Ground Cover Impacts on Nitrogen, Sediment, and Phosphorus Export from Simulated Rotational Grazing in Riparian Areas

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References

- Butler, D.M., D.H. Franklin, N.N. Ranells, M.H. Poore & J.T. Green Jr. 2006. Ground cover impacts on sediment and phosphorus export from manured riparian pasture. J. Environ. Qual. 35:2178-2185.
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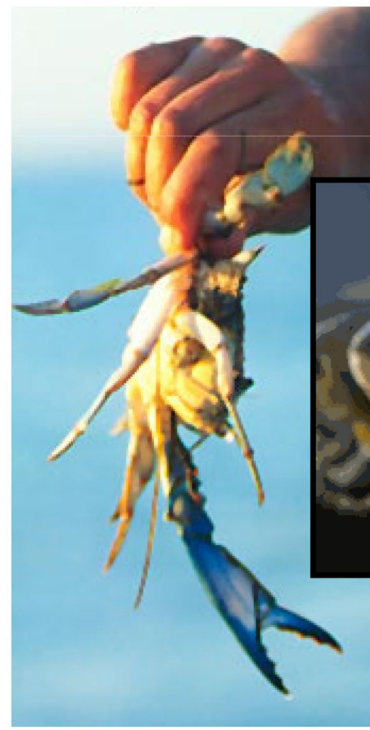
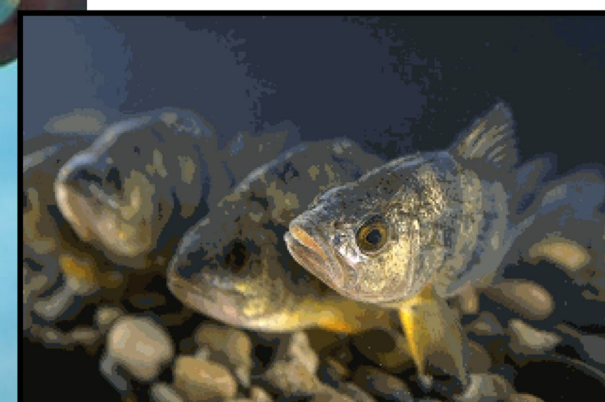
- Butler, D.M., N.N. Ranells, D.H. Franklin, M.H. Poore & J.T. Green Jr. 2008. Runoff water quality from manured riparian grasslands with contrasting drainage and simulated grazing pressure. Agric. Ecosyst. Environ. 126:250-260.

INTRODUCTION

- Nonpoint pollution of agricultural N & P
  - Ecological impact
    - Algal blooms
    - ↓ dissolved oxygen levels
    - Fish kills
    - ↓ in biodiversity
  - Economic and social impacts
    - Fisheries
    - Recreation/tourism
- Increased sediment
  - ↓ benthic organisms and fish
  - ↓ primary productivity





(Carpenter et al., 1998; Cooper, 1993)

RIPARIAN AREAS

- Transition areas between streams & uplands
- Riparian areas are often grazed
  - Less suitable for row crop production due to topography, seasonal flooding, hydrology
  - Perennial forages can be effective vegetative filter strips
  - Grazing an economical way to manage vegetation in these areas (e.g., manage weedy species, prevent succession to woody species)
  - Productivity can be high

(Images from: bayjournal.com, indiana.edu)

RIPARIAN AREAS

- Sovell et al. (2000) reported that rotational grazing may be a more effective conservation tool than wooded buffers for riparian areas in humid regions
  - Reduced turbidity and fecal coliform compared to continuous grazing
  - Reduced fine sediment compared to wooded buffer sites
  - Better physical bank condition than wooded sites
- Rotational grazing (an intermediate disturbance) may promote biodiversity and simulate historic ecosystem processes

GRAZING MANAGEMENT

- Riparian areas in humid regions may be able to be sustainably grazed for short time periods when environmental conditions are favorable, but there are concerns:
- Poor grazing management
  - Can lead to variable stand density, forage ground cover, and forage canopy height
  - Can lead to formation of heavy use areas (compacted, little vegetation, high nutrient concentrations)
  - Can negatively influence infiltration, runoff, erosion, filtering capacity and sediment deposition
  - Can reduce ecosystem services provided by riparian areas

(Alderfer and Robinson, 1947; McGinty et al., 1979; Self-Davis et al., 2003, Sovell et al., 2000)

GRAZING MANAGEMENT

- Manure (feces and urine) deposited in riparian zone could compromise the filtering capacity of grassed buffer strips
- Research indicates greater runoff & sediment loss when ground cover < 70%
- Data needed on percentage forage ground cover needed to help protect water quality when riparian areas are grazed

(Costin, 1980; Lang, 1979; Mwendera and Saleem, 1997)

OBJECTIVES

- Determine relationships between ground cover in riparian pastures and the export of sediment, N and P during rainfall events
- Variables
  - Ground cover
  - Site (slope, vegetation, and soil type differences)
  - Timing of rainfall following manure deposition

EXPERIMENTAL DESIGN

Experiment 1

- Existing tall fescue/ dallisgrass
- Slope ~10%; Appling sandy loam (Ultisol)
- Groundcover: 95%, 70%, 45%, and 0% (compacted /simulated lounging); 4 replicates

Experiment 2

- Existing tall fescue/ dallisgrass
- Slope ~20%; Wedoweee sandy loam (Ultisol)
- Groundcover: 95%, 70%, 45%, and 0% (compacted /simulated lounging); 4 replicates

Experiment 3

- Native wetland species, primarily rushes, sedges, brambles, and other forbs
- Slope ~ 10%; Wehadkee sandy loam (Inceptisol)
- Groundcover: 95% and 0% (compacted /simulated lounging); 4 replicates

Lake Wheeler Road Field Lab, Raleigh, NC

TALL FESCUE/ DALLISGRASS PLOTS

0%, compacted

70%

95%

45%

Photos from 11 Apr 2003
Plots 2 m by 0.75 m

PERCENT CANOPY COVER

Target Basal Cover Level	APR	MAY	JUN	SEP	OCT
	Measured Canopy Cover (%)				
0% (Bare)	0 a	0 a	0 a	0 a	0 a
45% (Low)	63 b	65 b	78 b	75 b	78 b
70% (Med)	76 c	78 c	83 c	80 c	80 b
95% (High)	94 d	95 d	98 d	92 d	83 b

WETLAND VEGETATION PLOTS

- Pickerelweed *(Pontederia cordata)*
- Showy goldenrod *(Solidago erecta)*
- Japanese honeysuckle *(Lonicera japonica)*
- Arrowleaf tearthumb *(Polygonum sagittatum*
- Leathery rush *(Juncus coriaceus)*

TIMELINE

- Rainfall Simulations
  - Baseline rainfall in Apr
  - Rainfall simulations in May, June, Sept, & Oct
  - 70 mm hr^{-1} for 1 hour
- Manure application
  - Feces: 2.5 kg; Urine: 1 L
  - Applied in May & Sept just prior to simulated rain
  - ~ 4 cows ha^{-1} yr^{-1} application rate

FECES AND URINE APPLICATION

METHODS

- Simulated grazing(prior to rainfall)
  - Fescue plots harvested at 10 cm
  - Native plots harvested at 40 cm
  - Dry matter, total nitrogen (TN), total phosphorus (TP)
- Soil sampling (prior to rainfall)
  - Three soil cores collected at 0 to 5 cm depth
  - Inorganic N, Mehlich-3 P, moisture content

ANALYSES

- Runoff volume
- Total suspended sediment (TSS)
- Total Kjeldahl P (TKP)
- Dissolved reactive P (DRP)
- Nitrate-N (NO_3-N)
- Ammonium-N (NH_4-N)
- Total N (TN)

  TN=TKN + NO_3-N

N & P APPLICATION RATES

	Total N (kg N ha^{-1})	Total P (kg P ha^{-1})	WSP[a] (kg P ha^{-1})
Manure component in May			
Feces	31.4	7.7	2.1
Urine	73.3	1.1	NA[b]
Manure component in September			
Feces	26.0	5.6	2.4
Urine	73.3	0.8	NA
Feces total	57.4	13.2	4.6
Urine total	146.6	1.9	NA
Total applied	204.0	15.1	NA

[a] Water soluble phosphorus.
[b] Not applicable.

(Butler et al., 2008)

EFFECT OF SLOPE

- Significant main effect of slope only for sediment export
- Sediment export from bare ground and low cover was 2.5-fold greater at 20% slope

(30 min runoff; Butler et al., 2006)

SEDIMENT EXPORT

Site		Cover			
Slope	Soil	Bare	Low	Medium	High
		TSS export, kg ha^{-1}			
10% slope	Appling sandy loam	215a†	10.5a	5.88a	4.68a
20% slope	Wedowee sandy loam	562b	30.0b	7.11a	8.73a

† Means within columns followed by the same letter are not significantly different ($P > 0.05$).

(Rain event average, 30 min runoff; Butler et al., 2006)

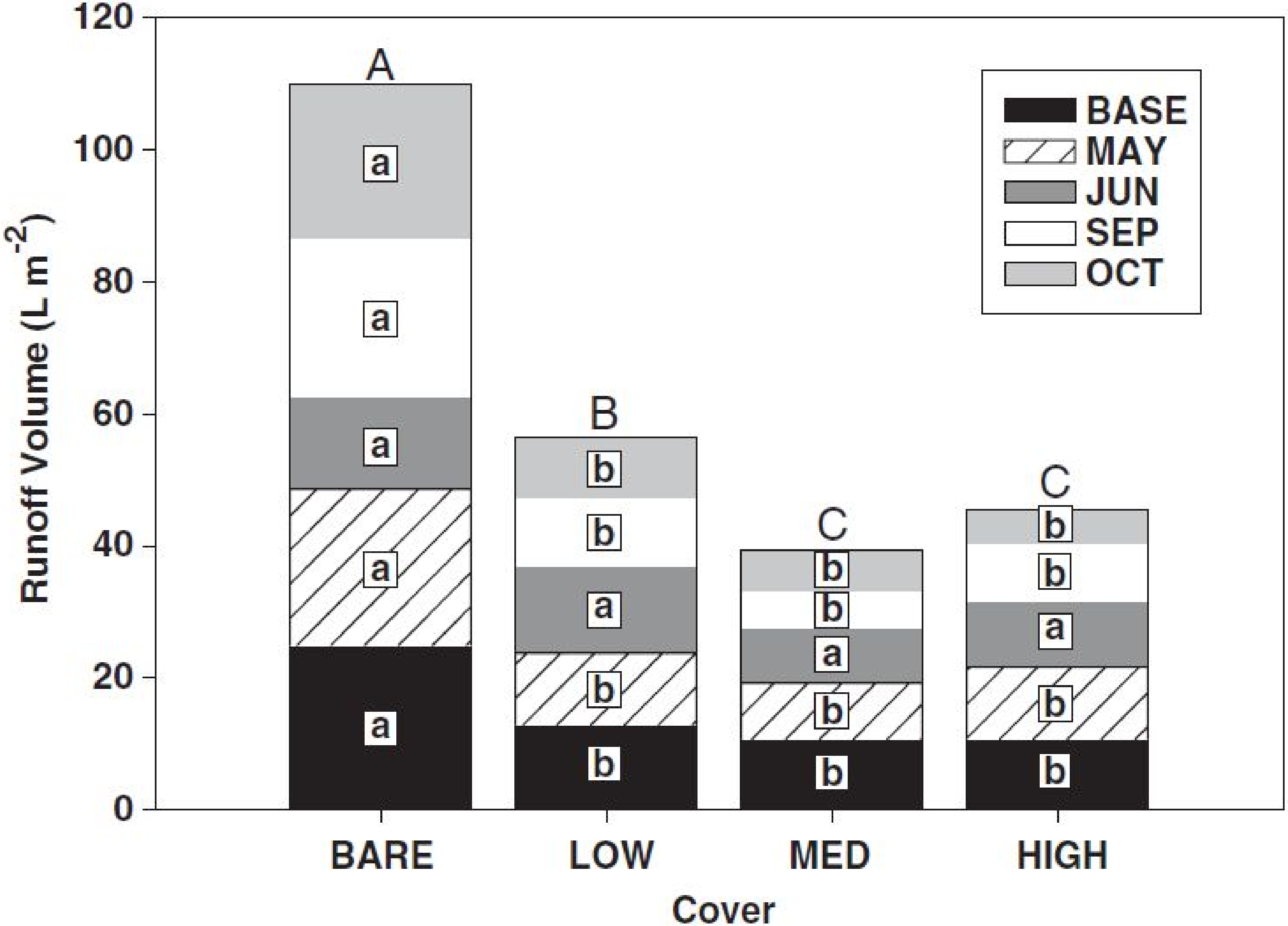
SEDIMENT EXPORT

95%

45%

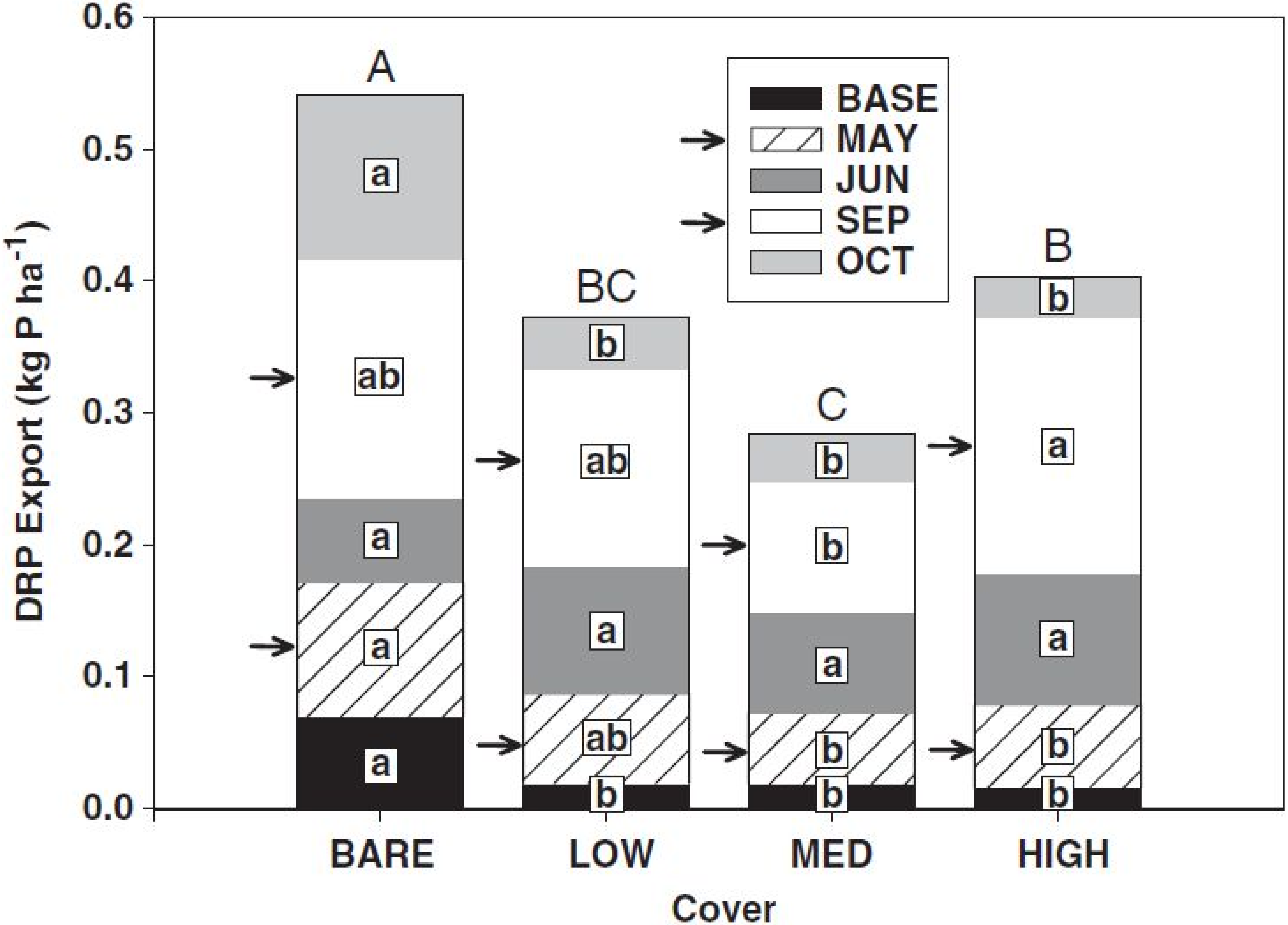
0%

RUNOFF VOLUME



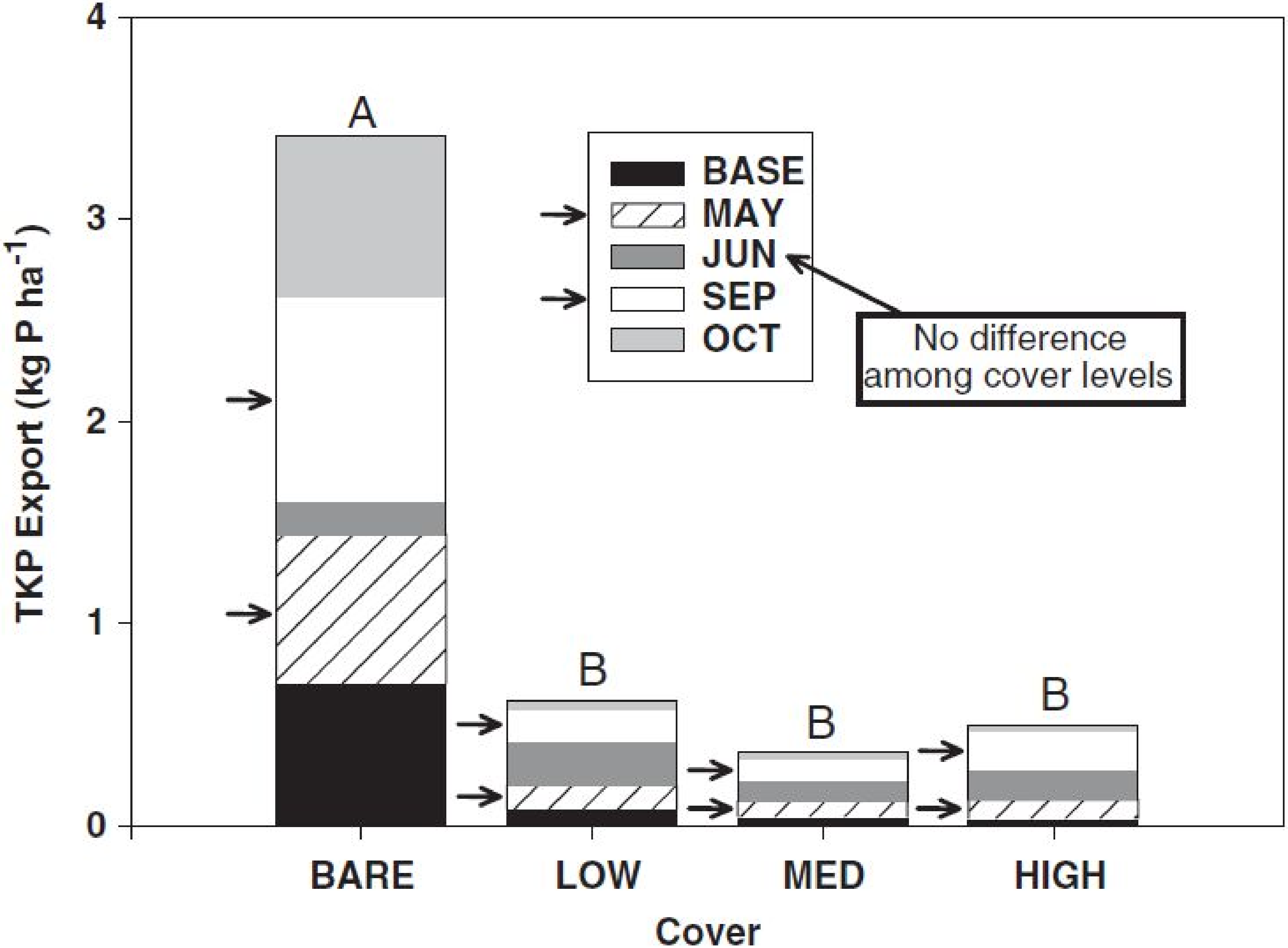
(30 min runoff; Butler et al., 2006)

DISSOLVED P EXPORT



(30 min runoff; Butler et al., 2006)

TOTAL P EXPORT



(30 min runoff; Butler et al., 2006)

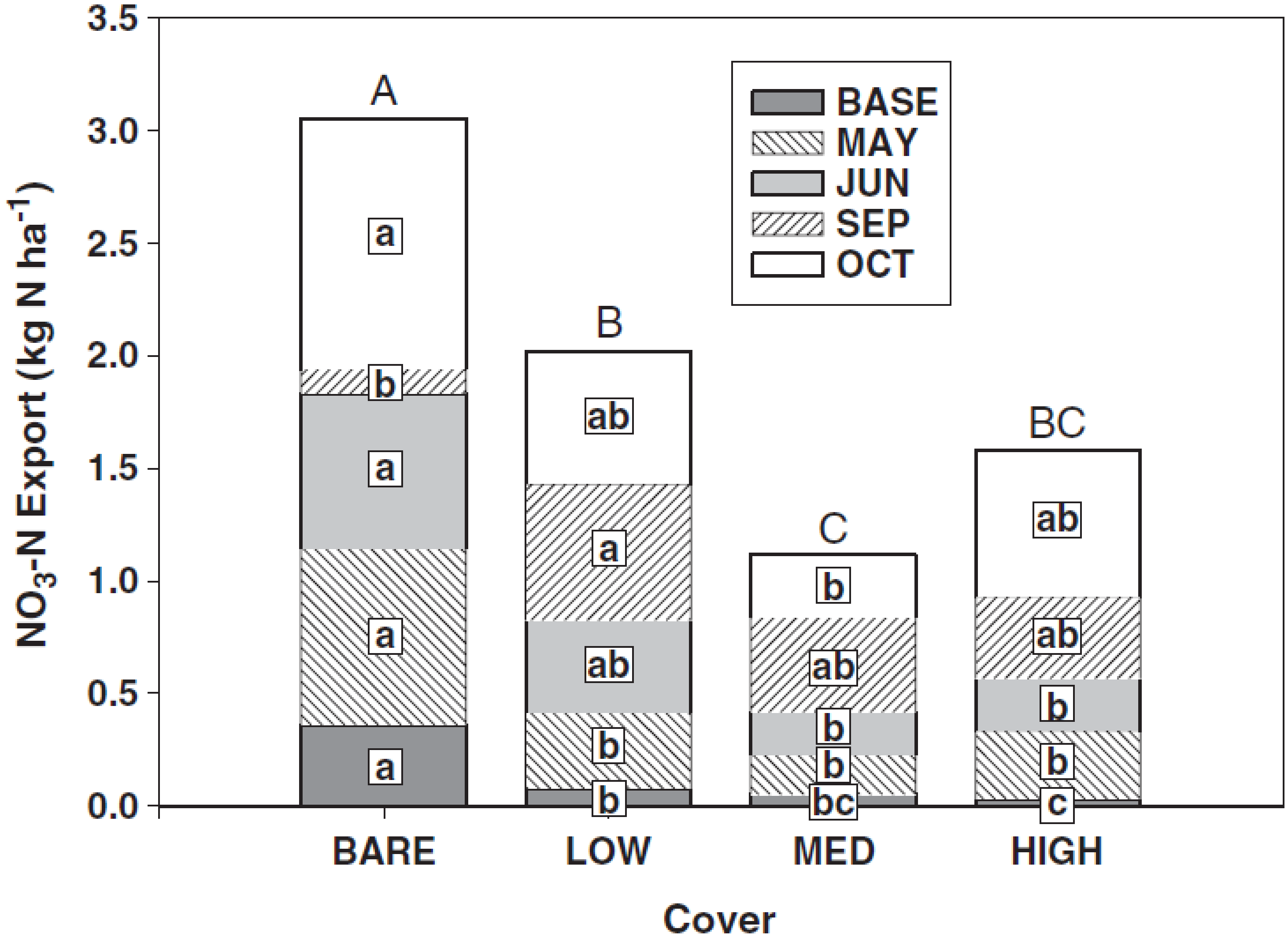
SOIL INORGANIC N

Cover	Soil inorganic N				
	Rain event				
	Base	May	June	Sept.	Oct.
	mg N kg^{-1}				
Bare	19.0	17.0a†	72.4a	55.0a	52.8a
Low	17.3	9.54b	15.7b	15.9b	13.2b
Medium	18.0	10.9b	19.4b	16.0b	15.8b
High	17.8	7.50b	23.0b	16.1b	16.4b

† Means in the same column followed by the same letter or no letters are not significantly different ($P > 0.05$).

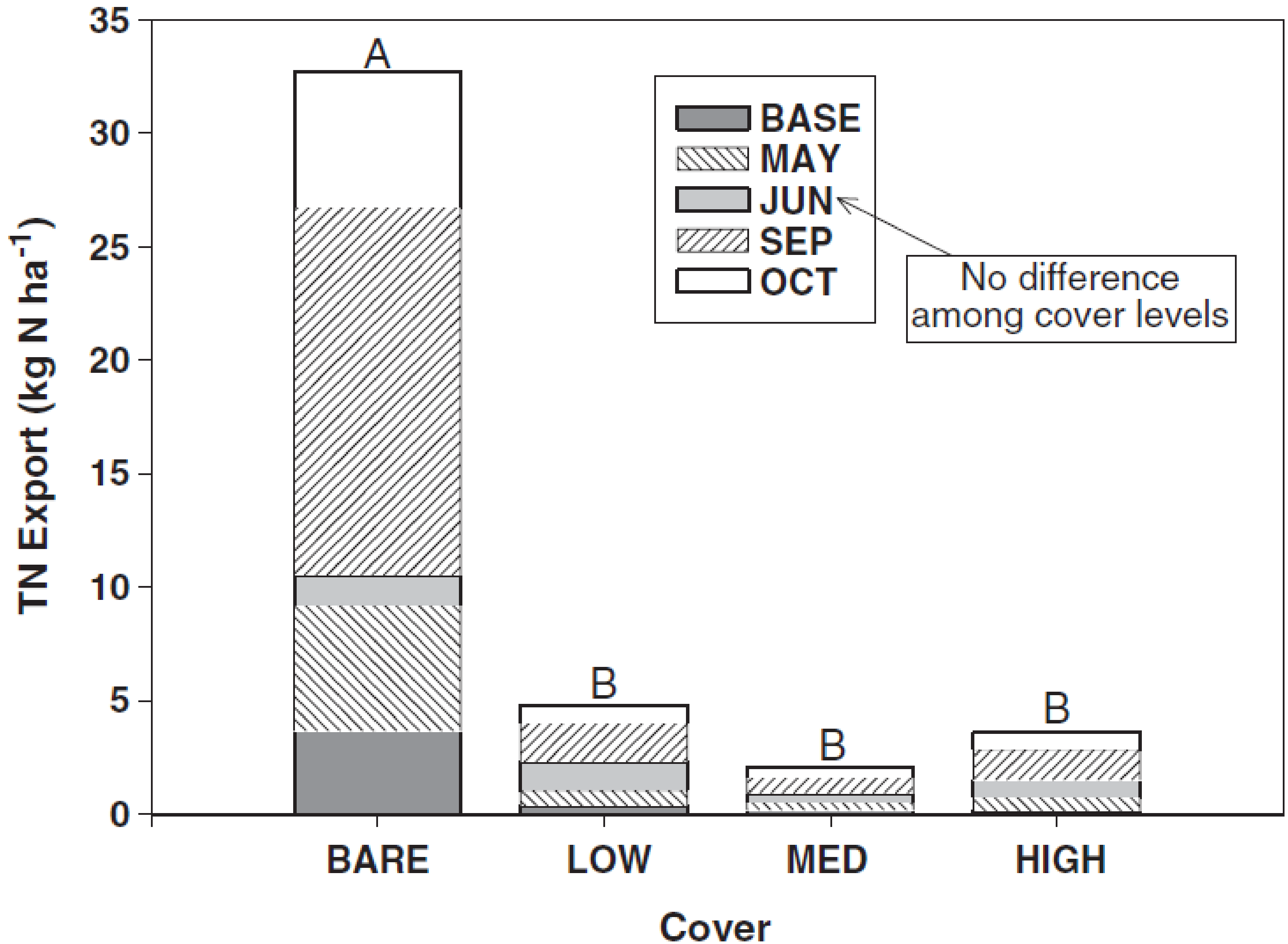
(30 min runoff; Butler et al., 2007)

NITRATE EXPORT



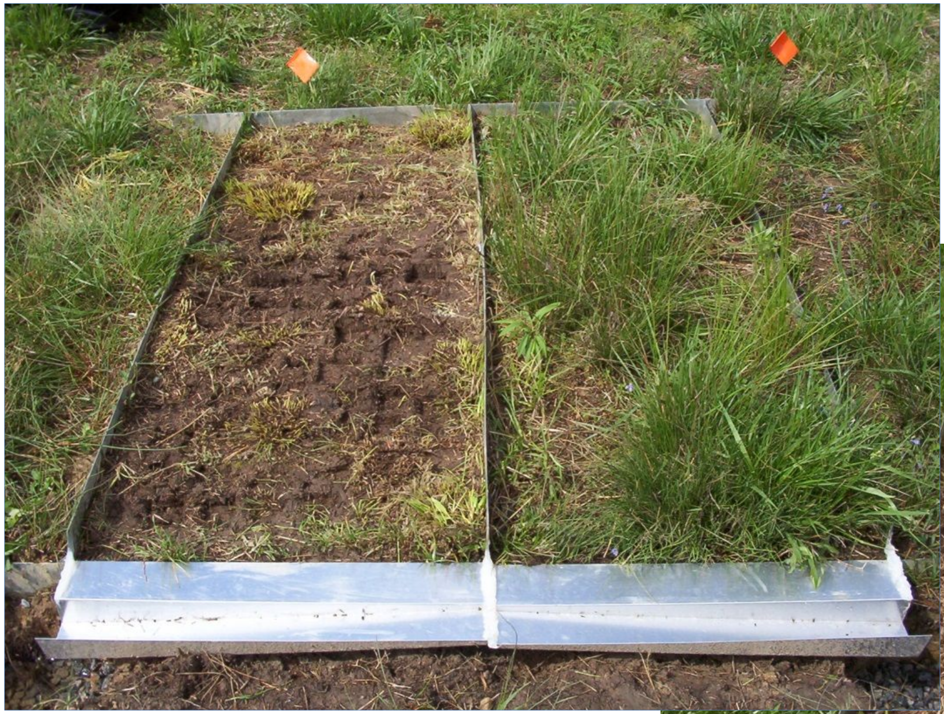
(30 min runoff; Butler et al., 2007)

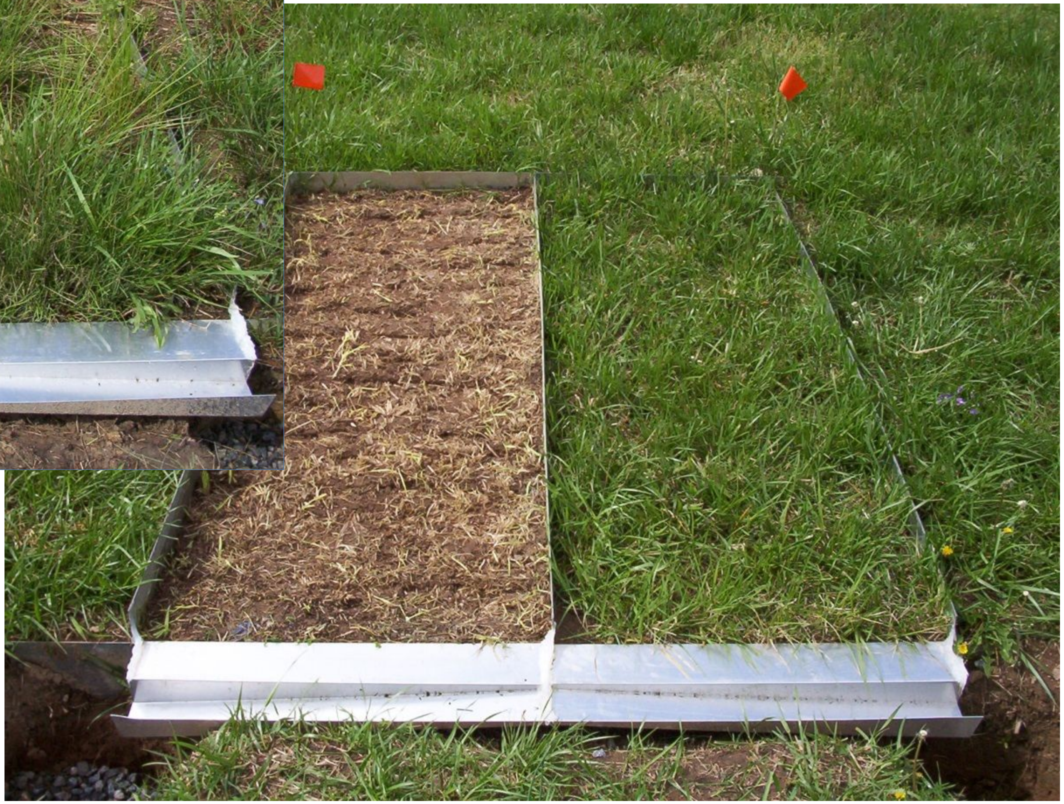
TOTAL N EXPORT



(30 min runoff; Butler et al., 2007)

VEGETATION/SOIL TYPE EFFECTS





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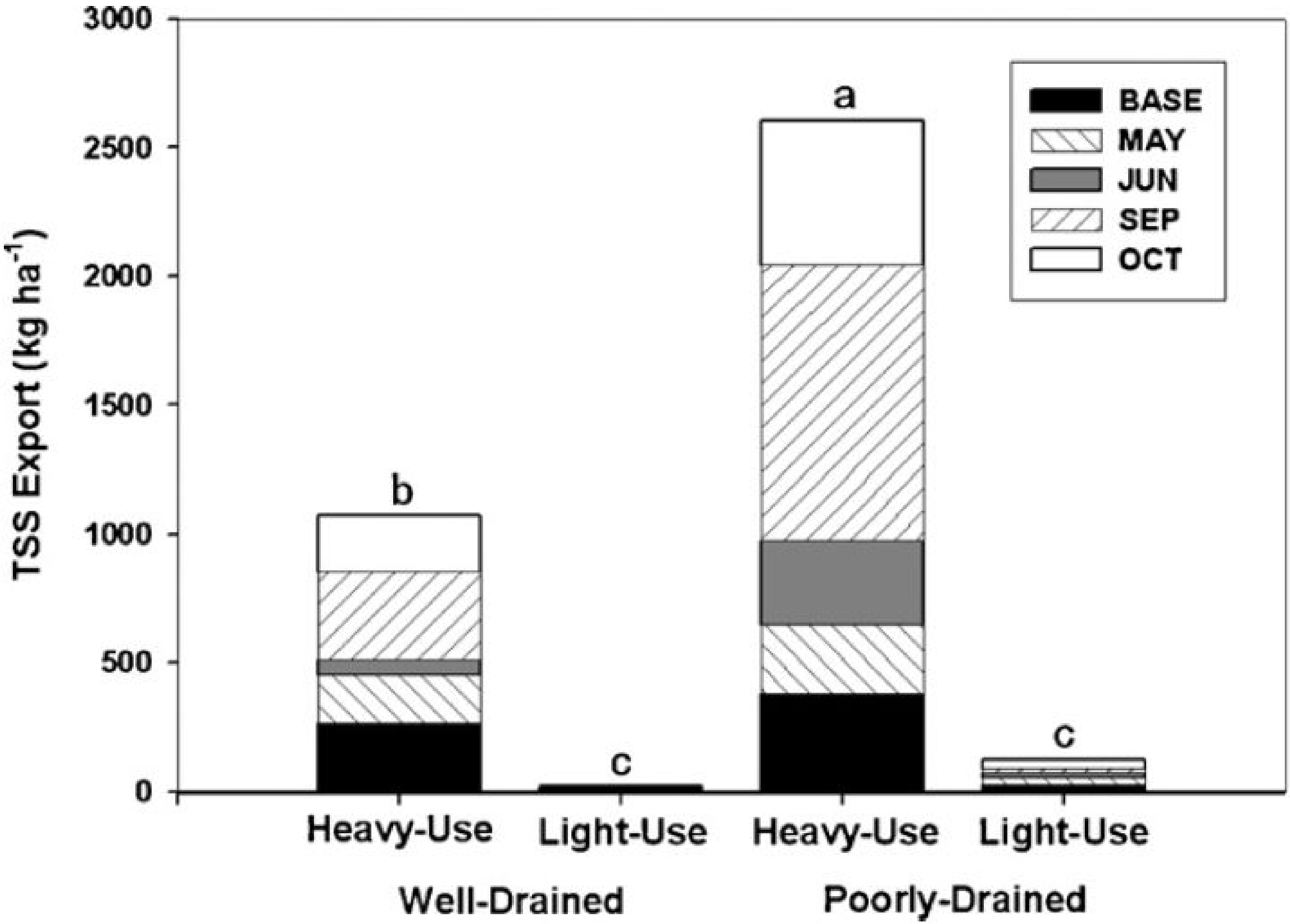
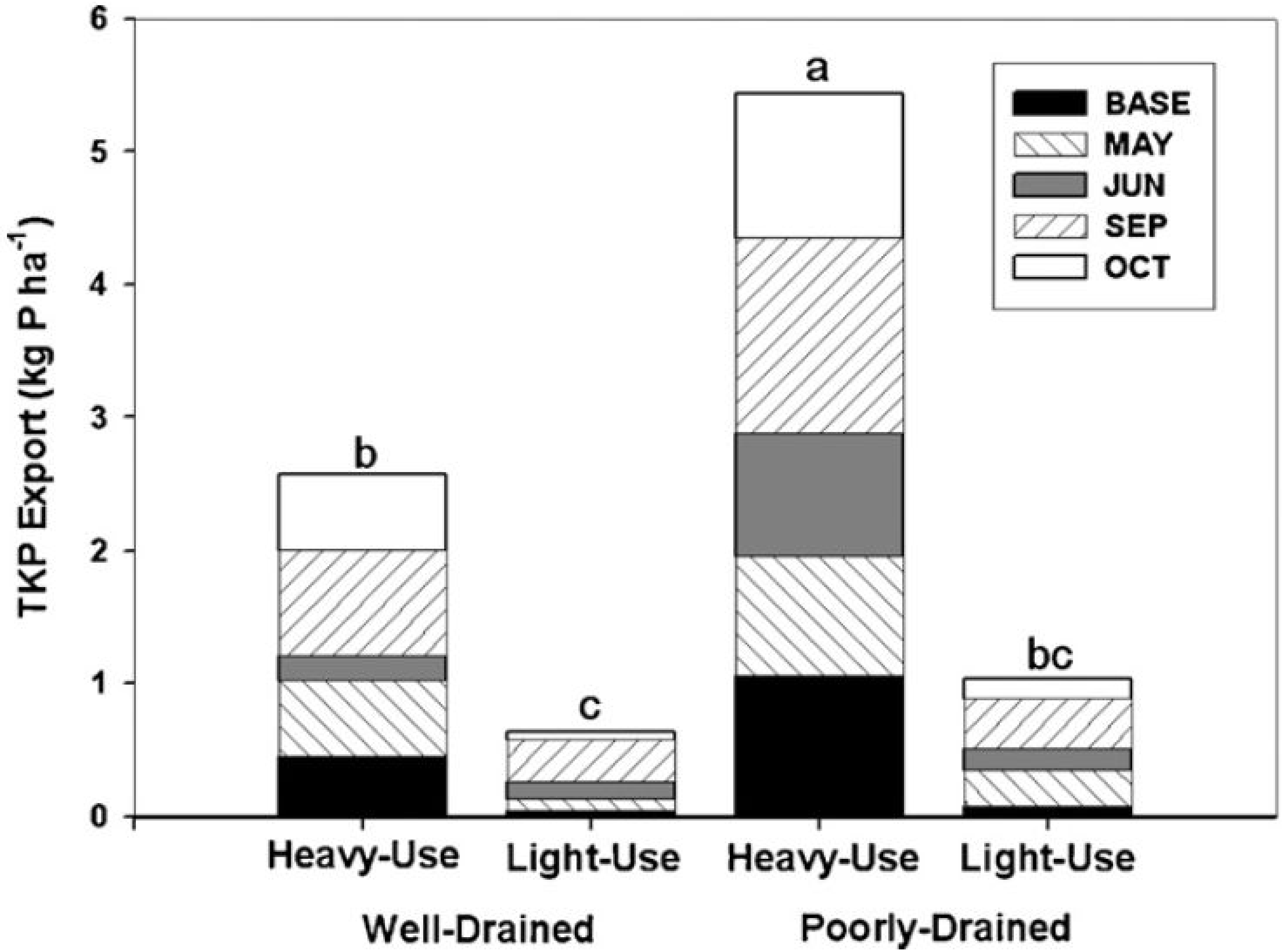


(30 min runoff; Butler et al., 2008)

SEDIMENT EXPORT

TOTAL P EXPORT



(30 min runoff; Butler et al., 2008)

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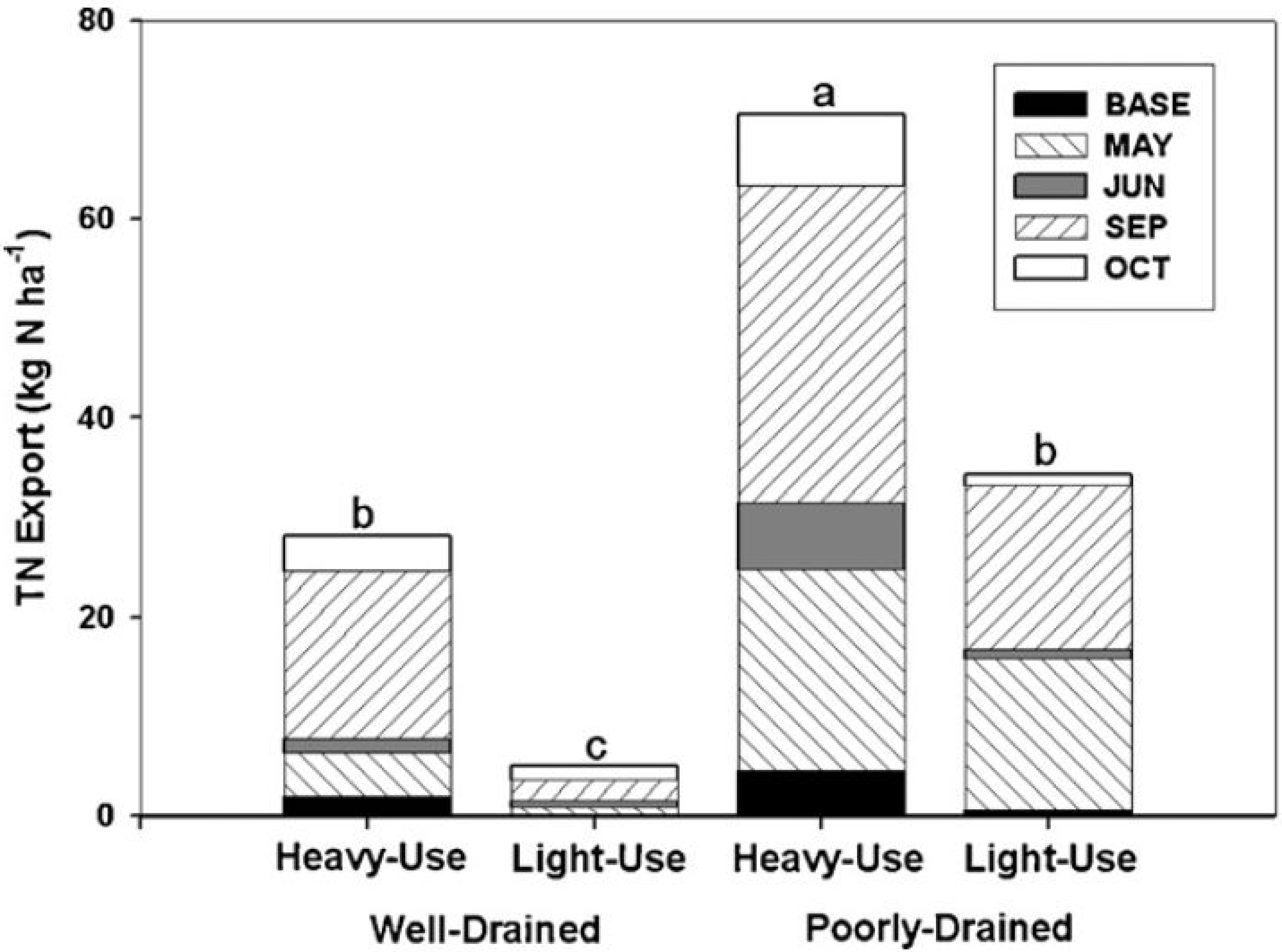

(30 min runoff; Butler et al., 2008)

CONCLUSIONS

- Cattle feces & urine in riparian areas can contribute nutrients to surface waters, but good cover can minimize impact
  - 45% cover (~65% canopy cover) similar to 70% & 95% cover for reducing nutrient export from cattle feces and urine in well-drained soils
- Timing of rainfall in relation to manure deposition is an important factor
  - Greater export of DRP and NH_4-N immediately after deposition
  - Runoff nitrate is less affected by timing

CONCLUSIONS

- Lounging or heavy use areas in the riparian zone can export significant amounts of sediment & nutrients
- Maintaining cover can help minimize impact of riparian grazing to surface waters
  - Rotational grazing systems which minimize livestock time near surface waters and maintain cover may be an effective management strategy
- More work is needed to evaluate management of these systems at the farm-scale for stream water quality impacts