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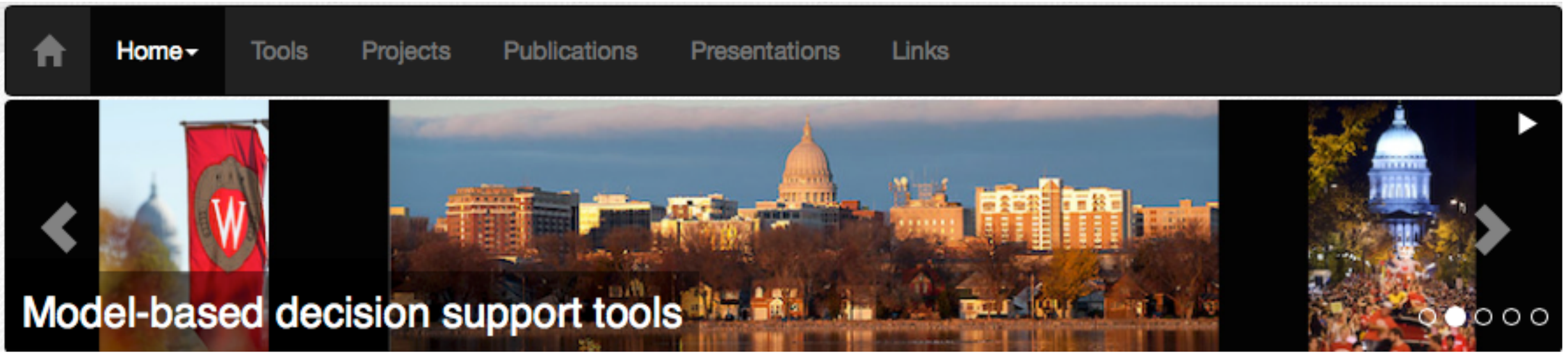

Economics of production efficiency: Nutritional grouping

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Outline and take-home messages

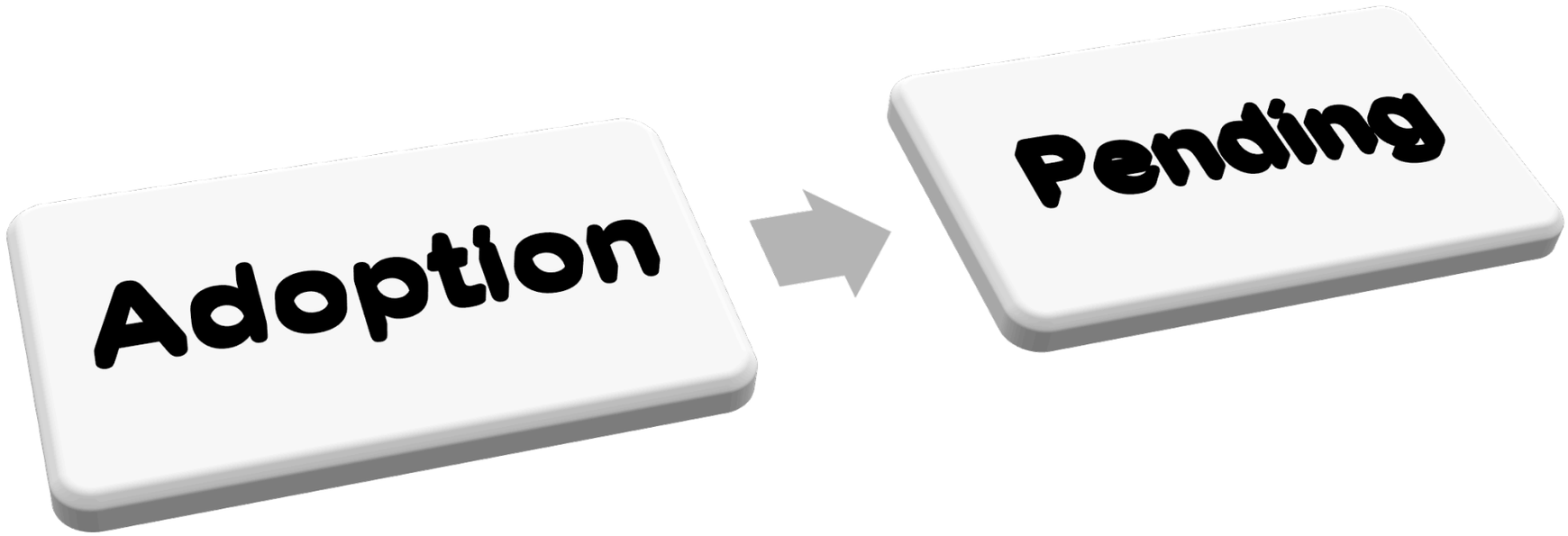
1. Multiple nutritional groups of lactating cows improves economic efficiency
2. Nutritional grouping is not widely adopted in the dairy industry
3. Greater adoption is expected when:
    a. Implementing optimal grouping strategies according to individual requirements
    b. Providing more precise diets founded on group nutrient requirements
    c. Additional positive effects of improved health and environmental benefits are included
    d. Only plausible possible deleterious effects of milk losses and additional costs are factored

Introduction

- Multiple diets is not a new concept
  - Smith and Coppock, 1974; Smith et al., 1978; McGilliard et al., 1983
- More homogeneous diets: less feed waste and costs, greater productivity and profitability
  - VandeHaar, 2011
- Nutritional grouping: better conditioning and health
  - Allen, 2009
- Grouping: less variation within a group and competition at the feed bunk
  - Grant and Albright, 2000
- Single TMR: not optimal allocation of ingredients, nutrients or additives
  - VandeHaar, 2011

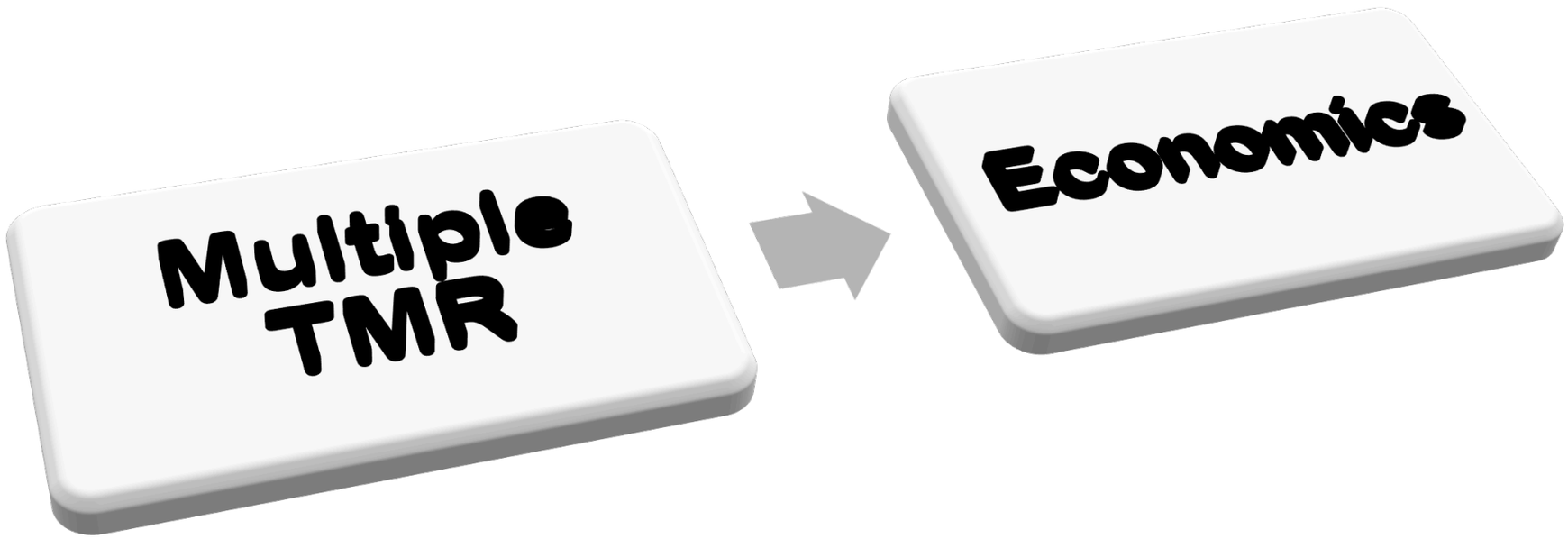
Introduction

- Although it is clearly established that different diets are warranted for dry and early postpartum cows
  - Grant and Albright, 2000
- There is not wide adoption of multiple-TMR for lactating cows
  - Jordan and Fourdraine, 1993; Jonker et al, 2002; Contreras-Govea et al., 2015



Objective

- Review and discuss the complexities of multiple-TMR feeding lactating cows with a focus on dairy farm economic efficiency



Economics of nutritional grouping

	T[1]	G[2]	Difference in income over feed cost ($/cow per yr)		
			3TMR[3] - 1TMR	3TMR - 2TMR	2TMR - 1TMR
Smith et al., 1978	F	DIM			+30
Cassel et al., 1984	F	DIM			-117[4]
Williams and Oltenacu, 1992	S	C		+31	
Østergaard et al., 1996	S	DIM/M	3TMR > 2TMR > 1TMR net revenue[5]		
St-Pierre and Thraen, 1999	S	C		+33	+44
Earleywine, 2001	S	DIM	+44		+38
Cabrera et al., 2012	S	NE_L	+396		
Cabrera and Kalantari, 2014	S	NE_L	+46	+25	+21
Kalantari et al., unpublished[6]	S	C	+46	+8	+39

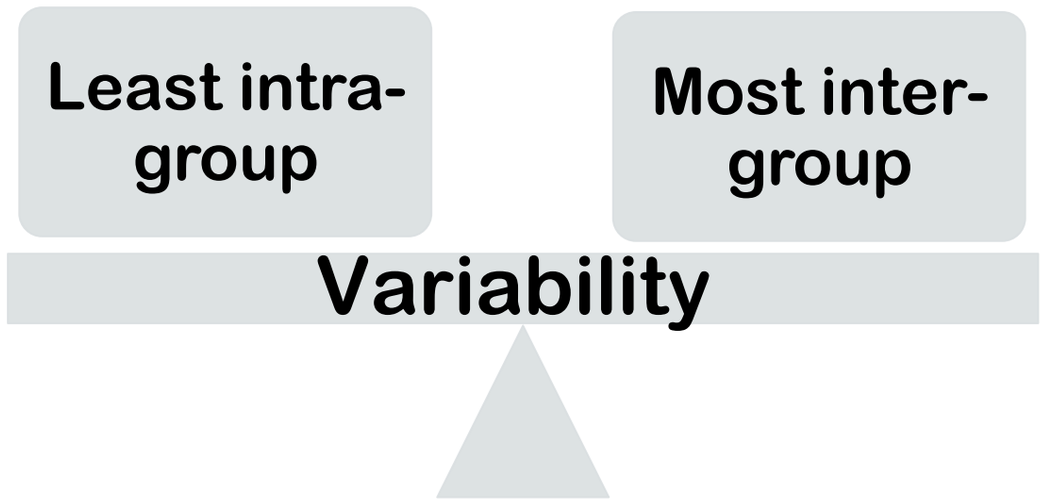
[1]T=Type of study: F=field trial, S=simulation; [2]G=grouping criteria: DIM=days in milk, C=cluster, M=milk, NE_L=sorted by NE_L; [3]TMR=total mixed ration; [4]Comparison made with a slight different treatment group of cows and including labor and replacement costs; [5]Large variation in results confounded with herd and production factors and including additional costs and revenues beyond the income over feed cost. [6]Used average NE_L and average MP + 1 SD for diet formulation.

Most important factors to evaluate economics of nutritional grouping

1. Criteria for grouping
2. Diet nutrient specification
3. Effects on milk production
4. Health benefits
5. Environmental benefits
6. Number, size, and frequency of grouping
7. Additional costs (and benefits)

Criteria for grouping

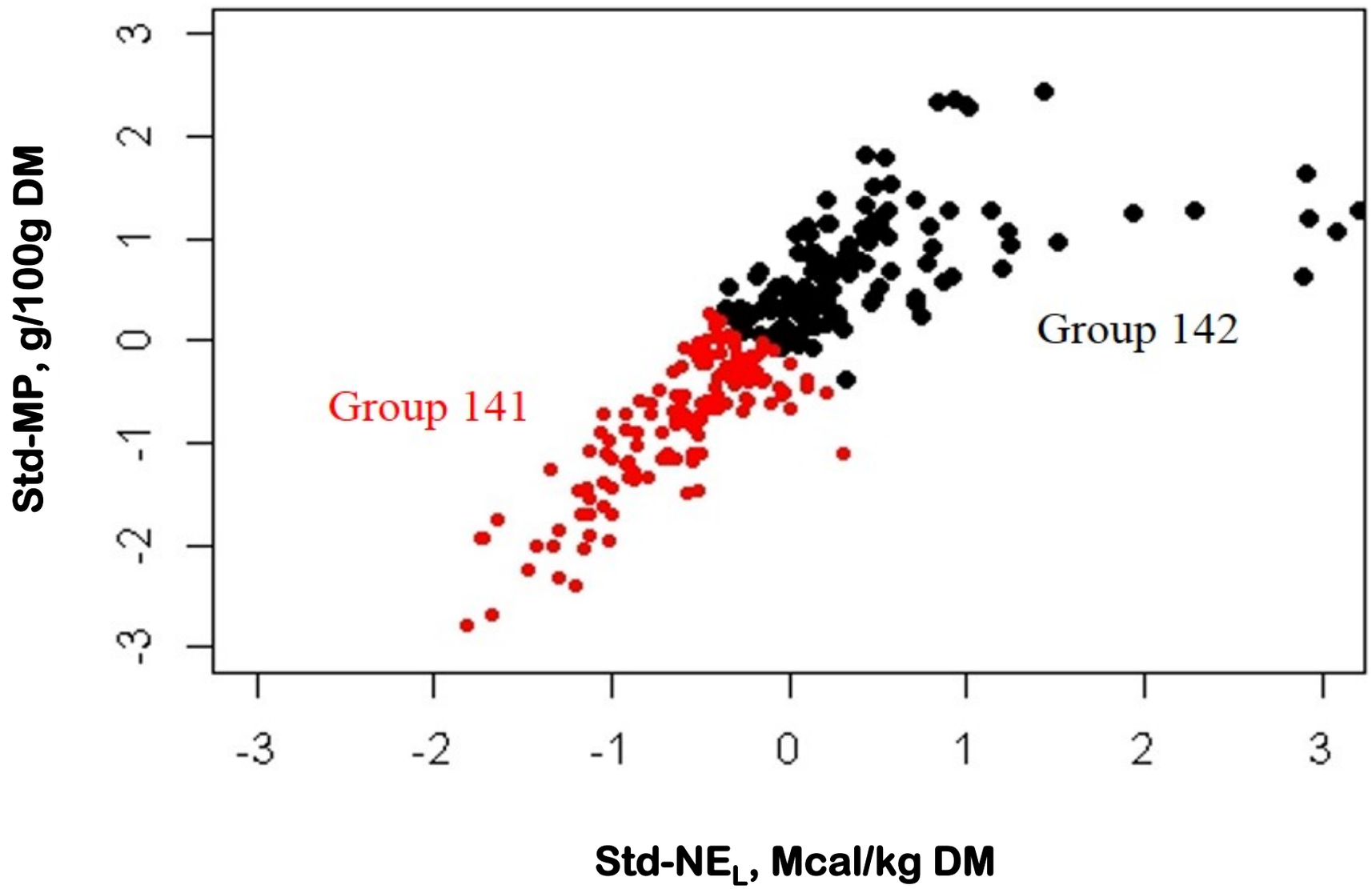
- Goal is to have cows into more homogeneous groups with respect to nutrient requirements
  - Least variability within groups
  - Greatest variability between groups
- Several criteria exist
  - Farmers need to conciliate them with general management
- Some compromise is needed



Best criteria for grouping

1. **Cluster by DMI or by NDF: considers simultaneous requirements of nutrients**

McGilliard et al., 1983; Williams and Oltenacu, 1993; St-Pierre and Thraen, 1999

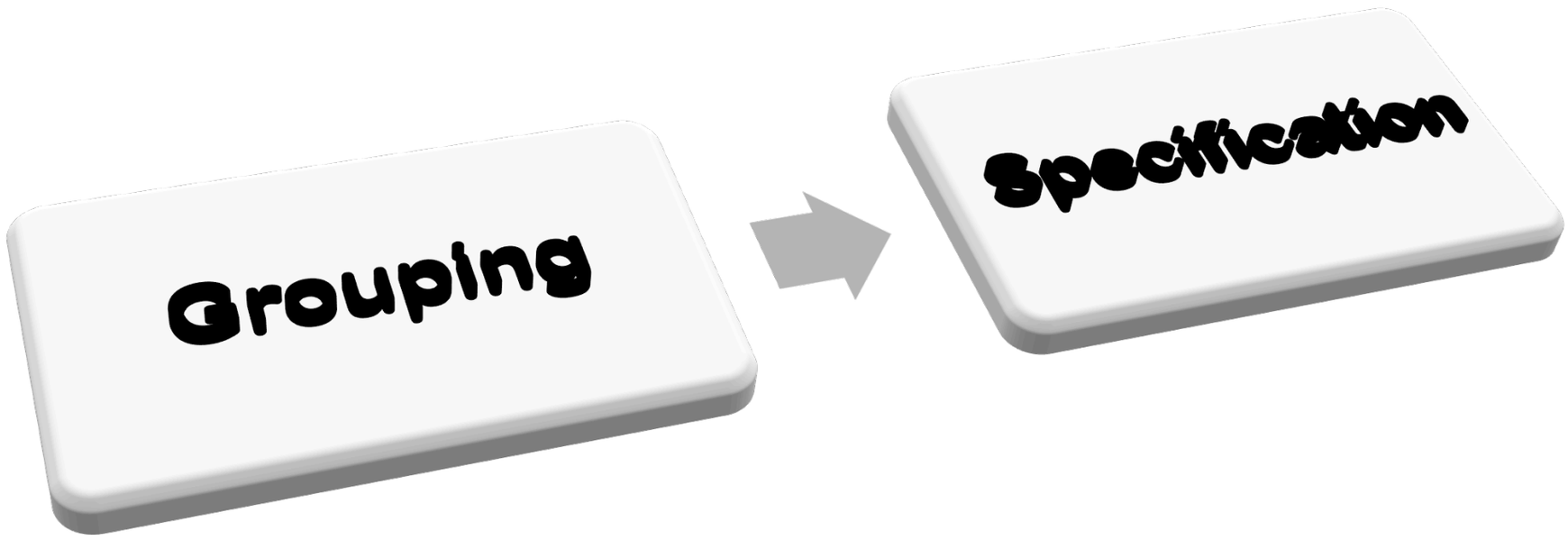


Kalantari, 2015

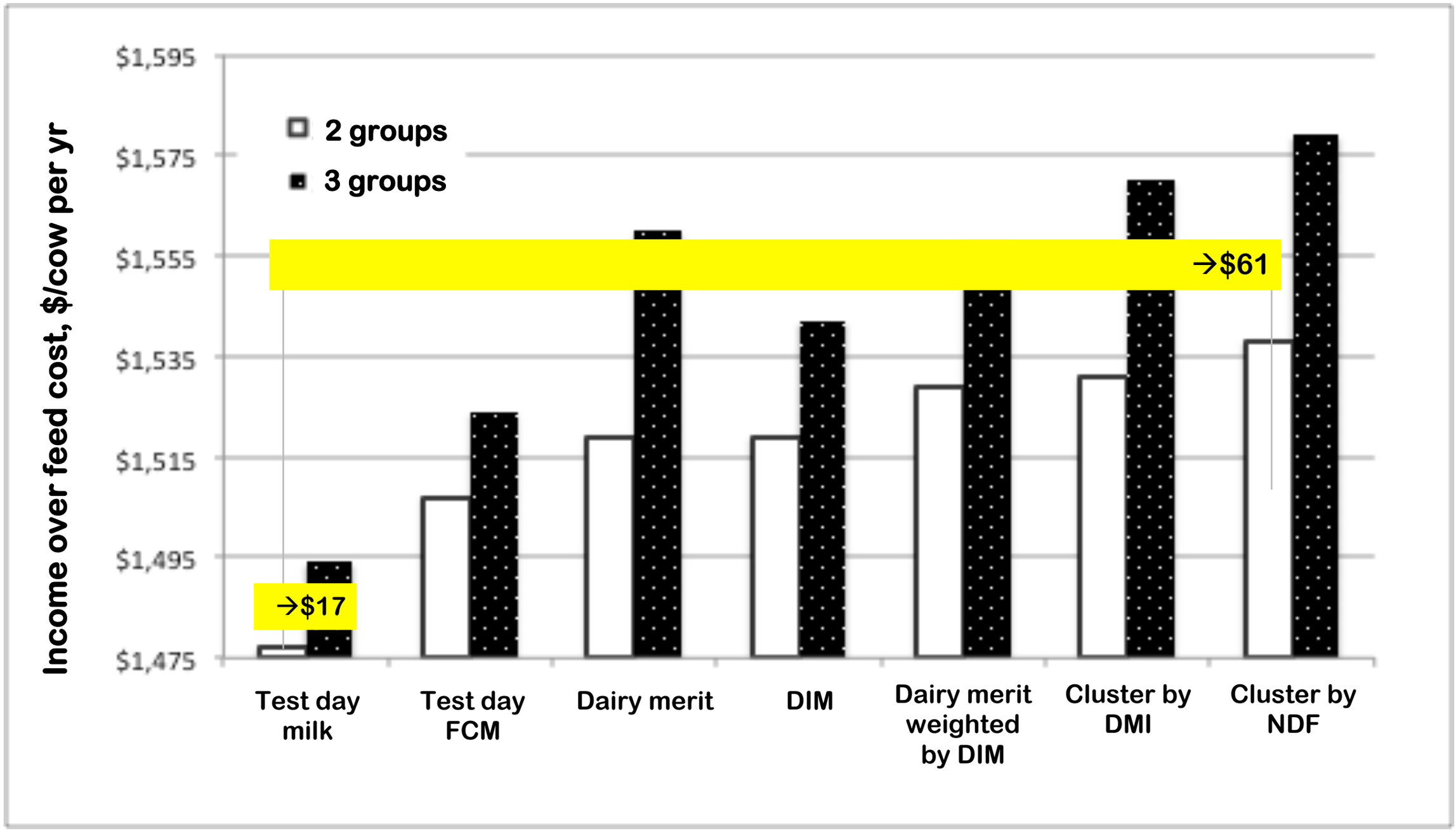
Best criteria for grouping

2. Dairy merit = 100 x 4% FCM/$BW^{0.75}$
3. Dairy merit weighted by DIM
4. DIM
5. FCM = 4% FCM = 0.4 Milk + 15 Fat Yield
6. Milk

McGilliard et al., 1983; Williams and Oltenacu, 1993



Economic value of grouping criteria



Adapted from Williams and Oltenacu, 1993

Grouping criteria conclusions

- Grouping efficiency is crucial
- Cluster is clearly superior to any other grouping criteria
  - Literature has widely adopted it
  - Industry has not adopted it
- Extension educational effort is required
- When compromise in grouping criteria is needed, use the next best criterion
- Decision support tools together with DHIA and software companies can help

Diet nutrient specification

- Diets are normally formulated for a specific cow that has greater than average milk production
  - Assures high producer cows reach their potential
  - Depends on the level of group-cow homogeneity (criteria)
- Tends to overfeed a large proportion of cows
- Cows can regulate intake to certain extent according to diet

Weiss, 2014

- Very difficult to formulate if cows are not grouped

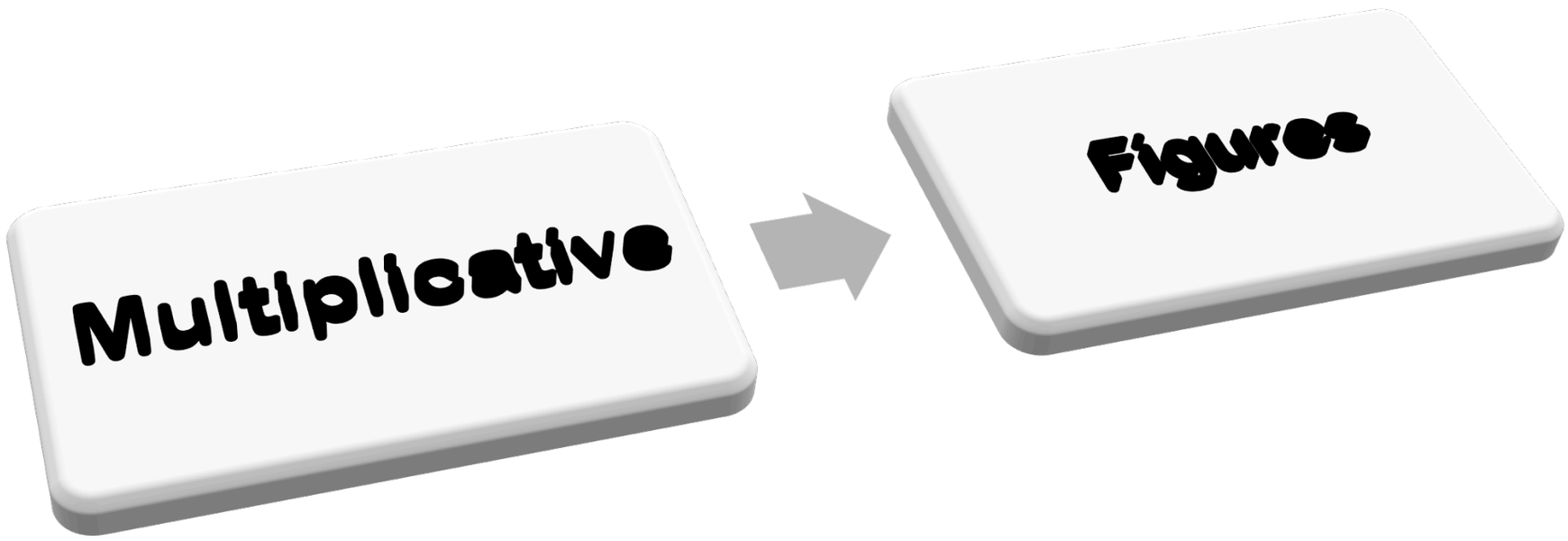
VandeHaar, 2011

Milk lead factors

- Multiplicative coefficients to average milk production of a group for diet formulation
  - Proposed 1.3 SD (~83rd percentile)
  - Separate by nutrients
  - Usually do not include or use default growth and maintenance requirements
- Very popular in the industry

Stallings and McGilliard, 1984

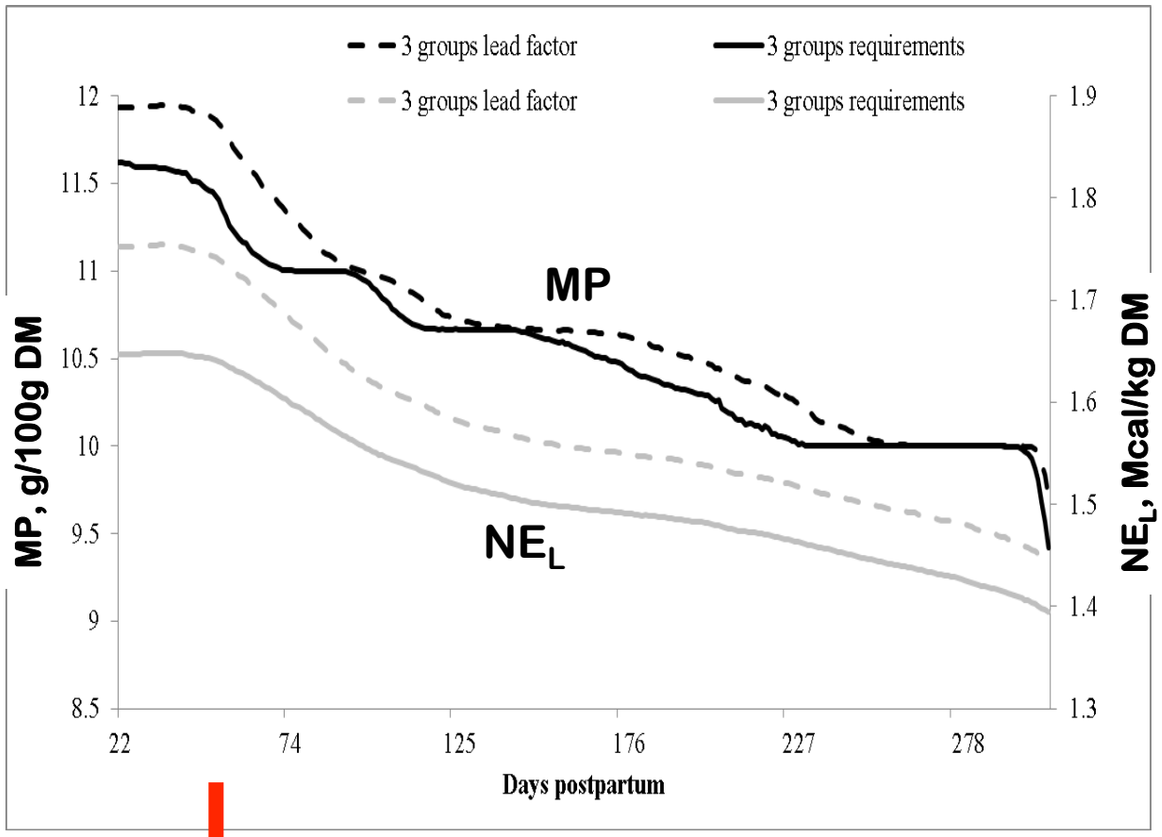
St-Pierre and Thraen, 1999



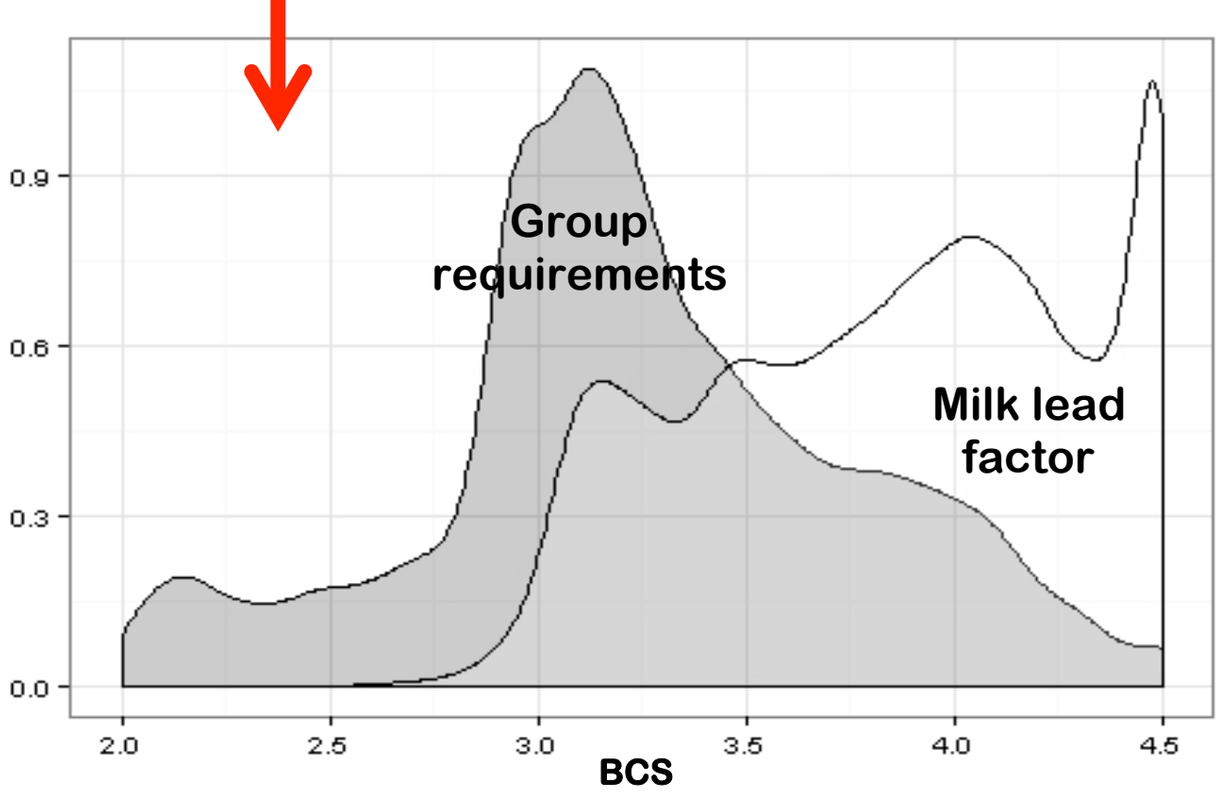
Optimal nutrient allocation

- Ideal: individual cow diet = precision feeding
  - Not practical or possible
  - A compromise normally is needed
- Providing cows are efficiently grouped by cluster:
  - There is less need for over formulation
  - Smaller differences between diet and requirements can be overcome by DMI individual regulation
- Milk lead factors are not needed
  - Many studies did not use milk lead factors

Williams and Oltenacu, 1992; Cabrera et al., 2012; Kalantari et al., unpublished)



Offered diets when using milk lead factors: 1.14 High, 1.10 Medium, and 1.21 Low and group requirements for NE_L (mean) and metabolizable protein (MP+1SD)

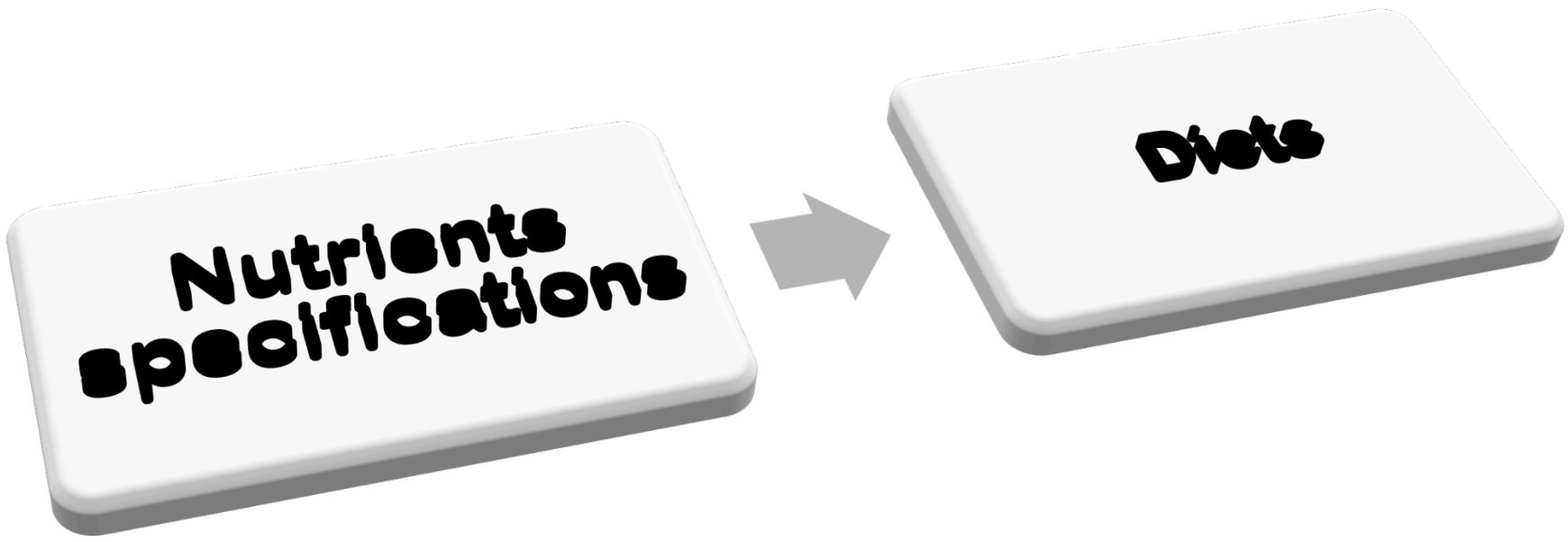


727-cow Wisconsin herd simulated diets and resulting BCS. Kalantari, 2015

Resulting body condition scores (BCS) when using milk lead factors (light shade) and when using group requirements

Diet specifications conclusions

- Diets should be based on group complete nutrient requirements (with or without a lead factor)
- Individual nutrients should be specified at different levels
- Future research should look on ways to optimize group-diet formulations



Effects on milk production

- Studies have reported inconsistently regarding milk production and nutritional grouping
  - Drop — Smith and Coppock, 19
  - No change — Coppock et al., 1981
  - Increase — St-Pierre and Thraen, 1999

- Milk production when grouping could potentially be affected because of 2 reasons:
  - Social hierarchy
  - Dietary changes

Social effects of (re)grouping

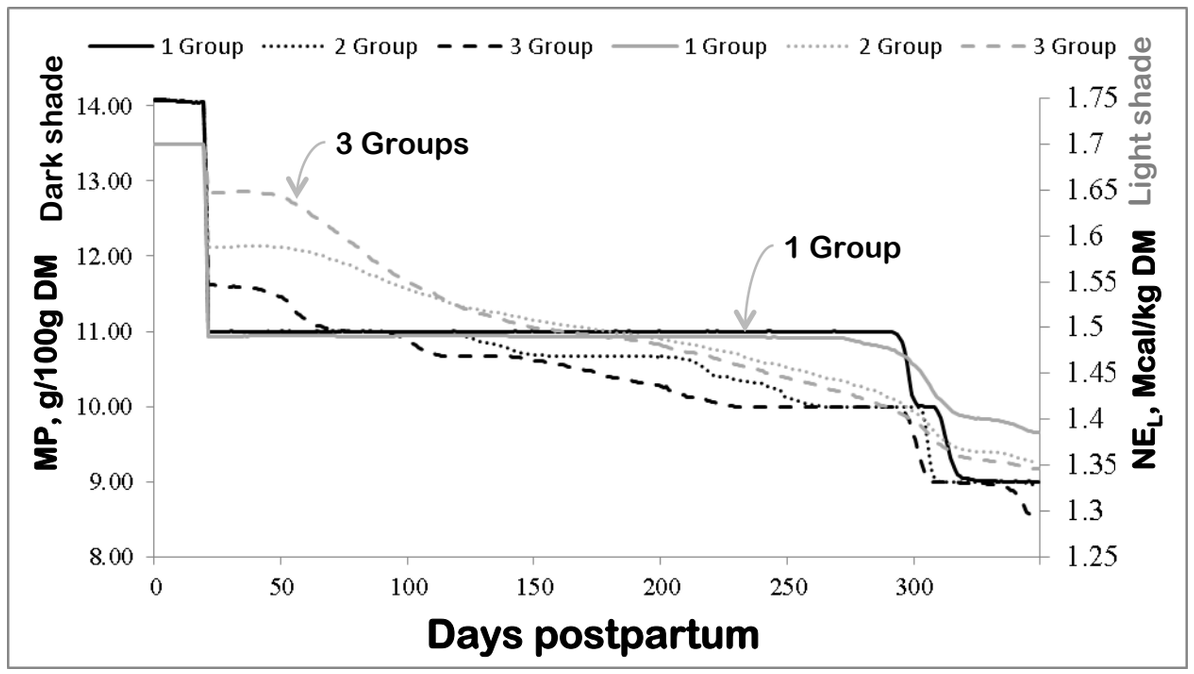
Study	Milk loss	Number cows
Brakel and Leis (1976)	0.51 kg/d or 3% in 4%FCM only during d=1	4 moved in groups of 20
Hasegawa et al. (1977)	4.7% milk production second wk	Half of the cows in 2 primiparous pens
Clark et al. (1977)	No change	
von Keyserlingk et al. (2008)	3.7 kg/d only during d=1	1 cow moved to a established group of 11
Zwald and Shaver (2012)	No change, no deleterious effects	Large pens of 60 or more cows (2 commercial farms)

Disruptive effects regrouping would be reduced or eliminated because of: large size of groups and enough resources (stalls, bunk space, water, feed)

Zwald and Shaver, 2012

Effects of diet changes

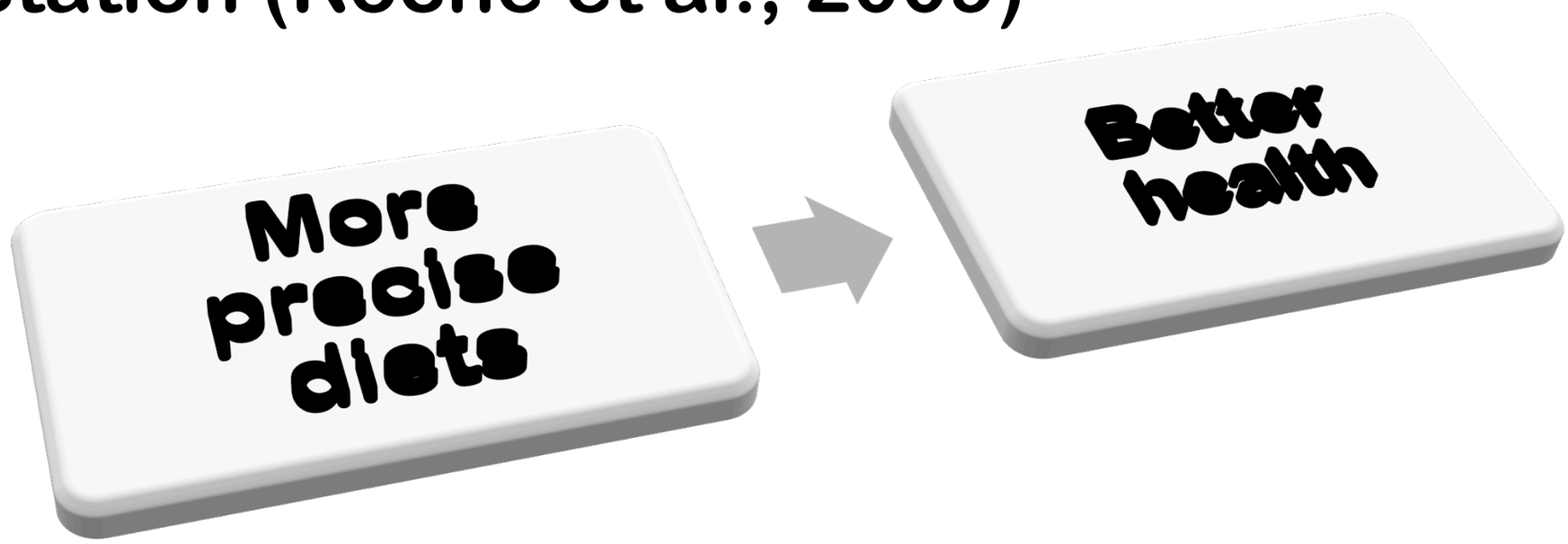
- Provided that cows are optimally clustered and diets are more precisely formulated, there is no reason cows become deprived of nutrients when grouped
  - Cows are more homogenous within groups
  - Cows would adjust moderately their DMI to their requirements



Kalantari et al., unpublished

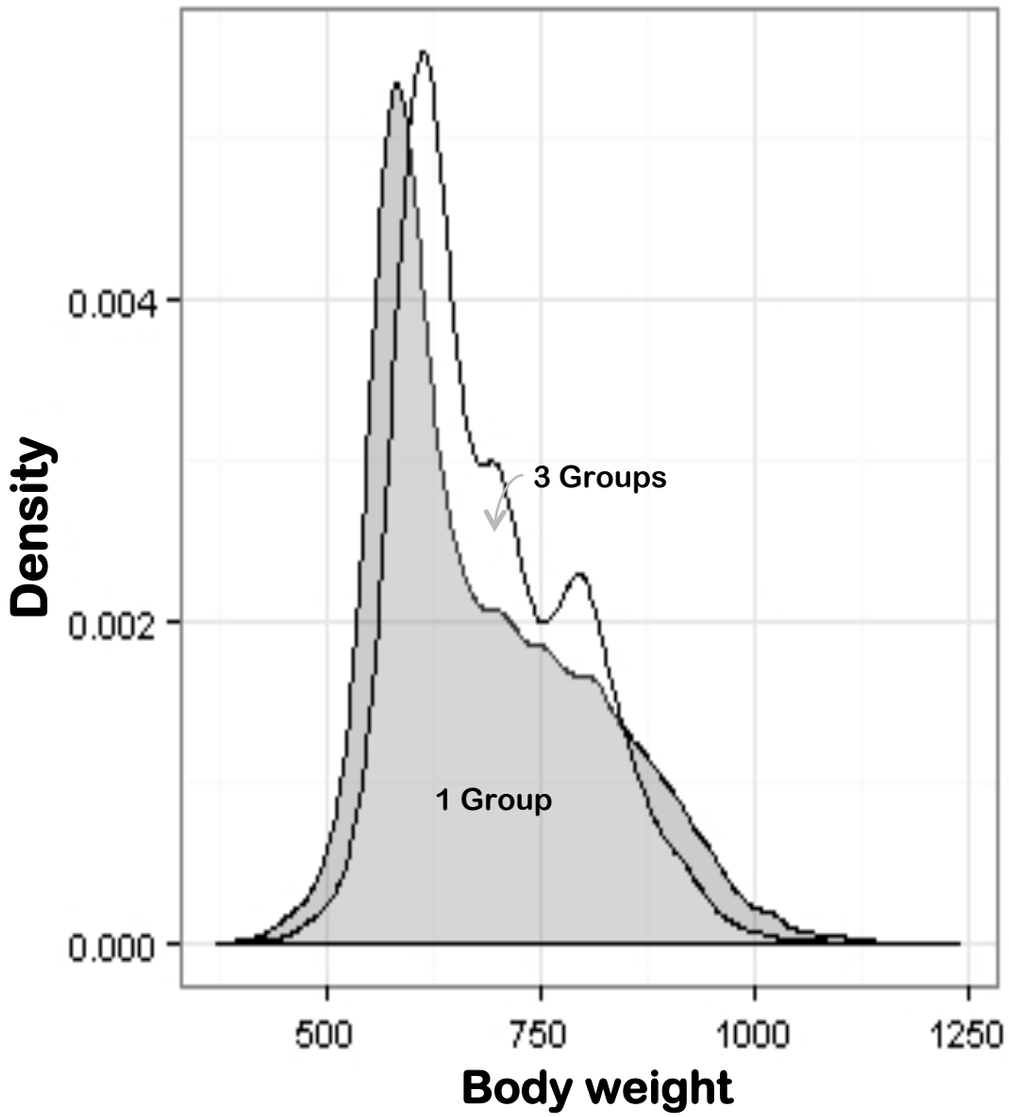
Health benefits

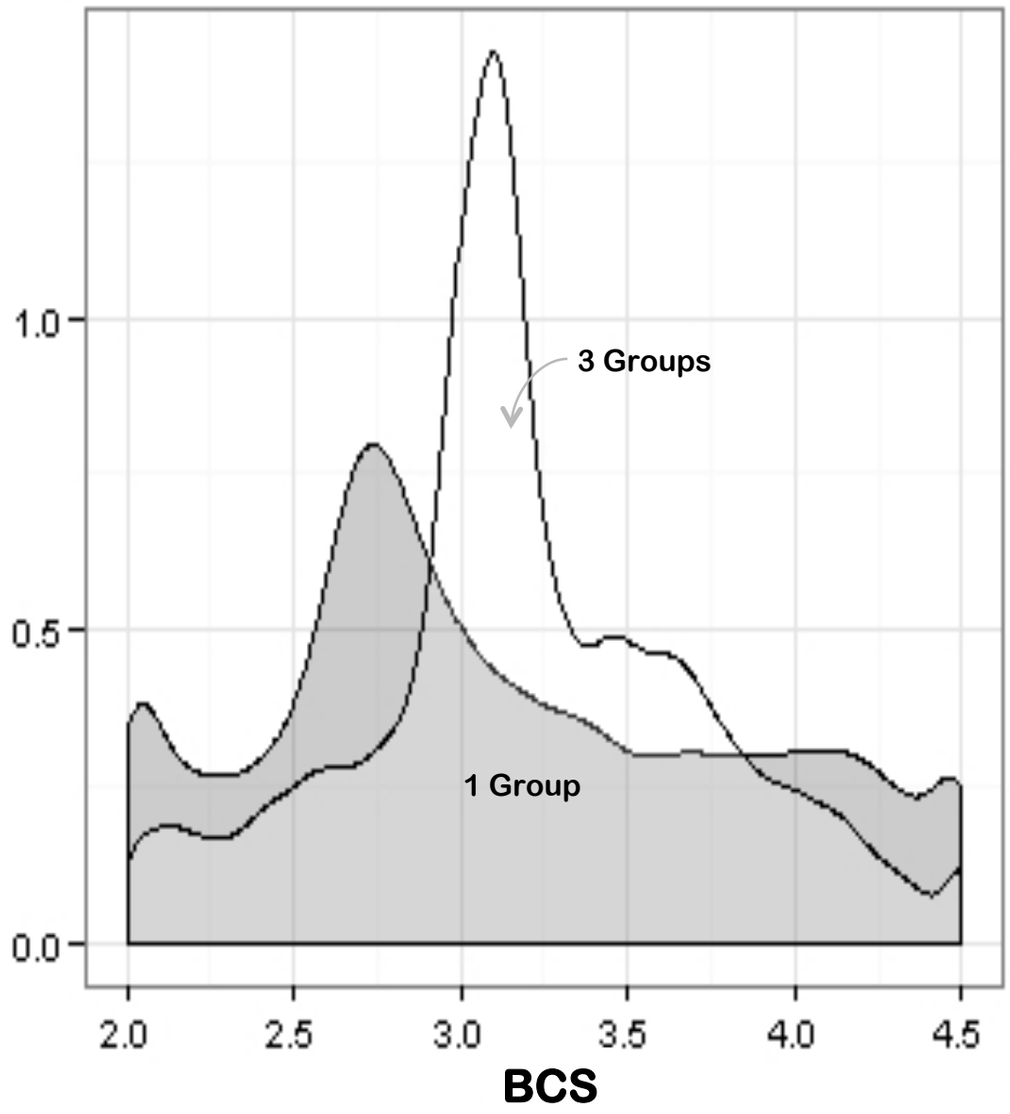
- Cows more precisely fed have less chance or becoming either under- or over-conditioned and therefore healthier
- Low BCS at calving is associated with reduced production and reproduction in subsequent lactations (Tessman et al., 1991)
- High BCS at calving is associated with reduced DMI, reduced milk yield, and increased metabolic disorders in next lactation (Roche et al., 2009)



Grouping effect on BW and BCS

Wisconsin 787-cow herd simulated for 1 yr





Kalantari et al., unpublished

Not much difference

Cassel et al., 1984; Kroll et al., 1987

Important differences
How this translates to $?

Health benefits <u>conclusions</u>

- Cows more precisely fed under groups are healthier

- Healthier cows produce more and incur in less expenses of treatments and therefore are more profitable

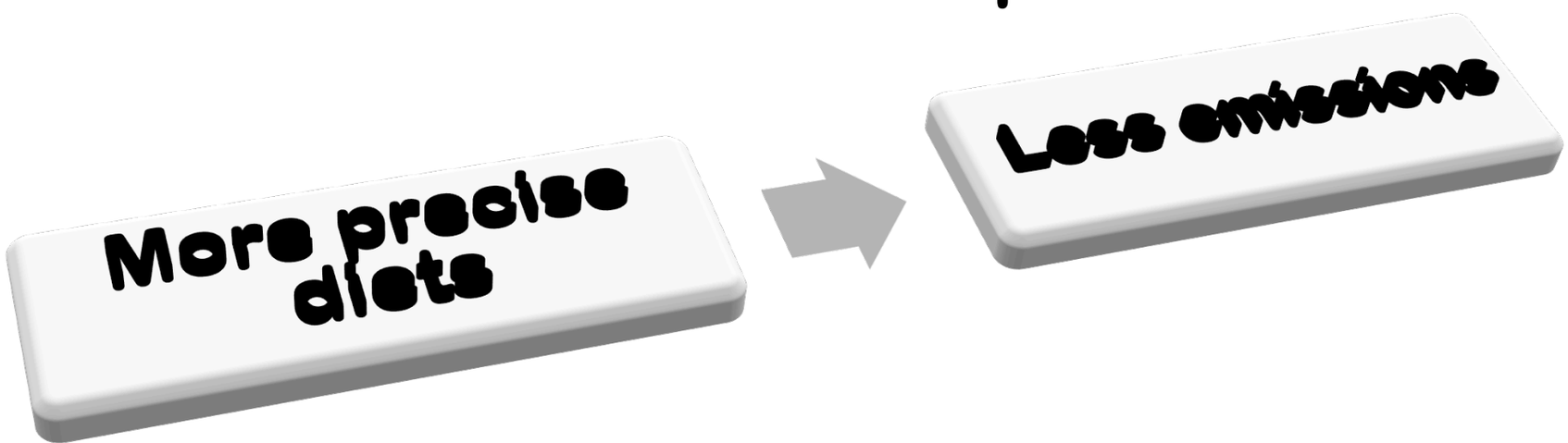
- Quantification of the economic benefits of improved health because of grouping requires further research

Environmental benefits

Study	Benefit	Comparison
St-Pierre and Thraen, 1999	3.7% less N excretion and 5.8% increased N efficiency	3 cluster vs. 1 cluster
Cabrera and Kalantari, 2014	1.0 and 2.6% increased N efficiency	2 and 3 clusters vs. 1 cluster
Kalantari et al., unpublished	1.9 and 2.7% increased N efficiency	
Jonker et al., 2002; Powell et al., 2006; Arriaga et al., 2009	No improvement in N-use efficiency	Less than optimal grouping criteria such as milk production, DIM, or reproductive status
Jonker et al., 2002; Powell et al., 2006	No improvement in P-use efficiency	
Arriaga et al., 2009	14% improvement in P-use efficiency	Claimed to increased milk yield rather than more precise diets

Environmental benefits conclusions

- Grouping strategies if optimally performed will improve nutrient use efficiency and decrease environmental emissions
- Decreased environmental impacts should be carefully translated to either or both reduced costs or economic benefits
- Farmers in the future will require to assess and included these values in their budgeting whether they are forced to stricter regulations or they need to take advantage of incentives to reduce environmental impacts

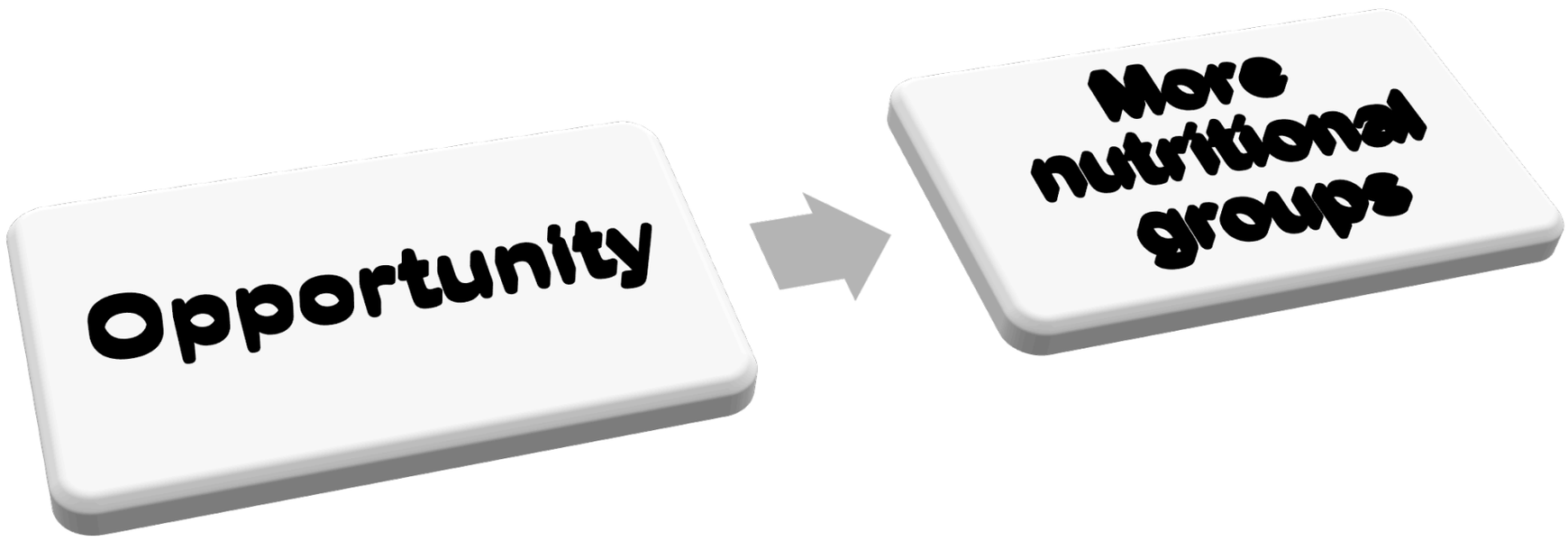


Number of groups

Study	Recommendation	Comments
Coppock et al., 1972 Nocek et al., 1985	3 lactation-diet groups	15% of lower production difference within a group
Kroll et al., 1987	3 groups including early lactation (<45 DIM)	1 high TMR and 1 low TMR
Bath and Sosnik, 1992	3 groups	Preferred 5 groups including 1 group of primiparous
Sniffen et al., 1993	3 lactation-diet groups	Review paper. Little justification to go beyond 3 groups
St-Pierre and Thraen, 1999	3 cluster groups	Additional cluster would not provide more benefits
Grant and Albright, 2001	1 group for early postpartum and 3 additional groups	3 wk of early postpartum group
Kalantari et al., unpublished	1 cluster early postpartum and 3 additional clusters	Larger herds (e.g., >1,000 cows) could include 1 more cluster

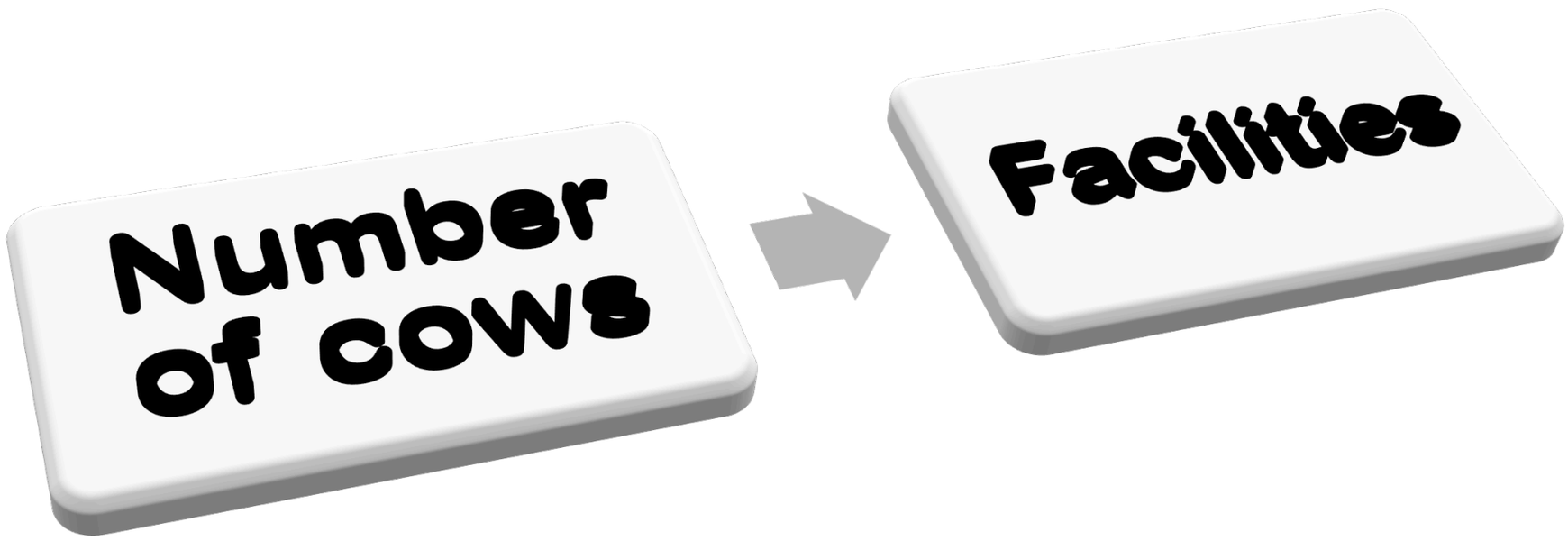
Number of groups

- There seems to be a disconnection between the recommendations of number of groups and actual farm practices (Jordan and Fourdraine, 1993; Contreras-Govea et al., 2015)
- An opportunity exists to improve economic efficiency in modern dairy farm systems by increasing the number of feeding groups



Size of groups

- Two factors play an important role in determining size of groups practically:
  - Number of lactating cows
  - Pens available
- Modern technologies could help: RFID and electronic gates, software, etc.



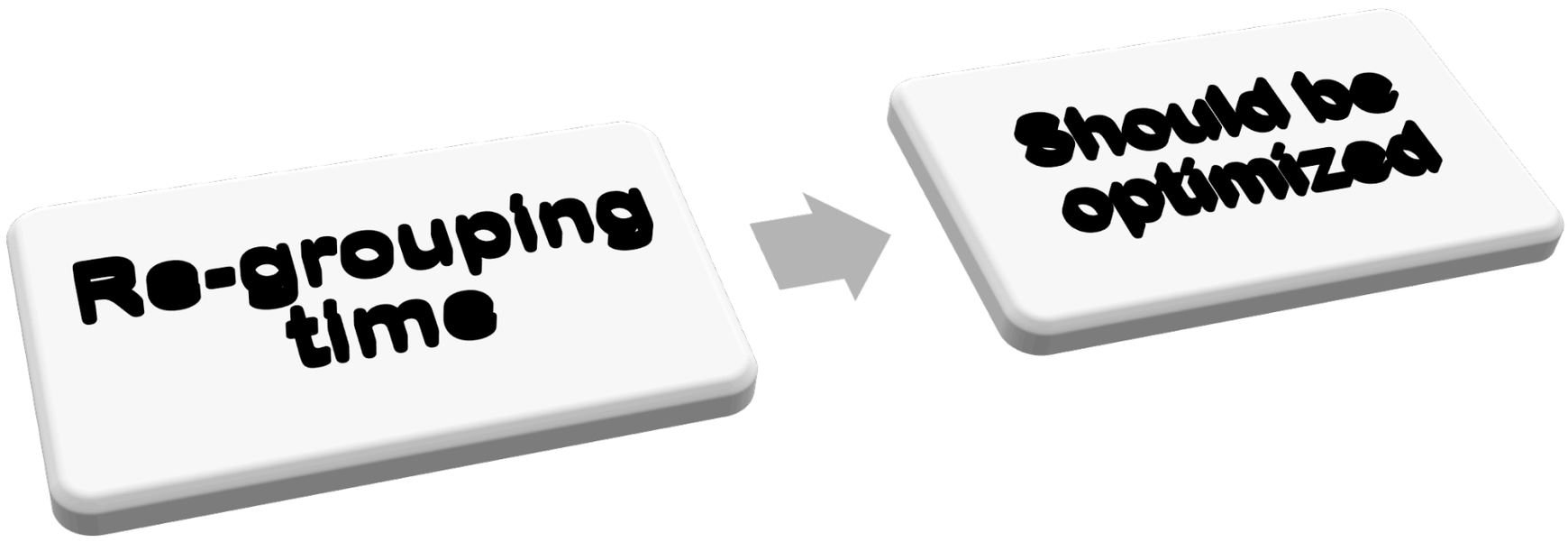
Frequency of grouping

- Despite its critical importance (re)grouping time have only arbitrarily set in studies

Study	Trigger (re)group
Smith et al., 1978; Cassell et al., 1984; Ostergaard et al., 1996	DIM, Milk production, or a combination
McGilliard et al., 1983; Schucker et al., 1988; Williams and Oltenacu, 1992; Cabrera and Kalantari, 2014	Pre-defined fixed time
Smith et al., 1978; Cassell et al., 1984; Ostergaard et al., 1996	Once during a lactation
Schucker et al., 1988	Every few months
Williams and Oltenacu, 1992; Cabrera and Kalantari, 2014	Every month
Earleywine, 2001	Every week

Frequency of grouping

- No study has formally analyzed timing and frequency of nutritional grouping strategies with respect to either or both performance or economic efficiency
- Ideally, the (re)grouping timing and frequency should be optimized (i.e., nutritional variability thresholds within and between groups could trigger (re)grouping events)



Overall conclusions

- The economic efficiency of dairy farms can be improved substantially by adopting optimal nutritional grouping strategies for lactating cows
- Large proportions of US modern dairy farms do not perform these nutritional groupings, or if they do, are not optimal
- Ideally, farms might consider implementing 1 nutritional group for early-postpartum cows and 3 nutritional cluster groups for the rest of the lactating cows

Overall conclusions

- Diets should be carefully specified based on the distribution of group nutrient requirements
- Nutrient specifications should be dynamically adjusted to group nutrient requirements
- Cows properly grouped will improve herd health, production and economic efficiency
- More precise diets reduce nutrient excretion and emissions to the environment
- Future studies should look at:
  - Optimize group diet formulation
  - Optimize time and frequency of grouping
  - Whole systems field/simulation research

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