The effects of hunting effort and weather on hunting success and population dynamics of Namaqua sandgrouse

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The effects of hunting effort and weather on hunting success and population dynamics of Namaqua sandgrouse

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There is an embryonic commercial hunting industry based on Namaqua sandgrouse *Pterocles namaqua* in the northern Cape Province, South Africa. Although this embryonic industry supplements agriculture in this semi-arid and desertification-prone environment, the full value of this resource is underestimated and the resource itself is underutilized. This study investigates the influence of weather on the time of arrival and the number of Namaqua sandgrouse at watering sites, the relationships between hunting effort, hunter efficiency and hunter satisfaction, and the impact of hunting at watering sites. There is a 9% drop in sandgrouse numbers and a six minute delay in arrival time at the watering site with every 25% increase in cloud cover. Hunter group size was not significantly correlated with hunter satisfaction. However, hunter efficiency was significantly negatively correlated and hunter satisfaction was significantly positively correlated with the number of birds counted during the hunt. Therefore, mean bag per hunter can be used as a reliable estimate of population size. The mean offtake per watering site per season was significantly positively correlated with the number of hunts at the watering site. We recommend that hunter group size should be at least 16, but that, given the apparently low reproductive levels of Namaqua sandgrouse, the number of hunts at a particular watering site in a season should preferably be limited to one hunt.

'n Kommersiële jag industrie, gebaseer op die Namaqua sandpatrys *Pterocles namaqua* is in wording in die noordelike Kaapprovinsie, Suid Afrika. Alhoewel hierdie embrionale industrie die landbou ondersteun in hierdie semi-ariede omgewing wat geneig is tot woestynvorming, word die volle kommersiële waarde van hierdie hulpbron onderskat en word die hulpbron opsigself onderbenut. Hierdie studie ondersoek die invloed van weersomstandighede op aankomstye en getalle sandpatryse by waterplekke, en maatstawwe van jag poging, jagter effektiwiteit, jagter satisfaksie en die impak van jag by waterplekke. Daar is 'n 9% daling in die sandpatrys getalle en 'n ses minute vertraging in die aankomstyd by die waterplek met elke 25% toename in die wolkbedekking. Jagtergroepgroottes was nie beduidend gekorreleer met jagter satisfaksie nie, maar jagter effektiwiteit was beduidend negetief gekorreleer en jagter satisfaksie beduidend positief gekorreleer met die aantal voëls getel gedurende die jag. Gevolglik kan die gemiddelde getal voëls gedood per jagter gebruik word as 'n betroubare skatting van bevolkingsgrootte. Die gemiddelde getal voëls verwyder per waterplek per seisoen was beduidend positief gekorreleer met die getal jaggeleenthede per waterplek. Ons beveel aan dat jagtergroepgroottes ten minste 16 moet wees, maar met die inagneming van die oënskynlike lae voorplantingsvlakke van die Namaqua sandpatrys, die getal jagte per waterplek per seisoen liefs beperk moet word tot slegs een.

Keywords: Gamebird, hunter efficiency, hunter satisfaction, hunting impact, Namaqua sandgrouse, *Pterocles namaqua*

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Introduction

Sandgrouse of the genus *Pterocles* inhabit hot, semi-arid and arid biotopes throughout Africa, the Middle East and southwestern Asia. Six *Pterocles* species are endemic to Africa and six species are shared between northern Africa and Asia. India and Madagascar each have one endemic species. All 14 species are adapted to exploit the often ephemeral productivity of semi-arid ecosystems (Maclean 1976; 1985; Thomas 1984a; 1984b). Although the natural history of sandgrouse (Pteroclеidae) has been reviewed extensively (Maclean & Fry 1986; Campbell & Lack 1985), and the behavioural and physiological ecology of sandgrouse is fairly well developed, there is virtually no information on their value as a sustainably utilizable natural resource.

Baker (1921) and Lynn-Allen (1951) described the great value placed on hunting of sandgrouse at their traditional watering sites, and their importance as a source of protein for indigenous peoples in east Africa and India. Ali & Ripley (1969) tell of 'prestige' shoots of blackbellied sandgrouse *P. orientalis* for entertaining British dignitaries. Witherby (1902) was probably the first to report that 'sandgrouse shooting at many points along the banks of the White Nile affords such sport that millionaires would give untold gold for, were it to be had in England or Scotland'.

In South Africa, the earliest documented hunting of sandgrouse was by Bushmen who used sticks to kill the birds at watering sites in Bushmanland during summer (Van Niekerk 1969). Thereafter, early settlers hunted sandgrouse with rifles in the southern Kalahari (Cornell 1986). By the late 19th century, following the arrival of the shotgun, sandgrouse hunting in the northern Cape Province supplied miners at Kimberley with an alternative source of protein (Horsbrugh 1912; Brooke 1987). Recently, commercial shooting of Namaqua *P. namaqua* and spotted *P. burchelli* sandgrouse has been offered at about US$150 per hunter per morning hunt in the northern Cape Province, South Africa. Although this embryonic industry supplements agriculture in that semi-arid and desertification-prone environment, we believe that the full commercial value of this resource is underestimated and that the resource itself is underutilized.

The aims of this study were to investigate: (i) the influence of weather on the time of arrival and the number of sandgrouse at watering sites, (ii) the relationships between the number of hunters and the number of shots fired (hunting effort), the number of shots per kill (hunter efficiency), and the number of birds bagged per hunter (hunter satisfaction), and (iii) the impact of one to three hunts per season, at particular watering sites, on sandgrouse populations.

Methods

We counted the number of Namaqua sandgrouse visiting watering sites from May to October 1990 and April to September 1991 at five watering sites at Rooipoort (28°38'S / 24°17'E), an estate about 50 km west of Kimberley, northern Cape Province. Counts, using the method described by Little, Malan & Crowe (1993) were done at least once, but usually more than once, at each watering site per month. A mean monthly count was calculated in cases where more than one count was done per watering site during a month. Counts started 90 minutes after sunrise and continued for two hours, straddling the peak drinking activity period of Namaqua sandgrouse (Maclean 1968) and, if birds were still present, the count continued until 10 minutes after the last bird had arrived.

Cloud cover, ambient temperature and wind speed were recorded during each count. Cloud cover was scored from 0 – 5 (0 = no clouds, 1 = <25% cloud cover; 2 = 25 – 50% cloud cover; 3 = 51 – 75% cloud cover; 4 = >75% cloud cover; 5 = visible precipitation). Because sandgrouse were mainly absent from watering sites when it rained, probably because of an increase in availability of rain water pools shortly after the rain had fallen (Knight 1989), and only returned in substantial numbers a few days after the rain, a rainfall index for each count (i.e. the inverse of the number of days since it had last rained) was calculated. Ambient temperature was recorded at the end of each count. Wind speed was recorded according to the Beaufort Wind Scale from 0 (calm) to 6 (strong breeze) (Earle & Bagnall 1990). We correlated the cloud cover score with the time (minutes) after actual sunrise (Anon. 1973) that the first birds arrived at a watering site to determine the delay in arrival times caused by cloud cover or rain. Because the first birds arrived up to 190 minutes after sunrise in overcast, rainy conditions (see Results), we assigned a maximum value of 200 minutes to all counts, i.e. when, because of adverse weather, no birds arrived and an arrival time could not be recorded.

Hunting effort, hunter efficiency and hunter satisfaction were recorded during 14 sandgrouse hunts conducted from 1990 – 1992 at Rooipoort Estate and Plaatjiesdam Farm (28°42'S / 22°34'E). Sandgrouse are traditionally hunted from butts laid out around a watering site while the birds are approaching the watering site. The butts are located in a circle 50 – 80 m from the water, and spaced 20 – 50 m apart. To study sandgrouse sensitivity to hunting, we recorded the number of birds arriving at a watering site some days before (reconnaissance counts) and during each hunt. The reconnaissance counts were done to allow the comparison of counts during hunts with counts of undisturbed birds at the same watering sites (Little *et al.* 1993), and were conducted as close as possible to the day of the hunt, but not earlier than seven days before the hunt. During each hunt, the number of hunters, the number of shots fired and the number of birds shot (the bag) were recorded. Not all shots were fired at Namaqua sandgrouse, because occasionally spotted sandgrouse would arrive at the watering sites and be shot at. Because it is impossible to separate the shots fired at each species, we used all shots fired in these analyses. The bag represents an underestimation of the birds killed because 10 – 20% of the shot birds were not retrieved owing to their falling on unsighted ground. Two indices of sandgrouse abundance were used in the analyses; the total number of birds, and the total number of flocks arriving at the watering site. Because the proportion of flocks with more than 40 birds was less than one per cent of all flocks, these flocks were discarded from the analyses. Flock size was therefore categorized either as 5 (= the median for flocks of 1 – 10 birds) or 25 (= the median for flocks of 11 – 40 birds).

To study the impact of hunting on sandgrouse populations, we determined if sandgrouse visited watering sites as distinct subpopulations, or if they moved between watering sites as part of a mega-population. During a more extensive study on the movements of Namaqua sandgrouse, 109 individuals were caught at watering sites, ringed and marked (dye-marked or patagial-tagged) during 17 capture operations conducted at Rooipoort and Plaatjiesdam (by the McGregor Museum (internal records); Lewis 1989; this study) from 1988 – 1992. Resightings and recoveries of marked individuals were recorded during this study at watering site counts and during hunts.

The number of hunts conducted at a watering site varied from one to three hunts per season. To measure the impact of hunting on sandgrouse numbers at a particular watering site, we compared the numbers of sandgrouse counted during each hunt at a watering site, during a season. Because numbers of sandgrouse varied at watering sites between years and peaked in different months within and between years at watering sites (Malan, Little & Crowe 1992), we treated a hunting season (year) at particular watering sites as separate entities. We calculated the total offtake per watering site as the per cent kill per maximum mean monthly count.

Between-year comparisons (1990 – 1991) of hunting effort, efficiency and hunter satisfaction were done using non-parametric comparison of two samples. Correlations between weather variables, hunter parameters, and between offtake and the number of hunts at a watering site were done using simple linear regression. All analyses were done using the Statgraphics statistical graphics software package (Anon. 1986).

Results

There were no significant between-year (1990 – 1991) differences in hunting effort (number of hunters and number of shots fired), hunter efficiency (shots per kill), or in hunter satisfaction (bag, % kill, bag per hunter) (Table 1; $p > 0{,}05$; Mann-Whitney U-test).

There was no significant correlation between wind speed ($r = 0{,}06$; $p = 0{,}52$; $n = 105$ counts) or ambient temperature ($r = 0{,}12$; $p = 0{,}42$; $n = 105$ counts) and the number of

Table 1 Mean hunting effort, hunter efficiency and hunter satisfaction, and standard error (in brackets) for 14 Namaqua sandgrouse hunts conducted from 1990 to 1992. n = number of hunts, (rec) = reconnaissance counts and (hunt) = counts during hunts

	1990	1991	1992	Overall
n	5	8	1	14
Birds (rec)	179,4 (37,6)	203,6 (48,6)	970,0	249,7 (62,9)
Birds (hunt)	259,8 (103,3)	368,1 (145,5)	1297,0	395,0 (112,7)
Hunters	10,0 (1,4)	12,3 (0,9)	9,0	11,2 (0,8)
Shots	199,4 (78,9)	246,5 (43,6)	474,0	245,9 (40,2)
Bag	24,8 (11,5)	38,9 (13,0)	151,0	41,9 (11,8)
Per cent kill	13,4 (3,9)	18,0 (2,2)	16,0	16,2 (1,9)
Shots/kill	7,6 (2,0)	9,1 (2,1)	3,0	8,1 (1,4)
Shots/hunter	40,6 (8,7)	39,9 (12,7)	53,0	45,4 (9,2)
Bag/hunter	2,2 (0,7)	3,6 (1,4)	17,0	4,1 (1,3)
No. flocks	40,6 (8,6)	39,9 (12,7)	114,0	45,4 (9,2)
No. small flocks	34,0 (7,6)	28,4 (7,8)	65,0	33,0 (5,6)
% small flocks	90,6 (2,9)	77,3 (5,7)	57,0	80,6 (4,1)
No. large flocks	4,8 (1,8)	11,1 (5,1)	49,0	11,6 (4,2)
% large flocks	9,4 (2,9)	22,8 (5,7)	43,0	19,4 (4,1)

Namaqua sandgrouse visiting a watering site. However, sandgrouse numbers were significantly negatively correlated with cloud cover ($r = -0,41$; $p < 0,001$) and with the rain index ($r = -0,42$; $p < 0,001$). The time of arrival of sandgrouse (minutes after sunrise) was significantly positively correlated with cloud cover ($r = 0,41$; $p < 0,001$; $n = 105$ counts). There is an apparent 9% drop in numbers and a 6-min delay in arrival time with every point increase in cloud cover score (Appendix 1). During only one of five counts done during rain (score = 5) were birds recorded visiting the watering sites, compared with eight of 12 counts done in totally overcast conditions (score = 4).

The reconnaissance counts and the bag were significantly positively correlated producing the regression formula:

$$y = -1,0 + 0,17x \qquad (r = 0,91; p < 0,001)$$

where y = predicted bag and x = reconnaissance count. The offtake (per cent kill) was calculated as the bag divided by the number of birds on the reconnaissance, because the reconnaissance count represents the actual bird numbers visiting a watering site (Little *et al.* 1993). On average, one out of every nine (11%) sandgrouse flying over a watering site during a hunt was shot, and the mean percentage kill related to reconnaissance counts at the same watering sites was 17% (Table 1).

The number of hunters on a hunt was neither significantly correlated with the number of birds bagged ($r = -0,19$; $p = 0,52$; $n = 14$) nor with the number of shots fired ($r = 0,21$; $p = 0,46$; $n = 14$). Nor was the proportion of birds killed significantly correlated with the number of birds counted during the hunt ($r = 0,46$; $p = 0,10$; $n = 14$). However, hunter efficiency (shots/kill) was significantly negatively correlated with the number of birds counted during the hunt ($r = -0,66$; $p < 0,001$; $n = 14$) (Figure 1a). Furthermore, hunter satisfaction (bag/hunter) was significantly positively

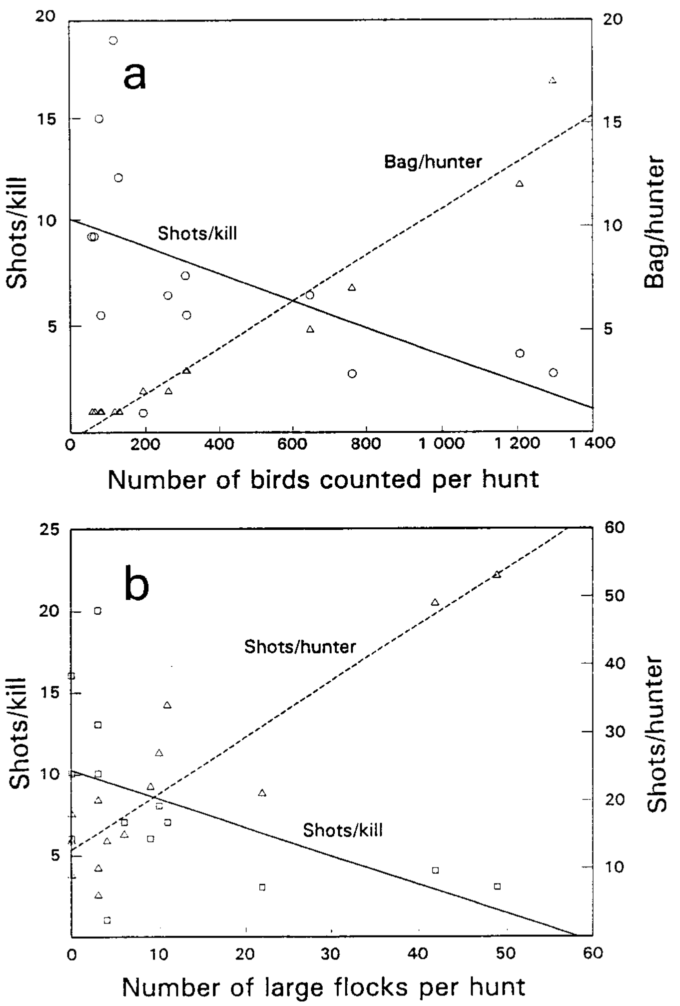

Figure 1 Comparison of (a) hunter skill (shots fired per kill) and hunter satisfaction (birds bagged per hunter) for various numbers of birds counted per hunt (n = 14 sandgrouse hunts), and (b) hunter skill (shots fired per kill) and hunting effort (shots fired per hunter) for various numbers of large flocks flying over the watering sites during the hunt (n = 14 sandgrouse hunts).

correlated with the number of birds counted during a hunt ($r = 0,97$; $p < 0,001$; $n = 14$). Hunter satisfaction (shots/hunter) was significantly positively correlated with the number of birds counted on the reconnaissance and during the hunt, producing the following regression formulae:

$$y = 10,0 + 0,05x \qquad (r = 0,84; p < 0,001; n = 14)$$

where y = shots/hunter and x = the number of birds counted on the reconnaissance; and

$$y = 10,4 + 0,03x \qquad (r = 0,92; p < 0,001; n = 14)$$

where y = shots/hunter and x = the number of birds counted during the hunt.

The number of small flocks (≤10 birds) was significantly negatively correlated ($r = -0,57$; $p = 0,03$; $n = 14$) and the number of large flocks (>10 birds) significantly positively correlated ($r = 0,57$; $p = 0,03$; $n = 14$) with the number of flocks counted during a hunt. Hunter efficiency (shots/kill) was significantly negatively correlated ($r = -0,57$; $p = 0,03$; $n = 14$), and hunter satisfaction (shots/hunter) significantly positively correlated ($r = 0,60$; $p = 0,02$; $n = 14$) with the number of large flocks (Figure 1b).

Of the 109 marked birds, 76 were resighted (marked birds resighted or ringed birds shot) within 1 – 234 days after capture. Of the 103 resightings, only 8 (8%) were at a different site to that of marking. The mean offtake per watering site for the various number of hunts per watering site was 13% (range = 5 – 21%, $n = 2$) for one hunt per site per season, 31% (range = 29 – 33%, $n = 2$) for two hunts per site per season, and 49% (range = 35 – 62%, $n = 3$) for three hunts per site per season. There was a positive correlation between mean offtake and the number of hunts per watering site ($r = 0,87$; $p = 0,01$; $n = 7$).

Discussion

Hunter efficiency (shots/kill) and hunter satisfaction (bag/hunter and shots/hunter) increased with more birds, since with a higher proportion of bigger flocks arriving at a watering site, hunters were apparently more effective at bagging birds from a large flock than from smaller flocks. Therefore, although hunters fired more shots when there was a higher proportion of large flocks arriving at a watering site, their actual efficiency increased. These results support Lynn-Allen (1951), who suggested that when hunters fired at bigger flocks they often bagged more birds, but not necessarily the targeted individuals. However, the percentage kill was not dependent on the bird-count during the hunt. This is probably because double-barrelled shotguns were used exclusively on sandgrouse hunts, thereby limiting the number of shots to two per gun during the time that a particular flock was overhead. Therefore, while total bag per hunt can be used as an estimate of the number of birds available to the hunters, the mean bag per hunter is a more reliable indicator of the number of birds available.

The economic viability of commercial Namaqua sandgrouse hunting is dependent on hunter group size and hunter satisfaction (shots/hunter) (various hunters, pers. comm.). However, because the number of shots fired and the bag size are not dependent on hunter group size, this does not necessarily mean that an unlimited number of hunters can partake in sandgrouse hunting. Hunter group sizes are limited by the number of hunters that can safely, and comfortably, circle a watering site. At 14 out of 23 (61%) watering sites studied in the northern Cape Province, sandgrouse visited watering points rather than soil dams or rivers (G. Malan, unpub. data). These watering points are either small cement dams built to provide sandgrouse with a reliable, all-year water source, or are leaking storage tanks or troughs. The cement dams are less than 2 m in diameter. If hunters are positioned 50 – 80 m from a watering point and spaced at least 20 m apart (a minimum safety distance), then a maximum of 16 – 25 hunters can be accommodated within the hunting circle. The number of shots fired per hunter to satisfy the hunter's recreational expectations, and therefore, for a hunt to become economically viable, must range between 25 and 50 shots (various hunters, pers. comm.). Therefore, the number of birds counted on a reconnaissance must range between 300 and 800, and between 500 and 1300 during a hunt (calculated from regression formulae provided) for a hunt to be economically viable. It is important to note the difference between required reconnaissance and hunt counts, because of the potential problem of over-estimating the resource by a factor of as much as ±0,3 if only counted on the day of the hunt (Little *et al.* 1993). We therefore recommend that estimates of the resource should, wherever possible, be made with the reconnaissance counts.

Ninety-two per cent of the marked individuals were resighted at the site of marking, therefore, the majority of Namaqua sandgrouse that visit watering sites at Rooipoort visit a specific watering site for the duration of the winter visiting period. The total offtake per watering site can therefore be regarded as being from a single subpopulation. However, to calculate a sustainable surplus for Namaqua sandgrouse at this stage is premature, because data on survival and reproductive rates are lacking. The reproductive behaviour of Namaqua sandgrouse has been studied briefly in the Kalahari Gemsbok National Park (25°30'S / 20°30'E; KGNP) (Cade & Maclean 1967; Maclean 1968; 1985) and at Rooipoort (Malan *et al.* 1992). If one or two of every three hatchlings survive, the reproductive success will vary between 23 and 45% in the KGNP ($n = 69$ eggs) and 16 and 32% at Rooipoort ($n = 19$ eggs). However, these reproductive rates do not allow for the number of sexually mature birds that do not breed (non belly-soaking birds). Adult sandgrouse transport water from the watering site in their belly/breast feathers to unfledged young (Cade & Maclean 1967), and this indicates the proportion of the population with chicks. In the KGNP a maximum of 4% of adult males belly-soaked and at Rooipoort 10% in 1990 and 4% in 1991. However, high levels of belly-soaking (51% and 40%) were recorded in the Goegap Nature Reserve (29°42'S / 18°00'E) which possibly indicates higher reproductive rates for Namaqua sandgrouse breeding in Bushmanland. Based on these reproductive rates, we can make preliminary recommendations regarding the frequency of hunting per watering site. A detailed study of Namaqua sandgrouse breeding success in Bushmanland is needed to estimate the survival and fecundity rates necessary to define an appropriate harvest strategy for this species.

Recommended hunting strategy

1. Heavily overcast and rainy mornings, as well as cold and windy conditions, should be avoided when hunting Namaqua sandgrouse.
2. Reconnaissance counts should be conducted, and adjusted for expected numbers on the day of the hunt in response to the disturbance of the hunt (Little *et al.* 1993; this study), and in response to the weather (Appendix 1).
3. To maximize revenue and recreational value from commercial hunts, hunter group sizes should be at least 16 and the number of birds counted on the reconnaissance, or during a hunt, should be at least 300 or 500, respectively.
4. Given the apparently low reproductive rate and the small percentage of the population that breed annually, the number of hunts per watering site in one season should preferably be limited to one, possibly two, but never three.

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Appendix 1 Proportion of the Namaqua sandgrouse population expected to arrive at a watering site, and expected arrival times of first birds, according to various cloud cover categories at Rooipoort Estate, northern Cape Province, during the hunting season (1 April – 15 July; Anon. 1993)

Cloud cover score[1]		0	1	2	3	4	5
Proportion of population		100	91	82	73	64	59
		Expected arrival times					
April	1	08:38	08:44	08:50	08:56	09:02	09:08
	7	08:46	08:52	08:58	09:04	09:10	09:16
	14	08:52	08:58	09:04	09:10	09:16	09:22
	21	08:58	09:04	09:10	09:16	09:22	09:28
	30	09:04	09:10	09:16	09:22	09:28	09:34
May	7	09:09	09:15	09:21	09:27	09:33	09:39
	14	09:13	09:19	09:25	09:31	09:37	09:43
	21	09:18	09:24	09:30	09:36	09:42	09:48
	28	09:22	09:28	09:34	09:40	09:46	09:52
June	1	09:25	09:31	09:37	09:43	09:49	09:55
	14	09:28	09:34	09:40	09:46	09:52	09:58
	21	09:30	09:36	09:42	09:48	09:54	10:00
	28	09:31	09:37	09:43	09:49	09:55	10:01
July	1	09:33	09:39	09:45	09:51	09:57	10:03
	7	09:31	09:37	09:43	09:49	09:55	10:01

[1] Score: 0 = no clouds; 1 = <26% cloud cover; 2 = 26 – 50% cloud cover; 3 = 51 – 75% cloud cover; 4 = >75% cloud cover; 5 = visible precipitation