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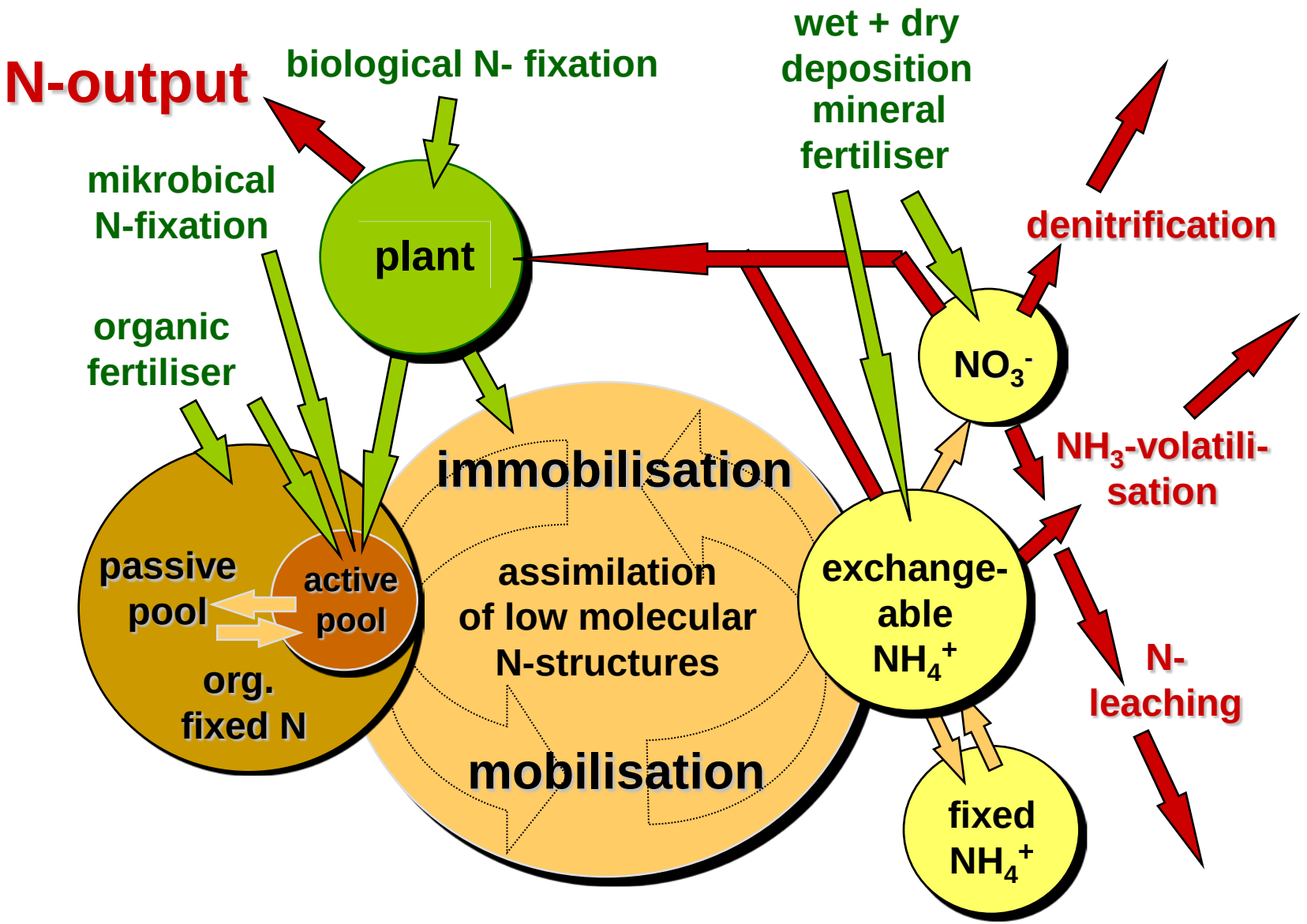
Nutrient Fluxes on Austrian Grassland and Dairy Farms

Grassland lecture II
May 2013

N-cycle in agricultural systems

(S.L. JANSSON in NIELSEN and MacDONALD, 1978)



Nutrient balances – balance models

- description of nutrients/energy-fluxes in different environments (agriculture, industry, trade …)
- measurement/prediction of as many components as possible
- calculation of input and output components for a defined period

→ nutrient balances from a regional/national to a holistic/global scale

agriculture:

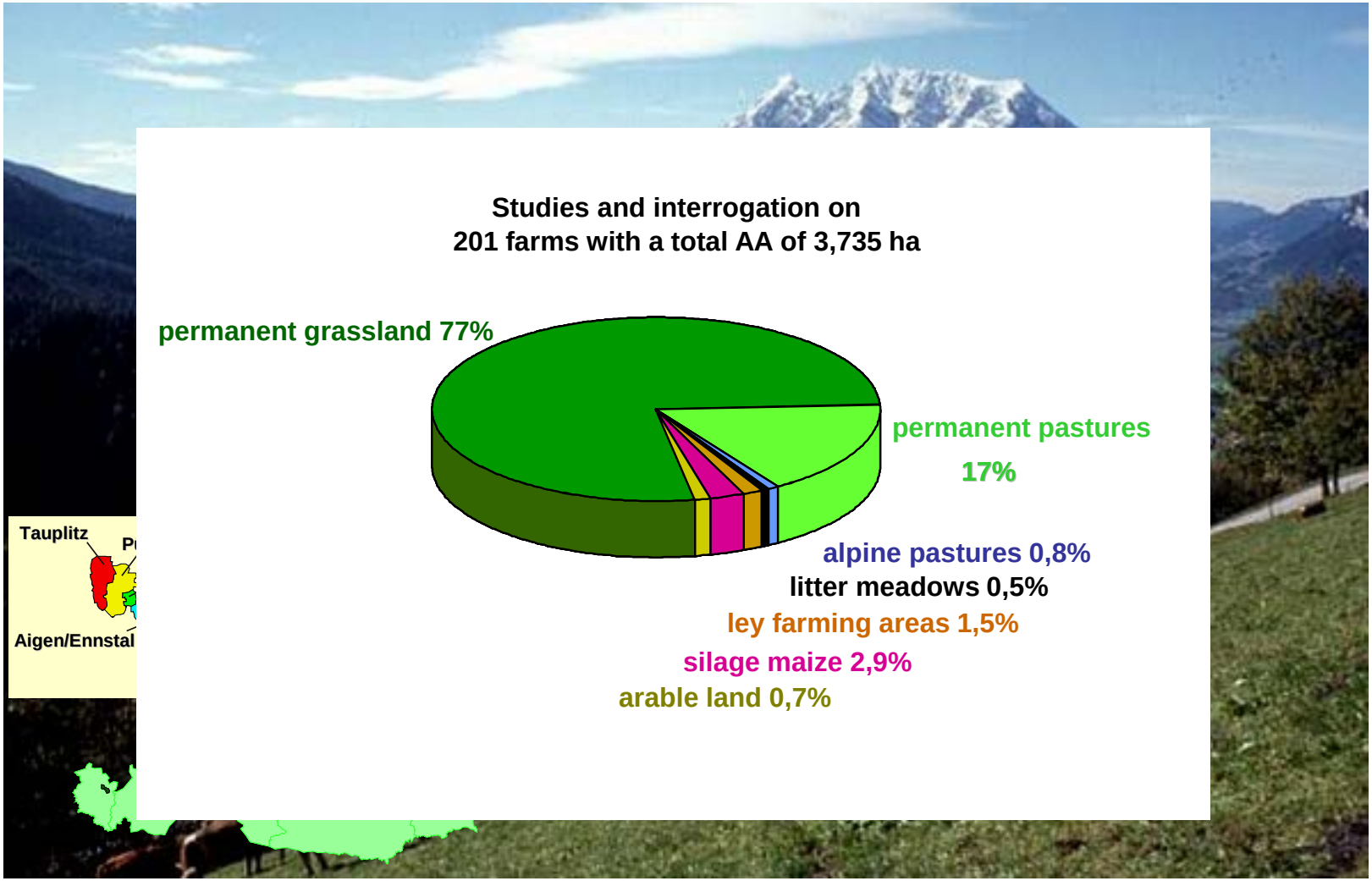
→
- farm gate-balance
- area specific-balance

Farm gate balance - design (for nitrogen)

Input components	Output components
mineral fertiliser	animal and plant products
feedstuff	
livestock	organic fertiliser
external organic fertiliser	
biological N-fixation	unavoidable N-losses
N- deposition (wet and dry)	

balance +/-

Man And Biosphere-project in the test region “Ennstal”



Studies and interrogation on
201 farms with a total AA of 3,735 ha

permanent grassland 77%

permanent pastures 17%

alpine pastures 0,8%

litter meadows 0,5%

ley farming areas 1,5%

silage maize 2,9%

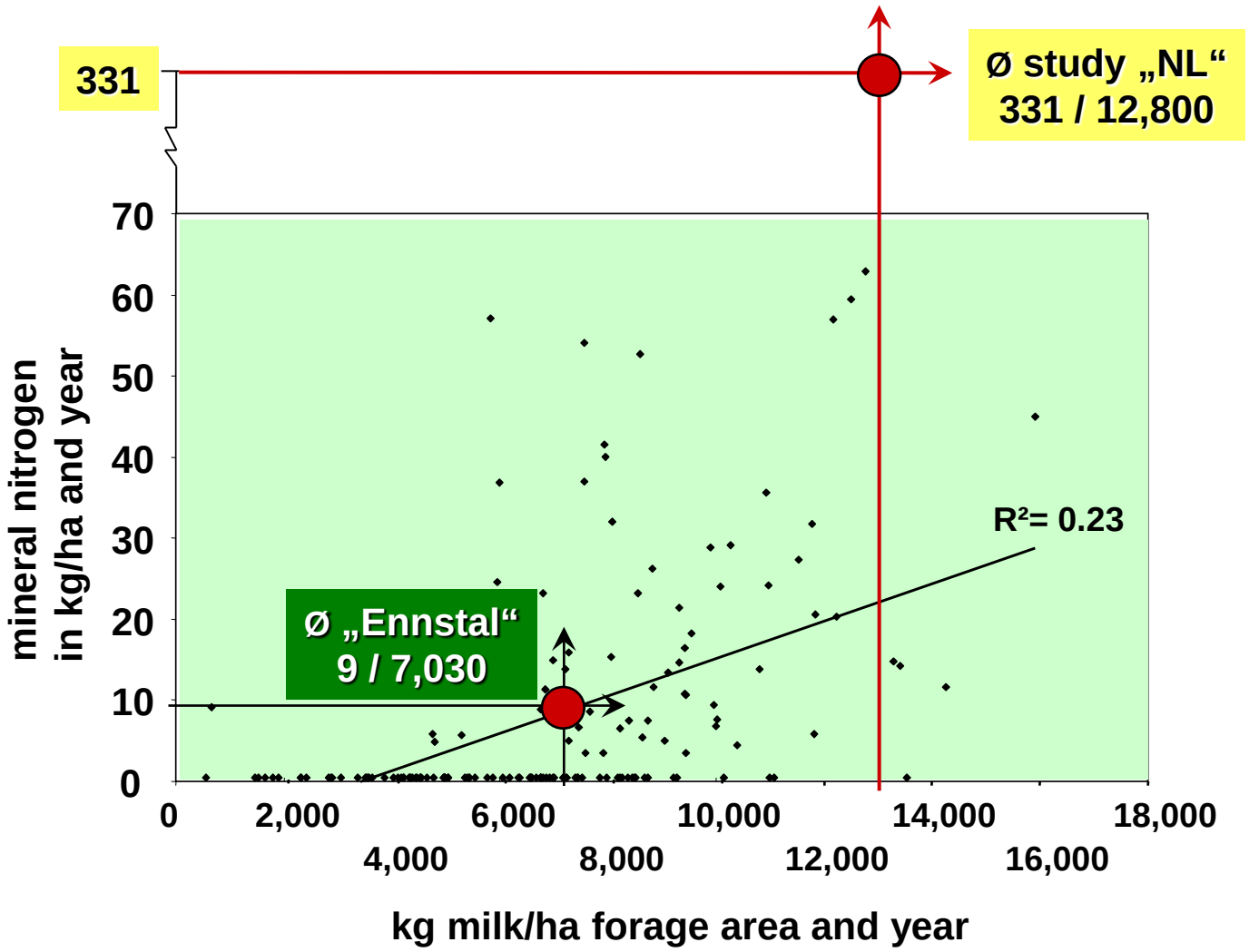
arable land 0,7%

N- regional balance in the Ennsvalley (data in kg N year^{-1})

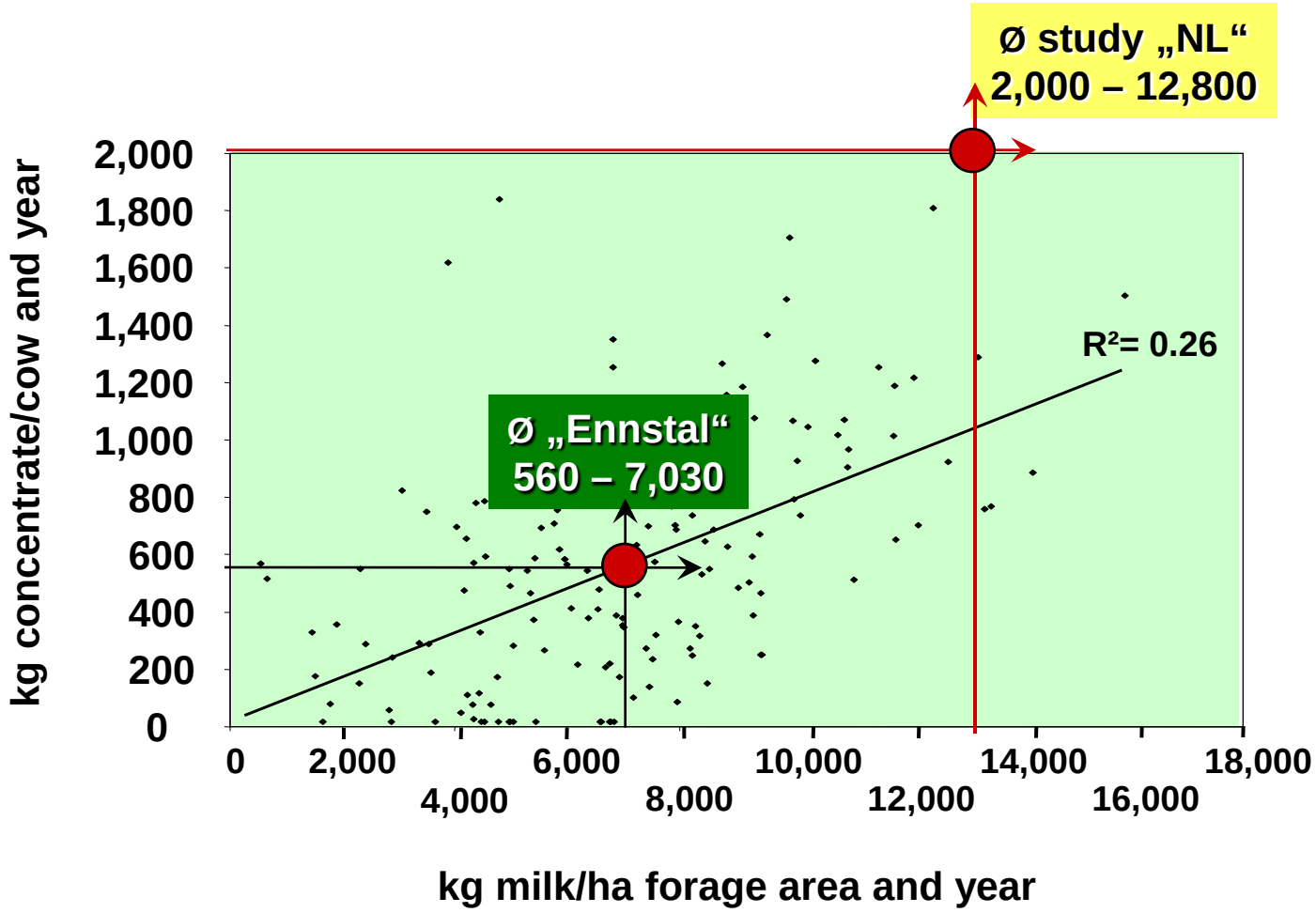
Input components		Output components	
mineral fertiliser	35,060	29,200	livestock
bedding material	4,560	52,500	milk
concentrates	42,370	2,870	plant products
other feedstuff	6,300	85,000	unavoidable N-losses
livestock	2,670		
biological N-fixation	142,000		
N - deposition	37,400		
sum of inputs	270,360	169,570	sum of outputs

⇨ balance: + 100,790 kg N

Use of mineral nitrogen fertiliser on farms in the test region “Ennsvalley”



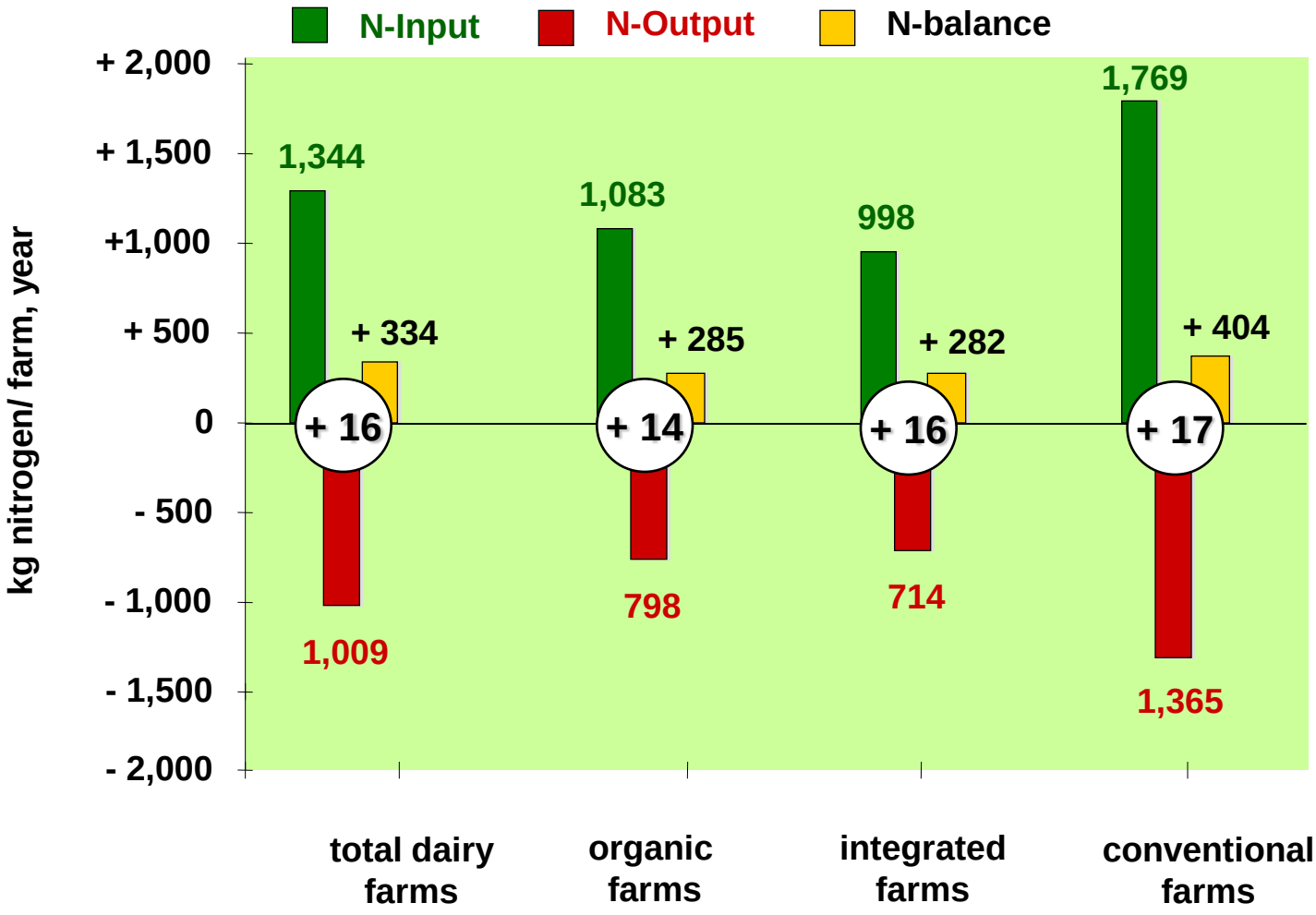
Use of concentrates
on farms in the test region “Ennsvalley”



Dairy farms (n = 157) in the test region “Ennsvalley” – structure and balance data

	organic farms (n = 40)	integrated farms (n = 51)	conventional farms (n = 66)
kg min.N / ha and year	0	0	20
kg concentrate / cow and year	276	437	806
kg milk / ha forage area	5,801	5,583	8,883
kg milk / cow	4,710	4,650	6,095
LU / ha AA	1.14	1.12	1.73

Farm gate nitrogen-balance for dairy farms in the test region “Ennsvalley”



source: POETSCH, 2002

N-balance results on dairy farms in Europe (based on field studies)

kg N ha^{-1} $year^{-1}$	A	NL 1	NL 2	CH	DK 1	DK 2	G 1	G 2
Nitrogen Inputs	64	486	226	152	287	156	252	144
Nitrogen Outputs	24	78	74	43	47	32	53	34
Nitrogen surplus	40	407	153	109	240	124	199	110
Nitrogen surplus (g kg^{-1} milk)	6	34	13	15	-	-	25	22
N output/ N input (%)	38	16	32	28	16	21	21	24

source: TAUBE and POETSCH, 2001

N-farm gate balance results on dairy farms in Austria

test region	n	Ø	s	min.	max.
Ennstal	78	+7.2	23.4	-47.6	**+84.3**
Pongau	25	+6.9	13.0	-23.7	+43.7
Kitzbühel	29	+6.0	17.7	-29.1	+37.8
Oberkärnten	19	-7.4	20.0	**-51.4**	+41.7
Hallein	16	+9.6	26.3	-21.0	+80.5

altitude	n	Ø	s	min.	max.
< 500m	6	+17.0	18.5	-7.4	+43.2
500 – 750m	65	+5.9	26.9	**-51.4**	+80.5
750 – 1.100m	83	+5.4	17.8	-23.7	**+84.3**
> 1.100m	13	-0.4	9.1	-16.6	+13.9

management system	n	Ø	s	min.	max.
conventional	86	+9.3	25.3	**-51.4**	**+84.3**
organic	81	+1.6	15.7	-47.6	+43.7

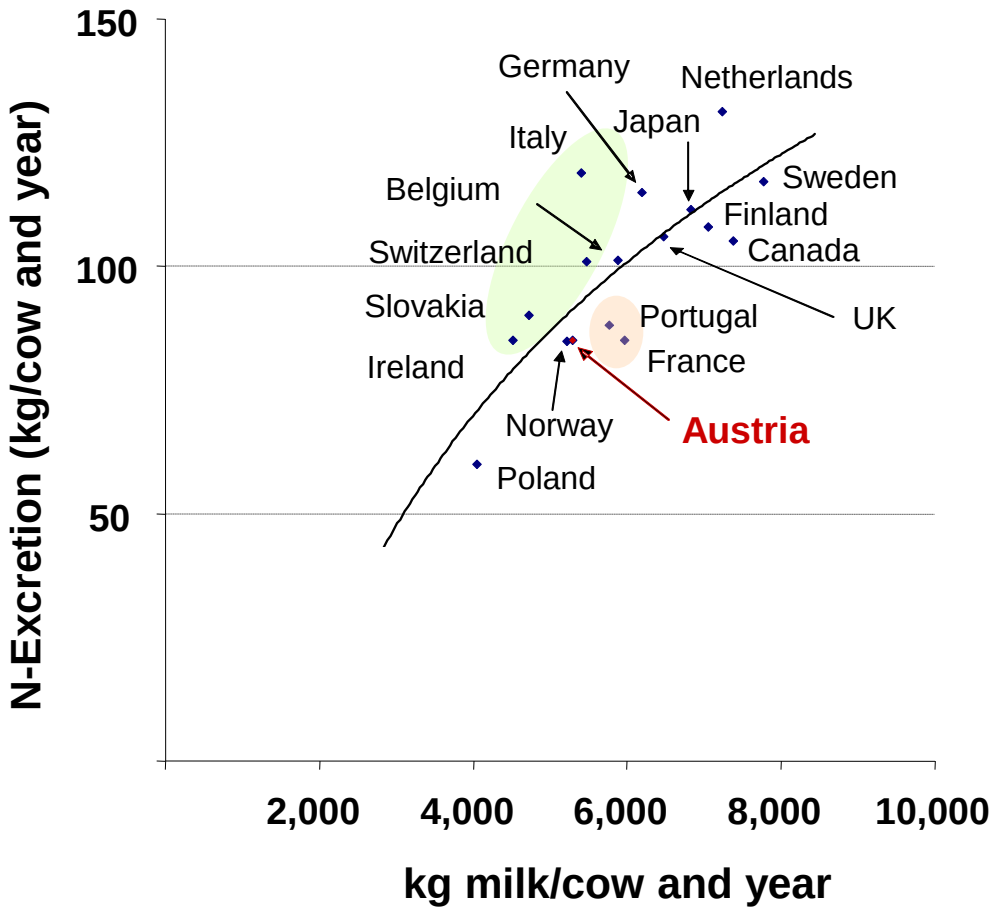
source: POETSCH and RESCH, 2005

Area specific balance - design (for nitrogen)

Input components	Output components
mineral fertiliser	crude protein yield (harvest)
organic fertiliser - manure	denitrification losses
biological N-fixation	NH_3-losses
N- deposition (wet and dry)	leaching losses

balance +/-

N-Excretion of dairy cows in Europe



source: FUNAKI und PARRIS, 2005

N- excretion of dairy cows

Calculation schemes:

- **table values** (Richtlinien für die sachgerechte Düngung, 1999 resp. 2006)
- **regression models based on balance experiments** (KIRCHGESSNER u.a., 1991; WINDISCH u.a., 1991; GRUBER et al., 2000)
- **calculation scheme** (LIVESTOCK MANURES, 1999):

$N_{feeding\ stuff}$ (= dry matter intake x $N_{content\ of\ feeding\ stuff}$)

\- $N_{animal\ products}$ (= milk x $N_{content}$ + gain x $N_{content}$)

\- N_{losses} ((= N_{feed} - $N_{animal\ products}$) x coefficient)

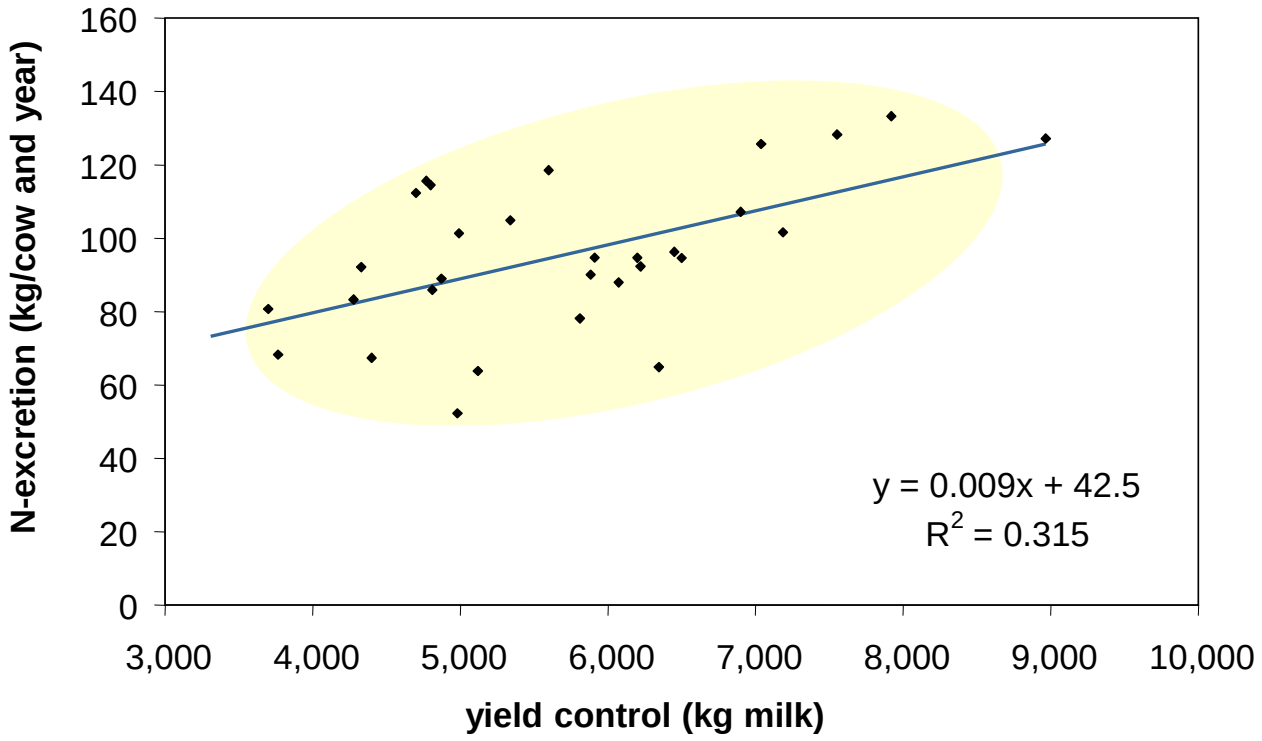
= N_{manure}

source: EUROPEAN COMMISSION, 1999

Calculation of N- excretion for dairy cows

- **regression equation:**

  - field study on practice farms (organic & conventional)
  - recordings of feed intake and milk yield
  - milk yield in the range of 3,700 bis 9,000 kg/cow and year



source: STEINWIDDER und GUGGENBERGER, 2003

N-excretion (gross) of dairy cows:
demand based feeding vs. practice feeding

	N-excretion (kg N_{gross}/cow and year)	
[1]milk yield per lactation	demand based feeding	practice feeding[2] (= actual values)
3,000 kg	80.8	69.5
4,000 kg	80.8	78.5
5,000 kg	83.6	87.5
6,000 kg	88.8	96.5
7,000 kg	95.2	105.5
8,000 kg	100.7	114.5
9,000 kg	107.6	123.5
10,000 kg	114.3	132.5

[1] up to a milk yield level of 6,000 kg calculations are based on Simmenthal (Ø live weight 700 kg) and above that level on Holstein-Friesian (Ø live weight 640 kg)

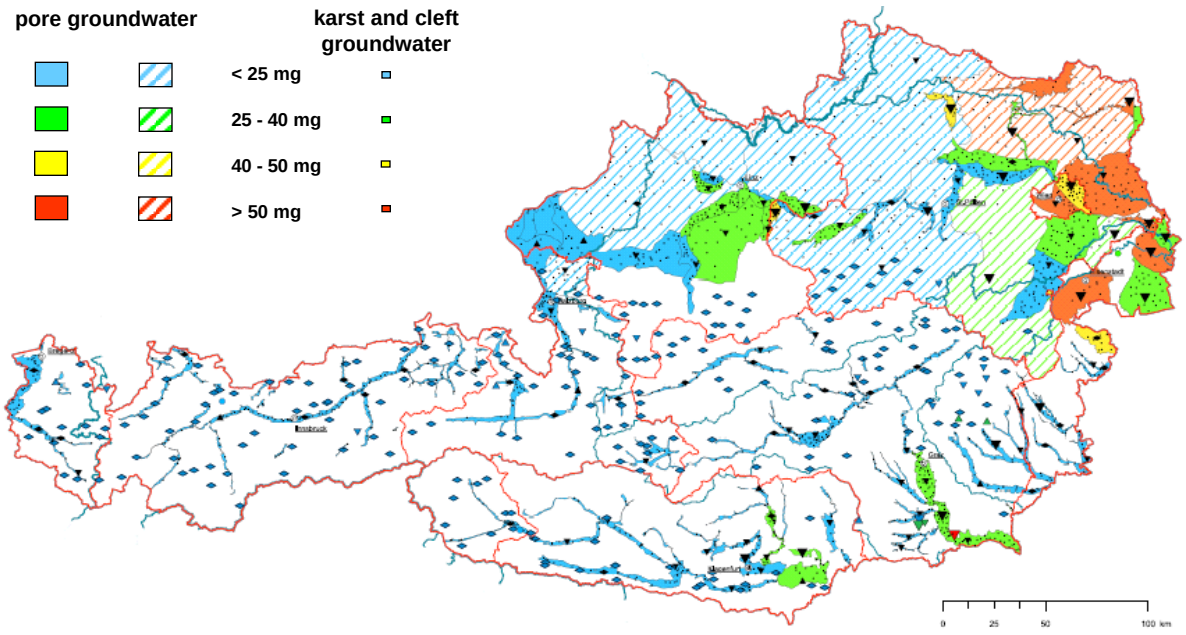
[2] calculations were set up on the basis of the actual and approved values – the gross N-excretion value is reduced by 15% of unavoidable losses in the stable house and storage

sources: STEINWIDDER and GUGGENBERGER, 2003; GRUBER and PÖTSCH, 2005; PÖTSCH, 2006

Guidelines for an appropriated fertilisation (6th edition, 2006)

Action program “Nitrate” (according 91/676 EWG – European nitrate directive)

- **area-wide program (without declaring vulnerable zones):** **Germany, Netherlands, Finland, Luxembourg, Denmark, Austria*, Ireland**



nitrate content in groundwater (Investigation period 1999-2003)

Action program “Nitrate” (according 91/676 EWG – European nitrate directive)

- **Seasonal restrictions for the application of N-containing fertilisers (arable and grassland, no regional differentiation – exceptions are possible!)**
- **Limitation for N-containing fertilisers if there is a risk for surface run-off (> 10% slope, special regulation for small sized fields in the mountainous region)**
- **Forbiddance of any N-fertilisation on frozen, afloated/water-saturated and snow covered soils**
- **Minimum distances to surface waters of 3-20 m**
- **Special regulations for out of farm-storage of solid manure**
- **Minimum storage capacity for farm manure – 6 months!**
- **Special demands for the application of fertilisers (dosage, distribution quality, soil pressure ...)**


BAUER

N-limitation for farm manure

maximum allowed N-amount from farm manure:

170 kg N/ha and year
(gross N excretion – 15% unavoidable losses)

special regulations/exceptions are possible on the basis of objective criteria:
long vegetation period, N-wasting crop rotations,
high precipitation rate, strong denitrification …

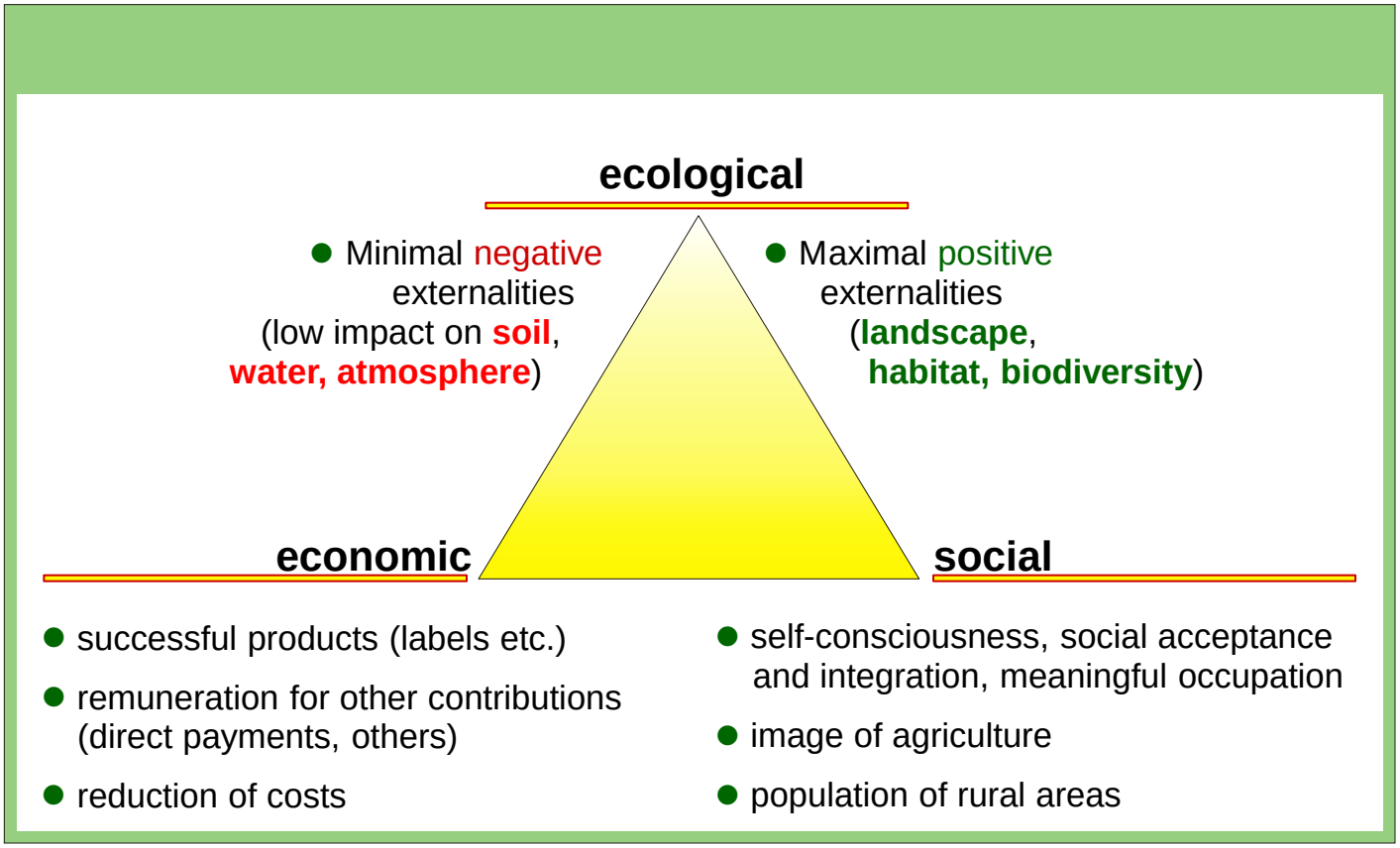
~~**Austrian exception application for**~~
~~**230 kg N/ha has passed the EC**~~

Conclusions for improving the nutrient management and for reducing/avoiding nutrient losses in agriculture

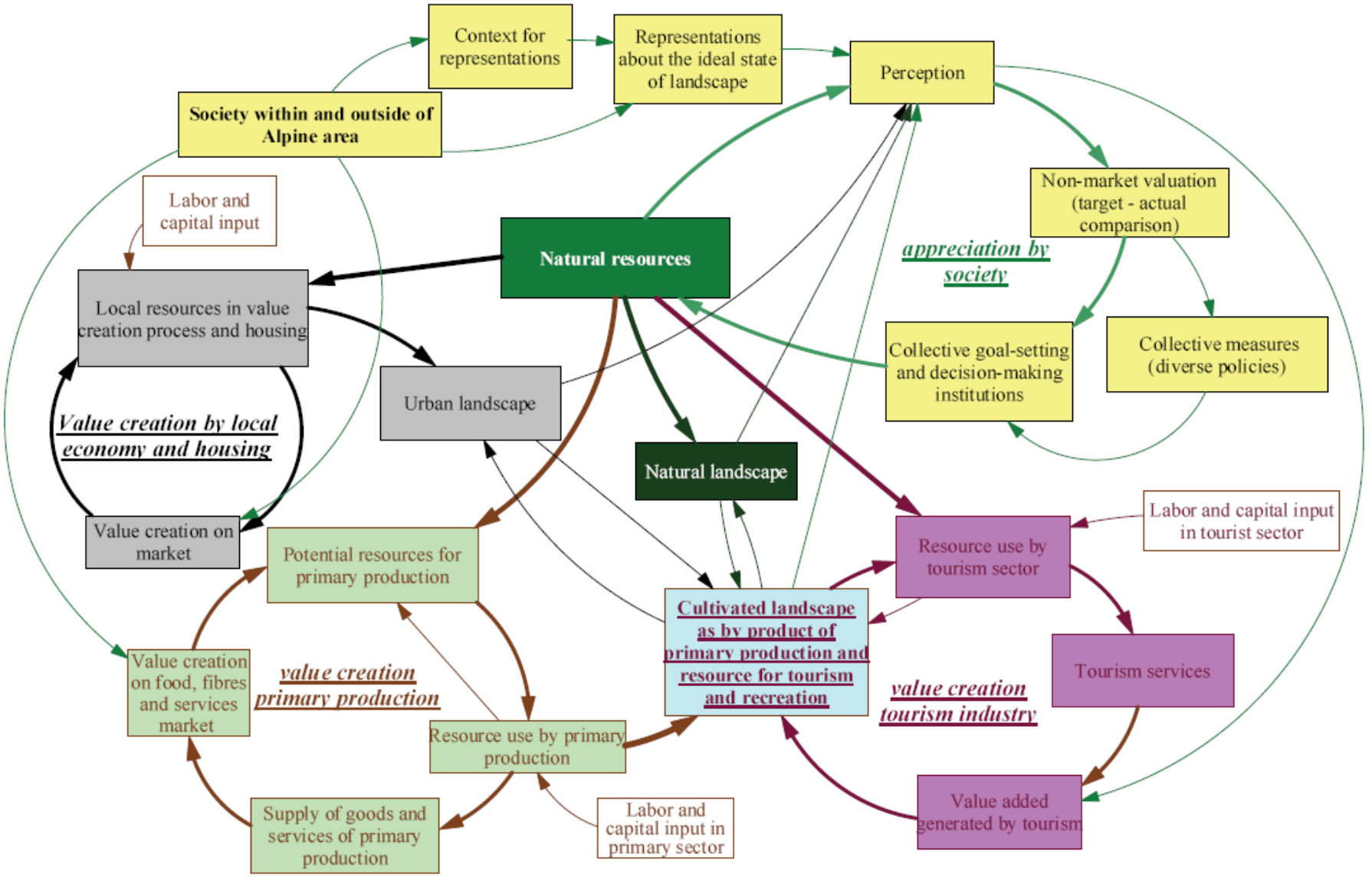
- **Reduction** of farm external inputs – mineral fertiliser, concentrates
- **Consideration** of the natural and local productivity = **site adapted management**
- **Improvement** of forage quality with an efficient use of legumes
- **Demand orientated** feeding strategy

- **Environmental** friendly use of farm manure:
  application within the vegetation period, splitting amounts, consideration of weather conditions to reduce NH_3 losses (low temperatures, windless!, water dilution of slurry ...)
- **Farm internal** nutrient management – yield based distribution
- **Assessment** of nutrient balances as a control mechanism

Low Input Farming Systems & Sustainability



Multi-functionality of grassland management (source: Lehmann, 2009)




thank you
& good luck