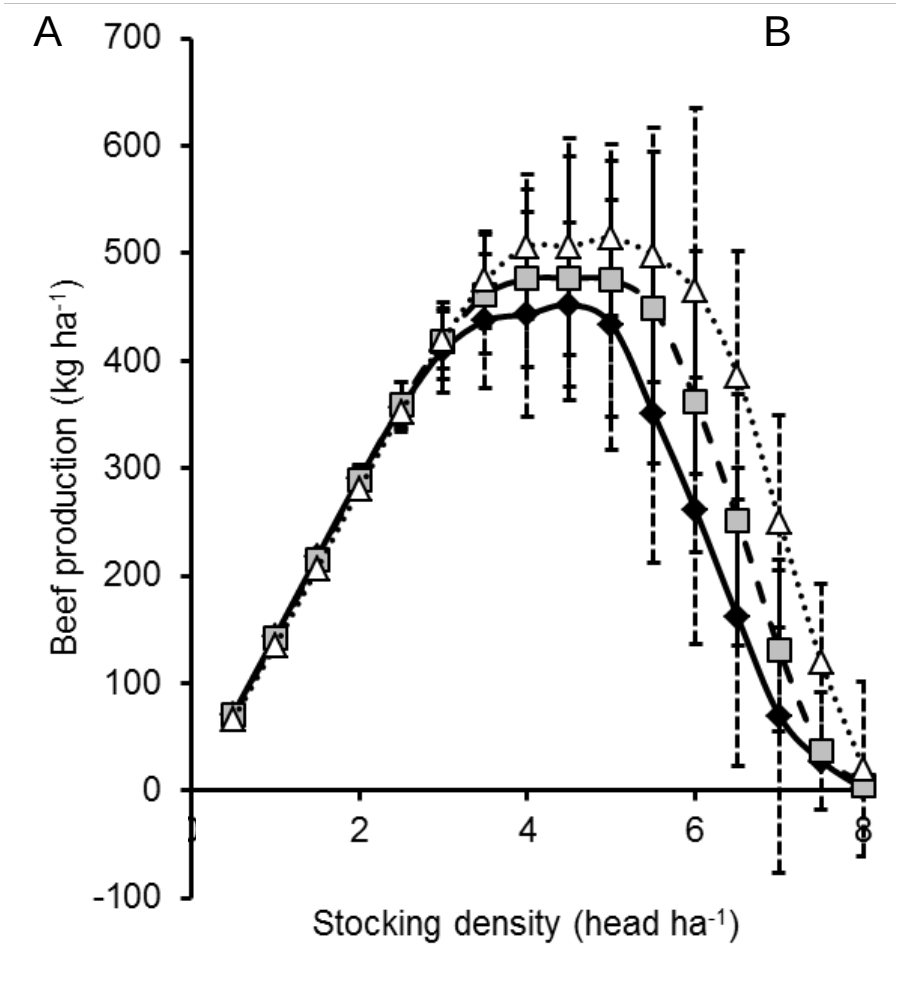

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% resource-limited production
11020
11031
11065
11105
11111
11131
11140
21010
21020
31020
31041
31060
Farm type
Selling/slaughter weights, culling rates, calving date, stocking density
Calf mortality and calving interval
Cow mortality, diseases, and stress, and nutrients, pests, diseases, and weeds in crops
Actual production

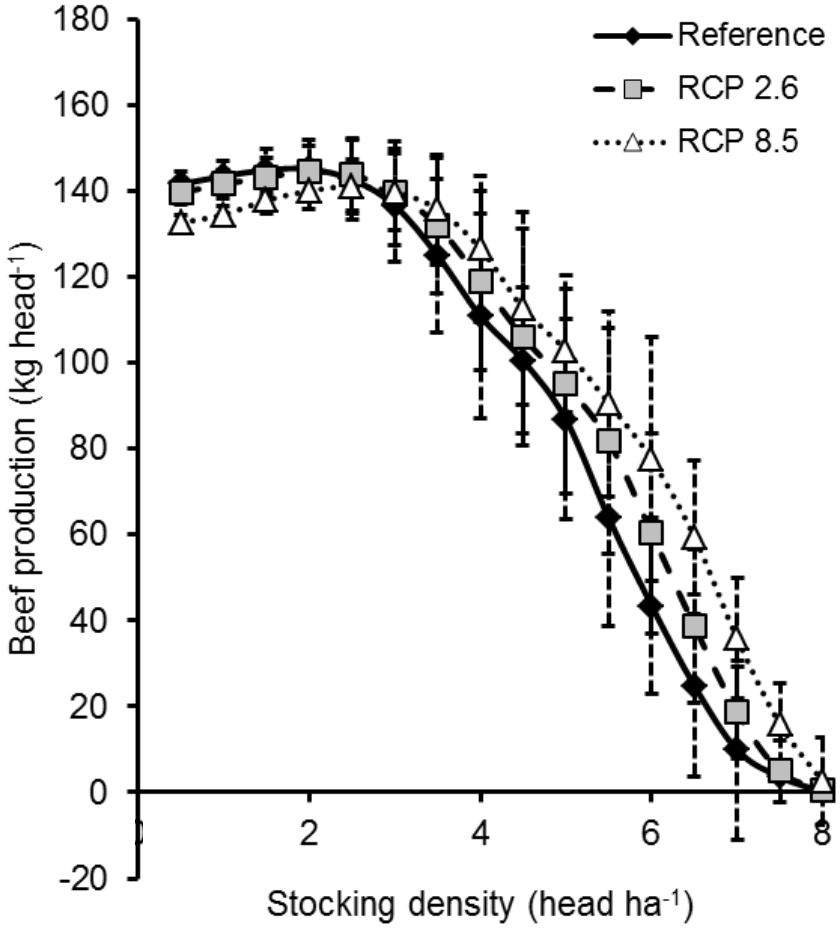
Results


Revenue beef cattle / operational profit (€ kg-1 LW)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
y = 0.007x + 2.08
y = 0.036x + 0.90 *
y = 0.016x + 0.95 *
15
20
25
30
35
Relative difference PL AL - M - Actual production (%)

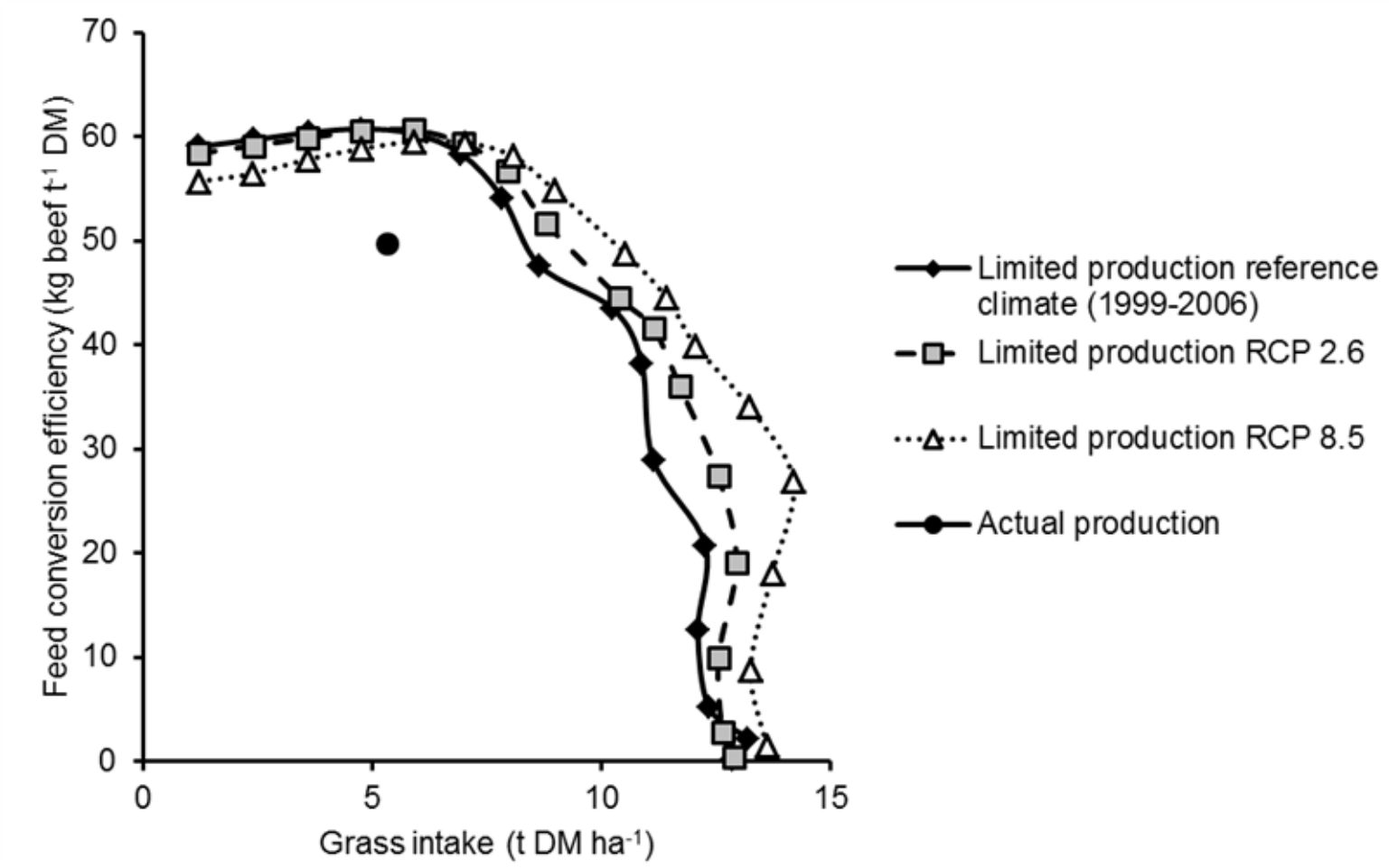

Revenue beef cattle
Operational profit + Bovine premiums + PHAE
Operational profit
Revenue beef cattle / operational profit (€ ha-1)
0
200
400
600
800
1000
y = -18.31x +1205 *
y = -2.69x + 655
y = -6.54 + 606
15
20
25
30
35
Relative difference PL AL - M - Actual production (%)

Results


A
B
700
600
500
400
300
200
100
0
-100
Beef production (kg ha-1)
2
4
6
8
Stocking density (head ha-1)


180
160
140
120
100
80
60
40
20
0
-20
Beef production (kg head-1)
Reference
RCP 2.6
RCP 8.5
2
4
6
8
Stocking density (head ha-1)

Results


70
60
50
40
30
20
10
0
Feed conversion efficiency (kg beef t-1 DM)
0
5
10
15
Grass intake (t DM ha-1)
Limited production reference climate (1999-2006)
Limited production RCP 2.6
Limited production RCP 8.5
Actual production