

**CONTESTANT NO. \_\_\_\_\_**

**2018 UNDERGRADUATE RANGE MANAGEMENT EXAM**

**Society for Range Management**

**Sparks, Nevada  
January 29, 2018**

**Instructions**

**This examination consists of 95 multiple choice questions. Choose the one best answer for each question and fill in the appropriate circle on the scantron answer sheet provided.**

**Put your assigned contestant number on this examination booklet. Put your name and contestant number on the scantron answer sheet.**

**Length of Testing Period**

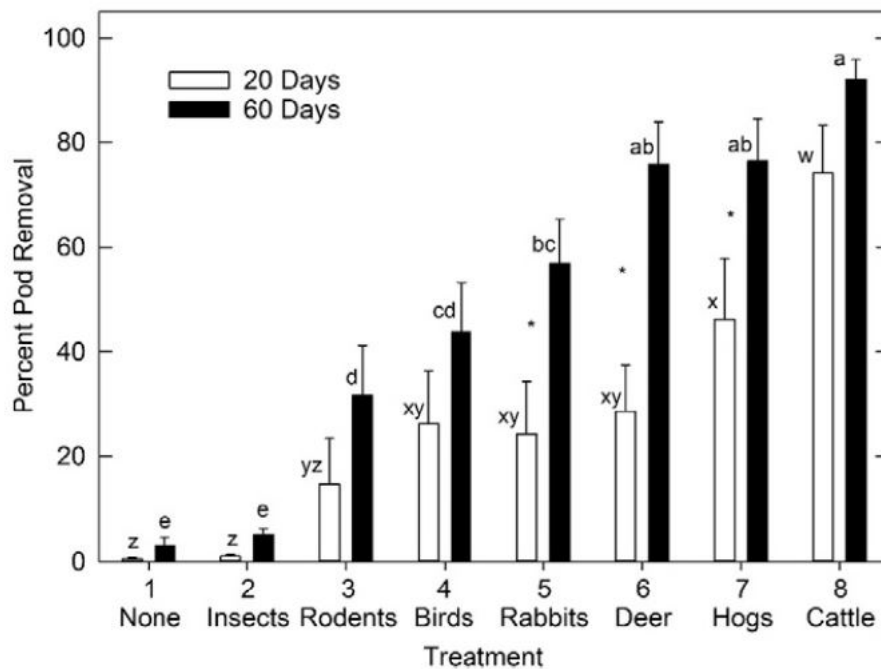
**120 Minutes**

**Grading**

**The entire examination is worth 300 points.**

## I. RANGE ECOLOGY (60 points)

For questions 1 and 2, please use the following figure (Ansley et al. 2017 REM)



**Figure 2.** Means of mesquite percent pod removal for each animal access treatment at 20 and 60-day sample periods during pod removal trials when pooled over all locations and years ( $n = 12$ ). Vertical lines above bars are standard error. Means with similar letters within each sample period are not significantly different at  $P \leq 0.05$ . Asterisk indicates significant ( $P \leq 0.05$ ) difference between days within an animal treatment.

1. **(4pts)** Mesquite percent pod removal differed between the 20 and 60 days for:
  - a. The insects and rodents treatments.
  - b. The cattle treatment.
  - c. The birds treatment but not the rabbits treatment.
  - d. The deer and hogs treatments.
  
2. **(4pts)** Mesquite percent pod removal:
  - a. Was consistently greater for the cattle treatment than the other treatments for both sampling dates.
  - b. Did not differ among the rabbits, deer and hogs treatments for either sampling date.
  - c. Differed between the rodents and rabbits treatments at the 20 days date but not at the 60 days date.
  - d. Differed between the insects treatment and the none (control) treatment for both sampling dates.

3. The atmospheric concentration of carbon dioxide (CO<sub>2</sub>) prior to the Industrial Revolution was:
  - a. 270 ppm.
  - b. 350 ppm.
  - c. 400 ppm.
  - d. 550 ppm.
4. What are the primary strategies that plants have evolved to cope with disturbances such as herbivory on rangelands?
  - a. Grazing tolerance
  - b. Grazing avoidance
  - c. Grazing resilience
  - d. A and B
  - e. None of the above
5. Which is the correct order of hierarchy in the development of grasses?
  - a. Tillers > phytomers > plants
  - b. Phytomers < plants < tillers
  - c. Phytomers < tillers < plants
  - d. All of the above
  - e. None of the above
6. Which of the following statements is FALSE about warm-season grasses?
  - a. Are also called C3 grasses
  - b. Are also called tropical grasses
  - c. They have more cell wall content than cool-season grasses
  - d. They are generally less palatable than cool-season grasses
7. Which of the following compounds are considered to be part of the cell wall?
  - a. Cellulose and lignin
  - b. Hemicellulose and starch
  - c. Lipids and fructosans
  - d. All of the above
  - e. None of the above
8. Which of the following plant life forms can regrow from intercalary meristems following removal of photosynthetic material?
  - a. Trees
  - b. Shrubs
  - c. Forbs
  - d. Perennial grasses
  - e. All of the above

For questions 9 and 10, please use the following table (Wang et al. 2017 REM)

**Table 1**

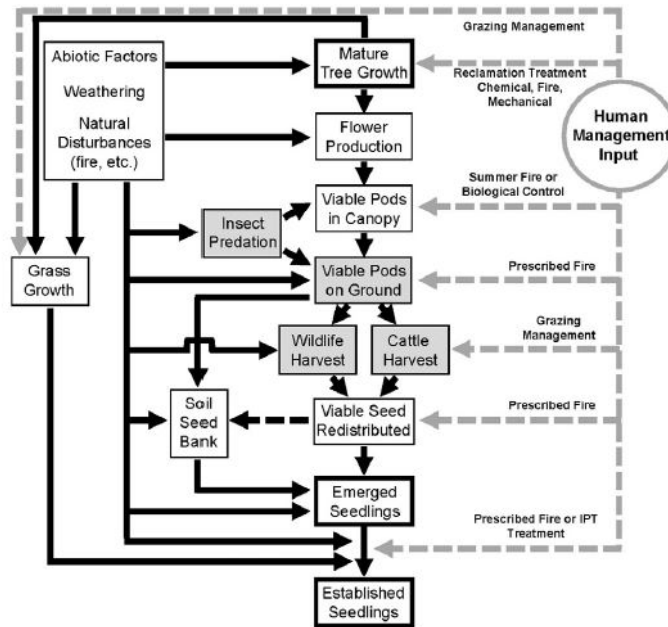
Tiller height, standing biomass, and tiller density at the ends of the 2002 and 2003 growing seasons, as well as soil organic matter and soil moisture at the end of the 2002 growing season, at five distances from the gate in the communal grazed grassland and the nature reserve. Different letters indicate the significant difference of distance from the gate on each variable at 0.05 level

	Yr	Distance from the gate (km)				
		1.5	2.1	2.5	3.1	3.5 (ungrazed control)
Tiller height (cm)	2002	6.9c	9.5c	13.7c	20.7b	36.0a
	2003	6.0d	8.4cd	14.5c	21.1b	31.6a
Standing biomass ( $\text{g m}^{-2}$ )	2002	9.8c	16.4c	79.4b	106.8b	283.8a
	2003	10.0c	21.1c	78.8b	98.8b	332.3a
Tiller density (tillers $\text{m}^{-2}$ )	2002	746d	691d	1872a	1360b	1078c
	2003	563b	666b	1363a	1155a	1232a
Soil organic matter ( $\text{g kg}^{-1}$ )	2002	15.4b	19.5b	12.9b	14.7b	25.3a
Soil moisture (%)	2002	4.4b	7.16b	11.9a	15.0a	13.6a

9. **(4pts)** Which of the following statements is most correct?
  - a. Tiller height in 2002 was unaffected by distance from the gate in the communal grazed grassland
  - b. Tiller density in 2002 was unaffected by distance from the gate in the communal grazed grassland
  - c. Tiller height in 2003 decreased as the distance from the gate in the communal grazed grassland increased.
  - d. Tiller density in 2003 differed between distances  $\leq 2.1$  km and  $> 2.1$  km from the gate in the communal grazed grassland
10. **(4pts)** As the distance from the gate in the communal grazed grassland increased (not including the ungrazed control):
  - a. Soil organic matter increases
  - b. Soil organic matter decreases
  - c. Soil moisture was greater at distances exceeding 2.1 km compared to distances 2.1 km or less.
  - d. Standing biomass was greater at distances exceeding 2.1 km compared to distances 2.1 km or less in both 2002 and 2003.
  - e. Both C and D
11. \_\_\_\_\_ is all of the animal life in a particular region.
  - a. Flora
  - b. Fauna
  - c. Benthic
  - d. Habitat

12. The primary distinction between nutrient and energy dynamics in rangeland ecosystems is:
- Nutrients cycle slow whereas energy cycles fast
  - Nutrients cycle fast whereas energy cycles slow
  - Energy flows slow whereas nutrients flow fast
  - Energy flows fast whereas nutrients flow slow
  - None of the above
13. Non-living factors in the environment such as the sun and rain are:
- Biotic
  - Abiotic
14. \_\_\_\_\_ is a group of individuals that belong to the same species and live in the same area.
- Population
  - Community
  - Taiga
  - Autotrophic
15. Which of the following is correct regarding ecological niche and habitat?
- An ecological niche is a set of particular activities, resources and strategies that a species explores to survive and reproduce
  - A habitat is the place where the species lives to explore its ecological niche.
  - A habitat is the set of all the ecosystems on the planet.
  - A and B
16. Which is the primary means by which autotrophic organisms obtain energy?
- Photosynthesis
  - Decomposition
  - Consumption
  - None of the above
17. **(4pts)** If there are 400 kilojoules of energy present at the producer level, how much of this energy would be transferred to the tertiary consumer level?
- 400 kilojoules
  - 40 kilojoules
  - 4 kilojoules
  - 0.4 kilojoules
  - Not enough information provided to answer this question
18. **(4pts)** The state of Nevada had an estimated human population of 2,890,845 persons in 2016 and 2,998,039 persons in 2017. Given this population growth rate, how many years will it take to double the population of Nevada?
- 19
  - 27
  - 53
  - Not enough information provided to determine an answer

For question 19, please use the following figure (Ansley et al. 2017 REM)



Flow chart depicting processes related to mesquite seedling establishment. Black solid lines indicate major processes; black dashed lines indicate probably processes. Gray dashed lines indicate human management activities that affect the process at different entry points.

19. (4pts) The flowchart depicts:

- that human management input is more influential on established seedlings compared to abiotic factors.
- that grazing management is more influential than prescribed fire regarding human management inputs on grass growth which affects the transition from emerged to established seedlings.
- that the natural disturbance associated with fire is more influential on established seedlings compared to prescribed fire with human management inputs.
- All of the above
- None of the above

20. Which of the following is correct regarding gross and net primary production?

- Net primary production is the quantity of organic matter found in a given area at a given period.
- Gross primary production is the net primary production minus the organic material consumed as an energy source in the metabolism of producers.
- Net primary production will always exceed gross primary production.
- All of the above
- None of the above

21. \_\_\_\_\_ species play a vital role in controlling the relative abundance of other species in a community.

- Pioneer
- Successional
- Keystone
- Edge

22. In a pyramid of numbers, in a grassland ecosystem, the largest population is that of:
- Producers
  - Tertiary consumers
  - Secondary consumers
  - Herbivores
  - Primary consumers
23. Habitat loss and fragmentation, over exploitation, alien species invasion, and co-extinction are causes for:
- Population exploitation
  - Migration
  - Ecological succession
  - Biodiversity loss

## II. GRAZING MANAGEMENT (50 points)

24. (4pts) If you manage a grazing system with 12 paddocks and the grazing period in each paddock is 5 days, how long does it take to complete one rotation through all the paddocks, and what is the rest period?
- 60, 5
  - 55, 5
  - 60, 55
  - 55, 60

For question 25, please use the following table (Leonard et al. 2017 REM)

**Table 2**

Bison diet selection index (mean  $\pm$  standard error) for functional groups during the summer on Olson's Conservation Bison Ranch's, Pine River Ranch, Manitoba, Canada.

Taxonomical Group	Month		
	June	July	August
Browse	6.76 $\pm$ 2.97	7.45 $\pm$ 1.44	10.98 $\pm$ 2.20
Forb	-0.06 $\pm$ 0.10	0.92 $\pm$ 0.13	0.74 $\pm$ 0.13
Grass	0.19 $\pm$ 0.09	-0.45 $\pm$ 0.05	-0.18 $\pm$ 0.06
Rush	-0.92 $\pm$ 0.06	-0.95 $\pm$ 0.02	-0.85 $\pm$ 0.04
Sedge	-0.98 $\pm$ 0.01	-0.94 $\pm$ 0.01	-0.90 $\pm$ 0.03

25. (4pts) Which of the following statements is most correct regarding bison diet selection index?
- For browse, August values were significantly greater than June values.
  - For forb, June values were significantly less than either July or August values
  - For grass, July values were significantly greater than either June or August values
  - For rush, June values were significantly lower than August values
  - For sedge, July values were significantly different than August values.

26. Which of the following is correct regarding the differentiation of rest and deferment?
- Rest means a pasture is ungrazed for at least 18 consecutive months while deferment means a pasture is ungrazed until seed set for key species during the growing season.
  - Rest means a pasture is ungrazed for at least 12 consecutive months while deferment means a pasture is ungrazed until seed set for key species during the growing season.
  - Deferment means a pasture is ungrazed until seed set for key species during the growing season while rest means a pasture is ungrazed for at least part of the current growing season.
  - Deferment means a pasture is ungrazed until seed set for key species during the growing season while rest means a pasture is ungrazed for at least 24 consecutive months.
27. Palatability is the interrelationship between a food's flavor and its post-ingestive feedback from nutrients and toxins, determined by:
- an animal's physiological condition
  - an animal's experiences with the food
  - a food's chemical characteristics
  - all of the above
  - none of the above

For questions 28 and 29, please use the following table (Borroum et al. 2017 REM)

**Table 3**

Average salt cedar intake ( $\text{g} \cdot \text{kg}^{-1} \text{ BW}$ ) when salt cedar was fed three times daily

Breed	Time		
	Morning	Noon	Afternoon
Rambouillet	$6.5 \pm 0.4$	$6.2 \pm 0.4$	$6.3 \pm 0.4$
Suffolk	$6.8 \pm 0.4$	$6.9 \pm 0.4$	$7.0 \pm 0.4$

28. (4pts) Which of the following statements is most correct?
- For the Rambouillet breed, salt cedar intake was significantly less at noon compared to the morning feeding time.
  - For the Suffolk breed, salt cedar intake was significantly greater in the afternoon compared to the morning feeding time.
  - For the Rambouillet breed, salt cedar intake was significantly less in the afternoon compared to the morning feeding time.
  - All of the above
  - None of the above
29. (4pts) Which of the following statements is most correct regarding time of feeding?
- Breed was a significant influence in salt cedar intake with a morning feeding.
  - Breed was a significant influence in salt cedar intake with a noon feeding.
  - Breed was a significant influence in salt cedar intake with an afternoon feeding.
  - All of the above
  - None of the above



For questions 30 and 31, please use the following table (Clark et al. 2017 REM)

**Table 5**

Least-squares means and 95% confidence limits from a mixed model of cattle daily travel distance (km) responses for each treatment by month combination, averaged across 5 study years (2008-2012).

Treatment Level	Months	LS <sup>†</sup> Means	Lower CL	Upper CL
		-----km per day-----		
Control	June	14.2 <sup>ab</sup>	13.2	15.2
	July	14.7 <sup>a</sup>	13.7	15.7
	August	14.0 <sup>abc</sup>	13.0	15.0
	September	13.5 <sup>abcd</sup>	12.4	14.5
	October	12.2 <sup>bcde</sup>	11.2	13.2
Impact	June	10.2 <sup>e</sup>	9.20	11.2
	July	11.8 <sup>cde</sup>	10.8	12.8
	August	11.9 <sup>bcde</sup>	10.9	12.9
	September	11.5 <sup>de</sup>	10.5	12.5
	October	11.4 <sup>de</sup>	10.3	12.4

<sup>†</sup> Least-squares means with different letter codes were significantly different at the 0.05 alpha level.

30. (4pts) Which of the following statements is most correct?

- Within the control treatment level, cattle daily travel distance was greater in June compared to October.
- Within the control treatment level, cattle daily travel distance was similar for August and September.
- Within the impact treatment level, cattle daily travel distance was greater in June compared to October.
- Within the impact treatment level, cattle daily travel distance was greater in August compared to September.

31. (4pts) Which of the following statements is most correct?

- For June, cattle daily travel distance was greater in the control versus the impact treatment level.
- For July, cattle daily travel distance was greater in the impact versus the control treatment level.
- For August, cattle daily travel distance was greater in the impact versus the control treatment level.
- For September, cattle daily travel distance was greater in the control versus the impact treatment level.
- For October, cattle daily travel distance was greater in the impact versus the control treatment level.

For question 32, please use the following table (Mosley et al 2017 REM)

**Table 3**

Sulfur cinquefoil dry matter (DM) intake ( $\pm$  SE) by supplemented and nonsupplemented yearling ewes grazing in late June or mid-July 2009 or 2010 ( $n = 3$  paddock replicates treatment<sup>-1</sup> mo<sup>-1</sup> yr<sup>-1</sup>) on sulfur cinquefoil – infested rangeland in northwestern Montana

Treatment	Month		Mean
	June	July	
	(kg DM sheep <sup>-1</sup> d <sup>-1</sup> ) <sup>1,2</sup>		
Supplemented	0.56 (0.1) aA	1.01 (0.2) bA	0.78 (0.1) A
No supplement	0.62 (0.2) aA	1.01 (0.2) bA	0.82 (0.1) A
Mean	0.59 (0.1) a	1.01 (0.1) b	

<sup>1</sup> Means within rows with the same lowercase letter are not different ( $P > 0.10$ ).

<sup>2</sup> Means within columns with the same uppercase letter are not different ( $P > 0.10$ ).

32. (4pts) Which of the following statements is most correct regarding sulfur cinquefoil dry matter intake by sheep?
- Supplement influenced intake in June.
  - Supplement influenced intake in July.
  - June intake was greater than July intake for supplemented but not for no supplement treatment sheep.
  - July intake was greater than June intake for supplemented and no supplement treatment sheep.
33. A hind-gut fermenter's digestive system can acquire energy from which of the following plant parts?
- Cellulose
  - Cell contents
  - Mast
  - All of the above
  - None of the above
34. Which of the statements is correct?
- Hind-gut fermenters rely on microbes to digest lignin
  - Ruminants rely on microbes to digest lignin
  - Hind-gut fermenters, but not ruminants, rely on microbes to digest cellulose
  - Ruminants, but not hind-gut fermenters, rely on microbes to digest cellulose
  - None of the above
35. Which rangeland plant part generally contains the highest fat concentration?
- Leaves
  - Stems
  - Bark
  - Mast

For questions 36 and 37, please use the following table (Montes-Sanchez et al. 2017 REM)

**Table 2**

Proportion of grazing events recorded and the correlation coefficients ( $r$ ) for those events between ewes and their respective lambs.

Grazing event <sup>1</sup>	Proportion (minimum-maximum)		<i>r</i>	<i>P</i> value
	Ewes	Lambs		
Supplemented sheep				
Total	0.40-0.74	0.36-0.97	0.58	0.0124
Medusahead	0.00-0.12	0.00-0.11	0.83	<0.0001
Other annual grasses	0.00-0.03	0.00-0.04	0.62	0.0059
Bunch grasses	0.23-0.50	0.26-0.67	0.52	0.0269
Forbs	0.07-0.28	0.06-0.25	0.33	0.1762
Nonsupplemented sheep				
Total	0.39-0.79	0.47-0.93	0.72	0.0008
Medusahead	0.01-0.12	0.00-0.10	0.83	<0.0001
Other annual grasses	0.00-0.02	0.00-0.03	0.24	0.3359
Bunch grasses	0.27-0.50	0.31-0.69	0.70	0.0013
Forbs	0.07-0.20	0.05-0.17	−0.08	0.7484

Eighteen ewes with their offspring were clustered into 6 groups, and they received an energy-rich supplement in the morning (supplemented ewes grazing with their offspring). A control group of 18 ewes clustered into 6 groups did not receive the supplement (nonsupplemented ewes grazing with their offspring).

<sup>1</sup> The proportion of grazing events was calculated from observations during 3.5 h of scan sampling (from 0830 to 1100 and from 1600 to 1700) during 6 d.

36. (4pts) Which of the following statements is most correct regarding correlation of the proportion of grazing events between ewes and their lambs?
- When supplemented, significant correlations were observed for total grazing events, and grazing events on medusahead and other annual grasses.
  - When supplemented, non-significant correlations were observed for bunch grasses and forbs.
  - When nonsupplemented, significant correlations were observed for total grazing events, and grazing events on medusahead and other annual grasses.
  - When nonsupplemented, non-significant correlations were observed for bunch grasses and forbs.
37. (4pts) Supplementation altered the correlation of the proportion of grazing events between ewes and their lambs for:
- Total grazing events
  - Medusahead
  - Other annual grasses
  - Bunch grasses
  - Forbs

For question 38, please use the following table (Leonard et al. 2017 REM)

**Table 3**

Forage availability and bison diet use percentages (mean  $\pm$  standard error) in South and North Sclater pastures for August 2015 on Olson's Conservation Bison Ranch's, Pine River Ranch, Manitoba, Canada.

Taxonomical Group	South Sclater		North Sclater	
	Available	Use	Available	Use
Grass	66.27 $\pm$ 3.31	34.54 $\pm$ 3.64	53.03 $\pm$ 4.21	55.24 $\pm$ 3.94
Forb	23.42 $\pm$ 1.50	44.86 $\pm$ 3.53	17.71 $\pm$ 1.41	25.31 $\pm$ 2.58
Sedge	8.21 $\pm$ 3.89	1.69 $\pm$ 0.60	23.25 $\pm$ 3.77	2.07 $\pm$ 0.91
Rush	0.90 $\pm$ 6.10	0.84 $\pm$ 0.43	6.44 $\pm$ 1.30	0.54 $\pm$ 0.12
Browse	—	18.06 $\pm$ 3.88	—	16.84 $\pm$ 4.91

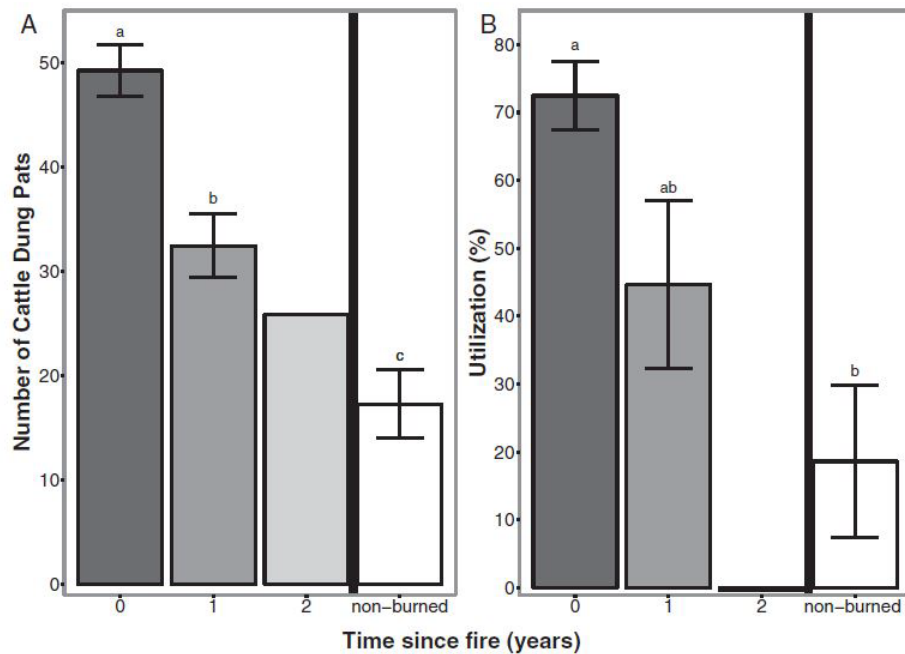
38. (4pts) Which of the following statements is most correct regarding bison preferences of taxonomical groups?
- Bison preferentially avoided grass at the South, but not North, Sclater site.
  - Bison preferentially selected forbs at both the South and North Sclater sites.
  - Bison preferentially avoided sedges at both the South and North Sclater sites.
  - All of the above
  - None of the above

## IIa. GRAZING MANAGEMENT PROBLEM (10 points) – See END OF TEST

## III. RANGE IMPROVEMENT (50 points)

39. (4pts) A herbicide sprayer has a 30-m spray width with an output of 25 liters per minute. How fast should the operator drive if the desired application rate is 140 liters per hectare?
- 2.2 km/hr
  - 2.9 km/hr
  - 3.6 km/hr
  - 5.2 km/hr
40. (4pts) How many kg of pure live seed are in a 255-kg sack of bulk seed with the following information: heterogenesis is 72%, purity is 82%, inert materials are 30% and germination is 67%?
- 40
  - 54
  - 101
  - 140

For question 41, please use the following figure (Powell et al. 2018 REM)



(A) Number of fresh cattle dung pats counted in nonburned and burned patches varying in time since fire (years) in the Northern Great Plains. Bars with different letters above them indicate significant differences ( $P < 0.05$ , Tukey's honestly significant difference test). Error bars represent one standard error. (B) Grazing utilization (%) for unburned and burned patches varying in time since fire (years). Only one burn was available at 2 yr since fire, shown here for comparison only and excluded from analysis.

41. (4pts) Which of the following statements is most correct regarding time since fire?
- Two lines of evidence (number of cattle dung pats and utilization) indicate that cattle preferentially select for the most recently burned areas.
  - Two lines of evidence (number of cattle dung pats and utilization) indicate that cattle preferentially select against the non-burned areas.
  - Number of cattle dung pats shows a stronger relationship with time since fire than utilization.
  - All of the above
  - None of the above
42. Which of the following economic analyses is most commonly used in range improvement projects?
- Benefit-cost
  - Rate of return
  - Trickle-down economics
  - Profitability



For questions 43 and 44, please use the following table (Bates et al. 2017 REM)

**Table 1**

Response variable *P* values from mixed-model analysis for the western juniper cutting study on Steens Mountain, southeast Oregon (1991 – 2016). Values in bold indicate significant treatment (Cut, Control) differences for main (treatment, year) effects and the interaction (treatment × year).

Response variables	Treatment	Yr	Treatment x Yr
<b>Standing crop (SC)</b>			
Perennial bunchgrass	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
<i>Poa secunda</i>	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
Total SC	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
<b>Yield</b>			
Perennial bunchgrass	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
<i>Poa secunda</i>	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
Invasive annual grass <sup>1</sup>	<b>0.007</b>	< <b>0.001</b>	< <b>0.001</b>
Perennial forb <sup>1</sup>	< <b>0.001</b>	< <b>0.001</b>	0.080
Annual forb <sup>1</sup>	< <b>0.010</b>	< <b>0.001</b>	< <b>0.001</b>
Total yield	< <b>0.001</b>	< <b>0.001</b>	< <b>0.001</b>
<b>Density</b>			
Perennial bunchgrass	< <b>0.001</b>	<b>0.020</b>	<b>0.029</b>
<i>Poa secunda</i>	0.093	0.071	0.489
Perennial Forb	<b>0.013</b>	<b>0.045</b>	0.718
Basin big sagebrush	<b>0.008</b>	0.585	0.487
Rabbitbrush	<b>0.026</b>	0.066	0.089
Other shrubs	<b>0.004</b>	0.506	0.534
Western juniper	0.318	0.540	0.277
<b>Woody Cover</b>			
Basin big sagebrush	<b>0.004</b>	0.919	0.638
Rabbitbrush	<b>0.023</b>	0.253	0.894
Other shrubs	<b>0.042</b>	0.934	0.588
Western juniper	< <b>0.001</b>	0.087	0.473

<sup>1</sup> Standing crop and yield are equivalent for invasive annual grass, perennial forb, and annual forb life-forms.

43. (4pts) Which of the following statements is most correct regarding treatment effects?
- Cutting vs. control effects on standing crop exhibited similar responses each year.
  - Cutting vs. control effects on density exhibited similar responses across years for basin big sagebrush and rabbitbrush.
  - Cutting vs. control effects on yield exhibited similar responses each year, except for perennial forb.
  - Cutting vs. control effects on woody cover exhibited non-similar responses each year for basin big sagebrush and rabbitbrush.
44. (4pts) Which of the following statements is most correct regarding year effects?
- Year affected standing crop with similar responses each year for perennial bunchgrasses, *Poa secunda*, and total standing crop.
  - Year effects on yield exhibited similar responses each year, except for perennial forb.
  - Year effects on density on density exhibited similar responses between treatments for basin big sagebrush and perennial forb.
  - Year effects were not existent for woody cover for any of the listed species.

For question 45, please use the following table (Stonecpher et al. 2017 REM)

**Table 2**

Biomass production ( $\text{kg} \cdot \text{ha}^{-1}$ ) of plant materials, seeded grass and weeds ( $\pm$  SE), for 2012 and 2013.

	-----2012-----		-----2013-----	
	Grass <sup>1</sup>	Weeds	Grass	Weeds
Control	0 $\pm$ 232 f	1254 $\pm$ 232 c	136 $\pm$ 232 e	1178 $\pm$ 232 c
Bozoisky II	105 $\pm$ 232 e	1481 $\pm$ 232 bc	139 $\pm$ 232 e	1301 $\pm$ 232 bc
Hycrest II	1455 $\pm$ 232 bc	562 $\pm$ 232 d	1181 $\pm$ 232 c	573 $\pm$ 232 d
Vavilov II	1797 $\pm$ 232 ab	429 $\pm$ 232 d	1229 $\pm$ 232 c	515 $\pm$ 232 d
Sherman	1940 $\pm$ 232 a	517 $\pm$ 232 d	1548 $\pm$ 232 abc	502 $\pm$ 232 d

<sup>1</sup> Means followed by different letters are significantly different ( $P < 0.05$ ).

45. (4pts) Which of the following statements is most correct regarding weed biomass?
- Bozoisky II reduced weed biomass in both 2012 and 2013.
  - Hycrest II was more effective at reducing weed biomass compared to Sherman in both 2012 and 2013.
  - Vavilov II was less effective at reducing weed biomass than Sherman in 2012 but not 2013.
  - Effectiveness of reducing weed biomass was similar among Hycrest II, Vavilov II and Sherman in both 2012 and 2013.
  - None of the above

For question 46, please use the following table (Stonecpher et al. 2017 REM)

**Table 3**

Biomass production ( $\text{kg} \cdot \text{ha}^{-1}$ ) of plant materials, seeded grass and weeds ( $\pm$  SE), for May and July combined over 2012 and 2013.

	-----May-----		-----July-----	
	Grass <sup>1</sup>	Weeds	Grass	Weeds
Control	124 $\pm$ 232 f	1070 $\pm$ 232 cd	12 $\pm$ 232 g	1362 $\pm$ 232 bc
Bozoisky II	123 $\pm$ 232 f	1270 $\pm$ 232 bcd	120 $\pm$ 232 f	1512 $\pm$ 232 ab
Hycrest II	971 $\pm$ 232 d	552 $\pm$ 232 e	1665 $\pm$ 232 ab	584 $\pm$ 232 e
Vavilov II	977 $\pm$ 232 d	502 $\pm$ 232 e	2049 $\pm$ 232 a	443 $\pm$ 232 e
Sherman	1554 $\pm$ 232 ab	532 $\pm$ 232 e	1935 $\pm$ 232 a	487 $\pm$ 232 e

<sup>1</sup> Means followed by different letters are significantly different ( $P < 0.05$ ).

46. (4pts) Which of the following statements is most correct regarding seasonal biomass production of grass and weeds?
- Bozoisky II biomass production was similar between May and July, but weed biomass in those plots was greater in July.
  - Hycrest II biomass production increased from May to July, whereas weed biomass in those plots was similar between the two months.
  - Vavilov II biomass production decreased from May to July, whereas weed biomass in those plots was similar between the two months.
  - Sherman biomass production was less in May compared to May, whereas weed biomass in those plots was similar between the two months.

For questions 47 and 48, please use the following table (Bombaci et al 2017 REM)

**Table 1**

Mean (standard of error) percent cover of vegetation and substrate characteristics measured in control and treatments plots in the first (2012) and second (2013) yr after mechanical woodland reduction treatments were applied.

% Cover	Control	Chain	Hydro-ax	Roller-chop
<i>2012</i>				
Bare soil	28.9 (5.0)	23.6 (4.7)	18.1 (3.5)	25.3 (3.9)
Litter	49.4 (4.9)	43.4 (3.3)	44.0 (4.5)	40.4 (4.0)
Slash	1.6 (0.5) <sup>CH,RC</sup>	32.5 (5.1) <sup>CO,HA</sup>	9.9 (1.1) <sup>CH,RC</sup>	26.9 (4.1) <sup>CO,HA</sup>
Mulch	0.8 (0.2) <sup>HA</sup>	2.1 (0.8) <sup>HA</sup>	21.9 (6.8) <sup>all</sup>	1.6 (0.3) <sup>HA</sup>
Trees	46.5 (7.0) <sup>all</sup>	0.0 <sup>CO</sup>	0.0 <sup>CO</sup>	0.0 <sup>CO</sup>
Shrubs	15.5 (4.8)	5.8 (3.1)	4.3 (2.5)	8.08 (3.5)
Grasses & herbs	0.3 (0.1)	0.2 (0.1)	0.1 (0.04)	0.2 (0.1)
<i>2013</i>				
Bare soil	17.2 (2.7)	22.0 (5.5)	15.5 (4.4)	26.3 (3.2)
Litter	66.5 (2.1) <sup>HA</sup>	56.1 (6.2)	37.0 (8.0) <sup>CO</sup>	46.9 (3.6)
Slash	3.8 (0.9) <sup>CH,RC</sup>	20.7 (5.8) <sup>CO,HA</sup>	5.1 (0.8) <sup>CH,RC</sup>	18.0 (2.1) <sup>CO,HA</sup>
Mulch	0.1 (0.1) <sup>HA</sup>	0.0 <sup>HA</sup>	36.3 (10.6) <sup>all</sup>	0.1 (0.1) <sup>HA</sup>
Trees	53.5 (6.3) <sup>all</sup>	0.0 <sup>CO</sup>	0.0 <sup>CO</sup>	0.0 <sup>CO</sup>
Shrubs	18.9 (7.2) <sup>all</sup>	2.2 (0.6) <sup>CO</sup>	2.2 (0.8) <sup>CO</sup>	2.3 (0.6) <sup>CO</sup>
Grasses & herbs	1.5 (0.2)	2.6 (0.2)	5.1 (2.3)	3.5 (0.5)

CH indicates chain; RC, roller-chop; CO, control; HA, hydro-ax.

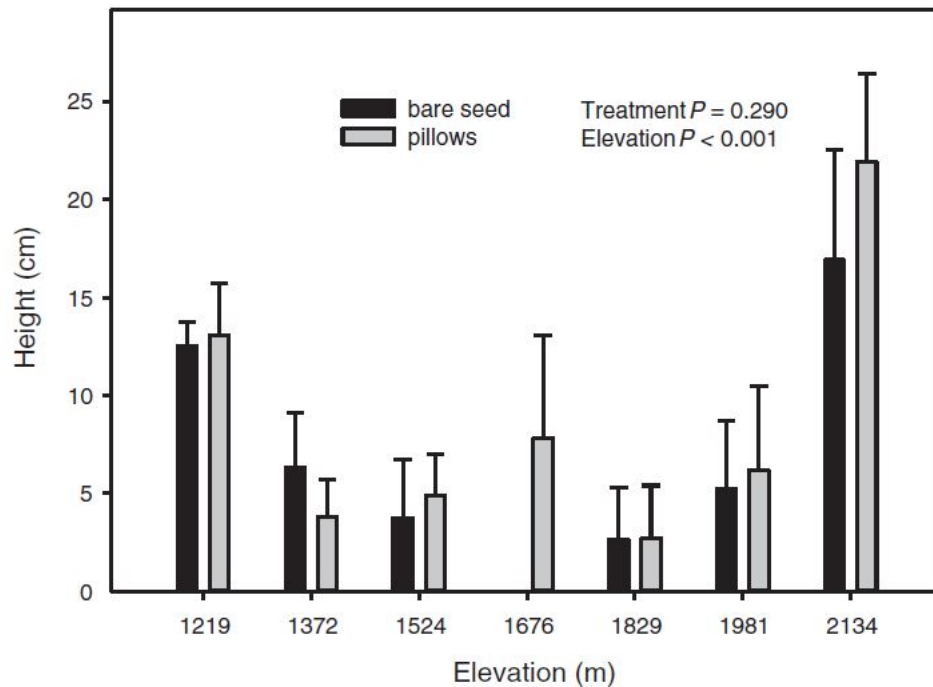
Superscripts indicate significant differences in mean percent cover (analysis of variance with Tukey honestly significant difference pairwise adjustment) between two or more treatment types.

47. (4pts) Which of the following statements is most correct regarding effects of mechanical woodland reduction treatments?
- Bare soil differed among treatments in 2012, but not 2013.
  - Litter did not differ among treatments in 2012, but the chain and roller chop treatments differed from the control treatment in 2013.
  - Mulch was significantly greater in the hydro-ax treatment compared to all other treatments in 2012, and in 2013.
  - Grasses and herbs increased across all treatments following the mechanical woodland reduction in 2012, and 2013.
48. (4pts) Which of the following statements is most correct regarding effects of chain, hydro-ax and roller chop treatments?
- Chain and hydro-ax treatments differed regarding slash and mulch in the first and second years after treatment.
  - Chain and roller chop treatments differed regarding slash and mulch in the first, but not the second, year after treatment.
  - Hydro-ax and roller chop treatments differed regarding slash and mulch in the first and second years after treatment.
  - Both A and C
  - All of the above



49. **(4pts)** 10 kg of a fertilizer with a grade of 18-46-0 will contain how much elemental phosphorus?
- 2024 grams
  - 1.8 kg
  - 4.6 kg
  - It will not contain any phosphorus, at least none intended for sale

For question 50, please use the following figure (Davies et al. 2017 REM)



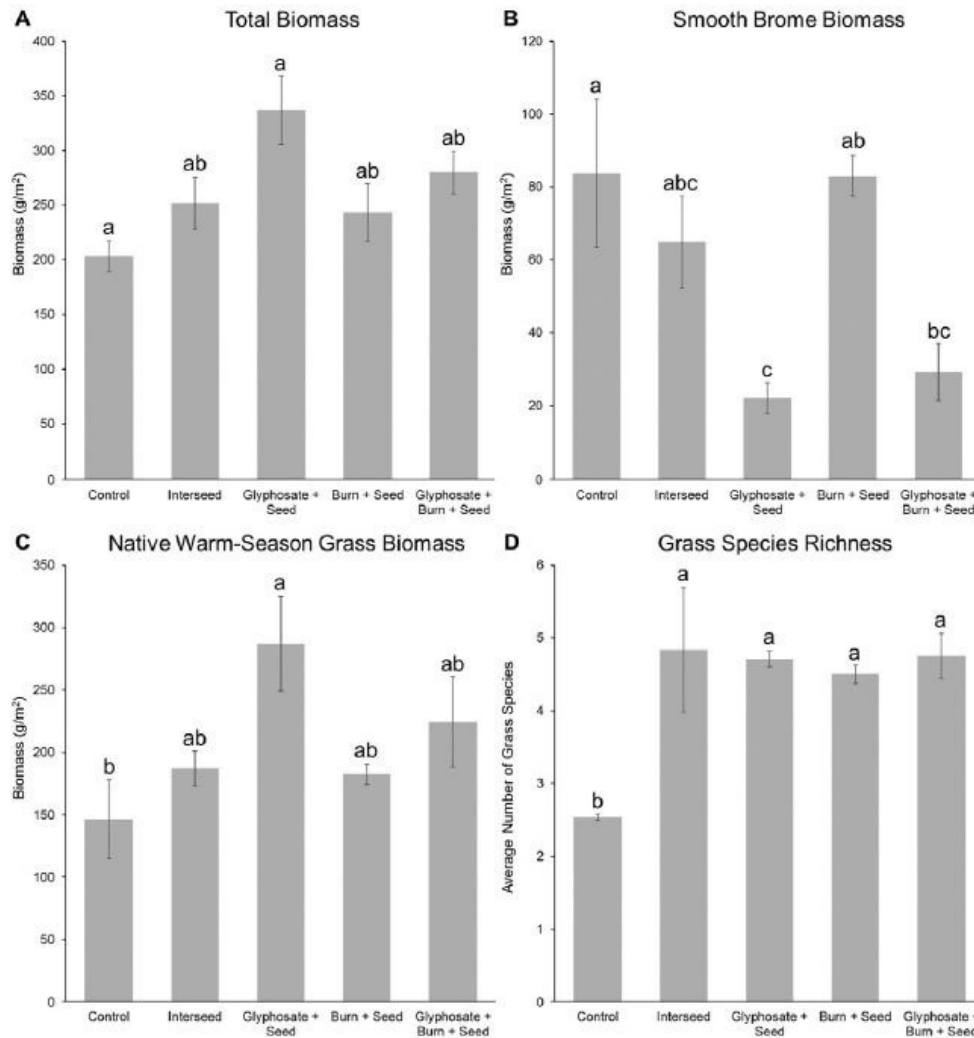
**Figure 3.** Sagebrush height in bare seed and seed pillow treatments in 2016 across a large elevation gradient in the northern Great Basin. Data were summarized for the 2013 and 2014 broadcast seedings.

50. **(4pts)** Which of the following statements is most correct regarding sagebrush height?
- Greater height was observed for the seed pillow treatment across the elevation gradient.
  - Greater height was observed for the bare seed treatment across the elevation gradient.
  - Greater height was observed for the seed pillow treatment when elevation  $> 1524$  m.
  - Greater height was observed for the bare seed treatment when elevation  $< 1676$  m.
  - None of the above

For question 51, please use the following figure (Link et al. 2017 REM)

602

A. Link et al. / Rangeland Ecology &amp; Management 70 (2017) 599–603



Mean ( $\pm$  SE) aboveground total biomass (A), smooth brome biomass (B), native warm-season grass biomass (C), and grass species richness (D) by restoration treatment. Significant differences are indicated by different letters ( $P < 0.05$ ).

51. (4pts) Which of the following statements is most correct regarding restoration treatments?
- Interseed affected total biomass, smooth brome biomass, native warm-season grass biomass, but not grass species richness.
  - Glyphosate + seed influenced smooth brome biomass, but not total biomass, native warm-season grass biomass, or grass species richness.
  - Effects of burn + seed were present for total biomass, smooth brome biomass, native warm-season grass biomass, but not grass species richness.
  - The combination of glyphosate + burn + seed displayed significant differences from control plots for total biomass and native warm-season grass biomass, but not for smooth brome biomass or grass species richness.

**IIIa. RANGE IMPROVEMENT PROBLEM (10 points) - SEE END OF TEST****IV. RANGE REGIONS (30 points)**

52. Which range region experienced severe drought in late spring/summer 2017?
- Eastern Deciduous Forest
  - Palouse Prairie
  - Northern Mixed-grass Prairie
  - Tallgrass Prairie
53. Invasion of Great Basin Sagebrush communities by *Bromus tectorum* has resulted in:
- An immediate decline in herbaceous productivity
  - A shortened wildfire cycle which creates a spiral of declining sagebrush and an ever-increasing dominance of *Bromus tectorum*.
  - A lengthening of the fire return interval which leads to an increasing dominance of *Artemisia tridentata*.
  - A gradual community shift to juniper woodland.
54. Using a global climate classification, which climatic region covers the most land area in North America?
- Mediterranean
  - Humid subtropical
  - Continental
  - None of the above
55. Which of the following vegetation associations has likely been altered the most by livestock grazing?
- Tallgrass prairie
  - Shortgrass prairie
  - Pinyon juniper
  - Fescue grasslands
56. Which range region has experienced substantial expansion in the last decade of cropland replacing rangeland/grassland?
- Eastern Deciduous Forest
  - Palouse Prairie
  - Northern Mixed-grass Prairie
  - Tallgrass Prairie

57. If you were on the boundary between the Northern mixed-grass Prairie and the Fescue Grasslands, you might expect to find:
- Festuca campestris* dominating north facing slopes and *Bouteloua dactyloides* dominating south facing slopes.
  - Danthonia parryi* dominating south facing slopes and *Schizachyrium scoparium* dominating north facing slopes.
  - Hesperostipa comata* dominating south facing slopes and *Festuca campestris* dominating north facing slopes.
  - Quercus* spp. dominating the warmer south facing slopes and *Populus tremuloides* dominating the cooler north facing slopes.

58. The dominant family or tribe in the Salt Desert Shrub vegetation community is:
- Andropogoneae
  - Chloridoideae
  - Chenopodiaceae
  - Zygophyllaceae

59. Which range type most likely has the following seasonal precipitation pattern (see figure, for the x-axis the left edge is January and the right edge is December; the y-axis is monthly precipitation).

- Eastern Oak Savanna
- Sage Brush Grass
- Ponderosa Pine
- Palouse Prairie



60. Which of the following statements is most correct (factor affected in parenthesis)?
- Moving north within any grassland would be similar to moving up in elevation (temperature)
  - Moving east across the Great Plains would be similar to moving downwards in elevation in the Sierra Nevada Mountains (precipitation)
  - Moving north in the Great Basin would be similar to moving south on the Great Plains (temperature)
  - Moving up in elevation would be similar to moving from a grassland to desert (salinity)

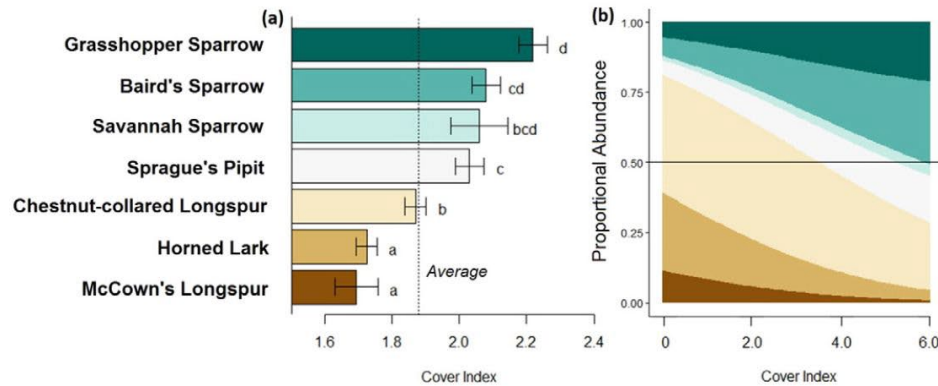
61. Plant-soil relationships are driven by:
- Aboveground constraints (e.g., light) in semiarid ecosystems
  - Belowground constraints (e.g., soil water) in semiarid ecosystems
  - Belowground constraints in mesic environments
  - Aboveground constraints in xeric environments

62. Which of the following are major terrestrial biomes?
- Tundra
  - Boreal forest
  - Grasslands
  - Deserts
  - All of the above

63. The savanna grassland of South America is called:
- a. Pampas
  - b. Cerrado
  - c. Veld
  - d. Karoo
  - e. Patagonia
64. Which of the following fauna are extremely rare in deserts?
- a. Reptiles
  - b. Arthropods
  - c. Amphibians
  - d. Small rodents
65. Which two biomes are the most similar with regards to annual precipitation?
- a. Tundra and taiga
  - b. Tundra and desert
  - c. Rain forest and savanna
  - d. Temperate forest and prairie
66. Which biome is characterized by a layer of permafrost?
- a. Taiga
  - b. Savanna
  - c. Chaparral
  - d. Tundra

## V. RANGE INVENTORY AND ANALYSIS (40 points)

For question 67, please use the following figure (Lipsey and Naugle 2017 REM)



(a) Average cover index at sites where common grassland species occurred in northeast Montana 2011-2013. Cover index calculated as the square root of (1-proportion bare) – proportion litter – total vegetation diversity. Dashed line indicates regional average. Letters on bars indicate significance at  $P < 0.05$  (on 1-way ANOVA with post-hoc Tukey test). Error bars indicate  $\pm 1$  SE. (b) predicted shift in species proportional abundance with change in cover using negative binomial mixed models, shown for 2012 with shrubs absent.

67. (4pts) Which of the following statements is most correct regarding cover and grassland birds?
- As cover increases, this will benefit grassland bird species like Horned Lark.
  - Sparrow species prefer low cover habitats.
  - When looking for Chestnut-collared longspurs, one should select areas with intermediate levels of cover.
  - Both Horned Lark and McCown's Longspur occur in parts of the landscape where cover is greater than the regional average.

For question 68, please use the following table (Gates et al. 2017 REM)

**Table 6**

Timing of defoliation effects on basal cover (%) across fire treatments and during the second growing season after fire (2014) with standard errors of the difference and  $P$  values for species within-year comparisons following the April 2013 Pautre wildfire.

Species	Control	Spring	Summer	Fall	SE <sub>diff</sub>	$P$ value
<i>Koeleria macrantha</i>	1.0 b	1.5 ab	3.7 a	2.5 ab	1.0	0.0928
<i>Nassella viridula</i>	4.2 a	2.2 ab	1.2 b	3.7 ab	1.2	0.0812
<i>Carex duriuscula</i>	0.2 b	1.3 ab	2.3 a	0.5 b	0.6	0.0083

68. (4pts) Which of the following statements is most correct regarding timing of defoliation effects?
- Spring defoliation influenced basal cover of all species.
  - Summer defoliation had an effect on basal cover of all species.
  - Fall defoliation affected basal cover of all species.
  - All of the above
  - None of the above

69. **(4pts)** A range utilization study provides data that use on key species was 30% in key areas of a pasture. The management goal on this pasture was 40%. The pasture was stocked with 200 animal units from May 15 to September 15. What is the estimated grazing capacity of this pasture in AUMs?
- a. 80
  - b. 600
  - c. 1067
  - d. 1333
70. Species in rangeland communities can be categorized into plant functional groups based on:
- a. Similarities in growth form and seasonality of growth
  - b. Suites of physiological characteristics
  - c. Suites of morphological characteristics
  - d. All of the above
  - e. None of the above
71. **(4pts)** You have developed a linear regression relationship for association of leader growth (in units of meters) to mass (in units of kg) for a key shrub in your plant community. The resulting equation is  $Y = B_0 + B_1X$ , with calculated values of 0.45 for  $B_0$  and 0.23 for  $B_1$ . After spending a few days collecting measurements, you determine that a typical plant of this shrub had leader growth of 132 cm. What is the predicted mass for this leader growth?
- a. 0.75
  - b. 0.82
  - c. 30.81
  - d. 59.63

For questions 72 and 73, please use the following figure (Davies and Johnson 2017 REM)

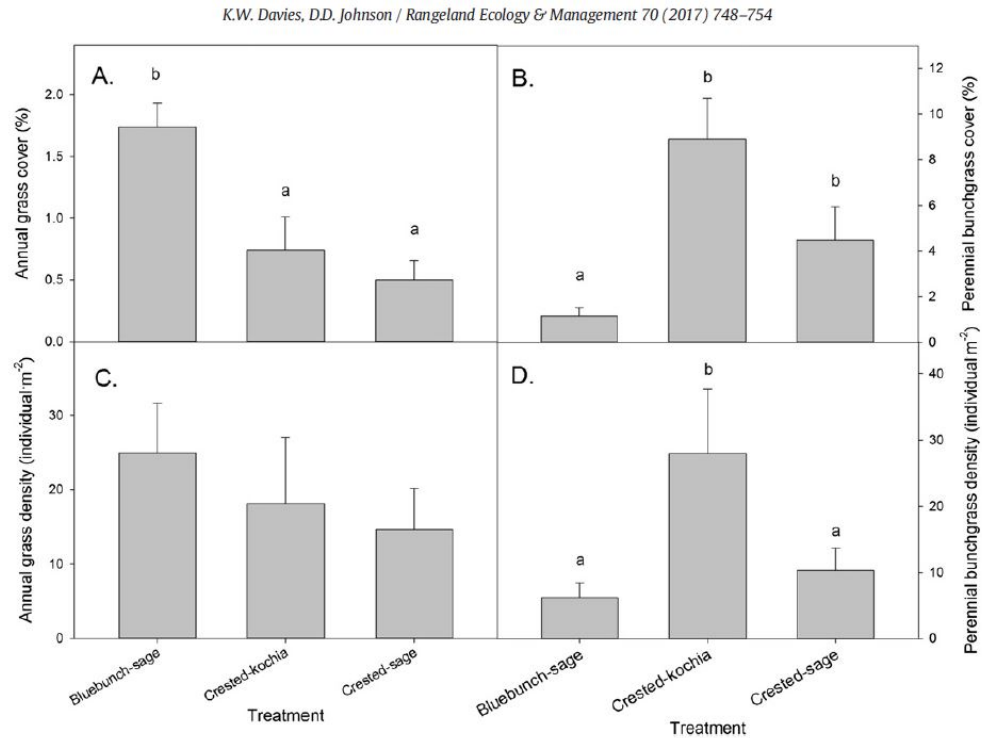


Fig. 2. Average exotic annual grass and bunchgrass foliar cover (A & B) and density (C & D) with standard error across treatments summarized for 2015 and 2016. Bluebunch-sage indicates bluebunch wheatgrass and Wyoming big sagebrush seedlings planted; Crested-kochia, crested wheatgrass and forage kochia seedlings planted; Crested-sage, crested wheatgrass and Wyoming big sagebrush seedlings planted. Different lowercase letters signify differences ( $P < 0.05$ ) among treatments for response variable.

72. (4pts) Which of the following statements is most correct regarding monitoring of annual grass cover and density?

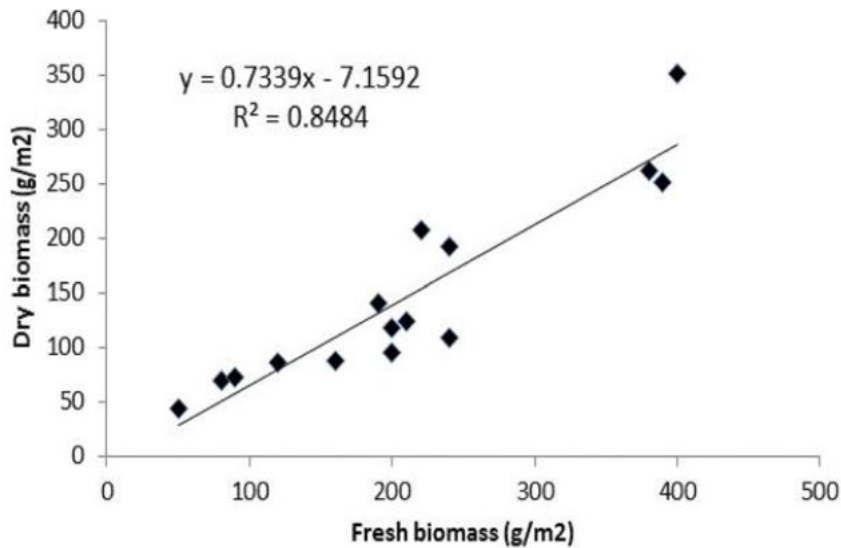
- Plantings of bluebunch wheatgrass and Wyoming big sagebrush had the lowest amounts of both.
- Plantings of crested wheatgrass and forage kochia had the lowest amounts of both.
- Plantings of crested wheatgrass and Wyoming big sagebrush had the lowest amounts of both.
- None of the above

73. (4pts) Which of the following statements is most correct regarding the efficacy of the plantings for annual and perennial bunchgrass cover and density?

- Plantings of bluebunch wheatgrass and Wyoming big sagebrush are the most effective in increasing cover of perennial bunchgrasses and reducing cover of annual grasses.
- Plantings of crested wheatgrass and forage kochia are the most effective in reducing cover of annual grasses and increasing cover and density of perennial bunchgrasses.
- Plantings of crested wheatgrass and Wyoming big sagebrush are the least effective in reducing cover of annual grasses and increasing cover of perennial bunchgrasses.
- None of the above



For questions 74-76, please use the following figure (Makuum-Massa 2017 Rangelands)



**Figure 9.** Relationship between fresh grass biomass and dry biomass.

74. The relationship displayed in this figure is characterized as:

- a. A negative linear relationship
- b. A positive linear relationship
- c. A curvilinear relationship
- d. A binomial distribution

75. (4pts) If you were provided data of 3,250 kg/ha of fresh biomass, what is the predicted dry biomass value?

- a. 231.4 g/m<sup>2</sup>
- b. 275.7 g/m<sup>2</sup>
- c. 2378.0 g/m<sup>2</sup>
- d. Unable to determine given the information provided.

76. (4pts) Which of the following statements is most correct regarding moisture content of the fresh biomass?

- a. Moisture content of fresh biomass decreases as the amount of fresh biomass increases.
- b. Moisture content of fresh biomass with a value of 400 g/m<sup>2</sup> is 75% of that for the fresh biomass with a value of 200 g/m<sup>2</sup>.
- c. Moisture content is 25.9% for a sample with 100 g/m<sup>2</sup> of fresh biomass and 33.8% moisture content for a sample with 400 g/m<sup>2</sup> of fresh biomass
- d. Unable to determine given the information provided.

For question 77, please use the following table (Gates et al. 2017 REM)

*E.A. Gates et al. / Rangeland Ecology & Management 70 (2017) 430–436*

433

**Table 2**

Timing of defoliation effects on biomass ( $\text{kg ha}^{-1}$ ) across fire treatments with standard errors of the difference and *P* values for biomass component within-year comparisons following the April 2013 Pautre wildfire.

Yr	Biomass component	Control	Spring	Summer	Fall	SE <sub>diff</sub>	<i>P</i> value
2014	Old dead	1413 a	936 b	776 b	850 b	86	< 0.0001
	Current year	3165 b	3730 a	2982 b	3014 b	245	0.0299
	Total standing	4578 a	4666 a	3758 b	3864 b	326	0.0258
2015	Current year	2004	2186	2063	2101	272	0.9234
	Total standing	2997	3657	3410	3567	296	0.1688

77. (4pts) Which of the following statements is most correct regarding timing of defoliation effects on biomass?

- Spring defoliation influenced old dead, current year and total standing biomass in 2014.
- Summer defoliation had an effect on old dead, current year and total standing biomass in 2014.
- Fall defoliation had an effect on old dead, current year and total standing biomass in 2014.
- Timing of defoliation did not influence current year or total standing crop in 2015.
- None of the above

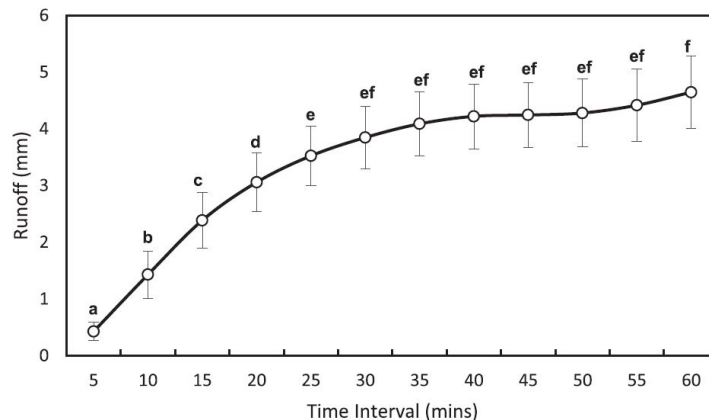
**Va. RANGE INVENTORY AND ANALYSIS PROBLEM (20 points) - SEE END OF TEST**

## VI. MULTIPLE USE RELATIONSHIPS (30 points)

For question 78, please use the following figure (Noelle et al. 2017 REM)

*S.M. Noelle et al. / Rangeland Ecology & Management 70 (2017) 774–780*

777



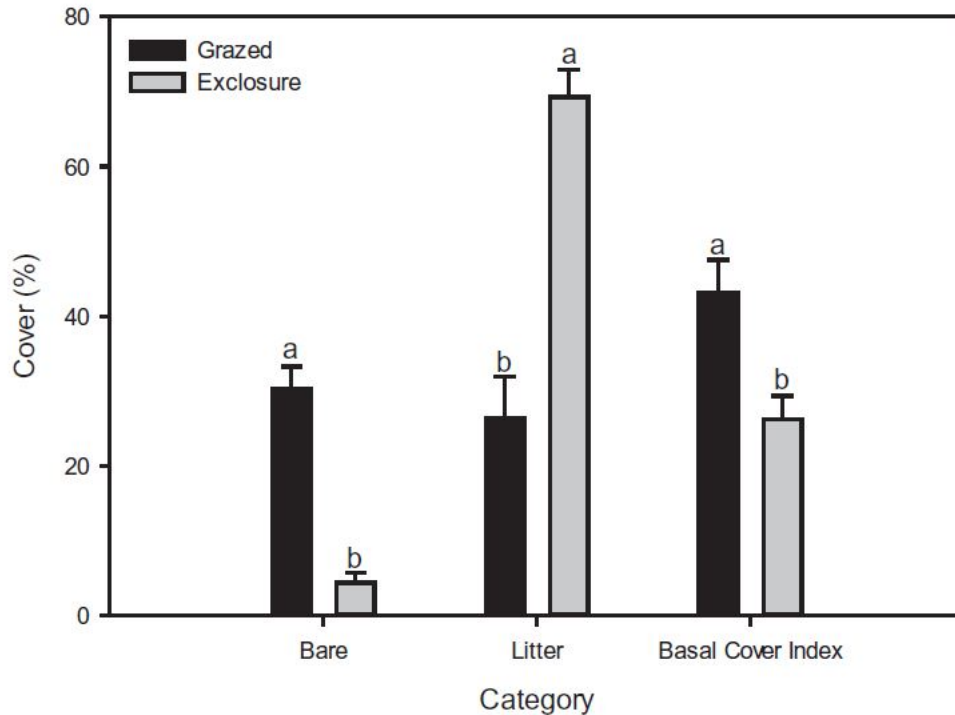
**Figure 2.** Mean runoff (mm) by time interval integrated across all slash and vegetation cover treatments. Differing letters indicate significant differences between time intervals at  $\alpha = 0.05$  level. Error bars are  $\pm$  SE.

78. (4pts) Which of the following statements is most correct?

- The slope of the line for runoff between 5 and 10 minutes is greater than for the line between 25 and 30 minutes
- Runoff does not differ for the time intervals between 25 and 55 minutes.
- Runoff differs for each time interval between 5 and 25 minutes.
- All of the above
- None of the above

79. A soil with a pH of 5 is \_\_\_\_\_ times as acidic as a soil with a pH of 9:
- 0.25
  - 4
  - 40
  - 10000

For question 80, please use the following figure (Boyd et al. 2017 REM)



**Figure 3.** Ground cover for riparian study plots in northern Nevada. Data are means for 2012 – 2013 with associated standard errors. Plots were excluded from horse grazing from 2009 – 2013 or were accessible to grazing during that time period. Within a category, bars without a common letter are different at  $\alpha = 0.05$ .

80. (4pts) Which of the following statements is most correct regarding horse grazing in riparian areas?
- Excluding horse grazing reduced bare soil and litter.
  - Excluding horse grazing increases bare soil, but not litter.
  - Proportional decreases in litter cover with excluding horse grazing were greater than the proportional increases in bare soil.
  - All of the above
  - None of the above

For question 81, please use the following figure (Fulbright et al. 2018 REM)

36

T.E. Fulbright et al. / Rangeland Ecology &amp; Management 71 (2018) 35–44

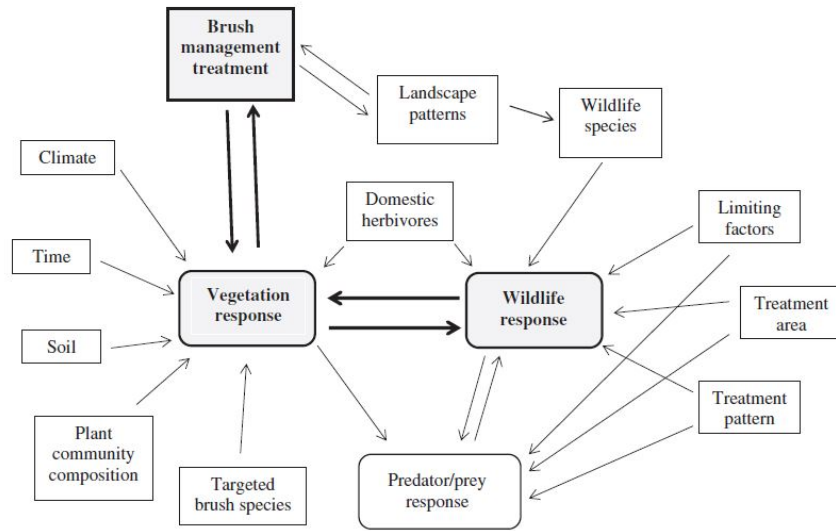
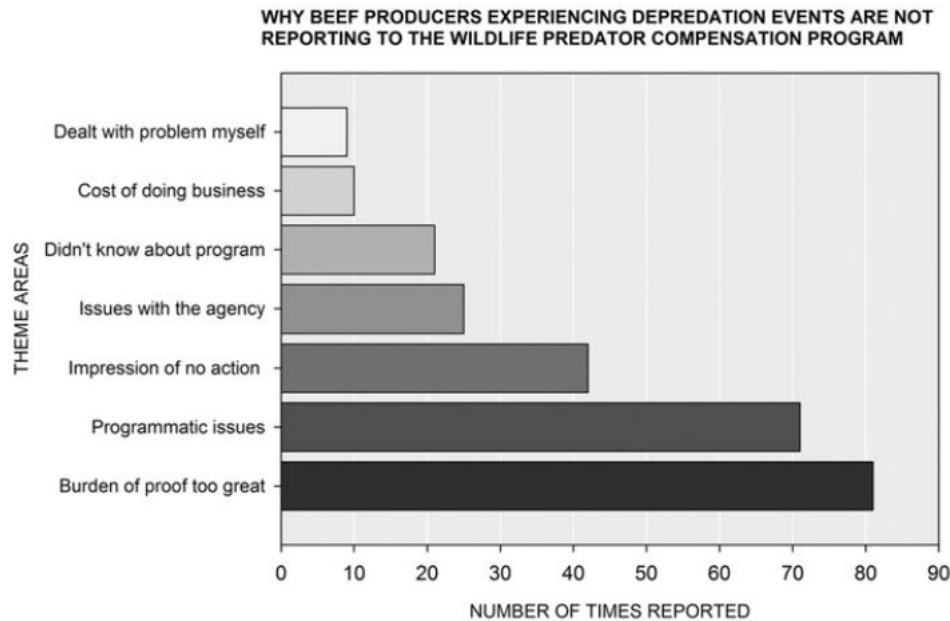


Figure 1. Wildlife response to brush management varies with time since treatment and is determined by a variety of interacting factors. For simplicity, only select feedbacks are shown.

81. **(4pts)** Which of the following statements is most correct regarding wildlife responses to brush management?
- Vegetation responses to a brush management treatment are influenced by soils, climate and existing plant community composition.
  - A brush management treatment has a direct effect on wildlife responses.
  - The influence of grazing/browsing by domestic herbivores on vegetation and wildlife responses is affected by landscape patterns.
  - All of the above
  - None of the above
82. As particle size decreases, the total surface area per gram of soil:
- Increases
  - Decreases
  - Stays the same
  - Fluctuates depending on temperature
83. For how long is grazing capacity impacted on land that has experienced accelerated erosion such that an ecological threshold has been crossed?
- Up to 5 years
  - Between 6 and 10 years
  - Between 10 and 25 years
  - Permanently, unless specific inputs or management are used to reverse the ecological threshold

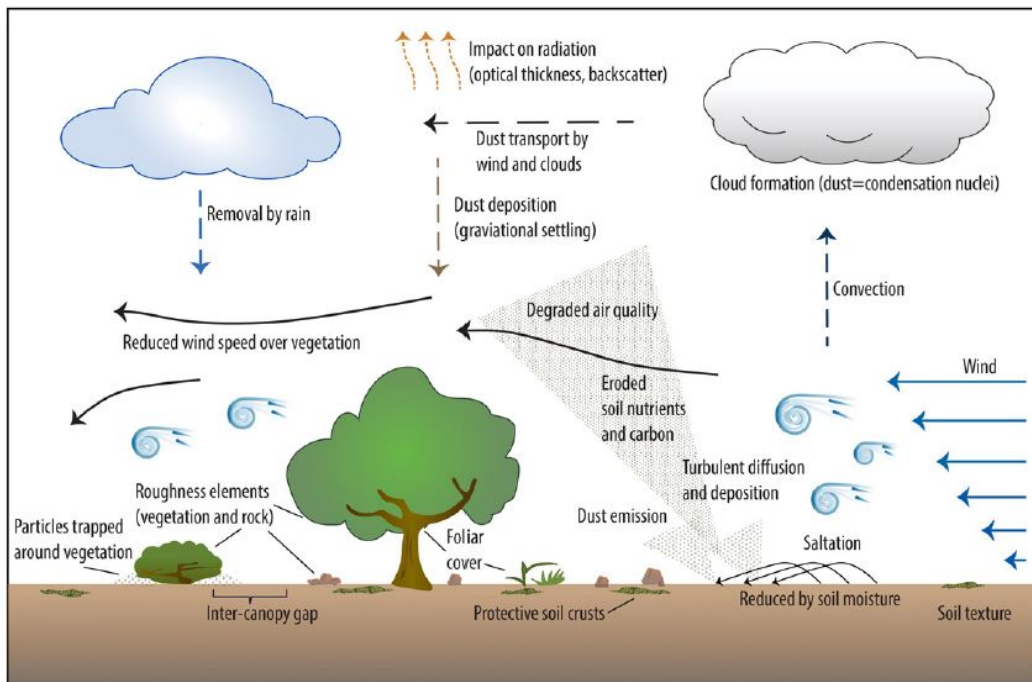
For question 84, please use the following figure (Lee et al. 2017 Rangelands)



**Figure 3.** Reasons why beef producers are not reporting depredation events to the Wildlife Predator Compensation Program.

84. (4pts) Which of the following statements is most correct?
- Beef producers make a lot of money from each depredation event.
  - Most of the beef producers who responded have issues with administrative aspects of this program.
  - Most of the beef producers do not have knowledge of the program.
  - Beef producers are happy with the amount of financial compensation for a depredation event.
85. Which type of ecosystem will typically support the greatest diversity of wildlife?
- Grassland
  - Shrubland
  - Savanna
  - Conifer forest
86. When plentiful quantities of nitrogen and phosphorus are introduced into aquatic systems they:
- are quite beneficial because of greatly increased aquatic growth.
  - increase oxygen levels and improve fish habitats.
  - result in excessive aquatic growth and low oxygen levels.

For question 87, please use the following figure (Webb et al. 2017 Rangelands)



**Figure 1.** Schematic showing the physical processes that influence wind erosion and dust emission (after Lu and Shao<sup>4</sup>). Core indicators of the surface resistance to wind erosion include the amount of foliar cover, the size and distribution of intercanopy gaps, vegetation height, and soil surface properties such as texture and physical and biological crust cover.

87. (4pts) Which of the following can be inferred from this schematic?
- Wind erosion will be less as vegetation height increases
  - Wind erosion will be greater with increasing inter-canopy gap sizes
  - Wind erosion will be less with protective soil crusts
  - All of the above
  - None of the above

### GRAZING MANAGEMENT PROBLEM (10 points)

Bork et al. 2017 (REM) provide a conceptual model depicting accumulated season-long productivity under continuous and rotational grazing in lowland and upland sites of the Northern Mixed-grass Prairie. From their data, in lowland sites, continuous grazing results in 7.4% more productivity, whereas in the upland sites, rotational grazing results in 3.5% more productivity. Use this information to answer the grazing management questions. Assumptions here are that productivity 1) for lowland sites with rotational grazing is 2,500 kg/ha, and 2) for upland sites with continuous grazing is 1,500 kg/ha.

88. **(7 pts)** You and both of your neighbors are interested in determining productivity of the ranches. All ranches have the same number of hectares (4000 total for each ranch), and the split is the same among ranches in terms of lowland (1/4 of the hectares,) and upland (3/4 of the hectares). You employ only rotational grazing; your neighbor Crooked River Ranch employs only continuous grazing; and your other neighbor Strait Road Ranch uses a 50:50 split of continuous and rotational grazing on both the lowland and upland hectares. According to the data provide above, which ranch should have the most productivity?
- Your ranch
  - Crooked River Ranch
  - Strait Road Ranch
  - Cannot determine from the information provided
89. **(3 pts)** You are interested in expanding your ranch and want to continue to use rotational grazing on this new ranch. Using the information provided above, what would be the ratio of upland to lowland site hectares that would result in half of the yield of the new ranch coming from each type of site?
- 0.559
  - 0.621
  - 1.61
  - 1.79
  - Cannot determine from the information provided

### RANGE IMPROVEMENTS PROBLEM (10 points)

Snake Oil Seed company salesman Sam was seen sporting a seed mix in the town of Sleepyville, Somewhere. Soon, several spectators sheepishly surveyed the seed. Some were even seen spending some heretofore stashed cash on this seemingly special stuff. Surprisingly, Sam submits a sample from his seedlot for you and your technician Shelia to study (assume that Sam satisfactorily stirred the seedlot prior to selecting the sample). Here is the data from your lab:

Species	Average seed number in 10 draws	Germination (%)	Average seed weights (seeds/kg)
Intermediate wheatgrass	520	89.0	194,000
Smooth brome	70	80.0	300,000
Alfalfa	160	98.0	440,000

90. (5 pts) What is the purity for Intermediate wheatgrass?

- a. 69%
- b. 73%
- c. 82%
- d. 89%
- e. Cannot determine from the information provided

91. (5 pts) What is the pure live seed for smooth brome?

- a. 5.6%
- b. 7.5%
- c. 18.4%
- d. 25.7%
- e. Cannot determine from the information provided



### RANGE INVENTORY AND ANALYSIS PROBLEM – 20 points total

Whatchamacallit Ranch, in between Winchester and Worland, in Washakie County, Wyoming, owned by the wild Watson brothers after purchasing from well-mannered Wallace Wilson one warm winter evening 35 years ago, is a wonderful wildscape with wildlife aplenty and worldly-recognized waters for fly fishing. The Whatchamacallit Ranch, comprised mainly of sagebrush steppe vegetation types, has 4 pastures (Northwest, Northeast, Southeast, and Southwest), with each pasture having a square shape and comprised of 10,000 ha. While whittling willow sticks one day, Wilbur Wilson (the younger of the wild Watson brothers) asked Walter (the elder brother) what he know about fire history on the Whatchamacallit Ranch. Walter's well-worn record book had notes of 7 wildfires which burned 6,500 ha since they owned the ranch. Also, the Watson brothers had implemented 14 prescribed fires, each about 1000 ha, over that same time period. Walter remembered some written records from Winston Wilson (Wallace's father), and those notes denoted 16 wildfires over 55 years, with an estimated cumulative total of 32,000 ha burned. Wilbur and Walter run a cow herd with small cows (454 kg average weight), and their 5-year running average number of cows in their herd is 1500. In addition, in years with above average precipitation or with excess stored forage, the brothers run additional yearlings in a flexible strategy with numbers of yearlings attempting to match forage availability with animal demand.

92. **(5 pts)** You would like to determine the natural fire return interval for the Whatchamacallit Ranch. Fire return interval is the time to burn an area equal to the area of interest and is determined by dividing the area of interest by the average area burned annually. The natural fire return interval for this ranch is:
  - a. 68.8 years
  - b. 85.4 years
  - c. 93.5 years
  - d. 215.4 years
  - e. Cannot determine from the information provided
93. **(5 pts)** If the Watson brothers stock their cow herd at a conservative rate (targeted 35%) utilization rather than at a moderate rate (50% use, take half/leave half), what is the estimated long-term average aboveground productivity (in kg/ha) for this ranch?
  - a. 204.3 kg/ha
  - b. 314.3 kg/ha
  - c. 408.6 kg/ha
  - d. 583.7 kg/ha
  - e. 1167.4 kg/ha
94. **(3 pts)** The Watson brothers use a Merrill 3-herd, 4-pasture deferred grazing system, use 1 bull for 25 cows, bulls are turned out in June for a 60-day breeding season, and cows calve in April. Assuming each pasture has similar carrying capacity, so the cow herd (with calves) is equitably split, what is the stocking density in a grazed pasture in July?
  - a. 9.8 ha/animal
  - b. 13.1 ha/animal
  - c. 19.2 ha/animal
  - d. 25.6 ha/animal

95. **(7 pts)** On the Whatchamacallit Ranch, about 1.5% of the ranch hectarage (on average) has burned annually through either wildfire or prescribed fire in the time the Watson brothers have owned the land. The Watson brothers would like to markedly increase this value to 20% annually through strategic planning of prescribed fire, using the patch-burn approach. The Watson brothers need you to help provide key fireline perimeter information to help them in their decision regarding individual prescribed fire size. Given that they have used 1000 ha size prescribed burns (square configurations) in the past, the Watson Brothers would like for you to calculate the fire perimeter ratios (relative to the 1000 ha size) for the total amount of land prescribed burned for two alternative sizes of prescribed burns: 400 ha or 1600 ha (all burns use a square configuration). The correct ratio for the length of the perimeter line with increasing size (400 ha, 1000 ha, 1600 ha) of prescribed burns is?
- a. 1.58 : 1 : 0.79
  - b. 1.26 : 1 : 0.63
  - c. 1.60 : 1 : 0.40
  - d. 2.50 : 1 : 0.63