The concordance between greenhouse gas emissions, livestock production and profitability of extensive beef farming systems

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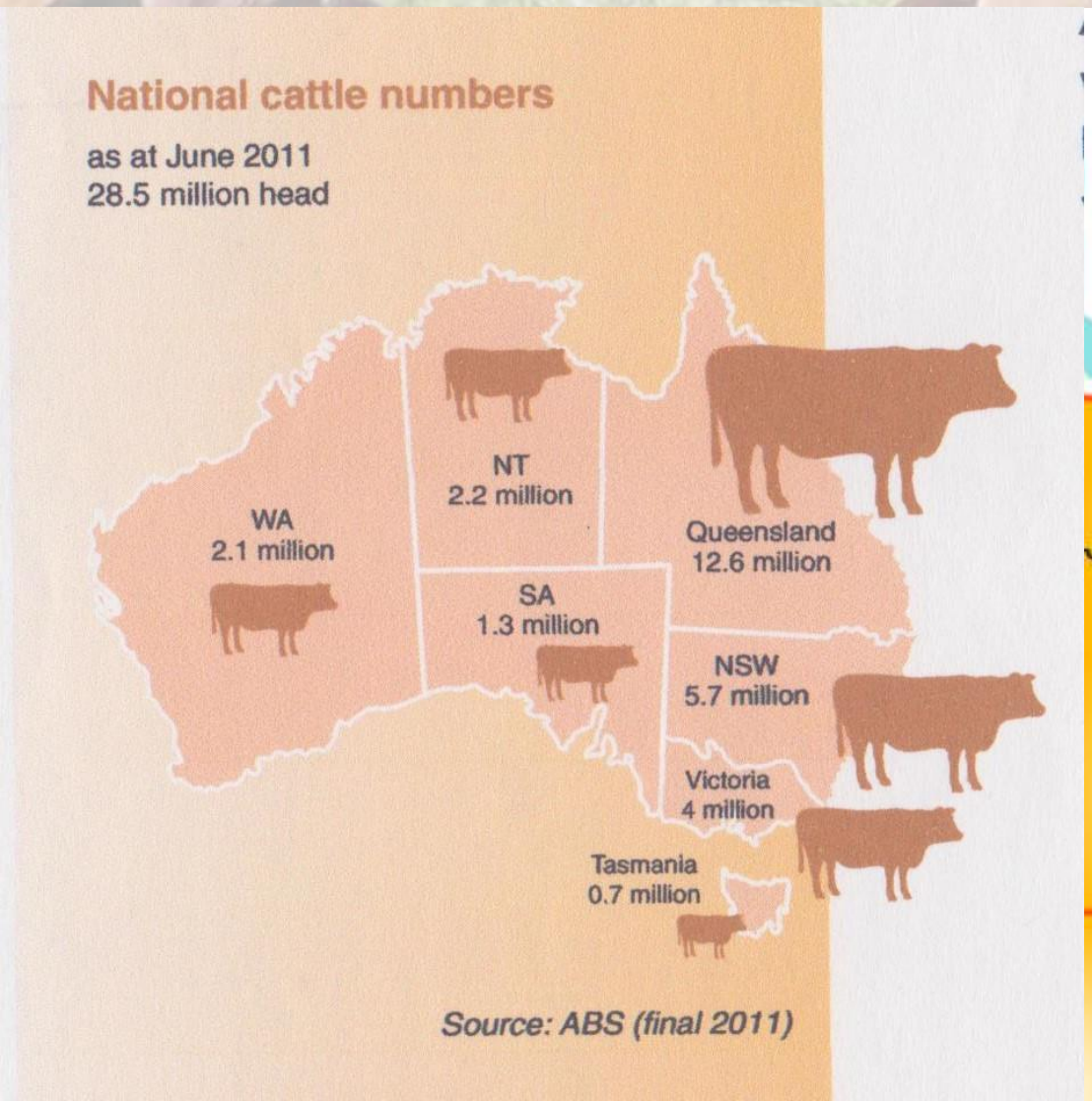
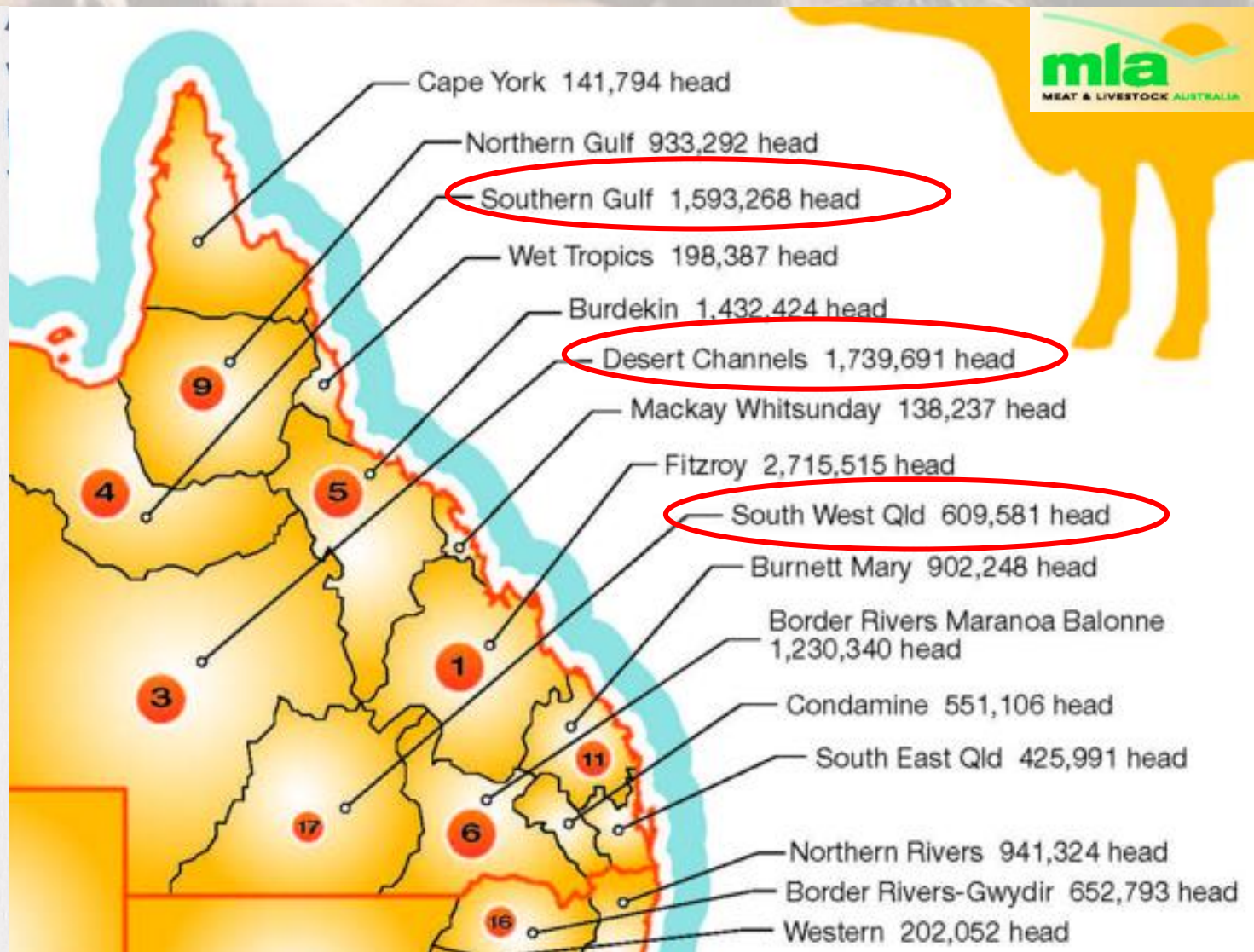
Extensive beef farming in Australia

- The majority of beef cattle production in Australia occurs in Queensland

Extensive beef farming in Australia





Extensive beef farming in Australia

- The majority of beef cattle production in Australia occurs in Queensland
- Productivity in extensive zones of QLD is generally low, presenting opportunities for increasing liveweight turnoff
- **Are there farm system interventions that can increase liveweight (LW) production and gross margin whilst maintaining (or reducing) total livestock GHG emissions?**

The modelling approach and scenarios examined

- A ‘baseline scenario’ was modelled using a case study property near Longreach in central QLD, with herd characteristics developed according to regional expert advice

- Farming system intervention scenarios were designed for emissions mitigation, increasing LW turnoff or both, with single or multiple changes made to the baseline

- Herd characteristics and economics were modelled with Breedcowplus V6 (Holmes 2012). Greenhouse gas (GHG) emissions were modelled using the Australian National Greenhouse Gas Inventory (DCCEE 2014)

The modelling approach and scenarios examined

- Scenarios were modelled assuming the same stocking rates (SR) as the baseline, except for two scenarios that increased SR such that net farm emissions matched those of the baseline

The modelling approach and scenarios examined

- Replacing urea supplementation with nitrate (N) in the dry season to suppress enteric CH_4 fermentation
- Transporting steers to a sub-tropical location for finishing on the perennial legume leucaena (L). This forage increased LW gain, inhibited enteric CH_4 emissions and increased soil C sequestration
- Matching emissions from the leucaena scenario with those of the baseline (leucaena equal emissions – LEE)
- Herd optimisation (HO) by reducing breeder turnover, increasing sales of steers and unmated (spayed) heifers and reducing steer sale age
- Increasing weaning rates by cross-breeding and selecting cows based on reproductive performance (High Fecundity, HF)
- Combined scenarios and Early Joining (EJ) (HF-HO-EJ, HF-HO-EJ-L, HF-HO-EJ-LEE)

	Baseline (B)	**Nitrates** (N)	
Total adult equivalents	1750	1750	
Heifers (t LW)	7	7	
Cows (t LW)	119	119	
Spayed & surplus females (t LW)	0	0	
Steers (t LW)	107	107	
Total LW sold	236	236	
Net cattle sales ($)	322,332	322,332	
Direct costs excluding bulls ($)	53,775	95,899	
Carbon offset income ($)	0	2,025	
Gross margin ($)	145,589	91,490	
CH4 - enteric (t CO2-e)	3165	3020	
N2O - total (t CO2-e)	161	161	
Net farm emissions (t CO2-e)	3425	3280	
Emissn intensity (t CO2-e/t LW)	14.5	13.9	-4%

	Baseline (B)	Nitrates (N)	Leuc (L)
Total adult equivalents	1750	1750	1750
Heifers (t LW)	7	7	7
Cows (t LW)	119	119	115
Spayed & surplus females (t LW)	0	0	0
Steers (t LW)	107	107	117
Total LW sold	236	236	242
Net cattle sales ($)	322,332	322,332	335,966
Direct costs excluding bulls ($)	53,775	95,899	52,136
Carbon offset income ($)	0	2,025	5,769
Gross margin ($)	145,589	91,490	152,988
CH4 - enteric (t CO2-e)	3165	3020	3133
N2O - total (t CO2-e)	161	161	180
Net farm emissions (t CO2-e)	3425	3280	3012
Emissn intensity (t CO2-e/t LW)	14.5	13.9	12.4

Leucaena scenario increased LW turnoff, carbon offset income and had higher gross margin

15% reduction in EI due to higher LW gain, CH_4 mitigation and soil C sequestration

	Baseline (B)	Nitrates (N)	Leuc (L)	Leuc equal emissns (LEE)
Total adult equivalents	1750	1750	1750	1843
Heifers (t LW)	7	7	7	7
Cows (t LW)	119	119	115	121
Spayed & surplus females (t LW)	0	0	0	0
Steers (t LW)	107	107	117	124
Total LW sold	236	236	242	255
Net cattle sales ($)	322,332	322,332	335,966	353,820
Direct costs excluding bulls ($)	53,775	95,899	52,136	54,907
Carbon offset income ($)	0	2,025	5,769	0
Gross margin ($)	145,589	91,490	152,988	169,799
CH4 - enteric (t CO2-e)	3165	3020	3133	3523
N2O - total (t CO2-e)	161	161	180	202
Net farm emissions (t CO2-e)	3425	3280	3012	3424
Emissn intensity (t CO2-e/t LW)	14.5	13.9	12.4	13.4

Gross margin increased further by matching baseline emissions (rather than stocking rate) despite no C mitigation income

Although the reduction in emissions intensity not as large cf. matching stocking rate

	Baseline (B)	**Nitrates** (N)	**Leuc** (L)	**Leuc equal emissns** (LEE)	**Herd optimsn** (HO)	**High fecund** (HF)
Total adult equivalents	1750	1750	1750	1843	1750	1750
Heifers (t LW)	7	7	7	7	10	6
Cows (t LW)	119	119	115	121	63	108
Spayed & surplus females (t LW)	0	0	0	0	49	0
Steers (t LW)	107	107	117	124	107	139
Total LW sold	236	236	242	255	231	256
Net cattle sales ($)	322,332	322,332	335,966	353,820	378,156	401,117
Direct costs excluding bulls ($)	53,775	95,899	52,136	54,907	56,912	56,375
Carbon offset income ($)	0	2,025	5,769	0	0	1,213
Gross margin ($)	145,589	91,490	152,988	169,799	203,785	216,013
CH4 - enteric (t CO2-e)	3165	3020	3133	3523	3168	3079
N2O - total (t CO2-e)	161	161	180	202	162	160
Net farm emissions (t CO2-e)	3425	3280	3012	3424	3429	3338
Emissn intensity (t CO2-e/t LW)	14.5	13.9	12.4	13.4	14.8	13.1

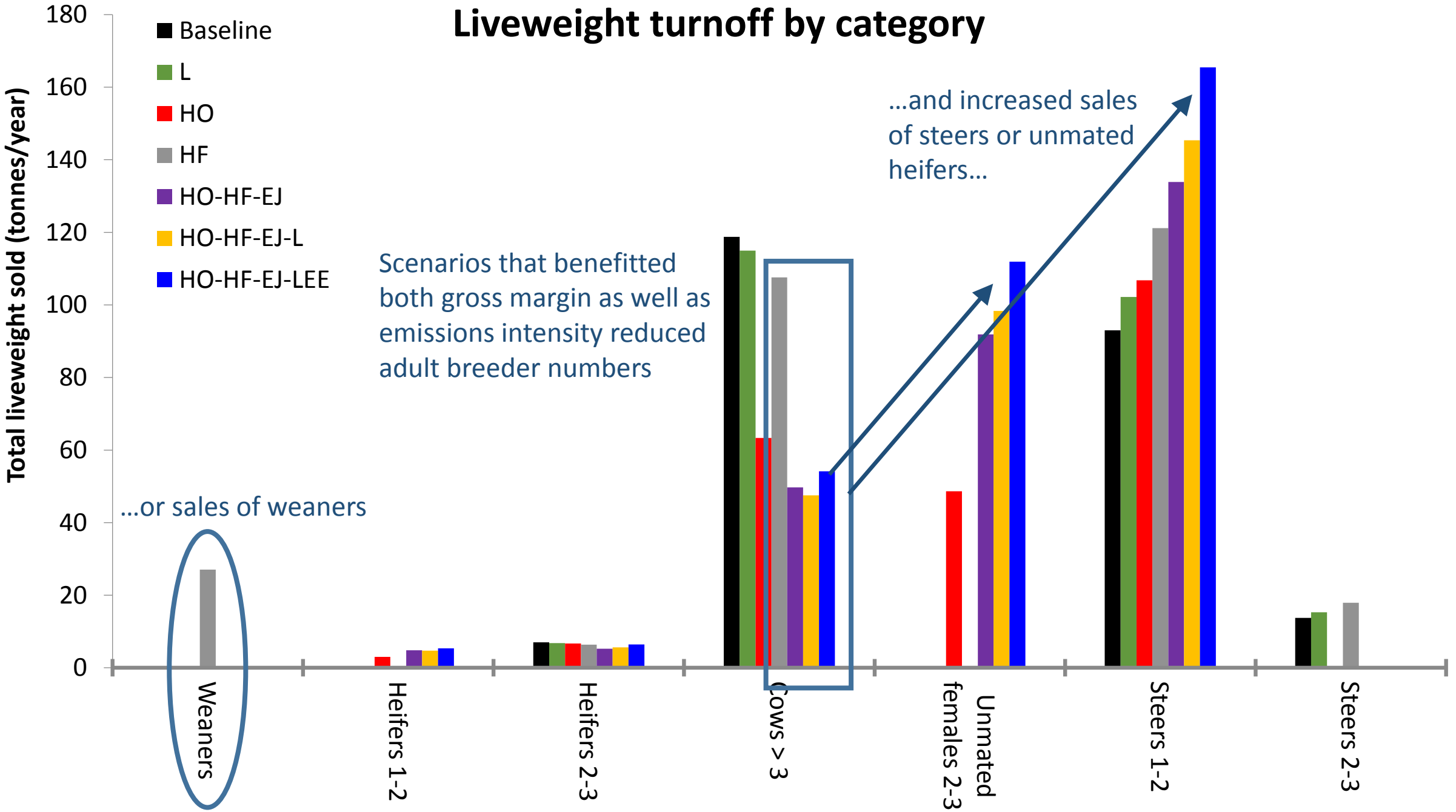
Both herd optimisation and higher weaning rates may increase gross margin…

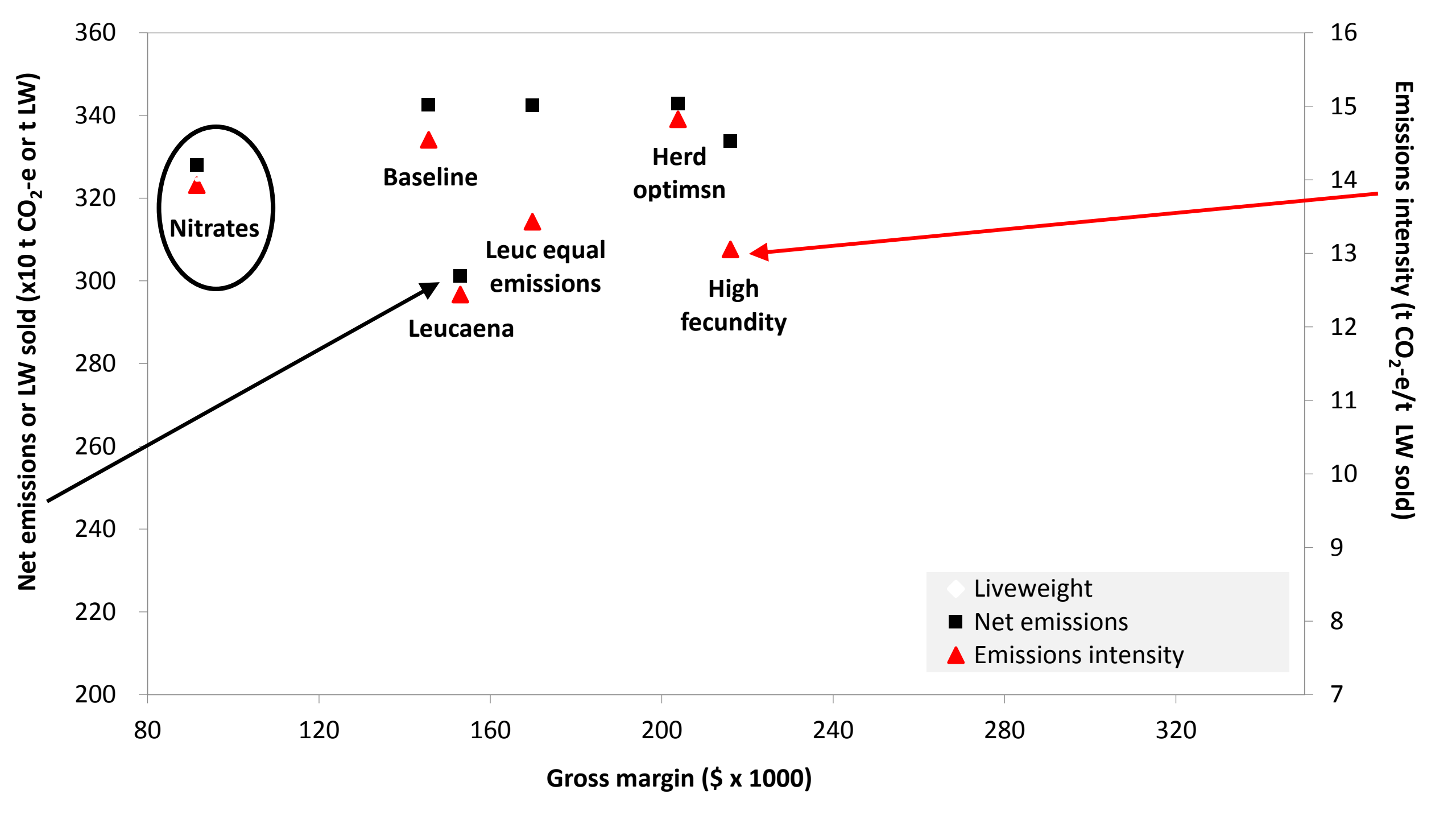
… but HO might not necessarily reduce emissions intensity

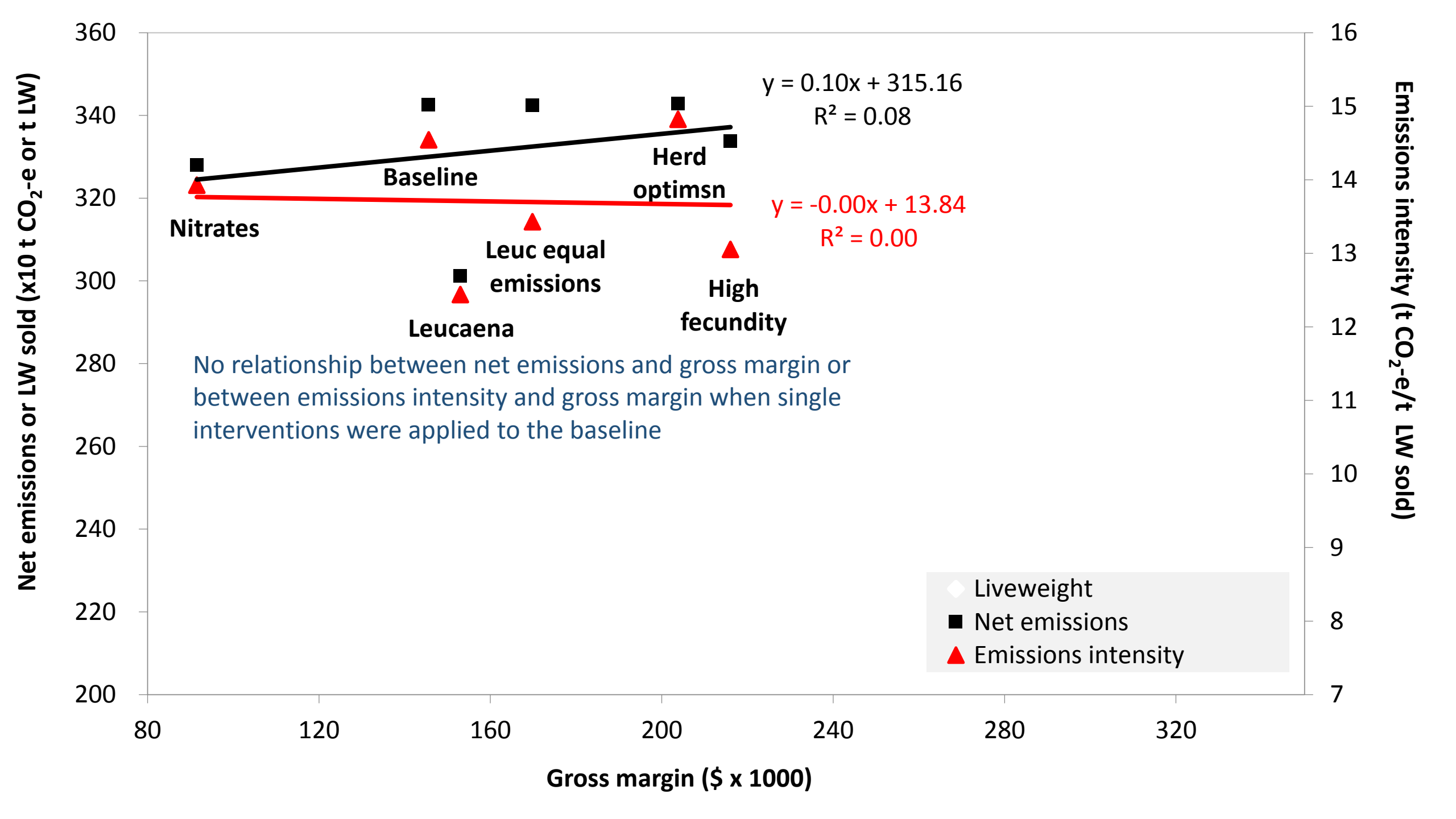
	Baseline (B)	**Nitrates** (N)	**Leuc** (L)	**Leuc equal emissns** (LEE)	**Herd optimsn** (HO)	**High fecund** (HF)	**HO, HF, early join** (HO, HF, EJ)	**HO, HF, EJ, leucaena** (HO, HF, EJ, L)	**HO, HF, EJ, leuc equal emissions** (HO, HF, EJ, LEE)
Total adult equivalents	1750	1750	1750	1843	1750	1750	1750	1750	1992
Heifers (t LW)	7	7	7	7	10	6	10	10	12
Cows (t LW)	119	119	115	121	63	108	50	48	54
Spayed & surplus females (t LW)	0	0	0	0	49	0	92	98	112
Steers (t LW)	107	107	117	124	107	139	134	145	165
Total LW sold	236	236	242	255	231	256	288	304	346
Net cattle sales ($)	322,332	322,332	335,966	353,820	378,156	401,117	510,844	450,605	512,917
Direct costs excluding bulls ($)	53,775	95,899	52,136	54,907	56,912	56,375	62,757	61,300	69,776
Carbon offset income ($)	0	2,025	5,769	0	0	1,213	975	6,334	0
Gross margin ($)	145,589	[illegible]	[illegible]	[illegible]	[illegible]	216,013	322,905	268,837	314,755
CH4 - enteric (t CO2-e)	3165					3079	3093	3036	3456
N2O - total (t CO2-e)	161					160	163		
Net farm emissions (t CO2-e)	3425					3338	3355	[illegible]	[illegible]
Emissn intensity (t CO2-e/t LW)	14.5	13.9	12.4	13.4	14.8	13.1	11.6	9.8	9.9

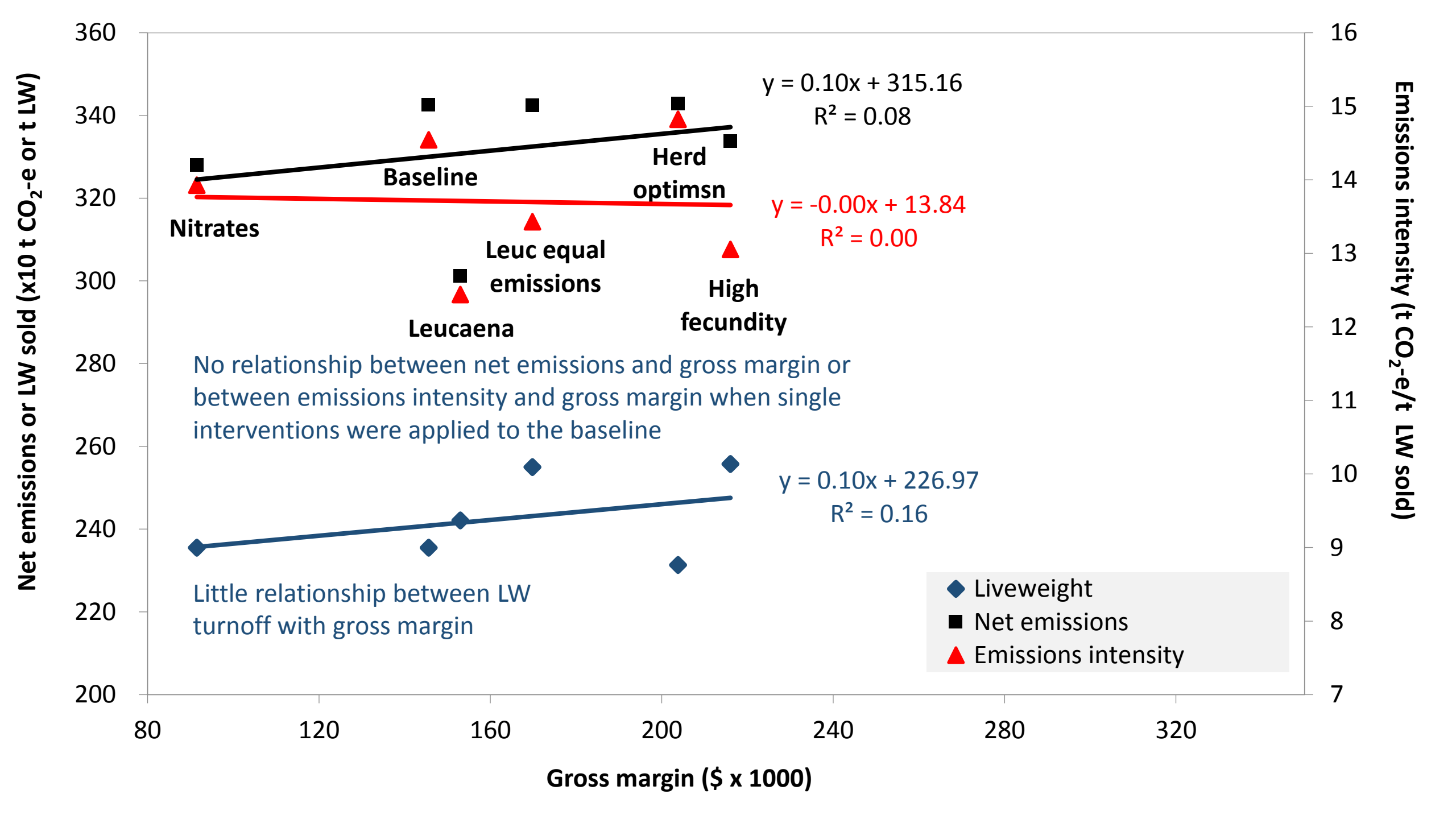
Combining several beneficial interventions can further increase gross margins and reduce emissions intensities

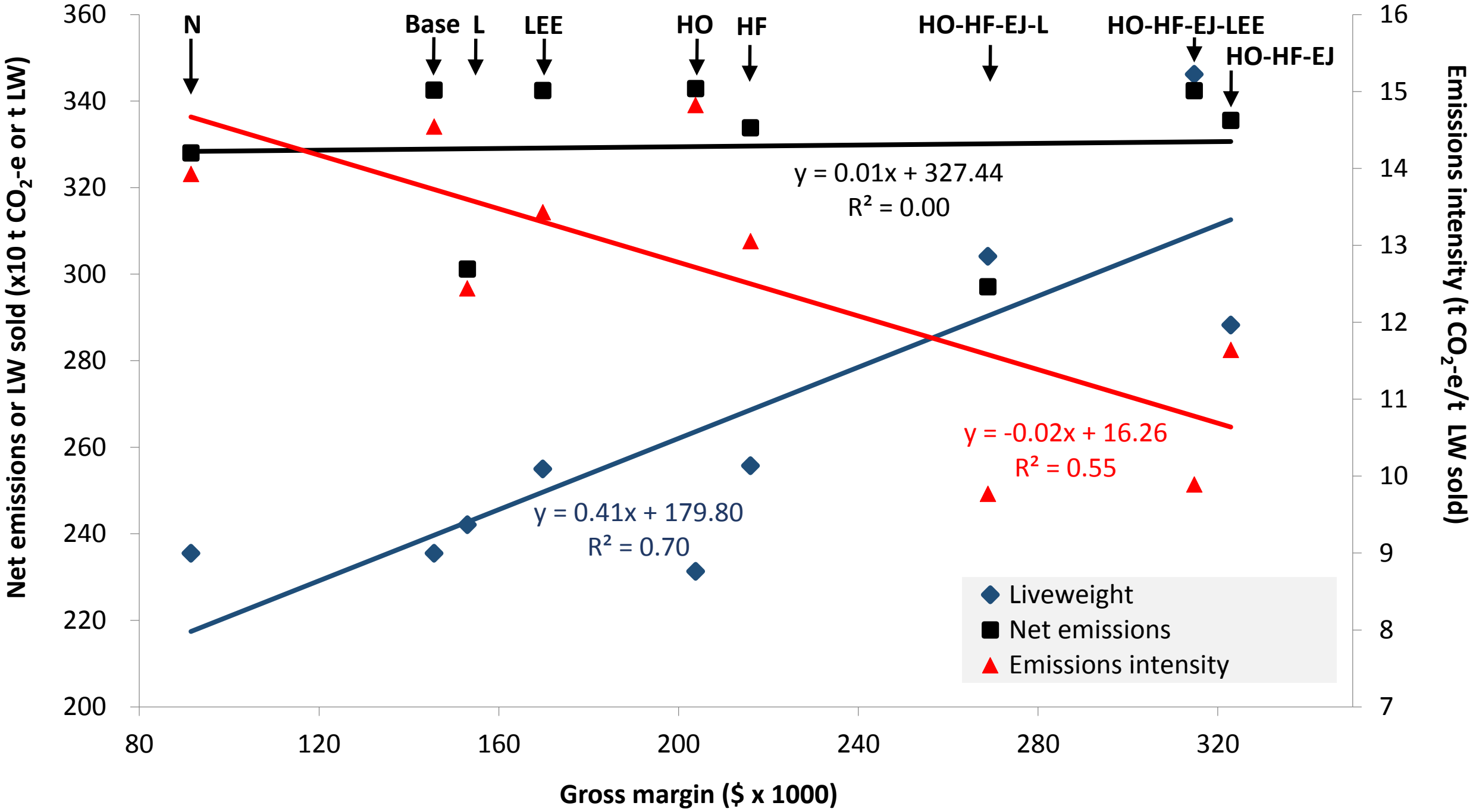
> 30% reduction in emissions intensity


Liveweight turnoff by category
Total liveweight sold (tonnes/year)
180
160
140
120
100
80
60
40
20
0
Baseline
L
HO
HF
HO-HF-EJ
HO-HF-EJ-L
HO-HF-EJ-LEE
…or sales of weaners
Scenarios that benefitted both gross margin as well as emissions intensity reduced adult breeder numbers
…and increased sales of steers or unmated heifers…
Weaners
Heifers 1-2
Heifers 2-3
Cows > 3
Unmated females 2-3
Steers 1-2
Steers 2-3


Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
260
240
220
200
16
15
14
13
12
11
10
9
8
7
80
120
160
200
240
280
320
Nitrates
Baseline
Herd optimsn
Leuc equal emissions
Leucaena
High fecundity
Liveweight
Net emissions
Emissions intensity


Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
260
240
220
200
16
15
14
13
12
11
10
9
8
7
80
120
160
200
240
280
320
y = 0.10x + 315.16
R² = 0.08
y = -0.00x + 13.84
R² = 0.00
Baseline
Herd optimsn
Nitrates
Leuc equal emissions
Leucaena
High fecundity
No relationship between net emissions and gross margin or between emissions intensity and gross margin when single interventions were applied to the baseline
Liveweight
Net emissions
Emissions intensity


Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
260
240
220
200
16
15
14
13
12
11
10
9
8
7
80
120
160
200
240
280
320
y = 0.10x + 315.16
R² = 0.08
y = -0.00x + 13.84
R² = 0.00
y = 0.10x + 226.97
R² = 0.16
Baseline
Herd optimsn
Nitrates
Leuc equal emissions
Leucaena
High fecundity
No relationship between net emissions and gross margin or between emissions intensity and gross margin when single interventions were applied to the baseline
Little relationship between LW turnoff with gross margin
Liveweight
Net emissions
Emissions intensity


N
Base
L
LEE
HO
HF
HO-HF-EJ-L
HO-HF-EJ-LEE
HO-HF-EJ
y = 0.01x + 327.44
R² = 0.00
y = 0.41x + 179.80
R² = 0.70
y = -0.02x + 16.26
R² = 0.55
Liveweight
Net emissions
Emissions intensity
Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
260
240
220
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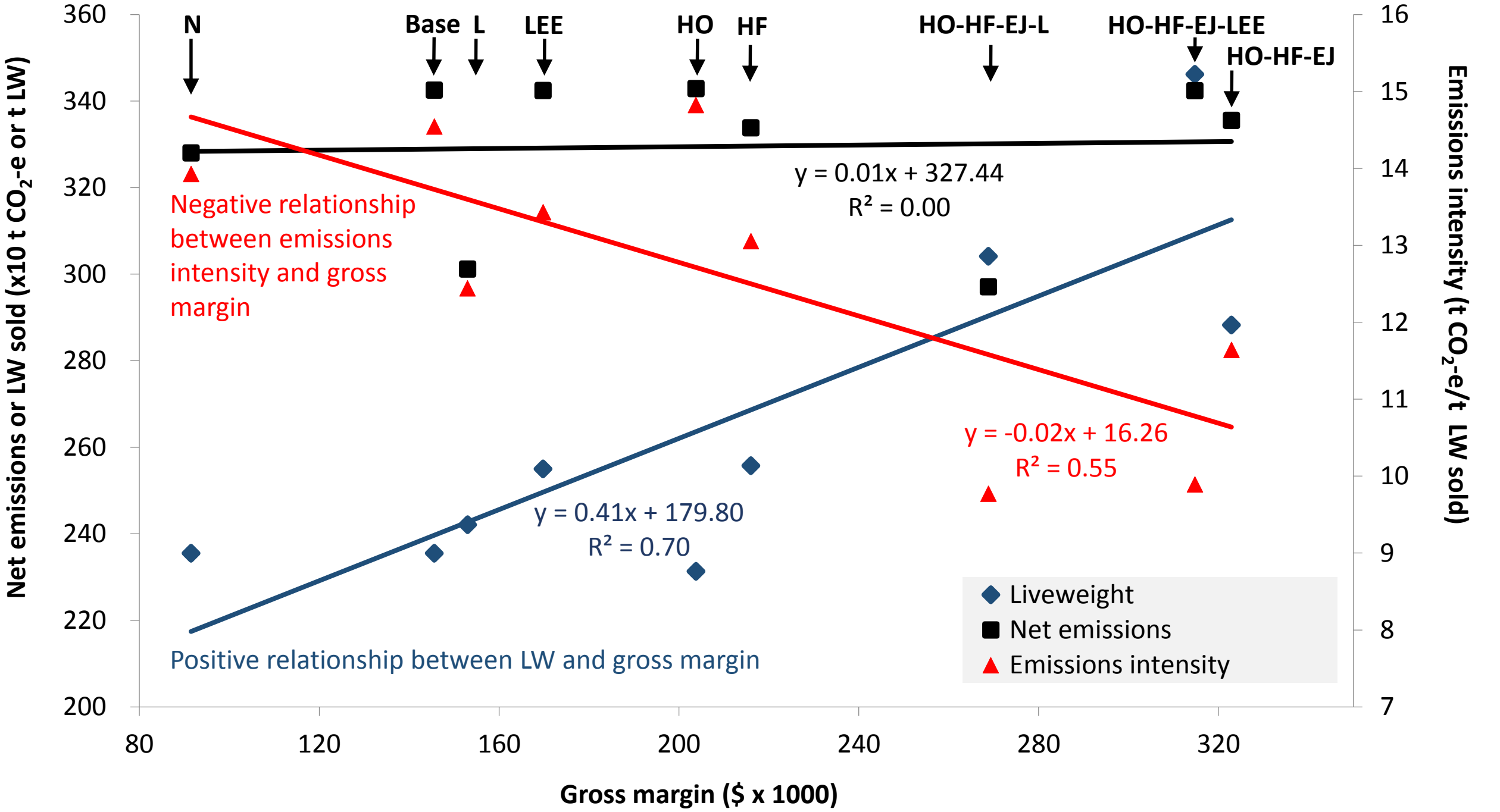
320


N
Base
L
LEE
HO
HF
HO-HF-EJ-L
HO-HF-EJ-LEE
HO-HF-EJ
y = 0.01x + 327.44
R² = 0.00
Negative relationship between emissions intensity and gross margin
y = -0.02x + 16.26
R² = 0.55
y = 0.41x + 179.80
R² = 0.70
Positive relationship between LW and gross margin
Liveweight
Net emissions
Emissions intensity
Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
260
240
220
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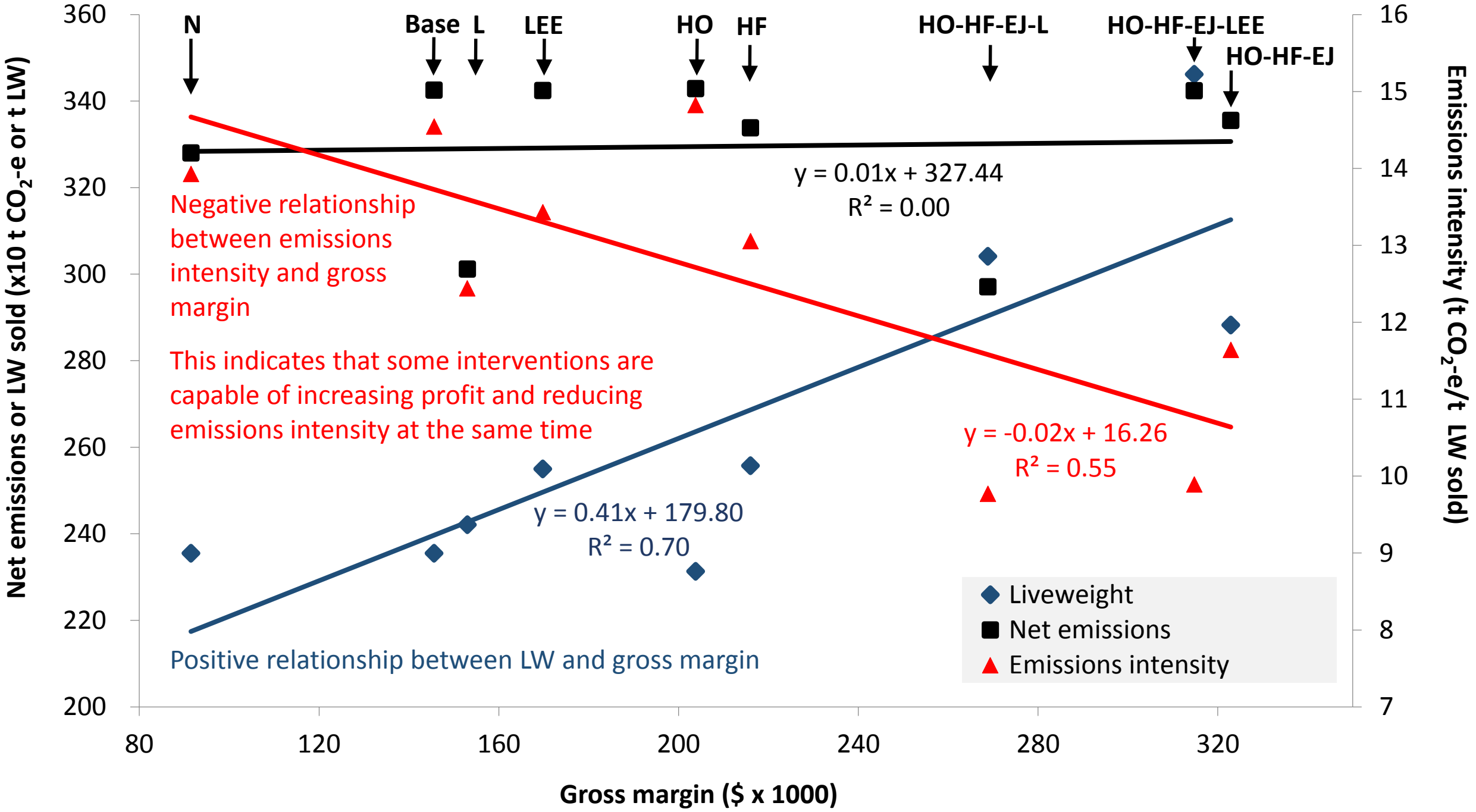
N
Base
L
LEE
HO
HF
HO-HF-EJ-L
HO-HF-EJ-LEE
HO-HF-EJ
y = 0.01x + 327.44
R² = 0.00
Negative relationship between emissions intensity and gross margin
This indicates that some interventions are capable of increasing profit and reducing emissions intensity at the same time
y = -0.02x + 16.26
R² = 0.55
y = 0.41x + 179.80
R² = 0.70
Positive relationship between LW and gross margin
Liveweight
Net emissions
Emissions intensity
Net emissions or LW sold (x10 t CO2-e or t LW)
Emissions intensity (t CO2-e/t LW sold)
Gross margin ($ x 1000)
360
340
320
300
280
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240
280
320

Key findings in summary

- **Carbon-offset income is generally small compared with income derived from profitable increases in LW production** (e.g. Leucaena cf. Leucaena Equal Emissions). This is because 1 kg of beef production is worth > 100 times more that 1 kg of CO_2 mitigation income.

- **Adopting forages that are capable of enhancing LW gain, mitigating CH_4 emissions and increasing soil C sequestration can achieve significant reductions in emissions intensity** (15% reduction in Leucaena scenario)

- **The strong association between emissions and LW production can be broken by increasing the number of animals sold relative to adult animals retained on farm** (e.g. by increasing weaning rates – HF scenario)

- **Combining several compatible scenarios delivers gains over and above single interventions** because each intervention acts on different factors in the system, e.g. HO-HF-EJ-L (leucaena and weaning rates reduced emissions intensity, and herd optimisation increased gross margins)

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