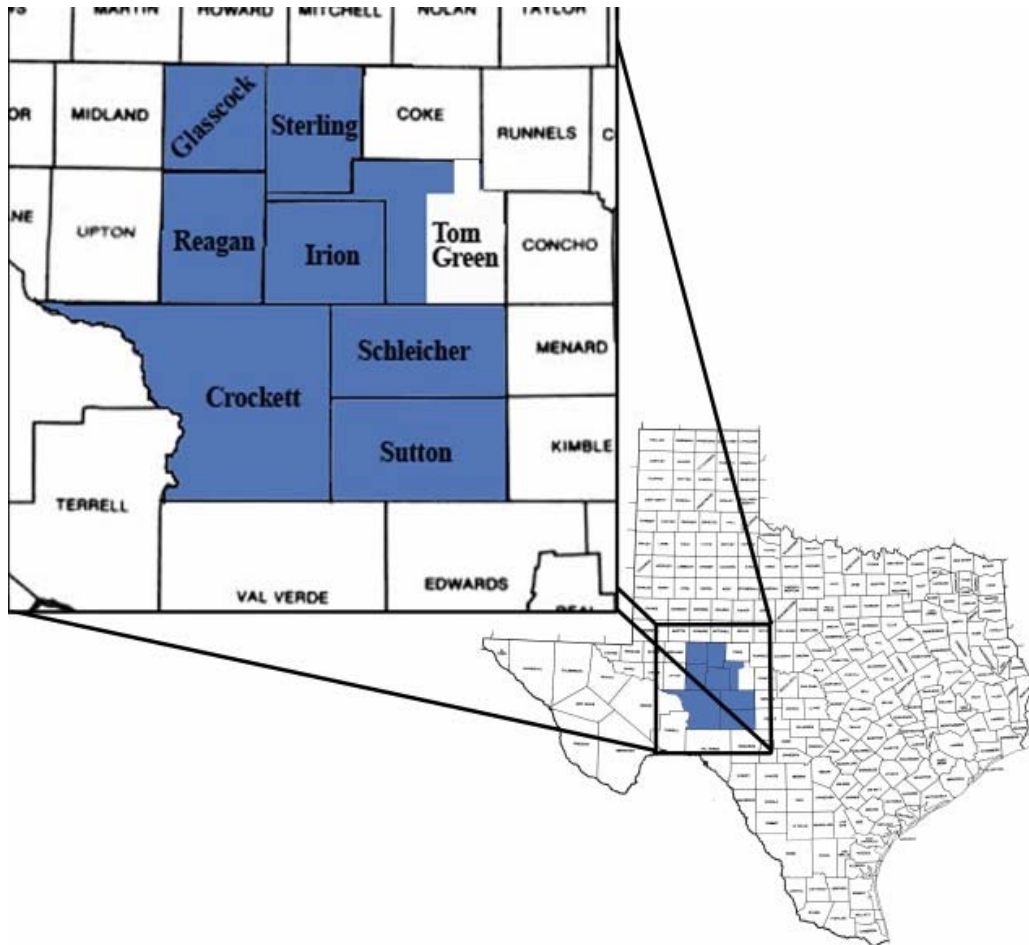


# 2007 ANNUAL REPORT WEST TEXAS WEATHER MODIFICATION ASSOCIATION



West Texas Weather Modification Association  
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West Texas Weather  
Modification Association  
2007 Annual Report

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Seeding operations started on March 26<sup>th</sup> and ended on October 3<sup>rd</sup> with 46 operational days. 95 clouds were seeded with 1263 flares during 82 flights. 14 reconnaissance flights were flown while making an attempt to find seedable clouds on marginal days. Pilots flew 188 flight hours. A pilot was hired full-time in March allowing for timely departure to clouds on days when seedable conditions were favorable. The pilot moved on at the end of August; many part time pilots were reachable but on days when activity began very quickly, untimely flights occurred allowing for two missed opportunities. A few repairs on aircraft had minor effects on operations. TITAN software operated without any major issues. On several occasions, the Southern Region Headquarters server went offline. Two days were not sufficient for analysis due to corrupted data or losses of radar feed.

2007 was a very wet year with a value (32.05in) at San Angelo over normal by 11.50 inches. Record rainfall across the region was associated with an abnormal pattern of the jet stream, several upper-level closed lows over Texas, and tropical systems affecting eastern Mexico and the transport of that moisture into Texas. July was the most active this season with 14 operational days. Precipitation and percent of normal maps show that much of Texas was well above normal. West Texas was on the periphery of slightly drier regions. The wet pattern ceased quickly in September and failed to provide many days for thunderstorms.

The statistical reports conducted by Arquímedes Ruiz-Columbié shows a majority of seeding operations results were excellent or very good with an average seasonal increases to precipitation at 11%. Timing to small and large seeded clouds, (77% - 97%) was excellent. Small clouds showed increases for precipitation mass at 103%, cloud mass increases of 50%, lifetime increases at 27%, increases to cloud area at 33%, cloud volume increases of 52%, and volume above 6Km of 108%. Increases in precipitation mass by county were shown between 2.8 and 21.3%. Crockett, Sutton, and Schleicher counties were below 10% but were a consequence of environmental circumstances that did not provide numerous seedable conditions during the season. Total increases in precipitation for the target area were calculated at 1,186,200 acre-feet.

Robert Rhodes  
Meteorologist

**Arquímedes Ruiz-Columbié**  
Active Influence & Scientific Management

Cloud seeding operations 2007 began over the West Texas Weather Modification Association target area in March. This annual report serves as a summary of results. A total of **95 clouds** were seeded and identified by TITAN in **46 operational days**. Table 1 in page 1 summarizes the general figures:

**Table 1: Generalities**

First operational day: **March 26<sup>th</sup> 2007**

Last operational day: **October 3<sup>rd</sup> 2007**

**Number of operational days: 46**

(One in March, four in April, six in May, seven in June, fourteen in July, six in August, six in September, and two in October)

According to the daily reports, operational days were qualified as:

**Twenty-one with excellent performance**

**Thirteen with very good performance**

**Seven with good performance**

**Two with fair performance**

**One with poor performance**

**Two with corrupted data: July 2<sup>nd</sup> and September 7<sup>th</sup>**

**Number of seeded clouds: 95 (27 small, 25 large, and 43 type B seeded clouds)**

**Missed Opportunities: 2 (0.2 %)**

**September 19<sup>th</sup>: Cloud # 415 over Reagan County (lifetime 68 minutes)**

**October 1<sup>st</sup>: Cloud # 224 over Schleicher County (lifetime 184 minutes)**

## Small Clouds

Evaluations were done using TITAN and NEXRAD data.

Table 2 shows the results from the classic TITAN evaluation for the 27 small seeded clouds which obtained proper control clouds.

**Table 2: Seeded Sample versus Control Sample (27 couples, averages)**

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
<b>Lifetime</b>	70 min	50 min	1.40	40 ( <b>27</b> )
<b>Area</b>	64.9 km <sup>2</sup>	46.0 km <sup>2</sup>	1.41	41 ( <b>33</b> )
<b>Volume</b>	229.4 km <sup>3</sup>	131.2 km <sup>3</sup>	1.75	75 ( <b>52</b> )
<b>Top Height</b>	9.0 km	8.0 km	1.13	13 ( <b>5</b> )
<b>Max dBz</b>	58.1	54.7	1.02	6 ( <b>3</b> )
<b>Top Height of max dBz</b>	4.4 km	4.3 km	1.02	2 ( <b>2</b> )
<b>Volume Above 6 km</b>	43.6 km <sup>3</sup>	13.7 km <sup>3</sup>	3.18	218 ( <b>108</b> )
<b>Prec.Flux</b>	542.7 m <sup>3</sup> /s	306.7 m <sup>3</sup> /s	1.76	76 ( <b>40</b> )
<b>Prec.Mass</b>	2657.1 kton	1130.0 kton	2.35	135 ( <b>103</b> )
<b>CloudMass</b>	192.5 kton	96.7 kton	1.99	99 ( <b>50</b> )
<b>η</b>	13.8	11.7	1.18	18 ( <b>35</b> )

Bold values in parentheses are modeled values, whereas **η** is defined as the quotient of Precipitation Mass divided by Cloud Mass, and is interpreted as efficiency. A total of 102 flares were used in this sub-sample with an excellent timing (**91 %**) for an effective dose about **70 ice-nuclei per liter**. The seeding operation for small clouds lasted about **9 minutes** in average. An excellent increase of **103 %** in precipitation mass together with an increase of 50 % in cloud mass illustrates that the seeded clouds grew at expenses of the environmental moisture (they are open systems) and used only a fraction of this moisture for their own maintenance. The increases in lifetime (27 %), area (33 %)

volume (52 %), volume above 6 km (108 %), and precipitation flux (50 %) are notable. There are slight increases in maximum reflectivity (3 %), and in top height (5 %). The seeded sub-sample seemed 35 % more efficient than the control sub-sample. Results are evaluated as **excellent**.

An increase of 103 % in precipitation mass for a control value of 1130.0 kton in 27 cases means:

$$\Delta_1 = 27 \times 1.03 \times 1130.0 \text{ kton} = 31\,425 \text{ kton} = 25\,486 \text{ ac-f}$$

## Large Clouds

The sub-sample of 25 large seeded clouds received a synergetic analysis. In average, the seeding operations on these large clouds affected 55 % of their whole volume; with an excellent timing (97 % of the material went to the clouds in their first half-lifetime). A total of 263 flares were used in this sub-sample for an effective dose about **75 ice-nuclei per liter**.

Also in average, large clouds were 37 minutes old when the operations took place; the operation lasted about 29 minutes, and the large seeded clouds lived 200 minutes.

Table 3 shows the corresponding results:

**Table 3: Large Seeded Sample versus Virtual Control Sample (25 couples, averages)**

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
<b>Lifetime</b>	200 min	180 min	1.11	11
<b>Area</b>	728 km <sup>2</sup>	629 km <sup>2</sup>	1.16	16
<b>Volume</b>	2873 km <sup>3</sup>	2333 km <sup>3</sup>	1.23	23
<b>Volume Above 6 km</b>	781 km <sup>3</sup>	558 km <sup>3</sup>	1.40	40
<b>Prec.Flux</b>	6283 m <sup>3</sup> /s	5295 m <sup>3</sup> /s	1.19	19
<b>Prec.Mass</b>	41 476 kton	29 901 kton	1.39	39

An increase of 39 % in precipitation mass for a control value of 29 901 kton in 25 cases may mean:

$$\Delta_2 = 25 \times 0.39 \times 29\,901 \text{ kton} = 291\,535 \text{ kton} = 236\,435 \text{ ac-f}$$

## Type B Clouds

The sub-sample of 43 type B seeded clouds received a synergetic analysis. In average, the seeding operations on the type B clouds affected 27 % of their whole volume; with an excellent timing (77 % of the material went to the clouds in their first half-lifetime). A total of 801 flares were used in this sub-sample for an effective dose ~ **95 ice-nuclei per liter**.

Also in average, type B clouds were 160 minutes old when the operations took place; the operation lasted about 45 minutes, and the type B seeded clouds lived ~ 300 minutes.

Table 4 shows the results:

**Table 4: Type B Seeded Sample versus Virtual Control Sample (43 couples, averages)**

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	300 min	265 min	1.13	13
Area	2689 km <sup>2</sup>	2509 km <sup>2</sup>	1.07	7
Volume	9386 km <sup>3</sup>	8519 km <sup>3</sup>	1.10	10
Volume Above 6 km	2349 km <sup>3</sup>	2020 km <sup>3</sup>	1.16	16
Prec.Flux	21854 m <sup>3</sup> /s	20168 m <sup>3</sup> /s	1.08	8
Prec.Mass	192 732 kton	166 328 kton	1.16	16

An increase of 16 % in precipitation mass for a control value of 166 328 kton in 43 cases may mean:

$$\Delta_3 = 43 \times 0.16 \times 166\,328 \text{ kton} = 1\,144\,337 \text{ kton} = 928\,057 \text{ ac-f}$$

$$\text{The total increase: } \Delta = \Delta_1 + \Delta_2 + \Delta_3 = 1\,189\,978 \text{ ac-f}$$

## Micro-regionalization

Increases in precipitation mass were analyzed county by county in an attempt to better describe the performance and corresponding results. **Table 5** below offers the details:

County	Initial Seeding	Extended Seeding	Acre-feet (increase)	Inches (increase)	Rain (season value)	% (increase)
<b>Glascock</b>	<b>12</b>	<b>16</b>	<b>140 700</b>	<b>2.93</b>	<b>23.20 in</b>	<b>12.6</b>
<b>Sterling</b>	<b>15</b>	<b>19</b>	<b>134 200</b>	<b>2.72</b>	<b>22.70 in*</b>	<b>12.0</b>
<b>Reagan</b>	<b>15</b>	<b>22</b>	<b>167 000</b>	<b>2.66</b>	<b>18.89 in</b>	<b>14.1</b>
<b>Irion</b>	<b>16</b>	<b>31</b>	<b>248 300</b>	<b>4.43</b>	<b>20.80 in</b>	<b>21.3</b>
<b>Tom Green</b>	<b>10</b>	<b>22</b>	<b>193 800</b>	<b>4.78**</b>	<b>28.57 in</b>	<b>16.8</b>
<b>Crocket</b>	<b>9</b>	<b>17</b>	<b>123 200</b>	<b>0.81</b>	<b>28.40 in</b>	<b>2.8</b>
<b>Schleicher</b>	<b>10</b>	<b>17</b>	<b>102 600</b>	<b>1.47</b>	<b>26.49 in</b>	<b>5.5</b>
<b>Sutton</b>	<b>8</b>	<b>15</b>	<b>76 400</b>	<b>0.99</b>	<b>26.65 in</b>	<b>3.7</b>
Coke		4				
<b>Total</b>	<b>95</b>	<b>163</b>	<b>1 186 200</b>			
<b>Average</b> (only for the bold values)				<b>2.30</b>	<b>24.46 in</b>	<b>11.1</b>

(\*) Missed data recreated by spatial interpolation

(\*\*) One half of the Tom Green Area considered

(**Initial seeding** means the counties where the operations began, whereas **extended seeding** means the counties favored by seeding after the initial operations took place).

## Final Comments

- 1) Results are evaluated as **excellent**; two operational day was lost due to corruption of data;
- 2) The micro-regionalization analysis showed increases per county; seedable conditions were more frequent over the central zone of the target area (Irion County); the average increase in precipitation, referred to the seasonal value, is about **11 %**;
- 3) Radar estimations of precipitation should be considered as measurements of trend. Nevertheless, seeding operations appeared to improve the dynamics of seeded clouds;
- 4) Season 2007 was very atypical in some regions in Texas due to an anomalous location of the sub-tropical jet stream during the early spring which in turn produced strong Pineapple Connection of Pacific Ocean moisture, whereas, in June, the long presence of an Upper Level Low over North Texas added even more atypical conditions. Tropical Storm Erin (August), in dissipation, also was an important factor. These patterns explain why the seedable conditions were relatively scarce in comparison with season 2006 (details in “**2007 Midseason Cloud Seeding Briefing**”: *The Texas Weather Modification Courier*, Volume 1, Issue 2, August 15, 2007, page 4).

**West Texas Weather Modification****2007 Flight Summary****March**

Date	Number	Call Sign	Takeoff	Landing	Duration	BIP	Eject.	Agl	Seeded	Pilot
26-Mar	1	6909P	21.15	23.00	2.30	19		494.00	CrIrr	Linderman
30-Mar	2	6909P			0.90	0		0.00	recon	Linderman
SubTotal					3.20	19.00		494.00		
Total					3.20	19.00		494.00		

**West Texas Weather Modification****2007 Flight Summary****April**

13-Apr	3	6909P	18.00	19.40	1.70	0		0.00	recon	Linderman
	4	6909P	20.00	21.50	1.90	0		0.00	recon	Linderman
17-Apr	5	6909P	19.00	20.20	1.50	6		156.00	Gl,St	Linderman
24-Apr	6	5141P	9.50	10.40	0.80	0		0.00	recon	Linderman
	7	6909P	17.20	19.10	1.90	10		260.00	Sc	Linderman
	8	6909P	20.00	20.50	0.90	0		0.00	recon	Linderman
	9	6909P	22.00	24.00	2.10	25		650.00	Sc,Su	Linderman
29-Apr	10	6909P	20.20	24.00	3.80	24		624.00	lr, Re, Tg	Linderman
	11	7924P	21.20	23.45	2.40	9		234.00	Gl,St	Bozzell
30-Apr	12	5141P	18.44	21.44	3.00	9		234.00	lr, St, Tg	Linderman
	13	30y			2.00	9		234.00	Sc, Su	Poynor
SubTotal					22.00	92.00		2392.00		
Total					25.20	111.00	0.00	2886.00		

**West Texas Weather Modification****2007 Flight Summary****May**

6-May	14	5141P	18.25	19.40	1.30	0		0.00	recon	Linderman
	15	5141P	21.20	22.30	1.20	3		78.00	Tg	Linderman
	16	5141P	22.45	24.30	1.90	32		832.00	lr, Tg	Linderman
8-May	17	5141P	20.20	23.30	3.20	35		910.00	Cr, lr, St, Tg	Linderman
	18	6909P	21.00	22.25	1.40	22		572.00	lr, Tg	Baker
12-May	19	5141P	19.00	22.40	3.80	53		1378.00	Gl, lr, Tg, St	Linderman
	20	6909P	22.20	24.10	1.90	21		546.00	Cr, Re	Baker
21-May	21	6909P	17.20	18.50	1.50	0		0.00	recon	Linderman
24-May	22	6909P	18.45	20.15	1.50	2		52.00	Cr	Linderman

25-May	23	6909P	21.55	22.35	0.60	0		0.00	recon	Linderman
	24	6909P	23.15	24.00	1.80	2		52.00	lr	Linderman
27-May	25	6909P	19.35					0.00	Cr, lr, Sc, Re, Tg	Linderman
	26	5141P	20.15	23.05	2.90	33		858.00	lr, Sc, Tg	Sleeper
SubTotal					23.00	203.00		5278.00		
Total					48.20	314.00	0.00	8164.00		

**West Texas Weather Modification**

**2007 Flight Summary**

**June**

3-Jun	27	6909P	20.50	23.40	3.60	62		1612.00	Re, St	Linderman
	28	5141P	21.00	23.20	3.30	51		1326.00	lr, St, Tg	Baker
9-Jun	29	6909P	17.20	20.10	2.90	6		156.00	lr, Re, St	Linderman
	30	6909P	21.20	22.50	1.70	2		52.00	St	Linderman
12-Jun	31	6909P	20.50	22.20	1.80	12		312.00	St	Linderman
13-Jun	32	6909P			1.40	0		0.00	recon	Linderman
15-Jun	33	6909P	0.40	1.40	1.00	25		650.00	lr, Cr, Tg	Linderman
16-Jun	34	6909P	19.40	20.40	1.00	3		78.00	Re	Linderman
	35	5141P	21.00	23.00	2.60	39		1014.00	Cr, lr, Sc, Tg	Linderman
21-Jun	36	6909P	23.25	0.45	1.60	2		52.00	Tg	Linderman
25-Jun	37	6909P	18.40	20.00	1.20	12		312.00	St	Linderman
SubTotal					22.10	214.00	0.00	5564.00		
Total					70.30	528.00	0.00	19292.00		

**West Texas Weather Modification**

**2007 Flight Summary**

**July**

2-Jul	38	6909P	19.15	21.50	2.60	37		962.00	lr, St, Tg	Linderman
3-Jul	39	6909P	17.15	20.40	3.40	56		1456.00	Sc, Su, Tg	Linderman
	40	6909P	21.25	23.45	2.60	29		754.00	Cr, lr, Tg	Linderman
6-Jul	41	5141P	19.45	22.00	2.60	7		182.00	lr, Re, St	Linderman
7-Jul	42	5141P	21.45	24.45	3.10	23		598.00	Sc, Su	Linderman
8-Jul	43	5141P	22.30	23.10	0.40	0		0.00	recon	Linderman
10-Jul	44	5141P	20.00	22.30	2.60	9		234.00	Gl, St	Linderman / Baker
13-Jul	45	5141P	18.50	19.40	1.70	7		182.00	lr	Linderman
	46	5141P	20.10	24.00	3.90	58		1508.00	Cr, Re	Linderman
14-Jul	47	6909P	19.20	20.40	1.50	0		0.00	recon	Linderman
17-Jul	48	6909P	23.55	24.55	1.20	2		52.00	Su	Linderman

23-Jul	49	6909P	20.20	22.50	2.60	17		442.00	Sc, Su	Linderman
24-Jul	50	5141P	22.25	24.45	2.30	8		208.00	Gl, Ir	Linderman
	51	7924P	23.00	24.40	1.60	7		182.00	Gl	Bozzell
25-Jul	52	5141P	21.40	23.30	1.90	0		0.00	Recon Sc, Su	Linderman
26-Jul	53	5141P	21.30	24.00	2.60	16		416.00	Su	Linderman
	54	6909P	23.00	24.00	1.10	1		26.00	Ir	Baker
27-Jul	55	6909P	18.25	22.10	3.90	19		494.00		Linderman
	56	7924P	20.35	23.15	2.70	19		494.00		Bozzell
28-Jul	57	6909P	16.45	23.30	6.70	46		1196.00		Linderman
	58	5141P	18.35	23.15	2.30	4		104.00		Bozzell
29-Jul	59	6909P	18.45	23.00	4.20	24		624.00		Linderman
	60	5141P	19.35	25.20	5.10	13		338.00		Bozzell / Cramer (T)
	61	6909P	23.40	25.20	1.70	24		624.00		Linderman
30-Jul	62	6909P	19.35	21.00	1.60	0		0.00	recon St, Tg	Linderman
31-Jul	63	7924P	18.35	19.35	2.00	8		208.00	Gl	Linderman
SubTotal					67.90	434.00	0.00	7176.00		
Total					138.20	962.00	0.00	20904.00		

**West Texas Weather Modification**

**2007 Flight Summary**

**August**

1-Aug	64	5141P	19.10	21.35	2.40	7		182.00	Gl, St	Bozzell
	65	6909P	22.25	24.55	2.30	21		546.00	Gl, Re, St	Linderman
2-Aug	66	6909P	20.15	24.00	3.60	36		936.00	Ir, Re, St	Linderman
3-Aug	67	6909P	21.20	24.10	2.90	16		416.00	Ir, Re, Tg	Linderman
29-Aug	68	6909P	19.15	22.35	3.20	9		234.00	Cr, Sc, Su	Linderman
30-Aug	69	6909P	19.00	21.50	2.80	12		312.00	Cr, Sc	Linderman
	70	30Y	19.00	21.45	2.60	2		52.00	St	Poynor
31-Aug	71	5141P	18.40	21.40	3.70	3		78.00	Cr, Su	Bozzell / Cramer (T)
SubTotal					23.50	106.00	0.00	2756.00		
Total					161.70	1068.00	0.00	23660.00		

**West Texas Weather Modification**

**2007 Flight Summary**

**September**

2-Sep	72	30Y	19.05	20.40	1.80	4		104.00	Re, Gl	Poynor
10-Sep	73	6909P	19.05	20.05	3.00	20		520.00	Re, St, Tg	Eggemeyer
18-Sep	74	5141P	22.05	25.00	3.10	27		702.00	Re, Sc, Tg	Cramer

19-Sep	75	5141P	19.25	22.55	3.30	30		780.00	Gl, Ir, Re	Baker
25-Sep	76	30Y	20.10	22.20	2.10	27		702.00	Ir, Tg	Poynor
	77	5141P	20.30	22.40	2.10	18		468.00	Cr	Cramer
	78	5141P	23.20	25.00	1.70	8		208.00	Cr	Bozzell
27-Sep	79	5141P	20.55	23.35	2.70	27		702.00	Ir, Re, St, Tg	Granaghan
					19.80	161.00	0.00	4186.00		
					181.50	1229.00	0.00	27846.00		
<b>West Texas Weather Modification</b>										
<b>2007 Flight Summary</b>										
<b>October</b>										
1-Oct	80	6909P	21.50	23.20	1.60	5		130.00	Ir	Sleeper
2-Oct	81	5141P	23.35	24.25	0.80	0		0.00	recon	Bozzell
3-Oct	82	5141P	20.00	24.00	4.00	29		754.00	Cr, Ir, Re, Su	Bozzell
SubTotal					6.40	34.00	0.00	884.00		
Total					187.90	1263.00	0.00	28730.00		