1974

Form D1 – Waterfowl Production Surveys

Units 3-18

Form D-1

Observer: ____________

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 3

Year: 1974

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
3	83	5/23	31	Ma	6		X													X						X	No	6/19				X			
	85	5/21	112	"	8		X													X							No	6/18				X			
	89	5/22	113	"	0					X										X							No	5/22				X			
	93	"	114	"	2	X													X	ⓧ							"	6/18				X			
	95		115	"	2	?	?													X							"	"				X			
	97		116	"	0	?				?										X							"	"				X			
	99		117	" ?	4	X														X							"	"	X	6					
	101		118	"	1	X														X							yes	"				X			
	101		119	"	0	?				?										X							No	"				X			
	101		120	Pint	8		X												ⓧ	X							No	7/11	X	8					
	101		121	Mall	6		X													X							No	6/19				X			
	85	6/18	153	unk	0					X										X							"	6/18				X			
	87	"	154	Mal	9		X																					7/15	X	7					
	87	"	155	"	0																							6/18	X	7					
	87	"	156	Teal	0					X																		"				X			
	87	"	157	Mal	4		X																					7/15	X	4					
	93	"	158	unk	0																							6/18	X	6					
	97	"	77	Mall						X										X								"				X			
	97	"	78	"	10		X													X								7/11	X	10					
	99	"	79	"	8		X										X											"	X	8					
	99	"	80	"	9		X										X											"	X	9					
	99	6/19	189	"	2		X													X								7/11				X			
	101	"	188	"	8		X													X								7/11	X						
	103	6/18	187	Teal	5?															X								6/18	X						
																													11			13			

Form D-1

Field Form

Unit No. 3

Observer: ______

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Year: 74

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
3	105	6/18	142	Mall	0					x										X								6/18				x			
3	105	"	143	Pint	0															X								"	x	6					
																													1			1			
																													12			14			

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Form D-1

Field Form

Unit No. 4

Observer: ______

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Year: 74

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No. & expl. on back
4	109	5/22	27	Ma	6		x													x							yes	7/15	X	6					
	113	"	28	unk	1					x										x							No	5/22				X			
	119	5/23	29	Ma	7		x																X				yes	6/21	X	7					
	123	"	122	"	0					x										X							No	5/23				X			
																													2			2			

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Form D-1

Observer:

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 6

Year: 1974

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
6	29	5/14	01	PinT.	3	X								ⓧ						X							No	6/13	X	5					
6	31	"	102	Mall	2	X								ⓧ		X											No	"				X			
6	35	"	103	Mall	8		X													X							Yes	"				X			
6	31	6/13	51	"	8		X													X							No	7/11			X				
6	31	"	52	"	7		X													X							No	"	X	7					
6	31	"	53	Unk.	-															X							No	6/13	X	6					
6	33	"	123	Pond	9		X													X							"	7/11				X			
6	33	"	124	Shov	9		X													X							"	7/11				X			
6	39	"	125	"	4		X													X							"	7/12				X			✓
6	35	"	176	Mall	0					X										X								6/13				X			
																													3		1	6			

Form D-1
Observer: ____________

Field Form
WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 8
Year: 1974

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
8	25	5/16	104	Mall	10		x													x							No	6/17				x			magpie
8	25	"	105	Mall	8		x													x							No	"				x			mammal
8	23	"	108	"	9		x													x							No	6/19	x	9					
																													1			2			0

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Form D-1

Observer:

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 9

Year: 1974

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
9	89	6/18	132	Mall	10		X													X							no	7/11				X			
	89	"	133	"						X										X							"	6/18				X			
	95	"	134	"	8		X													X							"	7/11	X	8					
	95	"	135	"	5		X													X							"	"	X	5					
	95	"	136	Gadw	10		X													X							"	"	X	10					
	95	"	137	Mall	7		X													X							"	"	X	6					
	95	"	138	Redh	8		X													X							yes	"			X				
	97	"	139	Pint	6		X							X													no	"	X	6					
	97	"	140	C. teal	7		X													X							"	"				X			[illegible]
	97	"	141	Mall						X										X							"	6/18				X			
	85	"	178	Teal ?	6		X													X							no	7/15			X				
	85	"	179	Mall	0					X										X							no	6/18				X			[illegible]
	91	"	180	Pint	0					X										X								"				X			
	91	"	181	Mall	2				X											X								"			X				
	91	"	182	"	6		X													X								7/11				X			
	91	"	183	"	8		X													X								"	X	8					
	91	"	184	"	0					X										X								6/18				X			[illegible]
	93	"	185	"	6		X													X								7/11	X	4					
	93	"	186	"	11		X													X								"	X	9					
	105	"	81	unk						X										X								6/18				X			
																													8		3	9			

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Form D-1

Observer: ____________

Field Form
WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 9

Year: 1974

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
9	87	5/21	07	unk	5	x														x							yes	6/18				x			
	87	"	08	Ma	10		x													x							yes	"				x			
	89	"	09	unk	1	x														x							yes	"			x				
	89	"	10	SHOV	7	x														x							yes	6/18	x	9					
	91	"	11	Pint	5		x													x							No	6/18	x						
	91	"	12	unk	6	x														x							yes	"				x			
	93	"	13	Ma	6		x													x							yes	"				x			
	93	"	14	Ma	9		x													x							yes	"	x						
	95	"	15	Ma	11		x													x							yes	"	x	11					✓
	95	"	16	Ma	7		x													x							yes	"				x			
	95	"	17	unk	2	x														x							No	"				x			
	95	"	18	Pint	6		x													x							No	"				x			
	97	"	19	Ma	7		x													x							No	"				x			
	97	"	20	Ma	8		x													x							yes	"				x			
	99	5/22	21	Ma	8		x													x							no	6/18				x			
	99		22	unk	2	x														x							yes	7/11				x			
	99		23	Ma	8		x													x							No	6/18	x	8					
	99		24	"	8		x													x							no	"				x			
	99		25	unk	2	x														x							no	"				x			
	99		26	"	2	x														x							no	7/11				x			
																													5		1	14			
																												Total unit 9	13		4	23			-

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Form D-1

Observer: ____________

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 11, 16, 19, 1, 7

Year: 1974

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
11	129	5/23	30	unk	2					X										X							No	5/23				X			
11	135	6/20	144	GADW	6		X												X	⊗							No	7/15				X			
16	67	6/17	130	Mall	9		X													X							no	7/12	X	9					
16	63	"	76	unk	0					X									⊗	X								6/17				X			
19	17	6/12	151	Mall	8		X										X			⊗							no	7/12				X			wire
1	65	6/13	177	PINTAIL	7		X												X								no	7/12	X	7					
1	63	6/13	126	Teal	0					X							X			⊗							no	6/13				X			2 eggs left
1	67	"	128	Mall	0					X										X							no	"				X			duck & partial destroyed eggs found
1	71	"	129	"	4		?			?										X							yes	7/12				X			
7	53	6/13	54	Mall	7		X													X							no	7/12				X			
7	63	6/13	127	Pint	0					X										X							no	6/13				X			
7	69	"	55	Unk						X										X							no	6/13				X			
																													2			10			

: 12

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Form D-1

Observer: ____________

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 14

Year: 1974

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
14	33	5/13	101	Mall	6		X													X								6/12	X	6					

Form D-1

Observer:

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 15

Year: 74

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
15	47	5/20	03	Mall.	5		X													X							No	6/14				X			
15	51	"	04	"	7		X													X							No	6/14			X				
15	47	"	05	"						X										X							No	5/20				X			
15	49	"	06	"						X										X							No	5/20				X			
15	47	6/14	56	Gadw.	1	X														X							No	7/11				X			

Form D-1

Observer: ______

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 17

Year: 1974

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
17	85	5/21	109	~~[illegible]~~ Cshov	6	x														x							N	6/19				X			
17	79	6/17	131	Mall	7		x													x							"	7/12				X			

Form D-1 Field Form Unit No. 18

Observer: WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA Year: 74

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
18	105	5/16	106	Mall	-					X				ⓧ		X											No	5/16				X			
18	103	"	107	"	9		X													X							yes	6/17				X			magpie
18	92	"	02	unk	3	X														X							yes	"				X			
18	93	5/21	110	unk	0					X										X							yes	5/21				X			
18	87	"	111	Mall	9		X							ⓧ		X											no	6/17	X	9					
18	97	6/17	152	"	0					X										X								"				X			
																																			1			5			0

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Form D1 – Waterfowl Production Surveys

Multiple Units

Form D-1

Field Form

Unit No. ______

Observer: CORNELIUS

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Year: ______

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbitbrush	Dst saltgrass	Gx grasses	Mof sweetclover	Wx weeds	Jba blue rush	Cx sedges	Ex spikerush	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No. & expl. on back
3	89	5/22	113	Mall	0					X										X							No	5/22				X			
3	93	"	114	"	2	X													X	⊗							No								
3	95	"	115	"	2	X	X													X							No								
3	97	"	116	"	0	X				X?										X							No								
3	99	"	117	" ?	4	X														X							No								
3	101	"	118	"	1	X														X							Yes								
3	101	"	119	"	0					[illegible]										X							No								
3	101	~~Pint~~ "	120	PinT	8		X												⊗	[illegible]							No								
3	101	~~Mall~~ "	121	Mall	6		X																				No								–
4	123	5/23	122	"	0					X										⊗			X				No								
																				X							No	5/23				X			[illegible]

Form D-1 No. 101 -200 Field Form Unit No.

Observer: CORNELIUS WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA Year: 1974 - 1ST Run

Unit No.	Transect No.	First Observation					Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs		Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbit brush	Dst saltgrass	Gx grass	Mof sweet clover	Wx weed	Jba black rush	Cx sedge	Ex spike rush	Tla cattail	Sva bulrush	Dike	Ditch	Flooded yes / no	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
14	33	5/12	~~101~~	MALL	6			X													X							No								
6	31	5/14	~~102~~	" ?	2		X								X		X											NO								
6	35	5/14	~~103~~	"	8			X													X							yes								
8	75	5/16	~~104~~	"	10			X													X							NO								
8	75	"	~~105~~	"	8			X													X							NO								
18	105	"	~~106~~	"	0						X				X		X											NO	5/16				X			
18	103	"	~~107~~	"	9			X													X							YES								
8	73	"	~~108~~	"	9			X													X							NO								
17	85	5/21	~~109~~	unk (shov	6		X														X							NO								✓
18	93	"	~~110~~	unk	0						X										X							yes	5/21				X			
18	87	"	~~111~~	Mall	9			X			[illegible]				X		X											NO								
3	85	"	~~112~~	"	8			X													X							NO								

Form D-1
Field Form
Unit No.
Observer:
WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA
Year:

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbitbrush	Dst saltgrass	Gx grass	Mof sweet clover	Wx weeds	Jba [illegible]	Cx carex	Ex spike rush	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
9	89	6/18	132	Mall	10		X													X							no								
"	"	"	133	"						X										X							"	6/18				X			
"	95	"	134	"	8		X													X							"	7/[illegible]	X	8					
"	"	"	135	"	5		X													X							"	"	X	5					
"	"	"	136	Gadw	10		X													X							"	"	X	10					
"	"	"	137	Mall	7		X													X							"	"	X	6					
"	"	"	138	Redhead	8		X													X							yes	"			X				
"	97	"	139	Pint	6		X							X						●							no	"	X	6					
"	"	"	140	C teal	7		X													X							no	"				X			[illegible]
"	"	"	141	Mall					X											X							no	6/18				X			
3	105	"	142	Mall					X											X							no	"				X			
3	"	"	143	Pintail																								"	X	6?					
			52																									7/11	X						
			51																									"			X				
			20																									"				X			
	97		19																									6/18				X			
9	87		08																									6/18				X			
			08																									"				X			
			09																									"			X				
			10	SHOV																								"	X	9		●			
	95		15	Mall																								"	X	11					
			16	"																								"				X			
			17																									"				X			
			18																									"				X			

Form D-1

Field Form

Unit No. ____________

Observer: CORNELIUS

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Year: 1974 2nd run

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve grease	Crx salt	Dst salt	Gx grass	Mof sweet	Wx weeds	Jba rush	Cx carex	Ex spikerush	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No.Hatch.	Desert.	Destr.	Flooded	Unknown	
6	33	6/13	~~123~~	PINT	9		X													X							No								
6	33	"	~~124~~	SHOV	9		X													X							"								
6	39	"	~~125~~	"	4		X													X							No								
			~~123~~	Mall																							"	6/13				X			
			~~122~~	"																							"	6/13				X			
1	63	"	126	Teal	-					X							X			⊗							"	"				X			2 eggs left
7	63	"	127	PINTAIL	0					X										X							"								
1	67	"	128	Mall	0					X										X							"	"				X			
1	71	"	129	"	4		X			X										X							yes								
16	102	6/17	130	Mall	9		X			●										X							no								
8	75		~~124~~	"																								6/17				X			[illegible]
8	75		~~125~~																									"				X			mammal
17	79	6/17	131	"	7		X			●										X							No								

Form D-1

Observer: Gretz

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No.

Year: 1974 - 2nd RUN

100 yds
S-1/2

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbitbrush	Dst saltgrass	Gx grasses	Mof sweet alfa	Wx weeds	Jba Black Rush	Cx sedges	Ex spikerushes	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
3	101	6/19	188	MALLARD	8		X													X								7/11	X						
3	101	~~6/19~~	~~187~~	~~MALLARD~~	~~7~~		~~X~~				off		line							X								7/11	X						
3	101	6/19	121	MALLARD						X										X								6/19				X			by unknown.
	89		132	MALLARD																								7/11				X			by Bird
	101		120	PINT.																								7/11	X						
	99		80	MALL																								7/11	X						
	99		79	MALL																								7/11	X						
	99		78	MALL																								7/11	X						
			123																									7/11				X			
			124																									7/11				X			

151-175
114,115

Form D-1

Field Form

Observer: Getman

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. 19

Year: 1974 2nd Run

First Observation						Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx	~~Dst~~	Gx grass	Mof sweetclover	Wx weeds	Jba	Cx sedges	Ex	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
19	17	6-12	151	Ma	8		✓										✓			✓							NO								
18	87	6-17	113	Ma																							no	6-17	✓						
18	97	6-17	152	Ma	0					✓										✓							Nd	6-17				✓			
3	85	6-18	153	Unknown	0					✓										✓							NO	6-18				✓			
3	85	6-18	112	Ma	0					✓										✓							NO	6-18				✓			
3	85	6-78	154	Ma	9		✓										✓			✓							NO	[illegible]							
3	87	6-18	155	Ma	0												✓			✓							NO	6-18	✓	5					
3	87	6-18	156	Teal	0					✓										✓							NO	6-18				✓			
"	"	"	157	Ma	4		✓												✓	✓							NO								✓
"	93	"	158	Unknown	0																						NO	6-18	✓	4					
"	"	"	114	Ma	0					✓																		6-18				✓			
"	"	"	115	Ma	0																							"				✓			

Form D-1 Field Form Unit No. ____________

Observer: Steenhof WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA Year: 1974 - 2nd Run

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No. & expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve Greasewood	Crx	Dst Saltgrass	Gx grass	Mof sweet clover	Wx weeds	Jba Black rush	Cx	Ex Spike rush	Tla Cattail	Sva Scirpus	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
1	33	6/12/74	101	Ma																✓							No	6/12/74	✓						
6	29	6/13/74	01	Pi					✓					✓						✓							No	6/13/74	✓						
6	31	6/13/74	51	Ma	8		✓													✓							No								
6	31	6/13/74	52	Ma	7		✓													✓							No								
6	31	6/13/74	53	Ux	[illegible]				✓											✓							No	6/13/74	✓	5+					
7	53	6/13/74	54	Ma	7		✓													✓							No								
7	57	6/13/74	55	Ux						✓																									
15	47	6/14/74	56	Go	1	✓														✓							No								
	47	6/14/74	03	Ma	(4)					✓										✓							No	6/14/74				✓			
	33	6/20/74	57																																

^ 53

Form D-1 Field Form Unit No.________

Observer: STEVE + D. GIRETZ WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA Year:________

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbitbrush	Dst saltgrass	Gx grasses	Mof sweetclover	Wx weeds	Jba Baltic rush	Cx Carex	Ex spikerush	Tla cattail	Sva bulrush	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl on back)
6	35	6/13	176	Mall	0					X										X								6/13			X				
[illegible]	65	6/13	177	Pintail	7		✓												X																
15	53	6/14	01	Mal																								6/14			X				
		~~6/14~~	~~178~~																									~~6/14~~	~~X~~						
9	85	6/18	178	? Teal	6		X													X															
9	85	6/18	179	MALLARD	0					X Predator (Carnivore)										X															
9	91	6/18	011	Pintail																X								6/18	X						
9	91	6/18	180	PINTAIL	0					X bird										X															✓
9	91	6/18	012	Mallard	0					X Carnivore pred.										X								6/18				X			
9	91	6/18	181	Mallard	2				X											X															
9	91	6/18 X	182	MALLARD	6		X													X								7/11				X			Skunk only 2 eggs first. – 4 eggs rolled
9	91	6/18 X	183	MALLARD	8		X													X								7/11	X						
9	91	6/18	184	MALLARD	0					X Bird										X															
9	93	6/18	013	MALLARD	0					X Birds										X								6/18				X			partially HATCHED when killed
9	93	6/18	014	MALLARD	0															X								6/18	X	4 eggs not fertile					
9	93	6/18 X	185	185 Mall	6		X													X								~~[illegible]~~ 7/11	X			~~X~~ 2			~~only 2 [illegible]~~
9	93	6/18 X	186	MALLARD	11		X													X								7/11	X	9 eggs out of 11					
3	101	6/18	118	MALLARD	0															V								6/18						X	nest empty
3	101	6/18	119	MALLARD															X									6/18						X	Couldn't find again
	~~101~~	~~6/18~~	~~187~~	~~MA~~	~~6~~		~~X~~						X				X																		
	~~101~~	~~6/18~~	~~188~~	~~MA~~	~~4~~	~~Xdly~~														X															
3	103	6/18	187	Teal	5															X								6/18	X						
4	73	6/18	108	Mal.																								6/18	X						

Unit 1

9

tale 81
73-75

Form D-1 76 - 100

Observer: Lee Jackson

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. ____________

Year: 1979 - 2nd Run

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbit Brush	Dst salt grass	Gx grasses	Mof sweet clover	Wx weeds	Jba Black rush	Cx sedge	Ex spike brush	Tla	Sva	Dike	Ditch	Flooded yes No	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
10	93	6-17	76	Unknown	0					X		X							ⓧ	X								6-17				X		X	
17	101	6-17	82	"	0					X										X								6-17				X		✓	
18	103	6-17	107	Mall	7					X										X								6-17				X			Bird
3	97	6-18	77	Mall						X										X								6-18				X			Magpie
3	97	6-18	116	"	0					X										X								6-18				X			
3	97	6-18	78	"	10		X													X								~~6-18~~	~~X~~						
3	99	6-18	117	Mall																								6-18	X						
3	99	6-18	29	Mall	8		X										4																		
3	99	6-18	80	"	9		X										X																		✓
9	99	6-18	21	Ma						X																		6-18				X			
9	99	6-18	23	Ma																								"	X	5					
9	99	"	24							X																		"				X			
9	99	"	25							X																		"				X			
9	105	"	31	Unknown						X										X															
3	99	[illegible] 7/11	189	Mall						X																									

Form D-1

Observer: ______

Field Form

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. ______

Year: ______

		First Observation				Nest Status							Cover Type															Fate							
Unit No.	Transect No.	Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	Remarks (No.& expl. on back
9	99	5-22-74	021	ma	8		X													X							no								
9	99	5-21-74	022	un	4	X				X										X							no								
9	99	5-21-74	023	ma	8		X													X							no								
9	99	5-21-74	024	ma	8		X													X							no								
9	99	5-21-74	025	un	2	X														X							no								
9	99	5-21-74	026	un	2	X				X										X							no								
4	109	5-22-74	027	ma	6		X													X							no								
4	113	5-22-74	028	un	1					X										X							no								
4	119	5-23-74	029	ma	7		X													X			⊕				no								✓
11	129	5-28-74	030	un	2					X										X							no								
3	83	5-22-74	031	ma	6		X													X							no								

Form D-1 No. 01-100

Field Form

Unit No. ______

Observer: GIESE, F. + Espinosa

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Year: 1974-1st Run

Unit No.	Transect No.	First Observation				Nest Status							Cover Type														Flooded yes no	Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx willow	Sve greasewood	Crx rabbit brush	Dst saltgrass	Gx grass	Mof clover	Wx weed	Jba black rush	Cx sedges	Ex spikerush	Tla cattail	Sva bulrush	Dike	Ditch		Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
EXAMP ~~19~~	~~7~~	~~5/10~~	~~01~~	~~Mall~~	~~6~~		~~X~~							~~X~~						~~X~~							[illegible]								
EXAMP ~~19~~	~~9~~	~~"~~	~~02~~	~~Mall unk~~	~~-~~					~~X~~										~~X~~							[illegible]	~~5/12~~				~~X~~			[illegible]
6	29	5-14-74	~~01~~	Pin	3	X								X						X							No								
18	97	5-16-74	~~02~~	UNK	3															X							Yes								
15	47	5-20-74	~~03~~	ma	5		X													X							no								
15	51	5-20-74	~~04~~	ma.	7		X													X							no								
15	47	"	~~05~~	"						X										X							No	5/20				X			
15	49	"	~~06~~	"						X										X							No	5/20				X			
9	87	5-21-74	07	unk	5	X														/							Yes								✓
9	87	5-21-74	08	ma.	10		X													X							Yes								
9	89	5-21-74	09	unk	1	X														X							Yes								
9	87	5-21-74	010	unk	7	X														X							Yes								
9	91	5-21-74	011	Pin	5		X													X							no								
9	91	5-21-74	012	un	6	X														X							Yes								
9	93	5-21-74	013	ma.	6		X													X							Yes								
9	93	5-21-74	014	ma	9		X													X							Yes								
9	95	5-21-74	015	ma.	11		X													X							Yes								
9	95	5-21-74	016	ma.	7		X													X							Yes								
9	95	5-21-74	017	un	2	X														X							no								
9	95	5-21-74	018	Pi	6		X													X							no								
9	97	5-21-74	019	ma.	7		X													X							no								
9	97	5-21-74	020	ma	8		X													X							Yes								

Form D-1

Field Form

Observer: CORNELIUS

WATERFOWL PRODUCTION SURVEY DUCK & COOT NESTING DATA

Unit No. ____________

Year: ____________

Unit No.	Transect No.	First Observation				Nest Status							Cover Type															Fate							Remarks (No.& expl. on back
		Date	Nest No.	Species	No. Eggs	Laying	Incub.	Covered	Desert.	Destr.	Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	Date	Hatched	No. Hatch.	Desert.	Destr.	Flooded	Unknown	
11	135	6/20	144	SHOWAH	6		X												X	Ⓧ							m								
	119		29																									6/21	X	7					
			31																									6/19				X			
4	109		27	still nested					6/18																			6/19							
17	85		109	SHOV																								6/19				X			

Form D3 – Duck Brood Sample Data

Form D-3
Observer: ________________

WATERFOWL PRODUCTION SURVEY -- DUCK BROOD SAMPLE DATA

Year: 1974

Class III & IIc

Date	Mallard			Pintail			Gadwall			Shoveller			B-W Teal			G-W Teal								
	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.
			3			6			4			4			5									
			6			3			8			7			9									
			6			4			5			5			6									
			4			8			9			3			6									
			5			2			3			4			5									
			4			6			2						7									
			7			1			4						4									
			7			9			6						1									
			8			5			7						4									
			4			4			8						2									
			3			8			8						3									
			6						6						8									
			7						2						9									
			8						4						3									
			3						6															
			8																					
			1			56			82			23			72									
			2			11			15			5			14									
			3			5.1			5.5			4.6			5.1									
			7																					
			6																					
			4																					
			8																					
			120																					

23

5.2

Form D-3
Observer:

WATERFOWL PRODUCTION SURVEY -- DUCK BROOD SAMPLE DATA

Class 2

Year:

	Mallard			Pintail			Gadwall			Shoveller			B-W Teal			G-W Teal								
Date	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.
			4			3						6			1									
			6			4						8			3									
			8			5									2									
			8			2									5									
			4												5									
			5												2									
			2												4									
			6												3									
			1												6									
			8																					
			6																					
			8																					
			6																					
			2																					
			4																					
Total			78			14						14			31									
No Brood			15			4						2			9									
Ave size			5.2			3.5						2.0			3.5									

Form D-3
Observer: ____________

WATERFOWL PRODUCTION SURVEY -- DUCK BROOD SAMPLE DATA

Class I

Year: 1974

Date	Mallard			Pintail			Gadwall			Shoveller			B-W Teal			G-W Teal								
	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.
7/19			4			9			11			7			2									
			7			6			6						2									
			2			2			1						4									
			3			3									2									
			8			4									4									
~~7/20~~			5												6									
			7												2									
			2												2									
			3																					
			6																					
			4																					
[illegible]			5																					
			7																					
			4																					
~~7/30~~			3																					
Total			70			24			1-8			7			24									
No Broo			15			5			3			1			8									
Ave			4.7			4.8			6.0			7.0			3.0									

Form D-3

Observer: ____________

WATERFOWL PRODUCTION SURVEY -- DUCK BROOD SAMPLE DATA

All classes

Year: ________

Class ~~Date~~	Mallard			Pintail			Gadwall			Shoveller			B-W Teal			G-W Teal								
	~~Unit No.~~ Ave. Size	Pond No. No. br.	No.duckl. ~~Class IIc & III Br.~~ Total	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No. duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.	Unit No.	Pond No.	No.duckl. Class IIc & III Br.
I	4.7	15	70	4.8	5	24	6.0	3	18	7.0	1	7	3.0	8	24									
II	5.2	15	78	3.5	4	14	—			7.0	2	14	3.5	9	31									
III	5.2	23	120	5.1	11	56	5.5	15	82	4.6	5	23	5.1	14	72									
Total	5.1	53	268	4.7	20	94	5.5	18	100	5.5	8	44	4.1	31	127									

Form D4 – Duck Nesting Transects Individual Unit Summaries

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 1 Recorder: ____________ Year: 1974

Transect Coverage in % ____ (All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	2	0	0		2										2							
Pintail	1	1	100											1								
Gadwall																						
Shoveller																						
Teal B-W & Cinn.	1	0	0		1										1							
G-W Teal																						
Ruddy																						
Unknown																						
Total	4	1	25		3									1	3							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 3 Recorder: ____________ Year: 1974

Transect Coverage in % ____ (All transects=100%, every other transect = 50%,etc.)

		Nests							Primary Covery Type (No. of nests in each primary tvpe)														
	Total Nests on Transects	No. Hatched	% Hatched	No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	
Mallard	20	8	40		12							2			18								
Pintail	2	2	100		0									1	1								
Gadwall																							
Shoveller																							
Teal B-W & Cinn.	2	1	50		1										2								
G-W Teal																							
Ruddy																							
Unknown	2	1	50		1										2								
Total	26	12	46%		14							2		1	23								
Coot																							

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 4 Recorder: ____________ Year: 1974

Transect Coverage in %____ (All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)														
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	
Mallard	3	2	66		1										2			1					
Pintail																							
Gadwall																							
Shoveller																							
Teal B-W & Cinn.																							
G-W Teal																							
Ruddy																							
Unknown	1	0	.0		1										1								
Total	4	2	50		2										3			1					
Coot																							

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 6 Recorder: ____________ Year: 1974

Transect Coverage in %_____(All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	5	1	20	1	3				1						4							
Pintail	2	1	50		1				1						1							
Gadwall																						
Shoveller	2		0		2										2							
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown	1	1	100												1							
Total	10	3	30	1	6				2						8							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 7 Recorder: __________ Year: 1979

Transect Coverage in % _____ (All transects=100%, every other transect = 50%, etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	1	0	0		1										1							
Pintail	1	0	0		1										1							
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown	1	0	0		1										1							
Total	3	0	0												3							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 8 Recorder: ______ Year: 1977

Transect Coverage in % _____ (All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	3	1	33												3							
Pintail																						
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown																						
Total	3	1	33												3							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 9 Recorder: Year: 1974

Transect Coverage in %_____(All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary tvne)														
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	
Mallard	23	9	39	1	13										23								
Pintail	4	2	50		2				1						3								
Gadwall	1	1	100												1								
Shoveller	1	1	100												1								
Teal B-W & Cinn.	2	0	0	1	1										2								
G-W Teal																							
Ruddy																							
Redhead	1	0	0	1											1								
Unknown	8	0	.0	1	2										8								
Total	40	13	32.5	4	23				1						39								
Coot																							

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 11　　Recorder: ____________　　Year: 1974

Transect Coverage in %_____ (All transects=100%, every other transect = 50%, etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard																						
Pintail																						
Gadwall	1	0	0		1										1							
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown	1	0	0		1										1							
Total	2	0	0		2										2							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 14　　Recorder: ______　　Year: 1977

Transect Coverage in % _____ (All transects=100%, every other transect = 50%, etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	1	1	100												1							
Pintail																						
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown																						
Total	1	1	100												1							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 15 Recorder: ______ Year: 1974

Transect Coverage in % _____ (All transects=100%, every other transect = 50%, etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary tvpe)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	4	0	0	1	3										4							
Pintail															1							
Gadwall	1	0	0	0	1																	
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown																						
Total	5	0	0	1	4										5							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 16 Recorder: ____________ Year: ________

Transect Coverage in %_____(All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary tvne)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	1	1	100												1							
Pintail																						
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown	1	0	.0		1										1							
Total	2	1	50		1										2							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 17 Recorder: ____________ Year: 1974

Transect Coverage in %_____ (All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary type)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	1	0	0		1										1							
Pintail																						
Gadwall																						
Shoveller	1	0	0		1										1							
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown																						
Total	2	0	0		2										2							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 18 Recorder: ____ Year: 1974

Transect Coverage in % ____ (All transects=100%, every other transect = 50%,etc.)

	Total Nests on Transects	Nests		No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Primary Covery Type (No. of nests in each primary tvne)													
		No. Hatched	% Hatched						Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	4	1	25						2						2							
Pintail																						
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown	2	0	.0												2							
Total	6	1	16.7						2						4							
Coot																						

*Obtain data from Field Form D-1

Form D-4

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----INDIVIDUAL UNIT SUMMARY*

Unit No. 19 Recorder: ____________ Year: ________

Transect Coverage in % _____ (All transects=100%, every other transect = 50%,etc.)

		Nests							Primary Covery Type (No. of nests in each primary tvne)													
	Total Nests on Transects	No. Hatched	% Hatched	No. Deserted	No. Destroyed	No. Flooded	Unknown	Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded
Mallard	1	0	0		1										1							
Pintail																						
Gadwall																						
Shoveller																						
Teal B-W & Cinn.																						
G-W Teal																						
Ruddy																						
Unknown																						
Total	1	0	0												1							
Coot																						

*Obtain data from Field Form D-1

Form D-5

WATERFOWL PRODUCTION SURVEY

DUCK NESTING TRANSECTS----REFUGE ANNUAL SUMMARY*

Recorder: ____________________

Year: 1974

Transect Coverage in % 72.7 (All transects 100%, every other transect 50%, etc.)

Species		Unit No.																					
(1) No. Nests on transect (2) % Refuge total (3) % Hatch		1	2	3	4	5	6	7	8	9	10	11	14	15	16	17	18	19	20	21	22	23	Total
Mallard	(1)	2		20	3		5	1	3	23			1	4	1	1	4	1					69
	(2)																						
	(3)	0		40	67		20	0	33	39			100	0	100	0	25	0					35
Pintail	(1)	1		2			2	1		4													10
	(2)																						
	(3)	100		100			50	0		50													60
Gadwall	(1)									1		1		1									3
	(2)																						
	(3)									100		0		0									33
Shov.	(1)						2			1						1							4
	(2)																						
	(3)						0			100						0							25
B-W & Cinn. Teal	(1)	1		2						2													5
	(2)																						
	(3)	0		50						0													20
G-W Teal	(1)																						
	(2)																						
	(3)																						
Redhead	(1)																						
	(2)																						
	(3)																						
Ruddy	(1)																						
	(2)																						
	(3)																						
Redhead	(1)									1													1
	(2)																						
	(3)									0													0
	(1)																						
	(2)																						
	(3)																						
Unknown	(1)			2	1		1	1		8		1			1		2						17
	(2)																						
	(3)			50	0		100	0		0		0			0		0						12
Total	(1)	4		26	4		10	3	3	40		2	1	5	2	2	6	1					109
	(2)																						
	(3)	25		46	50		30	0	33	33		0	100	0	50	0	17	0					32
Coot	(1)																						
	(2)																						
	(3)																						

* Obtain data from Summary Form D-4

Form D-6

CALCULATIONS FOR DETERMINATION OF CORRECTED SPECIES COMPOSITION

(1)	Species Composition of Transect Data			Species Composition of Breeding Population			(8)	Corrected Sp. Comp. of Nests	
Species	(2) No. Nests From Form D-5)	(3) Sp. Comp. Known Nests in %	(4) Weight (Col. 3 x [redacted]. 2	(5) No. Breeding Ducks	(6) Sp. Comp. in %	(7) Weight (Col. 6 x 1)	Weight (Col. 4 + Col. 7)	(9) Sp. Comp. in % $(\frac{\text{Col. 8}}{3})$	(10) Sp.Comp. in Nos. (Col. 9 x total(109
Mallard	69	75	150	3400	35.6	36	186	62.0	1720
Pintail	10	11	22	1800	18.8	19	41	13.7	380
Gadwall	3	3	6	1800	18.8	19	25	8,3	230
Shoveller	4	4.5	9	900	9.4	9	18	6,0	166
Cinn.Teal	5	5,5	11	1200	12,5	12	23	7.7	213✓
G.W. Teal				400	4.2	4	4	1,3	36
Redhead	1	1	2	20	.2	.4	2.4	.8	22
Ruddy				50	.5	.6	.16	.2	5
(Total)	92								
Unknown	17			9570					
TOTAL	109	100	200		100	100			2272
Coot									

Form D-6a

CALCULATIONS FOR DETERMINATION OF DUCKS PRODUCED BY SPECIES

		Hatching Success of Nests			Average Class IIc & III Broods			Sp.Comp.of Ducks Produced to Flight Age	
Species	(10) Sp. Comp. in Nos. (Col. 9 x total	(11) No. Nests Hatched on Transects (From Form D-5)	(12) Hatching Success in % $(\frac{\text{Col.11}}{\text{Col. 2}})$	(13) Total Nests Hatched (Col. 10 x Col.12)	(14) No. Broods Recorded (From Form D-3)	(15) No. Ducklings Recorded (From Form D-3)	(16) Average Brood Size $(\frac{\text{Col.15}}{\text{Col.14}})$	(17) No. Ducks Produced (Cols.13 x 16)	(18) Sp. Comp. in %
Mallard	1720	24	35	602	120	23	5.2	3224	61
Pintail	380	6	60	228	56	11	5.1	1163	22
Gadwall	230	1	33	76	82	15	5.5	418	8
Shoveller	166	1	25	42	23	5	4.6	193	4
B.W. Teal									
Cinn. Teal	213	1	20	42	72	14	5.1	214	4
G.W. Teal	36	-	20	7	-	-	ave 5.2	36	.5
Redhead	22	0	0 / 20	4	-	-	ave 5.2	21	.5
Ruddy	5		/ 20	1	-	-	ave 5.2	5	0
Unknown									
TOTAL	2772	-	-	1002	353	68	5.2	5274	100
Coot									

Form D-9

WATERFOWL PRODUCTION SURVEY

PRIMARY DUCK NESTING COVER TYPES----REFUGE ANNUAL SUMMARY*

Recorder: Cornelius

Year: 1974

(1) No.Nests (2) % in Primary Type		Primary Type															
		Sx	Sve	Crx	Dst	Gx	Mof	Wx	Jba	Cx	Ex	Tla	Sva	Dike	Ditch	Flooded	
Mallard	(1)		2			2			63								67
	(2)		3			3			94								
Pintail	(1)							2	7								9
	(2)							22	78								
Gadwall	(1)								2								2
	(2)								100								
Shoveller	(1)								4								4
	(2)								100								
B-W & Cinn. Teal	(1)								5								5
	(2)								100								
G.W. Teal	(1)																
	(2)																
Redhead	(1)								1								1
	(2)								100								
Ruddy	(1)																
	(2)																
Unk	(1)									7							7
	(2)									100							
	(1)																
	(2)																
Total	(1)		2			2		2	82	7							95
	(2)		2			2		2	86	7							
Coot	(1)																
	(2)																

* Obtain data from Summary Form D-4

Raw Data & Memo

Nest Companions 1973-1974
by unit

	1973		1974			
	1ST	TOTAL	1ST	2nd	TOTAL	
unit	#	#				
1	4	8	0 ✓	4	4	50%
2	1	3	0 ✓		-	–
3	24	45	11 ✓		26	40%
4	4	8	4 ✓		4	50%
6	9	19	3 ✓	–	10	48%
7	3	9	0 ✓	-	3	65%
8	4	14	3 ✓		3	80%
9	24	60	20 ✓		40	30%
10	3	5	0 ✓		-	–
11	5	8	1 ✓		2	80%
14	0	0	1		1	+
15	3	14	4 ✓	1	5	60%
16	2	6	0 ✓		2	60%
17	3	7	1 ✓		2	70%
18	13	29	5 ✓		6	80%
19	0	3	0 ✓		1	–
20	1	2	0 ✓		-	–
21	0	0	0 ✓		-	–
22	1	4	0 ✓		-	–
23	1	1	0 ✓		-	–
	105	248	53		109	60%

	still active or 2nd nest	hatched	abandoned	destroyed	Total
Mallard	~~卌 卌~~ 23	9	2	35	69
Pintail	~~卌~~ 4	3	-	3	10
Gadwall	3	-	-	-	3
Shoveler	~~|~~ 2	1	-	1	4
Teal	~~|~~ 3	1	-	1	5
Redhead	1		-	-	1
unknown	~~||~~ 3	2	1	11	17
Total	39	16	3	51	109

	act				
Mall	~~卌 卌 卌 |||~~	23	~~8~~	10 ~~卌 卌 卌 卌~~ 卌 ✳ —	35
Pint	||||	4		|||	3
Gad	|||	3			
Shov	||	2		|	1
Teal	|||	3		|	1
Redh	|				
unk	|||	3 39		卌 卌 |	11 51

Pete: Total of 109 nests found (53 on first run & 56 on 2nd)

So far: 16 hatched, 54 destroyed, & 39 still active

Present success = $\left(\frac{16}{70}\right)$ = 23%

Estimated success = $\left(\frac{36}{109}\right)$ = 33%

~~$\frac{109}{248}$~~

$$248 \times .49 \times x = \overset{1.89}{\frac{23000}{248 \times .49}}$$

$x =$ 121.

$$109 \times 33 \times \overset{1.89}{x} = \boxed{6800 \text{ ducks}}$$

Brood counts

7/19/74
7/30/74
8/21/74

	I		II		III		
Mallard	4, 7, 2, 3, 8 5, 7, 2, 3,6, 3, 4 5, 7, 4, —	[illegible] 70/15/4.7	4, 6, 8, 8, 4 5, 2, 6, 1, 8, 6, 8, 6, 2 4	30/6.0 78/15/5.2	3, 6, 6, 4, 5, 4 7, 7, 8 [illegible] 4, 3, 6, 7, 8, 3, 8, 1, 2, 3, 7, 6, 4, 8	28/ 5.2	96/18 5.3
Pintail	9, 6, 2, 3, 4,	24/5/4.8	3, 4, 5, 2	14/4/3.5	6, 3, 4, 8, 2, 6, 1, 9 5, 4, 8	5.1	
Gadwall	11, 6, 1	18/6.0			4, 8, 5, 9, 3, 2, 4, 6, 7, 8 8, 6, 2, 4, 6,	82/5.5	
Shov	7,		6, 8,	17	4, 7, 5, 3, 4,	23/4.6	
Teal	2, 2, 4, 2, 4, 6, 2, 2,	10/2.5 24/3	1, 3, 2, 5, 5, 2, 4, 3, 6,	16/3.2 31/3.5	5, 9, 6, 6, 5, 7, 4, 1, 4, 2, 3, 8, 9, 3,	26/6.2 72/5.1	58/4.0 204/40=5.1

MONTE VISTA NATIONAL WILDLIFE REFUGE
P.O. BOX 511
MONTE VISTA, COLORADO 81144

June 24, 1974

Richard M. Hopper
Game Research Center
P.O. Box 567
Fort Collins, Colorado 80521

Dear Dick:

Enclosed is a brief summary of our nesting data to date. We have just concluded our second run of transects. With both the amount of nesting and nesting success down very low, we aren't going to produce many ducks this year.

The 109 nests found compares with 245 nests found in 1973, and 145 nest found in 1972. The year 1972 was also a dry year and one of very low production. However nesting success was 49% in both previous years. It looks like nesting success will be 30% or less this year.

We will send you more complete data when the third round is complete.

Sincerely yours,

Charles R. Bryant

Species	Still Active	Hatched	Abandoned	Destroyed	Total
Mallard	23	9	2	35	69
Pintail	4	3	0	3	10
Gadwall	3	0	0	0	3
Shoveler	2	1	0	1	4
Teal	3	1	0	1	5
Redhead	1	0	0	0	1
Unknown	3	2	1	11	17
TOTAL	39	16	3	51	109

Published Nesting and Waterfowl Production Survey Reports 1972-1974

1. "Correction of Bias in Belt Transect Studies of Immotile Objects," D.R. Anderson, and R.S. Pospahla

2. "Field Tests of Strip Census Method," W.L. Robinette, C.M. Loveless, D.A. Jones

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Refuge Manager
Monte Vista National Wildlife Refuge
Monte Vista, Colorado

DATE: October 17, 1974

FROM : Research Biologist, Migratory Bird
and Habitat Research Laboratory
Laurel, Maryland

SUBJECT: Return of 1972, 1973, and 1974 nesting data

I am returning the three files containing the results of the nesting and production surveys conducted at Monte Vista National Wildlife Refuge. Thank you for the loan of this information.

We have also acquired the base data from Robinette's studies (JWM 38(1): 81-96) and hope to reanalyze his data using the methods that Ken Burnham and I recently developed. Robinette's data are particularly interesting because the true number of objects is known, making it possible to compare our estimates with the true value.

If we learn anything from all these analyses that might be useful at Monte Vista we will keep you informed.

Thanks again for your help.

David

David R. Anderson

5010-108

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

WRes

DATE: September 13, 1974

TO : Refuge Manager
Monte Vista National Wildlife Refuge

FROM : Research Biologist, Migratory Bird and
Habitat Research Lab., Laurel, Maryland

SUBJECT: 1972, 1973, and 1974 nesting data

Several years ago you allowed Dick Pospahala and I access to the nesting data collected on the Refuge in 1967 and 1968. As you recall, we used these data as an example in a Journal of Wildlife Management paper (copy attached). Subsequently, the width of the transects was increased from 16.5 feet to 24 feet.

Recently, Les Robinette and others published the results of an intensive study of line transect methods, also in the Journal of Wildlife Management (copy attached). The method that Dick and I developed using the Monte Vista data as an example, was shown to perform quite well. This has prompted additional thought on the subject by Ken Burnham and myself. We have submitted a paper extending the analysis methods in line transect studies to Biometrics and are tentatively planning a paper to explain the theory and illustrate some new techniques using several examples.

My reason for writing is to ask if it would be possible for us to obtain Form D1 sheets for the refuge nesting studies in 1972, 1973, and 1974. We would at least like to examine the data and perhaps use them as an example in the planned publication. As before, we would be happy to acknowledge you and your staff in the publication.

If this is agreeable with you, perhaps you would be willing to mail the forms (probably insured and certified), we would prepare xerox copies, and return the originals to you within a few days.

Sorry I didn't get a chance to speak with you in Denver this summer; you scurried in and out of the meeting room too fast.

David

David R. Anderson

10/1/74

Enclosure:

Yes Send out.

Sent to Dave 10/9/74.

ATTENTION OF:

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J. Wildl. Manage. 34(1):141-146. 1970

CORRECTION OF BIAS IN BELT TRANSECT STUDIES OF IMMOTILE OBJECTS

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R. S. POSPAHALA, Colorado Cooperative Wildlife Research Unit, Fort Collins[1]

Abstract: Unless a correction is made, population estimates derived from a sample of belt transects will be biased if a fraction of the individuals on the sample transects are not counted. An approach, useful for correcting this bias when sampling immotile populations using transects of a fixed width, is presented. The method assumes that a searcher's ability to find objects near the center of the transect is nearly perfect. The method utilizes a mathematical equation, estimated from the data, to represent the searcher's inability to find all objects at increasing distances from the center of the transect. An example of the analysis of data, formation of the equation, and application is presented using waterfowl nesting data collected in Colorado.

INTRODUCTION

Transect sampling has been widely used in wildlife management and research for estimating the size of populations of both animate and inanimate objects. Robinette et al. (1954) presented a discussion of transect methods and attempted to compare the results of several methods. Recently, Eberhardt (1968) classified transect studies, noted the need for field data and proposed several formulae. Gates et al. (1968) discussed a new method and attempted to apply it to grouse surveys.

Transect studies designed to estimate the population size of objects such as dead deer (*Odocoileus* spp.) or waterfowl nests usually proceed in the following manner: definition of the area to be sampled; random (or systematic) selection of transect lines throughout the area; and search of the transects to record the number of objects under study. If the transect has a predefined width and the center line is well marked, the estimate can be easily expanded into an estimate for the population of the total area. Several modifications have been suggested, particularly those which allow variable width transects (Kelker 1945, Webb 1942, and Hayne 1949).

An important source of bias is usually present in transect sampling methods. If some individuals on the sample transects are not counted, the expanded estimate will always be too low unless an adjusted value is used. Since individuals of many populations are small, well concealed, or secretive, the estimation of such populations becomes very difficult. When counting large, inanimate objects, such as dead deer, within a fairly narrow transect in sparse cover, this may not be an important source of bias. However, when searching a wide transect for a small, often concealed object, this bias may render the estimate nearly meaningless.

The purpose of this paper is to present a method for estimating the number of objects not recorded on sample transects. The method appears to be useful when sampling immotile objects within transects of a predetermined, fixed width. Transect studies of nests, burrows, and dead birds or big game could probably be improved by using the method described.

The authors wish to acknowledge the help of C. R. Bryant, and the staff of the Monte Vista National Wildlife Refuge, Colorado, who made the data analyzed in this report available. We also wish to acknowledge L. L. Eberhardt for his review of the manuscript.

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METHOD

This discussion relates to studies having the following characteristics:

1. The design should randomly sample the defined population. In some instances, a systematic sample with a random first start will produce satisfactory results. The population sampled is actually the *area* under consideration, not the individuals of the object of interest. The population being sampled is a population of strips, the sample units are the sample strips, and the object of interest (nests, dead deer, etc.) is the variate associated with the strips.
2. The transect must be of a predetermined width and the center line must be well marked to allow accurate distance measurements to be made.
3. A large number of individuals must be recorded on the sample transects. The size of the sample can be determined by specifying the precision of the estimate and presampling portions of the population as discussed by Cochran (1963).
4. Interested and qualified observers must be employed to accomplish the field work.

It is recognized that immotile wildlife populations (for example, nests) are rarely distributed uniformly in space. Such populations seem to be distributed randomly or in some "contagious" form. The important consideration for this method, and all transect sampling methods, was outlined by Moore (1955:394): "The practical ideal is that where game density, although not uniform, does not have a pattern correlated in any way with the pattern of census strips." Using any one of several statistical sampling designs should allow this important assumption to be met (Cochran 1963).

By examining the results of a large survey, as many recordings near the outer edges of the belt transect would be expected as would occur near the center line. If the units being counted are not correlated in any way with the sampling design, a uniform distribution of counts would be expected at each distance from the center line of the transect. This does not imply that the population is uniformly distributed, but only that all units have an equal likelihood of occurring anywhere within the transect. This is a key point and the concept upon which the method is based. Hayne (1949) and Breckenridge (1935) discuss this subject, primarily with reference to motile populations.

It seems reasonable that as the width of the transect increases, the observer is more likely to miss items near the outer edges of the transect. However, his ability to count and record items near the center line is probably not seriously affected. This concept applies even if the observer searches in an irregular pattern about the center line, as was recognized in dead deer studies conducted by Whitlock and Eberhardt (1956).

Other factors remaining constant, the narrower the transect, the more likely the observer is to record a higher proportion of the total items present on the transect. There are, of course, practical limitations of time and cost concerning how narrow the transect may be. A very narrow transect may be highly inefficient for sampling some populations, since an insufficient number of items might be counted after covering a great distance.

The method suggested requires a "right angle" measurement from the located object to the center line of the transect. This distance must be measured accurately for the data to be most useful. The direction from the center line is not essential.

The measurements are then grouped into class intervals of a reasonable width, and a frequency distribution or histogram made. The distance measurements yield a set of data continuous over the interval from the transect mid-line to the outer edge. The class intervals result in a series of discrete intervals. The size of these intervals requires that the investigator apply his biological knowledge of the data and its meaning. In general, the size of the interval will depend upon the width of the transect, the number of individuals found, and the accuracy with which the measurements were made.

Based on the frequency distribution, a curve must be found that accurately represents the data with Y (the dependent variable) being the number of individuals recorded in a particular interval, and X (the independent variable) being the distance interval from the center line of the transect to the midpoint of the class interval. A wide variety of mathematical curve-fitting procedures exist; some form of the least squares method will suffice in most cases.

The area below this calculated curve represents the number of items found and recorded. The area above this curve and below a line perpendicular to the Y intercept represents an estimate of the number of items not found and not recorded (Fig. 1).

Although it is usually known that items are missed, a statistical test should be made of the significance of the model resulting from fitting a curve to the data. Since the continuous variable X was grouped into class intervals, Sheppard's correction for the variance might be applied before any test of significance is made (see Fisher 1948:76, 186, and 255 for appropriate use of this correction). If the model is not statistically significant at a predefined probability level, probably nothing definite can be said concerning the number of units missed while covering the transects.

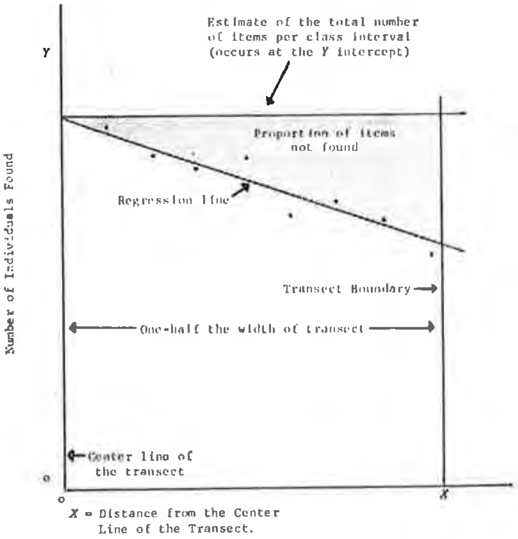

Fig. 1. Graph illustrating hypothetical data and regression line. Additional lines used in this procedure are also shown.

Fig. 1 represents a hypothetical case and shows a vertical line perpendicular to the X axis at the point where the transect ends. In addition, a horizontal line perpendicular to the Y axis represents the point where the curve intercepts the Y axis. The shaded area on the figure represents an index to the number of units not found and recorded while covering the transects. If a straight-line relationship adequately describes the data, simple trigonometry can be used to calculate the proportion of units not found. If a curvilinear relationship is required to properly represent the function, the proportion found could be estimated by dot-grid methods, planimeter, or numerical integration of the function. Numerical integration is the best procedure, and it is described in any calculus text (for example, Sherwood and Taylor 1955).

SAMPLE RESULTS

To illustrate the use of this technique and to show its field application, data collected in 1967 and 1968 on the Monte Vista National Wildlife Refuge are presented.

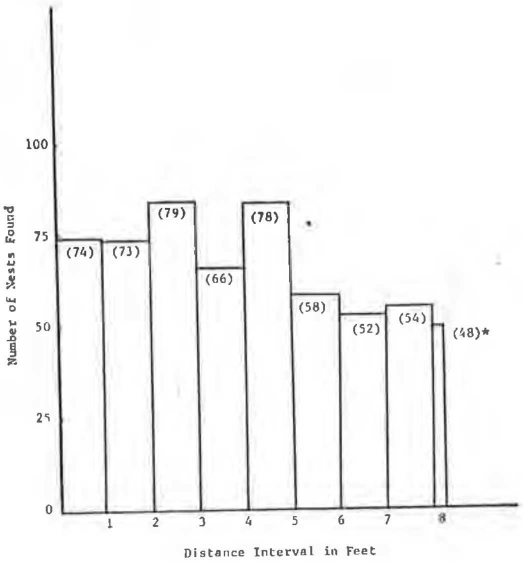

Fig. 2. Histogram of waterfowl nests located on belt transects, Monte Vista National Wildlife Refuge, Colorado, 1967 and 1968. *One-quarter-foot interval expanded by a factor of four (not used in calculations).

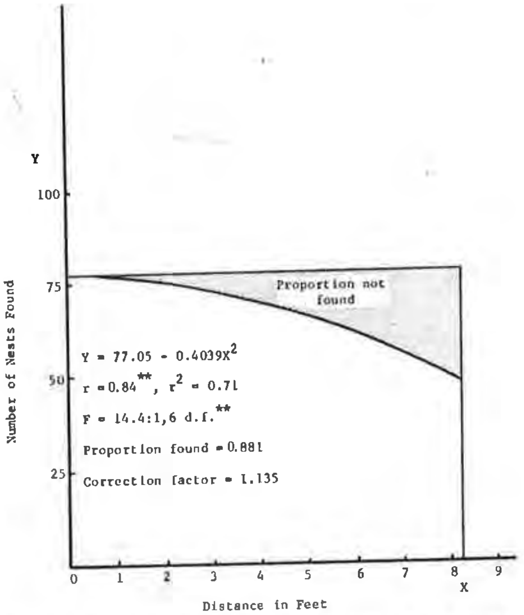

Fig. 3. Quadratic equation used to represent the relationship between distance from the center line of the transect and number of nests found on the Monte Vista National Wildlife Refuge, Colorado, 1967 and 1968. Estimates of the proportion not found in the outer 3 inches of the transect were derived using the quadratic equation; the data representing this small interval were not used in forming the equation. ** 99 percent level of significance.

The data are results of a study that conforms to the four points outlined in the previous section.

Approximately 10,000 acres of the refuge were systematically sampled by belt transects each year to estimate the total number of waterfowl nests. An intensive search along transect lines was conducted to determine nest distribution, nest success, etc. From these data, an estimate of total waterfowl production could be obtained. Details of the data collection procedures were standardized and presented in a manual on procedures (Monte Vista National Wildlife Refuge 1963).

The sampling design utilized belt transects in a systematic pattern with a random first-start. All transects ran parallel in a north-south direction and were spaced 300 ft apart. The transects were 16.5 ft wide, which gave a 5.5 percent sample of the area being studied. Approximately 320 miles of transect were covered three times in 1967 and twice in 1968. The data presented represent the coverage of 1,600 lineal miles of transect or 3,200 acres.

The mid-line of all transects was permanently marked by a series of red or yellow markers approximately 8 to 10 ft above the ground at ½-mile intervals. Three to nine markers on each transect enabled the observer to place himself accurately on the center of the transect within 2 or 3 inches by sighting with field glasses to the series of markers either ahead or behind him.

A histogram of the Monte Vista data is shown in Fig. 2. Data from both years were combined, representing 546 nests found and recorded on the sample transects. Our purpose in presenting these data is to illustrate the technique, not to present an estimate of bias in transect studies at the Monte Vista Refuge. Ideally, separate estimates could be made for each of the 2 years rather than combining the data. In using the nesting data from the Monte Vista Refuge, it was necessary to combine the 2 years of data. Experimental conditions may be quite different between years, and it is therefore necessary to realize the correction factor is an *average* value for the years and may not describe either individual year accurately. Several types of curves were experimentally fitted to the data and tested for significance. The curvilinear (quadratic) regression equation

$$Y = 77.05 - 0.4039\ X^2,$$

where Y = number of nests found, and

X = distance in feet from the center line of the transect,

was found to be satisfactory ($r = 0.84$; $F_{1,6} = 14.4$). Fig. 3 presents the regression statistics and a graph of the regression line. The two additional lines described above for Fig. 1 are also shown in this figure. The shaded area on the figure represents the proportion of the total nests that were missed while covering the transects. Since a quadratic relationship was shown to be satisfactory, the above equation was integrated to estimate the area under the observed curve (representing the number of nests found).

The result for the example given is as follows:

$$Y = 77.05 - 0.4039\ X^2$$

$$A = \int_0^{8.25} Y\ dX = \int_0^{8.25} (77.05 - 0.4039\ X^2)\ dX$$

$$= \left[77.05\ X - \frac{0.4039\ X^3}{3}\right]_0^{8.25}$$

$$= (635.6625 - 75.5987) - 0$$

$$= 560.0638.$$

The area below a horizontal line through the point $Y = 77.05$ and bounded by a vertical line from the edge of the transect ($X = 8.25$) can be calculated as a product as follows:

$$A' = 77.05 \times 8.25 = 635.6625.$$

The proportion of nests found can then be calculated by taking the ratio of the two areas.

$$\text{Proportion found} = \frac{\text{Area below observed curve}}{\text{Area below horizontal line}} = \frac{A}{A'}$$

$$= \frac{560.0638}{635.6625} = 0.881.$$

The factor by which the observed total should be expanded to obtain the corrected estimate is then $\frac{1}{0.881} = 1.135$.

The area under the curve has physical units and can be interpreted as nests per area of transect in increments of 1 ft.

DISCUSSION

The method described attempts to provide a correction of one source of bias in belt transect studies of immotile objects. It has several limitations and is not an "exact" correction. In theory, the method still yields a slightly biased estimate, because one cannot be sure that all items were found on the center line of the transect. The correction factor itself is an estimate of a parameter. It has a variance and is subject to confidence limits at a given level of significance. Transects must be well marked so that an observer can accurately determine the exact position of the center line of the transect. A large number of examples of the object being censused must be counted on the transects for this method to be useful. Within these limitations, this method, combined with the proper belt transect sampling scheme and some knowledge of curve-fitting techniques, appears to be a useful approach in estimating population sizes of immotile objects such as nests or dead deer.

We noted a problem while analyzing the Monte Vista data. While preparing histograms for different class intervals, it seemed that observers tended to record more nests at 4, 5, 6, and 8 ft than would be expected. There was a tendency to round measurements to the nearest ft. Gates et al. (1968) experienced similar "rounding" in their grouse data. Further data-gathering attempts should try to eliminate this problem.

The results of the curve-fitting can be taken only as an abstraction of a usable relationship between individuals found and distance from the mid-line, within the fixed boundary of the transect. The "true" *functional relationship* between these two variables is probably more complex and is not a subject of this paper. Eberhardt (1968) suggested intuitively that the true function may be a reversed sigmoid curve. The function would vary depending on cover type, type of items being counted, observer interest, etc.

The design of transect studies must then consider the proper values between a wide transect (for efficiency) and the bias (due to missing individuals within transects) relating to a wide transect. The very narrow width (16.5 ft) of the Monte Vista transects was chosen so that a high proportion of the nests could be found. For research purposes, it would be interesting to study data resulting from wider transects—for example, 30 ft. It is quite likely a more complex curvilinear relationship could be identified and the proportion of nests missed would be larger.

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FIELD TESTS OF STRIP CENSUS METHODS

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Abstract: Twenty strip censuses were conducted in areas containing known populations of inanimate objects or, in two instances, of live animals. Each census was based on sighting or perpendicular distances from straight-line transects. These data were then converted to population estimates according to 10 different strip census methods, and the results were compared with the known populations.

Of the 10 methods tested, only three provided estimates sufficiently close to the actual for serious consideration. The two most promising methods were the belt transects of Kelker (1945) and Anderson and Pospahala (1970), both of which require a frequency distribution of perpendicular distances of the sighted objects from the census lines. The third method was King's (Leopold 1933), which utilizes the mean of sighting or flushing distances to establish the width of the census strip. This method appears subject to some biases but less so than others based on sighting distances.

J. WILDL. MANAGE. 38(1):81–96

The primary aim of this study has been to test empirically a number of strip census methods with known populations under field conditions. A secondary aim was to determine the influence of stratification upon estimates from King's census method (Leopold 1933).

Earlier work by two of the present authors (Robinette et al. 1954, 1956) led to the conclusions that of four census methods tested on real or simulated deer carcasses, Kelker's (1945) belt transect method was the most promising. King's method (Leopold 1933) gave variable results, while Webb's (1942) and Hayne's (1949) methods were rejected because of a strong positive bias.

Although Kelker's method appeared the best of four considered, many of the senior author's deer mortality studies have been in rough terrain, which does not lend itself to the straight-line transects that are desirable for accurate measurements of perpendicular distances. Therefore, additional testing of King's method seemed justified to define, if possible, the conditions under which it might give acceptable estimates. Additional work with King's method was also thought necessary following its use by the senior author in a carcass census of red lechwe (*Kobus leche*) in Zambia. It was noted that the sum of separate estimates for rams, ewes, and lambs substantially exceeded a single overall estimate. This occurred because of varying sighting distances due to different carcass sizes and the conspicuous horns of adult males. The question arose as to which estimate would be more nearly correct. If the higher, it suggested that census areas with varying vegetative types affecting visibility or sighting distances should also be stratified, or that another method should be used.

These questions led to a series of census tests in Colorado and later in East Africa, where the senior author served as an instructor for 4 years at the College of African Wildlife Management. Each census was based on sighting or perpendicular distances from straight-line transects run through an area containing a known population of inanimate objects or, in two instances, of live animals. These sighting data were then converted to population estimates according to 10 different strip census methods, and the results were compared with the known populations in the areas censused. Because of our special interest in King's census method, only sighting distances were obtained on some censuses, resulting in no estimates for methods utilizing perpendicular distances.

The assistance provided by wildlife students and instructors from Colorado State University at Fort Collins, and the College of African Wildlife Management at Moshi, Tanzania, is gratefully acknowledged. Instructors and biologists who assisted with various phases of censuses included: D. L. Gilbert, Colorado State University; P. F. Gilbert, Colorado Division of Game, Fish and Parks; and A. Mence, V. C. Gilbert, P. Hemingway, A. Hecker, D. King, and R. Jingu, College of African Wildlife Management, Moshi, Tanzania. A. Jones of the Denver Wildlife Research Center of the U.S. Bureau of Sport Fisheries and Wildlife provided editorial assistance; C. Breidenstein and J. Oldemeyer helped with the statistical analyses.

STRIP CENSUS METHODS TESTED

Fig. 1 shows the general situation during a strip census, and Table 1 lists the 10 census methods considered and their formulas. Terminology has been standardized and generally follows that of Gates (1969).

The first four methods listed in Table 1 are based on sighting distances. As pointed out by Gates (1969), estimates from the geometric mean (Gates's III) will always be intermediate between King's (the lower) and Hayne's. Gates's II, by giving an estimate nearly double that of King's, will generally be highest.

The remaining six methods in Table 1 are based on perpendicular distances. It can be noted from the formulas that Webb's, Leopold's, and Gates's I should yield very nearly the same estimates. The only difference between Gates's I and Leopold's is the n-1 in the numerator of the former instead of n in the latter. The mean perpendicular distance as derived by Webb ($\bar{R}$ sin $\bar{T}$) tends to be greater than $\bar{Y}$ (the mean perpendicular distance); hence population estimates from Webb's are generally lower than from Gates's I and Leopold's. In earlier papers by two of the present authors (Robinette et al. 1954, 1956), we mistakenly used $\bar{Y}$ in Webb's method. The difference, however, would not have changed our conclusions regarding the utility of the method.

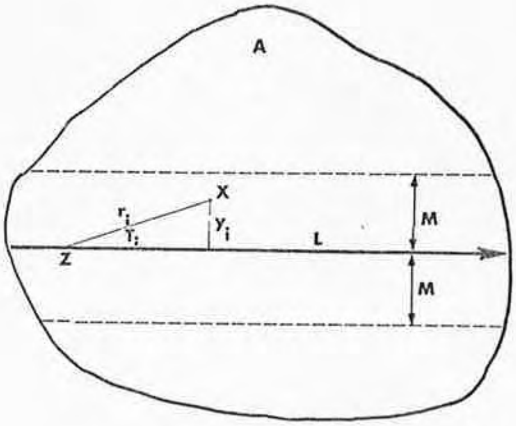

Fig. 1. The unit to be censused has area A, with census transect length L and width 2M. Z is position of observer when animal or object is first sighted at X. The sighting distance is r_i, sighting angle T_i, and the perpendicular distance from the line of travel is y_i.

In Kelker's method, a frequency distribution of observations by perpendicular distance classes is necessary. By inspection one determines the distance within which all animals or objects were probably observed but beyond which some were missed. This distance is doubled to derive the effective-width strip, with n'' being the number of animals or objects observed within this strip. Anderson and Pospahala's method is an elaboration of Kelker's in which a regression fitting for the frequency distribution is derived to permit an estimate of the propor-

Table 1. Strip census methods used.

Method	Source	Formula[a]
	Based on sighting distances	
King's	Leopold (1933)	$\hat{N} = nA/2L\bar{R}$
Hayne's	Hayne (1949)	$\hat{N} = nA/2L\bar{H}$
Gates's II	Gates (1969)	$\hat{N} = (2n-1)A/2L\bar{R}$
Gates's III	Gates (1969)	$\hat{N} = nA/2L\bar{G}$
	Based on perpendicular distances	
Webb's	Webb (1942)	$\hat{N} = nA/2L\bar{R} \sin \bar{T}$
Leopold's	Leopold et al. (1951)	$\hat{N} = nA/2L\bar{Y}$
Gates's I	Gates et al. (1968)	$\hat{N} = (n-1)A/2L\bar{Y}$
Frye's	Overton (1971)	$\hat{N} = n'A/2L\bar{Y}$
Kelker's	Kelker (1945)	$\hat{N} = n''A/2L\hat{D}$
Anderson and Pospahala's	Anderson and Pospahala (1970)	$\hat{N} =$ (*see* authors' paper)

[a] Definitions: A = area to be censused (in same units as distance measurements); $\hat{D}$ = estimated perpendicular threshold distance beyond which some animals were probably missed; $\bar{G}$ = geometric mean of sighting distances; $\bar{H}$ = harmonic mean of sighting distances; L = length of census lines; n = number of animals seen; n' = number of animals seen within $2\bar{Y}$; n'' = number of animals seen within $2\hat{D}$; $\hat{N}$ = estimated animal population; $\bar{R}$ = mean sighting distance; $\bar{T}$ = mean sighting angle; $\bar{Y}$ = mean perpendicular distance.

tion of objects or animals that were observed within the belt of attempted coverage. Emlen (1971) has independently developed a method employing the same principle as Kelker's. Banfield et al. (1955) also used this approach for determining the most efficient width of strip to use in the aerial censusing of caribou (*Rangifer tarandus*).

STUDY AREAS AND METHODS

Twenty censuses were run in Utah, Colorado, and East Africa. Table 2 summarizes the conditions, measurements, and known populations for each.

Kremmling, Colorado—A 40-acre area with alternating strips (about 130 feet wide) of drilled crested wheatgrass (*Agropyron cristatum*) and of undisturbed sagebrush (*Artemisia tridentata*) was selected as an area offering the desired differences in visibility conditions. Transects were established at 45° to the strips to insure that each transect would traverse both vegetative types. The sides were flagged at 2-chain (132-feet) intervals, and three colors of flagging were used to distinguish the corners and midpoints of each side from other boundary points and to assist the censusers in maintaining their courses. A total of 416 small wooden blocks (1 × 2 × 4 inches) were used for the census. Half were painted grey and the remainder left unpainted. It was hoped that painting would make the blocks less easily seen, thereby simulating the influence of size upon visibility. Twenty-six blocks (13 painted and 13 unpainted) were randomly placed in each of 16 equal units. Because grass covered

Table 2. Location, date, and description of 20 census method tests.

Census No.	Location	Date	Objects or animals censused	True population *N*	Census area (acres) *A*	Length of transects (miles) *L*
A—Individual censuses						
1[a]	Oak Creek, Utah	1952	Sacks	200	640	80
2[a]	Oak Creek, Utah	1951	Deer carcasses	38.4	640	60
3[a]	Cedar Ft., Utah	1952	Sacks	200	80	20
4	East Africa, Mweka	1/68	Blocks	200	4.43	4.76
5	East Africa, Mweka	8/68	Blocks	250	8.04	17.04
6	East Africa, Mweka I	1966	Blocks	200	5.21	7.27
7	East Africa, Mweka II	1966	Blocks	120	2.34	3.56
8	East Africa, Mweka III	1966	Blocks	80	3.36	2.25
9	East Africa, Murka	1967	Blocks	251	5.99	13.94
10	East Africa, Mzima	1969	Blocks	200	5.74	8.71
11	Kremmling, Colorado	4/65	UBG[b]	112	21.32	7.46
12	Kremmling, Colorado	4/65	PBG[b]	102	21.32	7.46
13	Kremmling, Colorado	4/65	UBS[b]	96	18.68	6.54
14	Kremmling, Colorado	4/65	PBS[b]	106	18.68	6.54
15	Kremmling, Colorado	6/65	UBG	112	21.32	4.80
16	Kremmling, Colorado	6/65	PBG	102	21.32	4.80
17	Kremmling, Colorado	6/65	UBS	96	18.68	4.20
18	Kremmling, Colorado	6/65	PBS	106	18.68	4.20
19	East Africa	1967	Elephants	137	28,857	29.89
20	East Africa	1968	Elephants	327	28,857	29.89
B—Combination of censuses in A						
5 & 11				362	29.36	10.28
6 & 8				280	8.57	5.75
7 & 8				200	6.70	4.49
6 & 7				320	8.56	9.05
4 & 7				320	7.77	8.29
11–14				416	40.00	14.00

[a] Censuses 1–3 previously reported by Robinette et al. (1954).
[b] G, grass; S, sage; UB, unpainted blocks; PB, painted blocks.

slightly more area than sage (53.3 percent grass) and because of random locations, the numbers of painted and unpainted blocks differed slightly in the two types (Table 2). Blocks falling near the margin of a vegetative type were shifted to eliminate any doubt as to which type they belonged. To increase visibility contrast, blocks falling in the grass type were placed in the nearest open spot, and those in the sage were placed under or in the closest cover.

On 27 April 1965, and immediately after block placement, 28 wildlife students from Colorado State University were divided into four seven-man crews, and each crossed the area twice—the second course at right angles to the first. A technician was assigned to each crew to record data. Crew A was assigned on the initial survey to one-half of the area and Crew B to the other half. After progressing approximately 5 chains (1 chain = 66 feet), they were respectively followed by Crews C and D. The starting point for the first man in each crew was randomly selected at a point 15–80 yards to the area border, a precaution to minimize the "edge" influence. An additional precaution was to start crews 15–20 feet outside the area borders. When a member made a sighting, he was asked to pace along his line of travel until at right angles to the block and then pace to it. The entire crew was halted until the information was recorded by the technician. Pacing measurements for each of the 28 students were recorded before the survey, over a measured 8-chain course that included both sage and grass types. Sighting distances were later computed as paces from the two legs of the right triangle, and then converted to feet by using specific conversion factors for the individuals involved.

Population estimates from these surveys revealed some unexplained inconsistencies for the sage type, so the three authors made a follow-up survey on 16 and 17 June 1965. In this survey, consisting of 12 transects by each man, only sighting distances were taken—measured to the nearest foot with a steel tape.

East Africa—Seven wooden block censuses were conducted from 1966–69 in Tanzania and Kenya under the direction of the senior author by students and instructors at the College of Wildlife Management, Moshi, Tanzania. Most of these were patterned after the Kremmling surveys in which a given number of unpainted wooden blocks were randomly placed within a flagged area of grassland or mixed grass and shrubs. Since most of the sighting distances were under 50 feet, all distances were actually measured with sticks marked at 1-foot intervals. Only sighting distances were taken on some censuses, but both perpendicular and sighting distances on others. When both distances were taken, the students were instructed to lay their clipboards on the ground at the point of sighting, then walk along the transect until at right angles with the blocks. The distances from the line to the block and the block to the initial point of sighting were then measured, which eliminated the need for computing the sighting distances.

In addition to the block censuses, two elephant surveys were made in Travo National Park (West) in August of 1967 and 1968. Simultaneous ground and aerial counts were made under conditions that we believed permitted a 100 percent aerial count. Two instructors made the aerial census from a Supercub at the time of the year when much of the foliage of woody plants had been shed and in an area where there were few trees that could conceal an elephant from aerial view. Locations of all elephants seen by the aerial and ground crews were later plotted on a map to ensure that none were overlooked in the aerial count. On the ground, seven parallel transects, 2 km apart, were simultaneously run by crews of three students per transect. Sighting and perpendicular distances were computed trigonometrically from compass bearings, which provided the sighting angles, and the number of paces along the transect between the sighting point and a point at right angles to where each group of animals was initially sighted. Computations were resorted to since it was impractical to pace the various sighting and perpendicular distances which often exceeded 1 km. Occasionally elephants were not sighted until the students were nearly at right angles or even past, in which case distances were computed from two bearings, one taken at the time of sighting and the other after taking 100 paces along the transect. Again paces were converted to meters by a factor obtained earlier for each student by having him pace a measured course.

The percentage relationship of the vari-

Table 3. Results of 20 census method tests.

			Sighting distance (feet)			Perpendicular distance (feet)			
Census No.	No. objects or animals sighted n	Mean sighting angle in degrees T	Mathematic mean $\bar{R}$	Harmonic mean $\bar{H}$	Geometric mean $\bar{Y}$	Mathematic mean $\bar{Y}$	Kelker's value $\hat{D}$	Webb's value $\bar{R}$ sin $\bar{T}$	C.V. (percent) of sighting distances
A—Individual censuses									
1	302	48.72	60.48	30.23	43.15	41.62	18	45.45	98.5
2	31.5	42.63	38.39	30.33	33.79	22.06	8	26.01	45.6
3	597	48.57	52.45	31.46	44.01	35.57	10	39.32	55.6
4	721		13.18	9.42	11.49				44.3
5	1,510	40.92	13.66	10.86	12.30	8.32	5	8.95	44.4
6	391		5.88	3.99	5.00				59.9
7	336		15.81	8.11	11.40				96.5
8	391		32.29	19.01	26.10				61.9
9	1,550		10.19	7.15	8.70				56.6
10	1,076	42.79	15.61	10.50	13.60	10.22	4	10.60	51.9
11	352	39.94	34.37	22.90	29.11	19.52	21	22.06	57.8
12	207	40.02	25.22	17.72	21.39	14.25	9	16.22	59.3
13	206	36.31	28.65	17.37	23.48	14.30	15	16.97	66.1
14	150	35.96	23.81	14.96	19.01	12.34	9	13.98	61.3
15	137		23.17	16.91	20.08				50.1
16	92		16.97	11.90	14.60				51.3
17	76		18.16	12.99	15.50				56.7
18	62		17.52	13.05	15.32				52.7
19	137	52.37	2,871	1,986	2,472	2,163	1,312	2,344	58.4
20	229	51.90	2,255	1,305	1,741	1,873	1,640	1,750	77.0
B—Combination of censuses in A									
5 & 11	601	40.43	25.76	15.66	20.24	14.97	9	16.70	72.9
6 & 8	579		23.82	8.61	15.44				86.5
7 & 8	604		26.87	13.86	20.12				75.5
6 & 7	633		11.12	5.66	7.85				112.4
4 & 7	1,057		14.02	8.96	10.13				70.8
11–14	915	38.49	29.38	18.69	23.99	15.98	17	18.28	61.9

ous estimates to the true population was determined. A statistical evaluation of these percentages provided a coefficient of variation for each method as well as a t value to denote the significance of the estimates from the actual population.

RESULTS AND DISCUSSION

Survey Data

Detailed data for 20 individual censuses based on more than 8,000 observations are presented in Section A of Tables 2 and 3. Population estimates, as percentages of the true population, are given for 10 strip census methods in Table 4. Five methods gave mean estimates within 15 percent of actual (King's, 6.4; Kelker's, 6.8; Anderson and Pospahala's, 7.3; Gates's III, 12.2; and Frye's, 12.4). The means for other methods exceeded the true population by 34–90 percent and appear unacceptable for estimating populations.

Comparison of t values (Table 4) indicates that all methods except Anderson and Pospahala's and Kelker's departed significantly from the true population. However, King's method had the next lower t value and was the only method based on sighting or flushing distances that showed promise.

Some of the results from the Kremmling

Table 4. Census estimates as percentages of true population for 10 strip census methods, using data from Tables 2 and 3.

Census No.	Method									
	King	Hayne	Gates II	Gates III	Webb	Leopold	Gates I	Frye	Kelker	Anderson & Pospahala
A—Individual censuses										
1	82.4	164.8	164.7	115.5	109.6	119.7	119.4	73.3	99.0	99.2
2	94.0	119.0	185.2	106.8	138.5	163.5	161.3	85.7	116.7	96.9
3	93.9	156.6	187.4	111.9	125.2	138.4	138.2	79.3	95.7	99.2
4	105.0	150.1	209.8	120.4						
5	86.0	108.1	171.4	95.5	131.2	142.9	142.8	83.0	90.5	91.3
6	98.4	145.2	195.9	115.7						
7	69.1	134.6	137.9	95.8						
8	93.1	158.2	185.9	115.2						
9	107.5	153.2	214.7	125.9						
10	93.6	139.2	187.1	107.4	137.9	143.0	142.9	86.4	94.4	94.2
11	107.8	161.7	215.2	127.3	167.9	189.7	189.4	115.9	142.7	129.9
12	94.8	135.0	188.6	111.8	147.4	167.8	167.6	102.9	116.9	110.4
13	88.2	145.6	173.7	107.6	149.1	176.9	175.2	104.8	126.9	149.0
14	70.1	111.5	139.7	87.8	119.3	135.2	134.7	78.4	96.3	125.7
15	96.8	132.6	192.9	111.7						
16	97.4	138.9	193.8	113.2						
17	79.9	145.7	158.8	93.6						
18	61.2	82.1	119.5	70.0						
19	106.6	147.5	211.2	123.7	134.6	145.8	144.5	71.3	107.0	97.1
20	99.3	157.2	197.6	126.9	126.2	117.9	117.4	82.4	88.2	87.5
Mean[a]	93.56	142.17	186.26	112.23	135.17	149.16	148.49	87.58	106.75	107.31
C.V. (%) of estimates	12.0	11.7	12.0	9.9	11.8	15.3	15.2	16.1	16.1	18.1
t value	2.439	10.785	16.337	4.675	7.336	7.152	7.116	2.922	1.302	1.250
P	$\cong 0.03$	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	$\cong 0.22$	$\cong 0.24$
Weighted mean	95.2	141.2	189.8	112.2	134.3	145.7	145.4	86.4	99.8	100.7
B—Combination of censuses in A										
5 & 11	76.0	124.9	151.8	96.7	117.2	130.7	130.5	80.5	99.5	108.8
6 & 8	53.4	147.6	106.7	82.4						
7 & 8	69.2	134.1	138.0	92.4						
6 & 7	69.3	136.2	138.6	98.2						
4 & 7	91.0	142.6	182.1	126.1						
11–14	88.2	138.9	176.4	108.0	141.9	162.2	161.9	89.6	117.8	122.7
Mean	74.5	137.3	148.9	100.6	129.4	146.3	146.1	85.0	108.6	115.7
Mean A&B[a]	88.79	140.96	176.92	109.93	134.29	148.73	148.12	87.18	107.04	108.60
C.V.A&B	16.1	10.5	16.1	11.7	11.5	14.7	14.6	15.0	15.0	16.8
t value A&B	3.759	13.273	12.943	3.691	7.976	8.060	8.032	3.529	1.577	1.704
P	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	$\cong 0.15$	$\cong 0.12$

[a] Censuses 17 and 18 omitted from summaries (*see* text).

surveys, particularly in the sagebrush, were so anomalous that they appear unusable. Our efforts to learn if stratification would improve estimates by King's methods were disappointing. Sighting distances did differ significantly between painted and unpainted blocks and between the grass and sagebrush types, but the differences were on the order of 20–30 percent instead of the 200–300 percent or more that we had hoped for. Thus, while the mean of four stratified estimates (Censuses 11–14, Section A, Table 4) was 90.2 percent of actual by King's method, this was only a slight improvement over the 88.2 percent derived as a single estimate from the unstratified data (Section B, Table 4).

In order to demonstrate the influence of stratification on population estimates, we have combined in Section B (Tables 2–4) results of some individual surveys which differed substantially in terms of sighting distances. For example, Censuses 6 and 7 (Section B, Tables 2–4) combine all data for Census 7 with a randomly selected proportion of the Census 6 sightings equivalent to the length of census line per unit of area used in Census 7. Thus 297, or 76 percent, of the Census 6 sightings were randomly selected and combined with the 336 of Census 7. By combining Censuses 6 and 7, which had respective mean sighting distances of 5.88 and 15.81 feet, the population estimate is only 69.3 percent of actual. In contrast, separate estimates were 98.4 and 69.1 percent, respectively, for a mean of 84 percent (or 87 percent if weighted by sample size as would be done in actual practice). This represents a substantial increase and improvement over the unstratified estimate and clearly demonstrates the advantage of stratifying results for widely differing visibility types.

Another unanticipated result from the Kremmling survey was the very low estimates obtained in the sagebrush type, especially for the painted blocks by King's method in April (Tables 2–4). The mean for the two estimates was 101.3 percent of actual in the grass type (Censuses 11 and 12), compared with only 79.2 percent in the sagebrush (Censuses 13 and 14). The percentage for painted blocks in sage (Census 14) was even lower—70.1 percent. We wondered if perhaps the students had missed blocks in the sagebrush because of looking at a set distance instead of varying the distance with visibility conditions. Because of this possibility, we recensused the area 2 months later and came up with even lower estimates—slightly lower for the grass type (mean, 97.1 percent of actual) and considerably lower for sage (79.4 percent for unpainted blocks and 61.2 percent for painted).

In retrospect, it appears that placement of blocks under the sagebrush to increase variability in sighting distances was a mistake. Some blocks were apparently so well hidden that they were not visible to the observers at close distances. The situation in the sage type was apparently even worse in June because of new spring growth of cheatgrass (*Bromus tectorum*) and sagebrush. The same problem did not prevail in the grass type because most of the blocks had been placed in spaces between drill rows where they remained visible. It is because of this probable bias that June results for the sage type have been omitted from the summaries of Tables 3 and 4.

Estimates from Kelker's and Anderson and Pospahala's methods for the Kremmling April surveys seemingly do not support the belief that some blocks were not visible, since both showed a strong positive bias. An analysis of the frequency distribution of perpendicular distances, however, indicates a probable measuring bias that appears to have more than offset the influence of some blocks not being visible. Of 915 perpendicular measurements, 118 were recorded as being 0 feet from the line, 0 at 1 foot, 54 at 2 feet, 5 at 3 feet, 3 at 4 feet, 71 at 5 feet, etc. While pacing necessarily gives unequal frequencies by 1-foot-classes, it seems doubtful that 13 percent of all distances would have fallen directly on the census line. Some observers may have veered towards the blocks in pacing along their lines to the right angle points, or perhaps fractional paces were dropped rather than rounded off to the nearest full pace. Either of these biases could have influenced estimates substantially where the mean perpendicular distance was only 16 feet.

In the African block surveys, distances were actually measured instead of paced, and the necessity for closely following census lines until the right angle points were reached was strongly stressed to the students. In the two of these censuses calculable by perpendicular distances (Censuses 5 and 9), no strong positive bias was noted for estimates by Kelker's or Anderson and Pospahala's methods. The overall mean estimate for the six methods utilizing perpendicular distances has been unduly influenced by the April Kremmling censuses, since these surveys provided 36 percent of the estimates (4 of 11) but only 19 percent of the observations. If the estimates as percent of actual are weighted according to sample size, the mean becomes a more favorable 99.8 percent for Kelker's and 100.7 percent for Anderson and Pospahala's (Table 4). A similar weighting for the next three best methods gives 95.2 percent for King's, 112.2 percent for Gates's III, and 86.4 percent for Frye's.

Methods Based on Perpendicular Distance

On the basis of our studies, we recommend Anderson and Pospahala's or Kelker's census methods for situations where the prerequisite conditions for strip censusing have been met. In addition to the conditions listed by Gates et al. (1968), one must have 100 percent coverage for at least a short distance on both sides of the census line. To determine this distance, Kelker recommended a frequency distribution table; Emlen (1971), whose method is similar, used a histogram of the observations by distance classes from the line of travel. If the classes are small enough and the sample size is adequate, one can determine by inspection the distance within which all items were probably observed and beyond which some were missed. Both methods utilize density estimates within the band of 100 percent coverage for population determination.

Kelker rejects observations falling outside this band, and although Emlen uses all data, his method represents no improvement, since the density in the band of complete coverage is applied to the bands where some censused objects were missed. Both methods involve some subjectivity in determining the distance of complete coverage, since the number of observations in the bands of 100 percent coverage will rarely if ever be identical.

The procedures proposed by Anderson and Pospahala make their method less subjective since the 100 percent density level and the proportion of objects that were missed within the range of attempted coverage can be estimated mathematically. In applying their method, we divided the data for each census into 10 equal width classes so that about 95 percent of the observations were included. Some of the regression fittings were linear, while others were second- or third-degree polynomials. Anderson and Pospahala propose that the *Y* intercept as derived from the formula will position the horizontal line that serves as an estimate of the total number of items in each distance class. While this doubtless generally applies, we found this point in one third-degree polynomial to be lower than a more nearly correct eye-fitting would have given. In another equation, the *Y* intercept exceeded the maximum frequency in the histogram and was consequently higher than one would subjectively have selected. These deviations are minor, however, in considering the overall merits of the method and could well have reflected biases in our field data.

We have noticed, as have Anderson and Pospahala (1970) and Gates et al. (1968), an occasional bias in determining distances. This is particularly true in estimating but may also occur in measuring. For example, in our African block surveys, distances that were multiples of the measuring stick lengths were more frequent than expected. The influence of such biases can often be minimized through judicious selection of the class interval (Gates et al. 1968).

Methods Based on Sighting Distances

While we are recommending Kelker's and Anderson and Pospahala's methods, there are situations in which a method based on the sighting or flushing distance would be more practical. This is particularly true in rough terrain where compass-line courses are difficult if not impossible to follow. The measurement of perpendicular distances usually requires a straight-line course from which to measure, or at least a road or trail or a series of short straight-line segments planned in advance. Sighting distances, on the other hand, can be measured from a meandering course as easily as from a straight line. In such situations, King's method, which provided the best estimates of those based on sighting distance, appears the best choice.

There is considerable literature on the use of King's and similar methods. Hahn (1949) and Lamprey (1963) independently developed strip census methods that we did not test but that are closely related in principle to King's method. Hahn used his method for censusing white-tailed deer (*Odocoileus virginianus*) along premarked census lines. To determine the width of the strip on which all deer could be seen, he measured the perpendicular distances, at 100-yard intervals, at which an assistant carrying a white flag (to simulate a deer) disappeared from view. Doubling the mean of these visibility distances gave the effective-width strip. Independently, Lamprey (1963) used much the same method in Tanzania, measuring the perpendicular distances at 100-yard intervals at which an assistant in khaki uniform disappeared from view. These values were plotted to scale on graph paper to yield a "visibility profile" from which acreages and game densities could be derived. Distances at which various game species disappeared were checked against the profile measurements and were in good agreement for 11 of 14 species. Estimate corrections were necessary only for elephant (*Loxodonta africana*), giraffe (*Giraffa cameleopardalis*), and dik-dik (*Rhynchotragus kirkii*).

Hirst (1969) tested Hahn's and Lamprey's visibility method and Kelker's belt transect method on an enclosed population of about 1,550 blesbok (*Damaliscus dorcas*) in South Africa. He found that the visibility method provided estimates within 5 percent of actual, whereas Kelker's was about 15 percent low. He attributed the negative bias of Kelker's to animal behavior, in that the blesbok either were remaining a set distance from the census roads to avoid disturbance or had moved without being seen when they heard the vehicle approach. Hirst noted that there were fewer animals in each of the

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first two 75-foot bands on either side of the roads than in each of the next eight. Such a movement could depress estimates from Kelker's method but would not influence those from the visibility profile method, providing the animals that moved still remained within visible range. He derived his width of visible field through right-angle measurements with a range finder at quarter-mile intervals along the census lines. He noted, however, that visibility could just as accurately have been determined in any other direction and was perhaps best obtainable from disappearing animals.

Both Lamprey (1963) and Hirst (1969) emphasized the close relationship between profile measurements and those of disappearing animals. We feel that the initial sighting or flushing distances of King's method would establish the effective width of field just as accurately. We agree with Hirst's observation that the range of visibility could be derived from measurements taken in any direction and are perhaps best obtained from the animals themselves. This is the same principle upon which King's method is based. Measurements of the animals, either when first seen or as they are disappearing, would in fact seem preferable to precensus profile measurements of simulated animals, because visibility can vary with animal species, vegetative types, seasons, and observers, and probably with time of day and weather conditions as well. Although both Hirst and Lamprey were able to provide evidence for the success of the visibility profile method (Hirst through agreement of census results with a known population and Lamprey through agreement with aerial censuses for some species), we feel that King's method is more responsive to the various factors affecting visibility. In addition, the extra step required by the visibility profile method makes it practical only where repeated censuses are to be made over the same transects.

Bergerud and Mercer (1966) obtained acceptable agreement between complete flushing counts of willow grouse (*L. lagopus*) and estimates by King's method. Similarly, Rusch and Keith (1971) concluded that King's method provided more accurate estimates of ruffed grouse (*Bonasa umbellus*) than Hayne's, Webb's, and Gates's I, since results agreed more closely with those from the Lincoln Index and total counts of sample areas. Two of these methods, Webb's and Gates's I, are based on mean perpendicular distances, and we found them, as well as Leopold's method, to consistently overestimate the true population (Table 4). Amman and Baldwin (1960) concluded from repeated woodpecker censuses on 20-acre timbered plots that estimates based on the mean perpendicular distance were 40–80 percent higher (compared with our 18–90 percent) than the total counts that they believed accurate. However, the mean of the greatest perpendicular distances at which the birds were seen or heard provided good estimates. The fact that satisfactory results can be obtained by using only the longer perpendicular distances to establish the effective-width strip, we believe, explains the excessively high estimate given by Webb's, Gates's I, and Leopold's methods. It is only the longer distances that establish the limits of visibility (as in King's and the visibility profile methods), and to average them with the shorter ones gives a narrower strip than the one on which the animals were actually observed.

To our knowledge the only census of a known population in which the mean perpendicular distance has given satisfactory estimates is that of Dasmann and Mossman (1962). They made repeated censuses of game animals from vehicles along roads within the fenced 1-mile^2 Livingstone Game Park in Zambia. King's method gave negatively biased estimates, but those based on the mean of the perpendicular distances were reasonably good. The authors, however, recognized that there could have been some undetected movement of animals away from the roads when the vehicle approached, a situation encountered by Hirst (1969). Such a movement would lower density estimates by increasing the mean perpendicular distance, but it violates one of the basic assumptions of strip censusing, that "the animal is seen at the exact position it occupied when startled" (Gates et al. 1968). For this reason, vehicles should probably be used only where the observers can see further than the alarm distance of the animals.

In addition to the results of our study with known populations, the senior author has applied King's method on censuses of live and of dead deer. Estimates of live deer were about 20 percent less than those derived from pellet group counts, Lincoln Index, and Kelker's (1940) sex and age ratio methods, which were believed to be reasonably accurate. This negative bias was believed largely due to the rough terrain of the study area and nonrandomness of the census lines. The census was made in conjunction with the prehunt sex and age counts which took priority. The observers followed ridgetops to facilitate sightings and to minimize disturbance of the deer. In so doing deer were often more easily seen on opposite slopes than on those immediately below the observers, and this depressed the estimates. The problem could have been minimized and perhaps eliminated if the transects had been run at right angles to the contour and the observers had confined their observations to distances within which they could expect to see most of the deer.

On the other hand, carcass surveys by King's method have checked out quite well with expected mortality as derived from population analyses. We believe King's method has provided particularly good estimates of hunt crippling losses. A 10-year study (manuscript in preparation) gave an annual estimated crippling loss of 174 deer by King's method on a Utah study area compared to an independent estimate of 183 from the dead deer–entrail ratio method. Entrails from field-dressed deer are an index to the legal kill which is known. Before the ratio between dead deer and entrails observed on posthunt surveys can be applied to the legal kill for a crippling loss estimate, a correction is first necessary because of differing sight distances for entrails and dead deer. Sighting distances have shown that dead deer were observable 1.81 times further on the average than entrails. This factor was thus applied to the number of entrails so that they could be compared directly with the number of dead deer.

Our experience with King's census method has been that satisfactory results may be expected if the prerequisites for strip censusing have been met and sighting conditions are not too variable. The question arises as to what is "too variable." Ordinarily, we feel it is sufficient in censusing a single species to stratify only by those readily identifiable vegetative types where differing visibility conditions are demonstrable. Such stratification improved all estimates by King's methods in Table 4. Certain vegetative types, however, are too heterogeneous for practical stratification, Census 7 being an example. Grass in the census area had been closely grazed by cattle except for that growing from numerous old cow droppings. This patchiness created variable sighting conditions, as indicated by the high co-

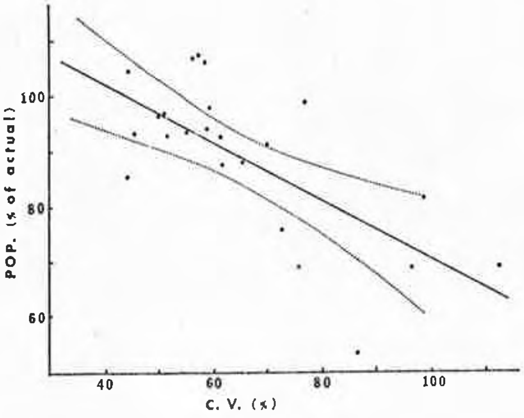

Fig. 2. Linear regression and 95 percent confidence limits of population estimates by King's method as percent of actual *Y* on C.V.—coefficient of variation *X* of sighting distances ($\hat{Y} = 123.52 - 0.529X$; $r = -0.657$; $n = 25$).

efficient of variation (C.V.) of the sighting distances (96.5 percent). This was accompanied by a low population estimate—69 percent of actual. We found a highly significant negative correlation between 24 sets of percentages in Table 4 representing the C.V. of the sighting distances and the percent of the true population estimated by King's method ($r = -0.657$; $P < 0.01$). A linear regression of these data (Fig. 2) suggests that estimates by King's method may be acceptable (within 10 percent of actual) if the C.V. of the sighting distances is between 30 and 60 percent. If the C.V. falls outside this range, one should reject the estimate, or possibly correct it on the basis of the regression formula of Fig. 2. For example, if the C.V. of the sighting distances were 80 percent, the regression formula indicates that the population estimate would be 81.2 percent of actual. The user should be cautioned, however, that we had few C.V. values exceeding 70 percent and none less than 40 percent, so that the regression is weak beyond these limits. It is of interest that the formula predicts a population estimate of 124 percent of actual when the C.V. of sighting distance is zero. This condition exists with Hayne's method, which in effect determines separate populations for each recorded distance class so that the C.V. within each class has been reduced to zero. Our surveys, however, indicated that estimates for Hayne's method exceeded the actual by 42 percent instead of the predicted 24.

Sources of Error

We have already pointed out the similarity between King's and the visibility profile methods. Failure to stratify on the basis of visibility can bias estimates from the profile method as readily as from King's.

Separate estimates versus a combined estimate for two areas with varying visibility and the following statistics illustrate the point:

	Area 1	*Area 2*
L	1 mile	1 mile
N	50	100
A	1 mile^2	1 mile^2
2M	0.1 mile	0.4 mile
n	5	40

A single estimate for the two areas is 180 since a transect through both would provide 25 percent coverage and an expected 45 animals seen. This exceeds the actual population by 20 percent. A 20 percent underestimate would have resulted had either animal density or visibility been interposed for the two areas. Variable visibility, however, does not influence the estimates if animal densities are uniform.

Both Hirst and Lamprey recognized the potential importance of varying visibility and animal density by vegetative types but found that on their particular study areas it was either impractical to stratify or that this source of error was unimportant. However, if more than one species is being censused and differing mean sighting or flushing dis-

Table 5. Sighting distances and angles and perpendicular distances from census line obtained from game animals in Tsavo National Park (West), Kenya, by students from The College of African Wildlife Management, 1966–69.

	Number		Mean distance (m)		Mean sighting angle (degrees)	
Species	Groups	Animals	Sight $\bar{r}$	Perpendicular $\bar{y}$	$\bar{T}$	Sin $\bar{T} = \bar{y}/\bar{r}$
Dik-dik (*Rhynchotragus kirkii*)	21	30	43	24	29.53	33.93
Eland (*Taurotragus oryx*)	21	220	798	644	51.22	53.80
Elephant (*Loxodonta africana*)	71	434	734	580	51.69	52.17
Gerenuk (*Litocranius walleri*)	33	73	202	104	34.67	30.98
Giraffe (*Giraffa camelopardalis*)	47	247	409	233	41.92	34.62
Grant's Gazelle (*Gazella granti*)	50	210	295	175	39.21	36.53
Hartebeest (*Alcelaphus buselaphus*)	158	672	423	238	41.77	34.23
Impala (*Aepyceros melampus*)	52	433	214	120	35.79	34.25
Oryx (*Oryx beisa*)	49	145	405	268	43.17	41.43
Rhinoceros (*Diceros bicornis*)	51	68	280	155	41.91	33.62
Zebra (*Equus burchellii*)	60	645	491	275	40.21	34.07

tances are demonstrable, it is important to stratify not only by vegetative types but by animal species as well. Similarly, in making carcass surveys, one should stratify if sighting distances differ significantly by sex or age classes. Hirst noted that the visibility field varied significantly by species and season. The senior author also found significant species differences during game animal censuses in East Africa. Table 5 lists the mean sighting distances for several species of game observed in a limited savanna area of Tsavo National Park. The mean sighting distance of 491 m for zebra (*Equus burchelli*) differed significantly ($P < 0.01$) from the 423 m for hartebeest (*Alcelaphus buselaphus*), and the 295 m for Grant's gazelle (*Gazella granti*) differed significantly ($P < 0.01$) from the 214 m for impala (*Aepyceros melampus*).

Data in Table 5 also suggest species differences in some of the mean sighting angles. Thus the 52° angle for elephants differed significantly ($P < 0.01$) from the 30° recorded for dik-dik. The later species is usually not seen in a savanna type until flushed, which likely explains its narrower sighting angle. Sighting angles also differed significantly ($P < 0.01$) for eland (*Taurotragus oryx*) and gerenuk (*Litocranius walleri*). Evidence that these species differences may be real is indicated by the uniformity in sighting angles for given sets of conditions in Table 3. Thus the two elephant surveys (No. 19 and 20), which were made in the same area but by different observers in different years, gave mean angles of 52.37° and 51.90°, respectively. The two sack surveys (1 and 3), made in part by different people and in different areas but both in a predominantly sagebrush type, gave values of 48.72° and 48.47°. The two block surveys in sagebrush near Kremmling (13 and 14) gave angles of 36.31° and 35.96°, respectively, for the unpainted and painted blocks; concurrent surveys in grass (11 and 12) gave angles of 39.94° and 40.02°. As noted previously, the observational angles may influence estimates from sighting distances. Gates et al. (1968) have listed among the assumptions for application of strip censuses that "the animals are distributed uniformly and independently." While this would certainly be desirable, it is probably not often met in nature, and a certain amount of contagious distribution can probably be tolerated. Thus, although the elephants of Censuses 19 and 20 were found as singles and in herds of up to 50 and obviously not uniformly distributed, the three methods which we are recommending gave acceptable estimates. Sampling intensity, however, was high, as it must necessarily be with contagious, nonuniform distributions.

Doubtless other factors influence population estimates besides those already mentioned. In some of our surveys, population estimates varied significantly among observers. Mean sighting angles also differed significantly for some individuals, suggesting that their angle of coverage may have varied. A person who covered only 45° on either side of his line of travel would make fewer observations than one covering the full 90°, and yet the mean sighting distance could be the same. Differences in sighting angles would influence estimates from methods based on sighting distances but not those based on perpendicular distances. Another source of error is the probable failure by some individuals to vary their distance of visual search. Searching at a set distance can mean that some inanimate objects, visible only at close distances, would be missed. This potential bias would affect the results of all strip census methods.

Our observations support Eberhardt's (1968) statement that "flushing intensity" curves can be influenced by many factors. The truth of this statement has been impressed upon us many times during our study. While many of the biases we have identified arise from the censusing conditions and the animal or object being censused, many others arise from the censuser himself. The participants in most of our surveys were wildlife students conducting censuses for the first time. Any variability attributable to them could unquestionably have been reduced with increased training and experience. Eberhardt (1968) has suggested the development of population estimates based on fixed probability models. The similarities we have noted in sighting angles for a given set of conditions provides some optimism for this proposal. On the other hand, the variability in frequency distributions of perpendicular and sighting distances in our surveys indicate that much more work must be done before this becomes a workable reality.

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