GCE 2003
June Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Environmental Science – ESC7
(6441)

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Environmental Science

Summer 2003 **ESC7**

Instructions: ; = 1 mark / = alternative response A = accept R = reject

SECTION A

Question 1

(a) (i) Greater number of broad-leaved plant species found in organic fields;
greater number of grass species found in organic fields;
drift of inorganic fertiliser inhibits wild flowers in intensively farmed fields;
inorganic fertilisers encourage growth of grasses at expense of broad-leaved species;
inorganic fertilisers encourage growth of more dominant grass species; MAX 3
[**A** no of broad-leaf plant species > grass in all fields]
[**R** ref to amount of fertiliser]
(Max of 2 trends, minimum of 1 trend for full mark to be awarded)

(ii) Counting species equates rare species with more common ones;
gives no indication of relative abundance; MAX 2
[**A** problems of identification]
[**R** ref to sampling method/area]

(iii) Calculating index of diversity takes relative abundance into account/
e.g. of suitable technique such as Simpson's Diversity Index; 1

(b) (i) No gradient/change (of vegetation) present so transect inappropriate;
statistical tests require data to be random;
random sampling eliminates bias; MAX 2

(ii) *Species frequency*:
adequate number of quadrats (>10); (Score once only in part (b) (ii).)
appropriate method of ensuring randomisation: (Score once only in part (b) (ii).)
appropriate quadrat size used (side length 0.5m / 1m)/point quadrat used;
<u>record presence</u> of individual species/no of hits;
as % of total quadrats/hits;

Species density:
adequate number of quadrats (>10); (Score once only in part (b) (ii).)
appropriate method of ensuring randomisation; (Score only only in part (b) (ii).)
known area of quadrat/field;
<u>count individuals</u> of each species;
find mean per quadrat;
express as number per unit area; MAX 5

(c) (i) 7/10 / 70%; 1

(ii) Mean number per 0.25 m^2 quadrat = 2.5;
10 poppies m^{-2}; 2

(iii) Use quadrat subdivided into smaller squares;
estimate area of ground/count number of squares covered by each species;

Use abundance scale/e.g. of abundance scale (Domin/Braun-Blanquet/DACFOR etc);
OR
Use of point quadrat;
record number of "hits"; MAX 2
[**A** appropriate]

Total marks = 18

Question 2

(a) Gradient expected with distance (from hedgerow);

(b) (i)

A	32.27/32.3			
B	18.5	4 correct	= 2 marks	
E	26.5	3 correct	= 1 mark	
F	13.87/13.9	1 or 2 correct	= 0 marks	MAX 2

(ii) correct title to graph;
use of <u>bar chart</u> [**R** line graph/scatter graph];
suitable labelling for axes;
points plotted correctly (according to figures calculated in (a) (i));
appropriate scale; MAX 4

(c) Greater growth in fields with inorganic fertiliser (or converse);
OR
Greater growth of winter cereals compared to spring crops;
OR
Crops taller with distance away from hedgerow; MAX 1
[**A** taller with distance downslope / towards chalk stream]
[**A** null hypotheses as alternatives to the above]

(d) Winter crops taller than spring crops;
because winter crops have longer growing period;

inorganic crops taller than equivalent organic crops;
inorganic fertiliser has known nutrient content/manure nutrient content unknown;
inorganic quick release of nutrients/slow release of nutrients in manure;
manure must decompose in order for nutrient to be released;
inorganic fertilisers can be "tailor-made" to suit crop;

crops taller with distance from hedgerow;
less competition from hedge/headland plants; MAX 6

Total marks = 14

Question 3

(a) (i) Mann-Whitney *U* test;
test of significance rather than correlation or association;
data calculated (rather than measured/counted);
no evidence to suggest a normal distribution/non-parametric test;
appropriate amount of data; MAX 3

(ii) That there is no difference in the % organic matter in fields treated with inorganic/organic fertilisers; 1

(iii) Attempt to rank data;
correct ranking of data;
correct application of formula and working for each dataset;;
correct value for *U* for each dataset;
correct critical value extracted from the table (13);
correct conclusion of significance;
[**A** conclusion from candidates calculated value even if incorrect]
possibility of obtaining result by chance is 5%/confidence level of 95%; MAX 7

[If another statistical test (e.g. t test) is used, correct working and conclusions will be credited up to a maximum of 7 marks for the whole of parts (a)(i) and (a) (iii)]

(b) (i) pH:
pH higher in inorganic fields/lower in organic;
both types of field within good fertile range / no obvious difference;
humic acid from organic matter decreases pH;
decrease in pH with distance from field margin;
% organic matter:
organic matter content greater in fields fertilised with manure;
manure contains high proportion of organic matter;
Credit reference to figures in table e.g. means calculated for each test in each field;; MAX 4

(ii) Moisture content/soil texture/soil organisms/named nutrient;
[**A** reference to soil characteristics measured in the field]
details of method;;
relevance to study; 4

(Max 4 marks for one factor tested – 1 mark for correct factor chosen, 2 marks for outline of test method, 1 mark for explanation of relevance to this study).

Total marks = 19

Question 4

Spring crops more bird diversity than winter crops;
organic fields have more birds;
organic field have more plant species;
qualified ref to suitability of habitat(cover/nest sites);
more seeds/hedgerow and soil insects present/more food available for birds;
ref to effects of pesticides/bioaccumulation/biomagnification;
type of fertiliser more important than time of application;
more species restricted to organic fields; MAX 4

Total marks = 4

TOTAL FOR SECTION A = 55

SECTION B

Question 5

Crops grow better with inorganic fertilisers;
crops grow better with distance from hedge;
hedge holds predators of crop pests;
inorganic reduces plant diversity;
inorganic reduces bird/insect/animal diversity;
hedges increases biodiversity;
acts as corridor/habitat/consists of native plants;
grasses outcompete broad leaved plants;
due to effect of spray drift;
pesticides reduce biodiversity by killing non-target organisms;
ref to uniform harvesting times/different sowing times of crop; MAX 6

(a) *Variables controlled*:
location of the unimproved meadows to act as buffers between inorganic and organic fields;
all transect run W → E;
all trial fields sown with cereals;
trial fields comprise two winter and two spring crops;
times bird surveys carried out;

Variables not controlled:
sampling spread over 2 months;
comments regarding accuracy of measurements;
inadequate number of replicates/samples unrepresentative;
crops not comparable (inorganic fields – winter barley and spring wheat/organic fields were winter wheat and spring barley);
original condition of soils in trial fields not known;
errors may arise because of spray drift in direction of prevailing wind/no equivalence in fertiliser application;
length of time spent in field for bird surveys/number of observers;
identification errors;
no control field with no fertiliser application;
position of headland samples differs in relation to pasture/stream; MAX 5

(b) Investigate the effects of other agrochemicals on biodiversity e.g. pesticides;
investigate the effects of other organic methods/cultivation techniques/soil types;
insect/mammal surveys
investigate soil organisms;
investigate different amounts/timing of fertilisers;
investigate effect on stream biodiversity; MAX 4
[Max 2 marks for modifications relevant to answers to part (b)]

(c) Encourage hedgerow planting for increased biodiversity;
encourage hedgerow planting to reduce soil erosion;
ref to Hedgerow Incentive Scheme;
ref to Environmentally Sensitive Areas;
ref: to Countryside Stewardship Scheme/set aside;
encourage (conversion) to organic methods of farming;
encourage with grants/subsidies (for organic farming/farm management plans);
reduce use of nitrate/inorganic fertilisers;
control timing of application of nitrate fertilisers;
reasons related to weakening of soil structure with use of inorganic fertilisers;
problems of use of inorganic fertilisers (e.g. eutrophication/health issues);
ref to Nitrate Sensitive Areas;
raising public awareness; MAX 5

Total Marks = 20

Sample calculations for question 3(a)(iii)

Mann-Whitney U test

Method 1 – using the formula:

$U = n_1n_2 + n_1(n_1 + 1) - R_1$ $\qquad$ $U' = n_1n_2 + n_2(n_2 + 1) - R_2$

(i) Organise data into order for both sites combined and rank each:

10.9	11.2	12.5	12.5	14.0	14.5	14.6	15.2	15.5	15.7	16.2	16.4	16.9	17.3	18.6	19.5
1	2	3.5	3.5	5	6	7	8	9	10	11	12	13	14	15	16

(ii) Calculate total rank for each dataset:

Inorganic		Organic	
Data	Rank	Data	Rank
10.9	1	12.5	3.5
11.2	2	14.5	6
12.5	3.5	15.7	10
14.0	5	16.2	11
14.6	7	16.9	13
15.2	8	17.3	14
15.5	9	18.6	15
16.4	12	19.5	16
	$R_1 = 47.5$		$R_2 = 88.5$

(iii) Substitute calculated values for R_1 and R_2 into formula:

$$U = (8 \times 8) + \frac{(8 \times 9)}{2} - 47.5 = 64 + 36 - 47.5 = \mathbf{52.5}$$

$$U' = (8 \times 8) + \frac{(8 \times 9)}{2} - 88.5 = 64 + 36 - 88.5 = \mathbf{11.5}$$

Method 2 without using formula:

Arrange data into a lineplot for each site and count the number of each sample smaller than values in the other sample:

	0	*0*	*0.5*	*1*	*2*	*2*	*2*		*4*				**U = *11.5***
Inorganic	10.9	11.2	12.5	14.0	14.6	15.2	15.5		16.4				
Organic			12.5		14.5		15.7	16.2	16.9	17.3	18.6	19.5	
			2.5		*4*		*7*	*7*	*8*	*8*	*8*	*8*	**U = *52.5***

Conclusion

Calculated value for the smallest U value (11.5) is less than the critical value of U for n_1 (8) and n_2 (8) which is **13**, therefore the results are significant at p = 0.05. i.e. the possibility of the differences in the organic matter being due to chance is less than 5%. Accept positive hypothesis.

t-test

Inorganic			Organic		
x =	13.79		x =	16.40	
s =	2.04	(1.91)	s =	2.23	(2.09)
s^2 =	4.16	(3.64)	s^2 =	4.98	(4.36)
$\frac{s^2}{n}$ =	0.52	(0.46)	$\frac{s^2}{n}$ =	0.62	(0.54)

figures in brackets indicate values obtained if θ_n used on calculator instead of θ_{n-1}

$$t = \frac{16.40 - 13.79}{\sqrt{0.52 + 0.62}} = \frac{2.61}{\sqrt{1.14}} \qquad \frac{2.61}{1.07\ (1.00)}$$

t = 2.44 (2.61)

degrees of freedom = $n_1 + n_2 - 2 = 14$

Conclusion

Calculated value of t is greater than the critical value for t for 14 degrees of freedom (2.15) at p = 0.05. Therefore the results are significant at p = 0.05 level. Therefore the possibility of achieving the results by chance is less than 5%.