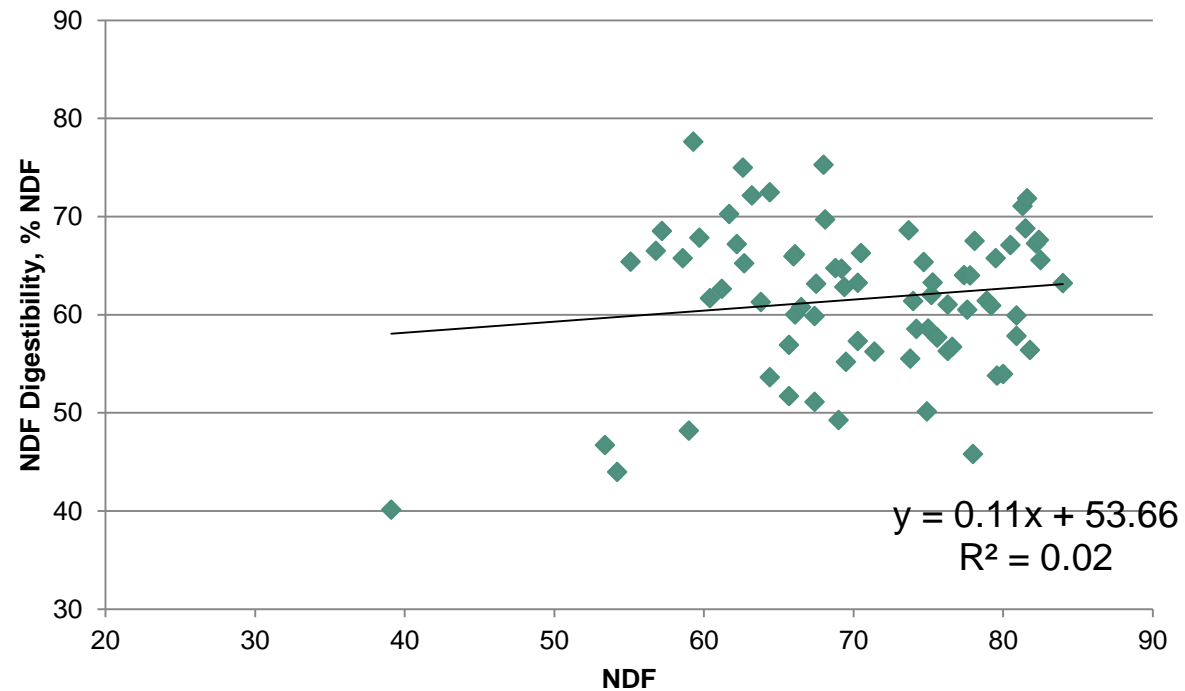


# Estimating NDF Digestibility

Dr. Dan Undersander  
University of Wisconsin

# Relationship of NDF to NDF Digestibility



# Why concerned about NDF Digestibility?

- Forage is 40 to 70% NDF

Fiber range over 10 years UW Forage Testing Laboratory		
Component	Alfalfa Haylage	Hay
ADF	33.5	32.3
NDF	42.8	46

# Why concerned about NDF Digestibility?

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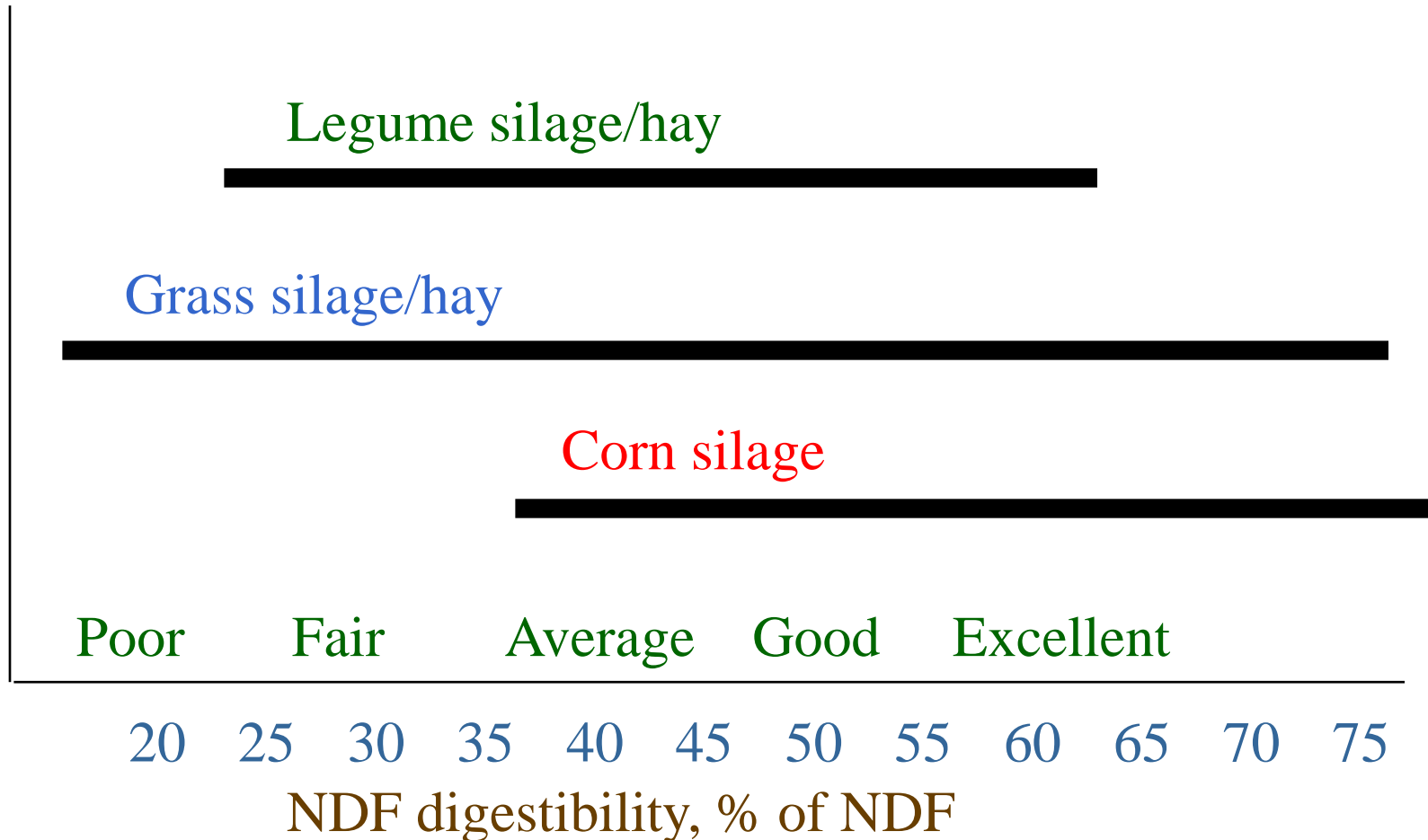
- Forage is 40 to 70% NDF
- Ruminants can digest fiber
  - Carbohydrates undergoing microbial fermentation produce VFA's which can provide up to 80% of animal energy needs

# Why concerned about NDF Digestibility?

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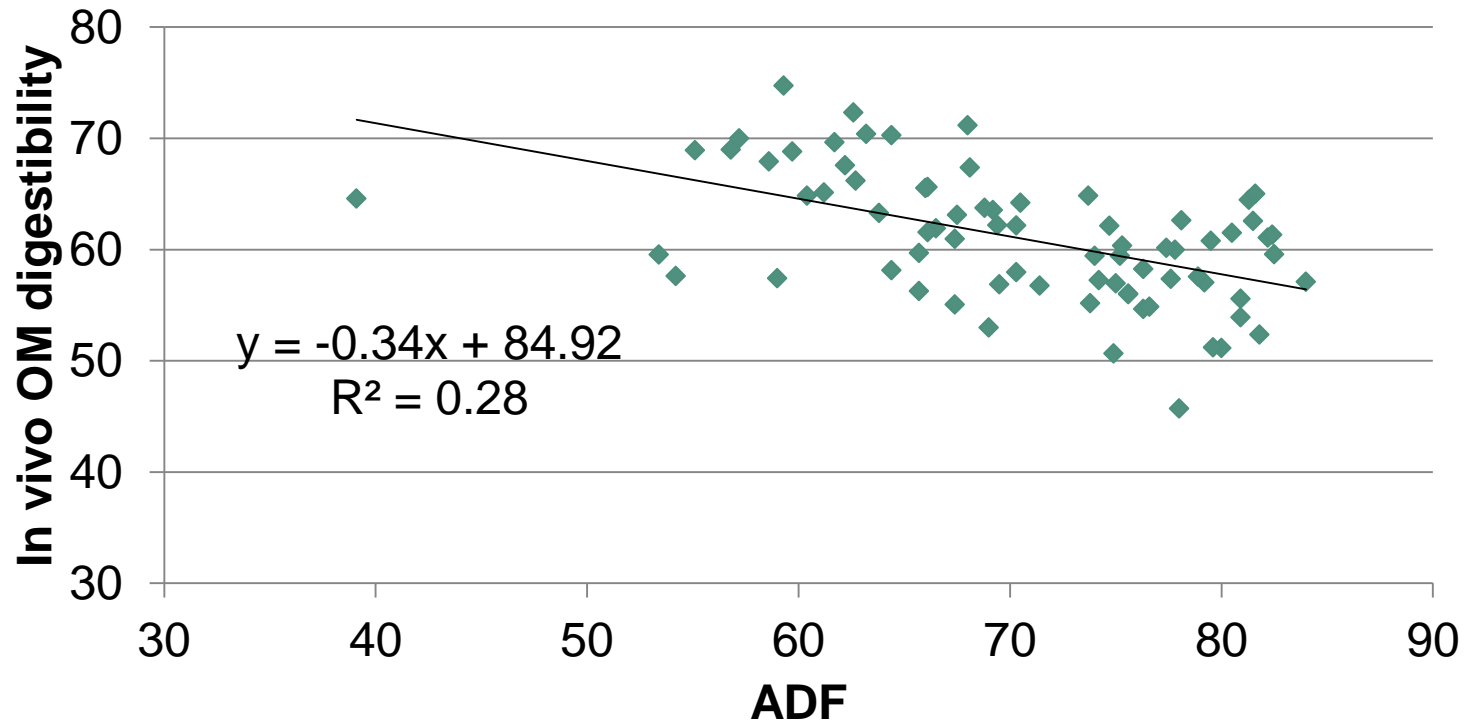
- Forage is 40 to 70% NDF
- Ruminants can digest fiber
  - Carbohydrates undergoing microbial fermentation produce VFA's which can provide up to 80% of animal energy needs
- Fiber digestibility varies significantly

# NDF Digestibility of Forages



# Estimating Forage Digestibility

## ■ ADF and NDF



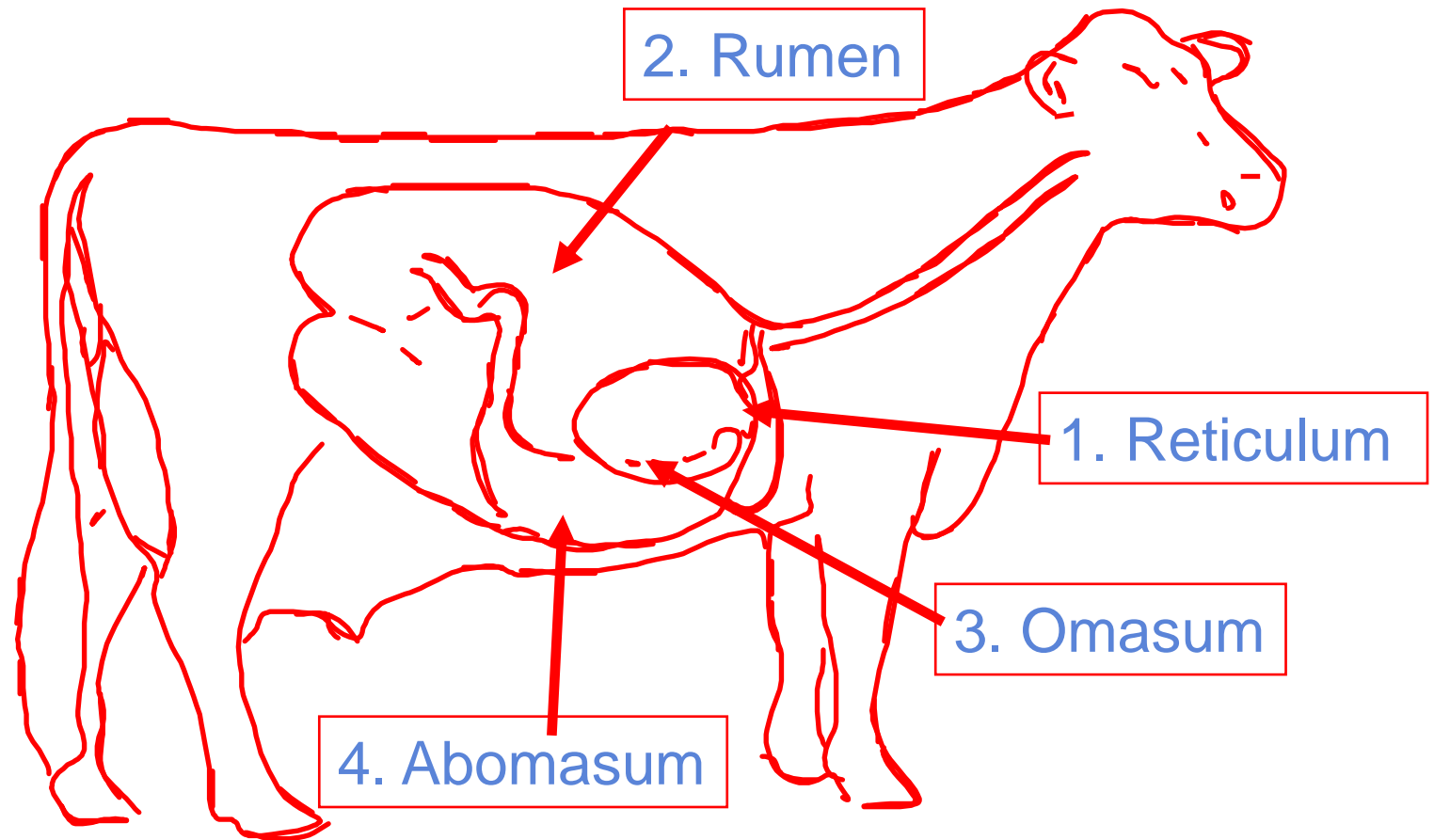
# Estimating Forage Digestibility

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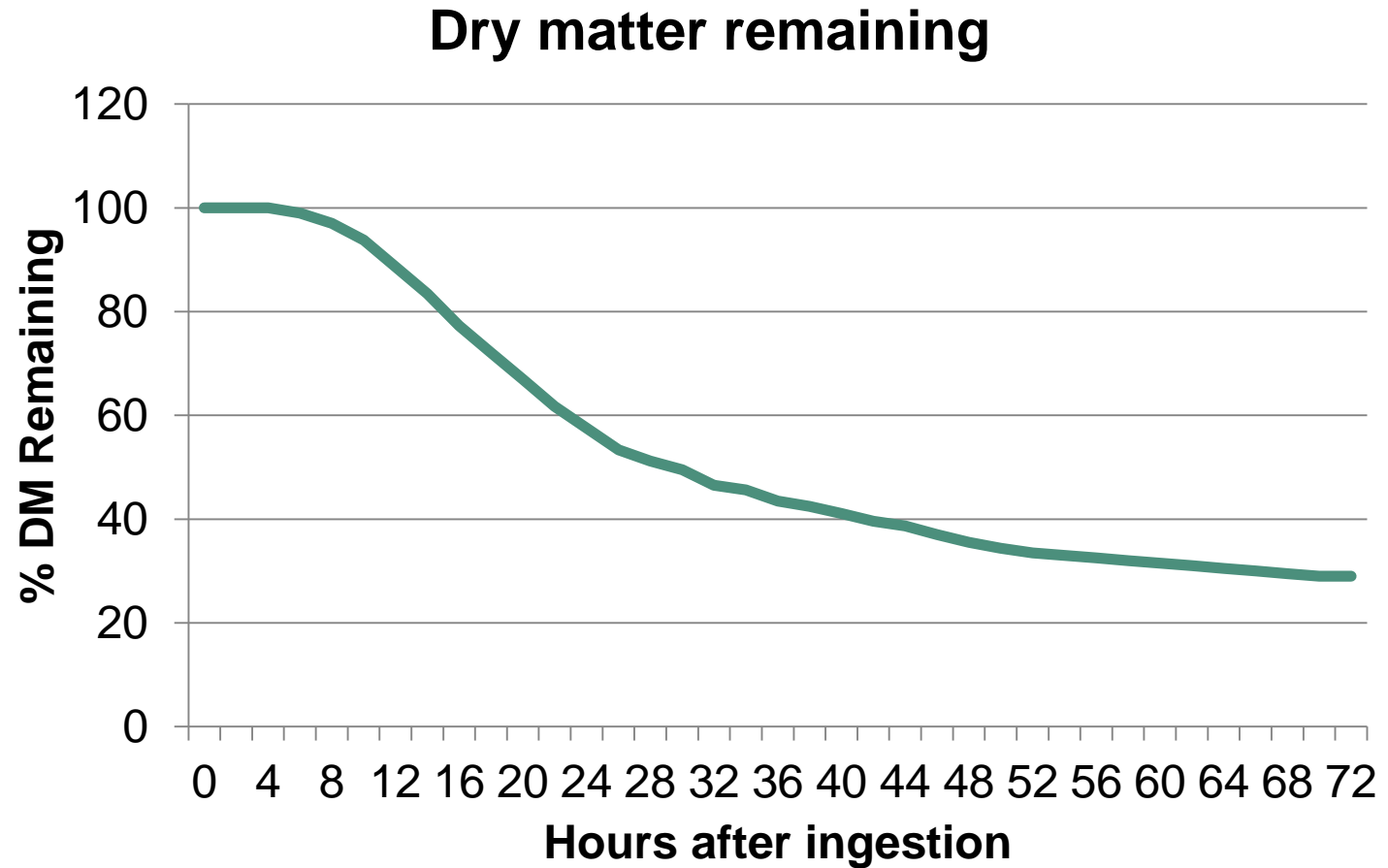
- ADF and NDF
- In vitro (in situ) digestibility



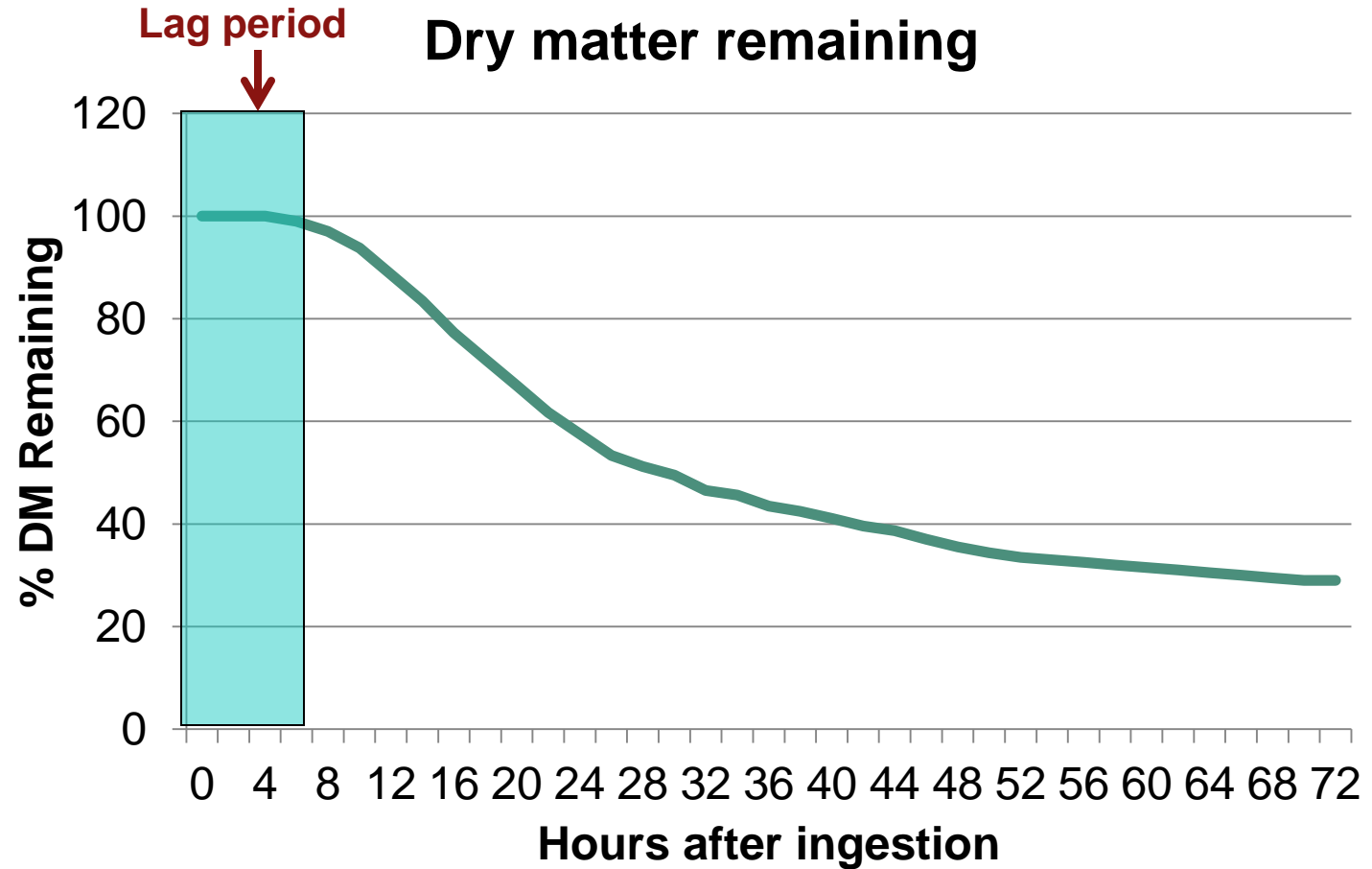
# Passage of Food through the Ruminant Stomach



# Digestion Phases



# Digestion Phases



# Biological Factors Affecting Lag Time

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- Rate of hydration
- Bacterial penetration of the epidermal layer
- Rate of removal of chemical and physical inhibitors
- Diet composition
- Rate of microbial attachment
- Increased numbers of bacteria and enzymes

# Biological Factors Affecting Lag Time (and Digestion)

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Animal to animal variation

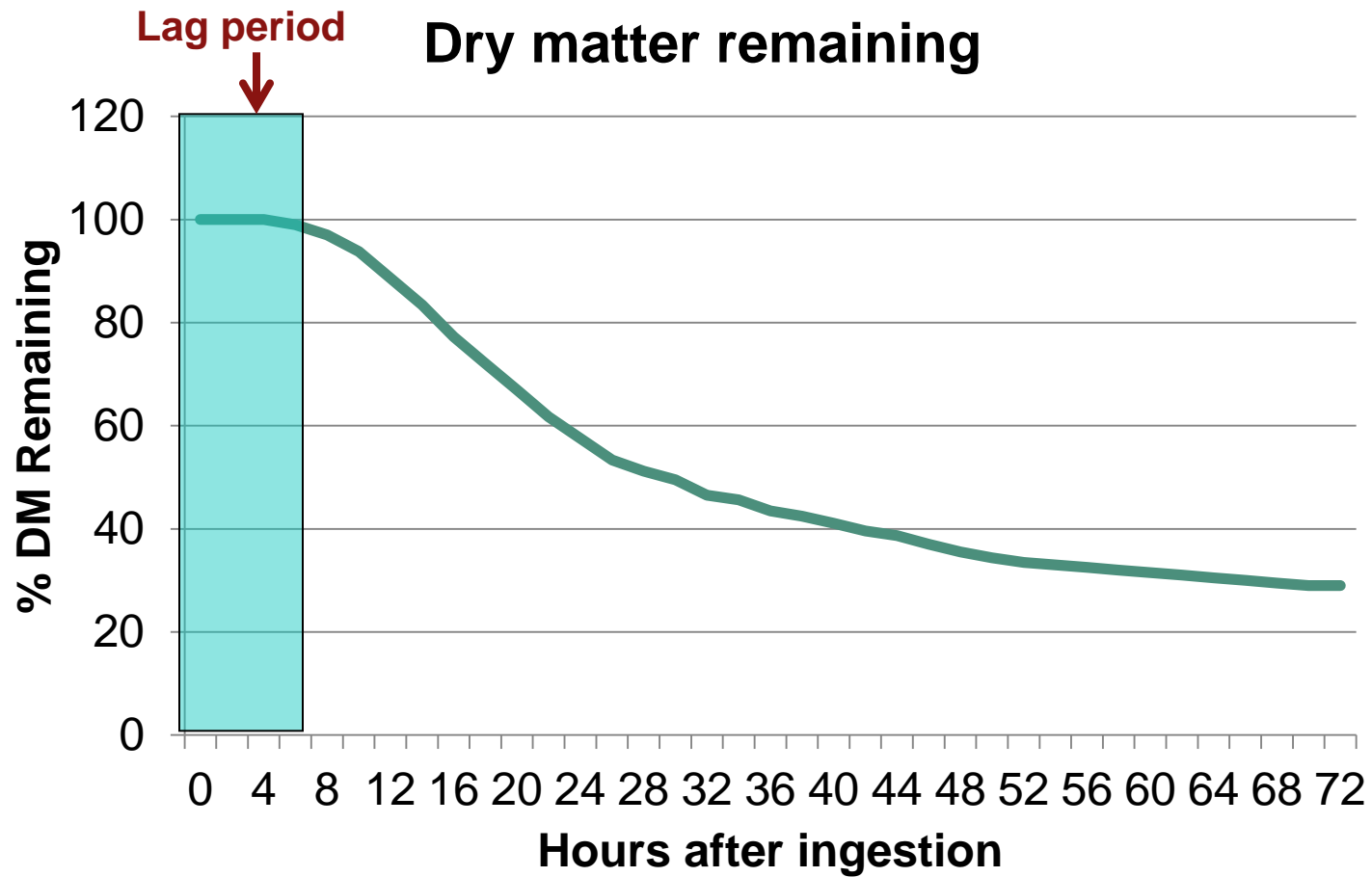
- Animal Scientists
  - ❖ One forage sample and multiple cows
- Agronomists
  - ❖ Multiple forage samples and one cow

# Standardizing Lag Time

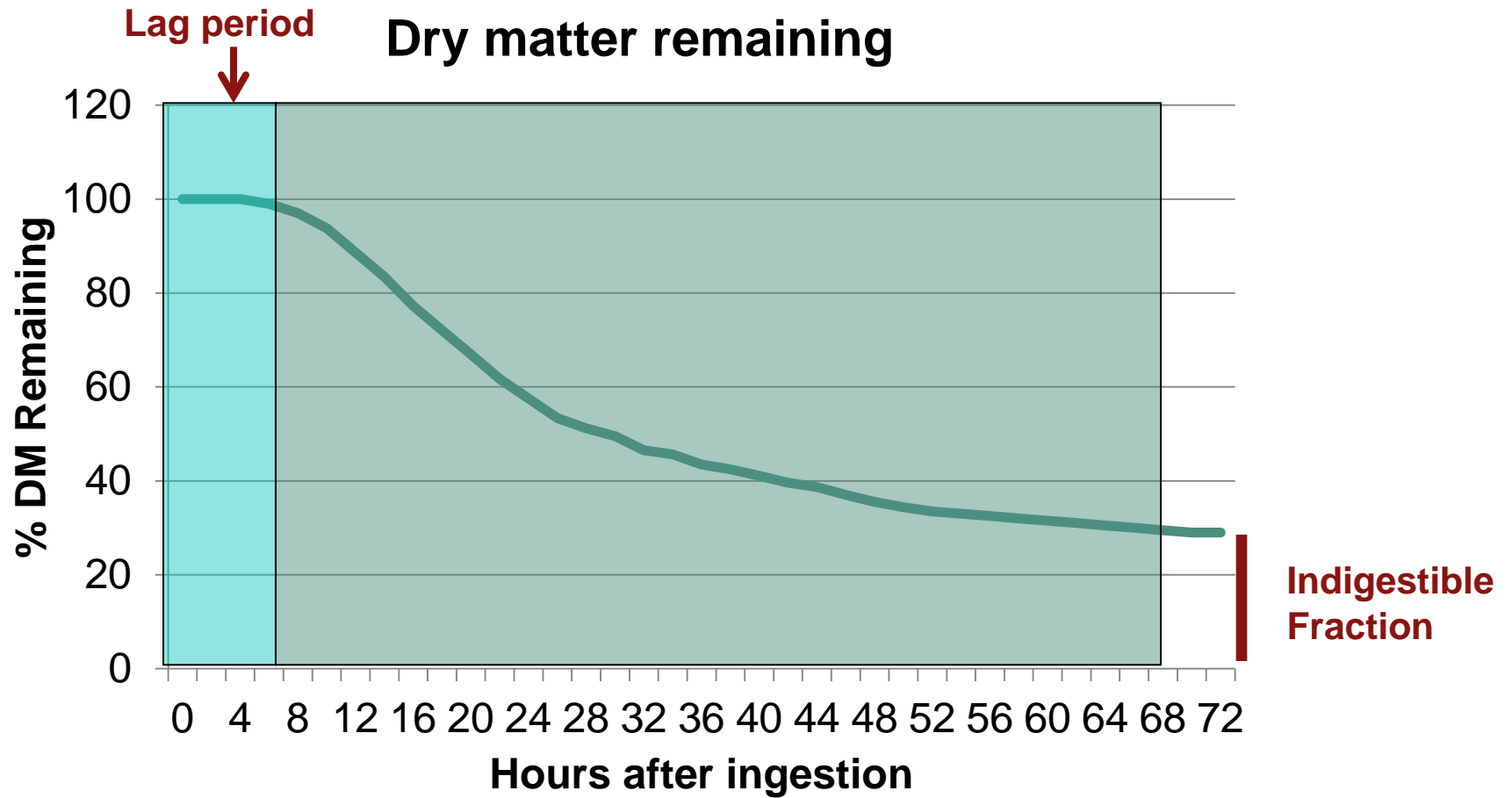
Method to measure in vitro neutral detergent fiber (NDF) digestibility (ivNDFD) based on a primed rumen fluid inoculum.

- Pretreating rumen fluid inoculum with cellulose and
  - Holding the inoculum until it generates 0.3 mL of gas/mL of rumen fluid.
- 
- Goeser, J. P., and D. K. Combs. 2009. An alternative method to assess 24-h ruminal in vitro neutral detergent fiber digestibility. *J. Dairy Sci.* 92:3833–3841.
  - Goeser, J. P., P. C. Hoffman, and D. K. Combs. 2009. Modification of a rumen fluid priming technique for measuring in vitro neutral detergent fiber digestibility. *J. Dairy Sci.* 92 :3842–3848

# Digestion Phases



# Digestion Phases





# Importance of digestive kinetics in ruminant animals

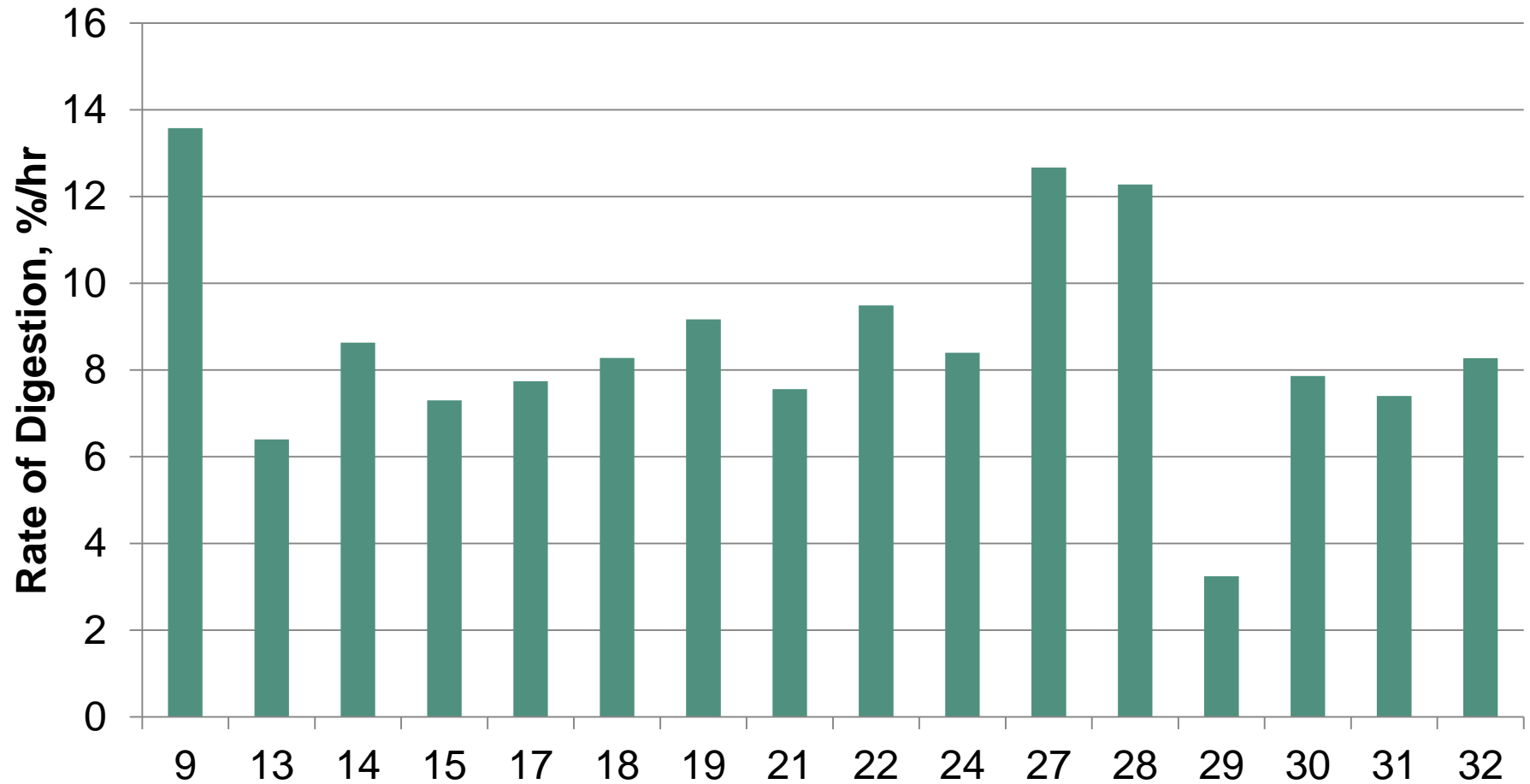
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When a feed particle enters the rumen, it can only leave by one of two mechanisms:

- Fermentative digestion
  - 61 to 85% of OM
- Passage

These two processes compete with each other

# Rate of Digestion of Alfalfa Selections

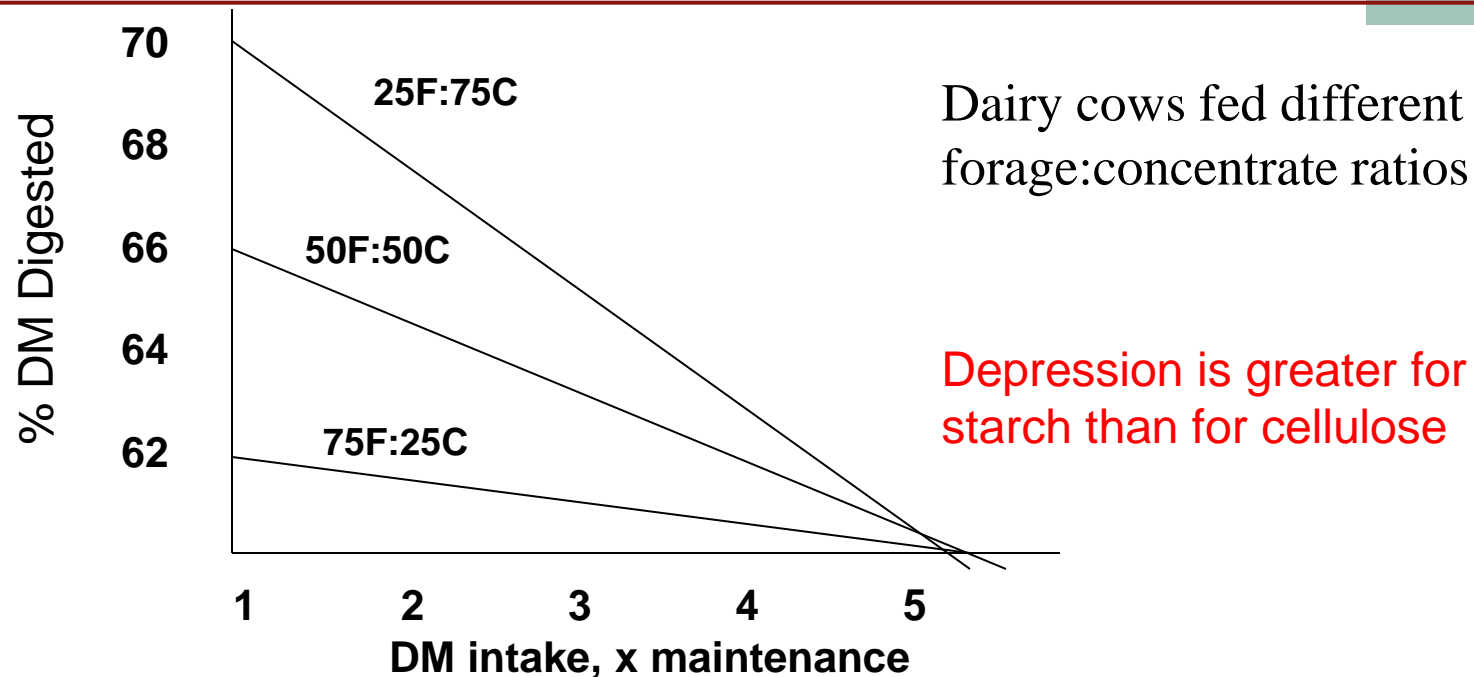


# If alfalfa is fed as the forage:

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- Digesta separates into a liquid fraction and a fiber mat in the rumen.
- Grain particles fall into the liquid fraction
- Increasing the amount of forage in the diet increases the amount of chewing which increase secretion of salivary buffers.
- Increased amounts of salivary buffers increases the osmotic pressure of the rumen contents and increases passage of the liquid digesta.

# Depression in digestibility associated with increased rate of passage



## ■ Implications

- Since many digestion trials are conducted at 1x maintenance, the energy values may not apply to lactating dairy cows
- Forages are of more value to dairy cows than estimated at 1x maintenance

# Implications of Rate of Passage and Rate of Digestion

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The extent of digestion of a feed is controlled by the relationship between  $k_p$  and  $k_d$

$k_p$  and  $k_d$  will affect:

- Feed digestibility
- Feed intake
- Fermentation endproducts

# Factors affecting Rates of Digestion and Passage

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- Reducing the physical form of the diet by grinding, pelleting etc.
  - ❖ Reduces the passage rate of liquid digesta
  - ❖ Increases the passage rate of feed particles
  - ❖ May be related to increased DM intake
- Increasing the rate of digestion
  - ❖ Increases the passage rate of the feed particles
- Increasing the specific gravity to 1.2 will increase rate of passage of particles
  - ❖ Heavy particles settle in the reticulum and ventral sac

# Factors affecting Rates of Digestion and Passage

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- Pregnancy - In third trimester, conceptus will take up volume in the gut cavity which will:
  - ❖ Increase passage rate of liquid digesta
  - ❖ Increase passage rate of feed particles
- Lactation - Increased milk production will:
  - ❖ Increase passage rate of the liquid digesta
  - ❖ Increase passage rate of feed particles

# Factors affecting Rates of Digestion and Passage

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- Environmental temperature - Decreasing the environmental temperature will:
  - ❖ Increase passage rate of the liquid digesta
  - ❖ Increase passage rate of feed particles
- Increasing the osmolarity of the rumen fluid with NaCl or NaHCO<sub>3</sub>
  - ❖ Increases passage of liquid digesta
  - ❖ Increases passage of the feed particle



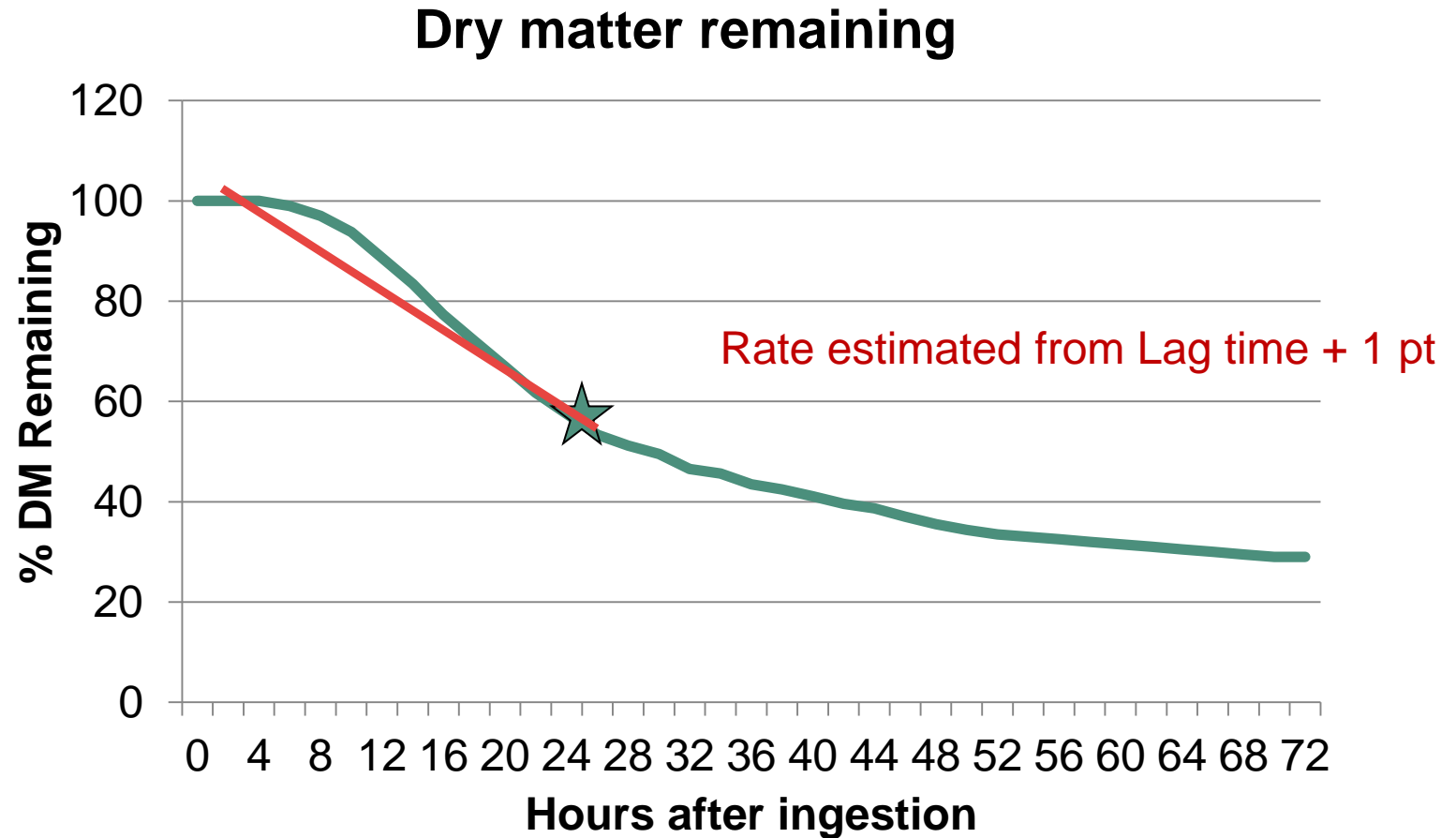
# Rate of passage affects both rate and site of digestion

- At a constant rate of digestion, increasing the rate of passage will:
  - decrease the digestibility of a feed in the total tract
  - increase the proportion of digestion occurs in the lower GI tract

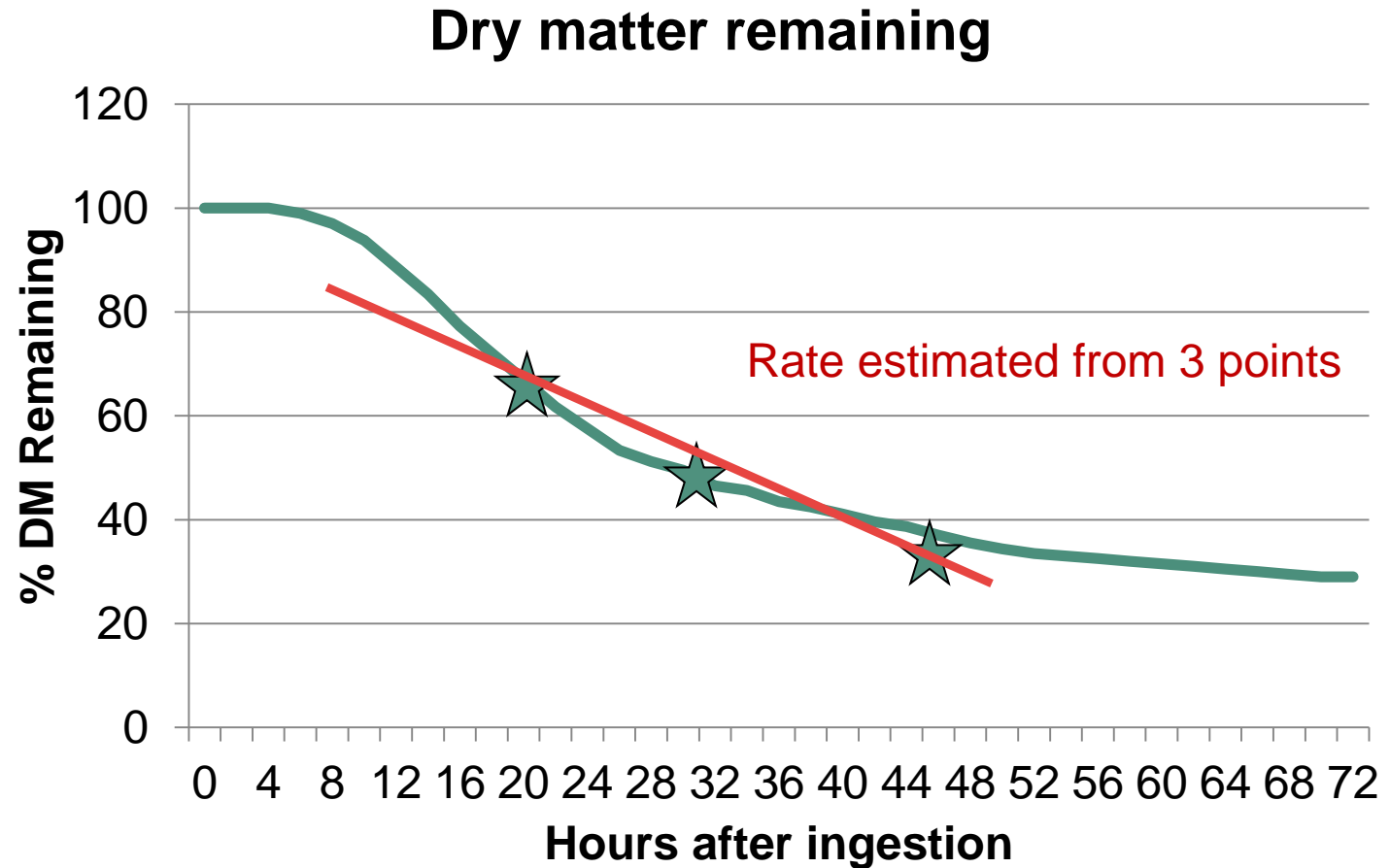
	<u>Sheep fed grass hay</u>	
	<u>Coarse chopped</u>	<u>Ground pelleted</u>
Passage rate, /hr	.037	.042
OM intake, gm/d	559	606
Digestion,		
Rumen, gm	200	186
%	35.8	30.7
Total tract, gm	288	309
%	53.3	51.0

Increased rate of passage will decrease digestibility 1.8% for each 10°C decrease in ambient temperature below 20°C

# Estimating Digestion Rate



# Estimating Digestion Rate

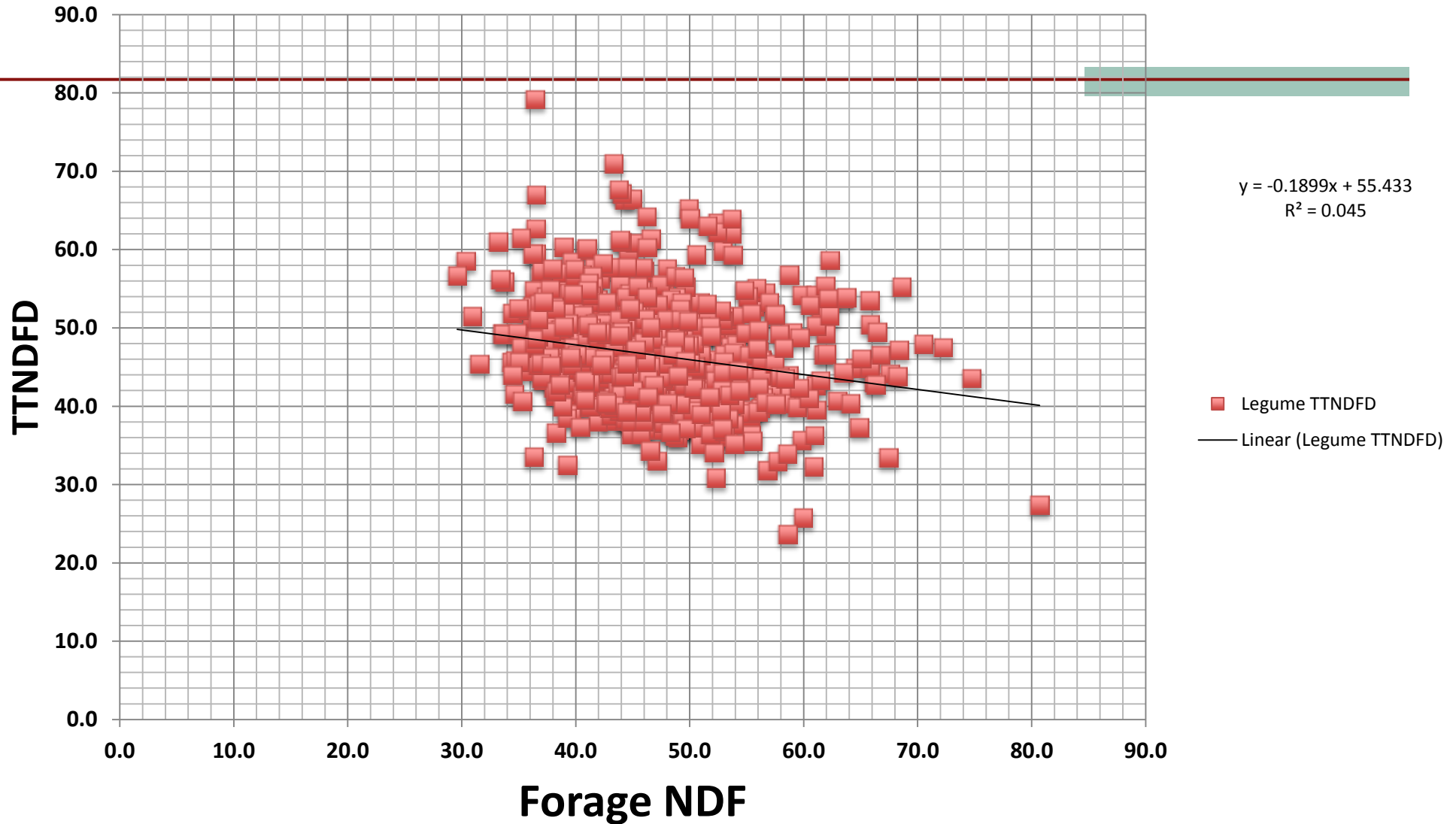


## Performance of Two Methods Estimating Rate of Digestion for Alfalfa

Method	Mean	Median	Minimum	Maximum
Lag time + 1 digestion point	4.27	4.17	1.37	10.36
3 Digestion points	4.10	3.75	0.89	15.62

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- Using rate of digestion and rate of passage, total tract digestibility can be calculated
  - This allows approximation of forage use the more closely approximated actual in vivo animal values.
  - This allow estimation of forage use in different animal types.

# Legume TTNDFD



# Summary

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- In vivo digestion of forage is gold standard
- In vitro digestion of forage has 80 to 90% correlation with in vivo digestion
- Rate of digestion can now be estimated for forages using NIR for multiple time points
- Using digestion rate and rate of passage, total tract digestibility can be estimated