

# PRECIPITATION MEASURED BY GAGES PROTECTED BY THE WYOMING SHIELD AND THE DUAL-GAGE SYSTEM

by

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## INTRODUCTION

Undermeasurement of precipitation, especially snowfall, when precipitation gages are not protected naturally as they are in small forest clearings, is a major problem in obtaining accurate point measurements. The Wyoming shield (Rechard and Wei, 1980) and the dual-gage system (Hamon, 1973) were developed to measure snowfall under windy conditions.

This study was conducted on the Reynolds Creek Watershed in southwest Idaho to: 1) compare the computed catch between a dual-gage site located in an opening in a grove of trees and a dual-gage site outside the protection of the trees; 2) compare the catch by a Wyoming shielded gage to the two dual-gage sites at the grove of trees; and 3) summarize results from several locations where Wyoming shielded gages and dual-gage systems were located together on the Watershed.

## Experimental Sites, Materials and Methods

The grove experimental site was located on the Reynolds Creek Watershed in southwest Idaho (Robins, et al. 1965). Elevation at the unprotected dual-gage site near the grove was 1807 m where the 25-year mean annual precipitation was 944 mm (1962-1986). The protected dual-gage site was located in a 36 x 47 m opening in a stand of 24 m tall Douglas fir. The unprotected dual-gage site was located 275 m east of the protected site which was 100 m east of the edge of the trees. The Wyoming shielded gage was 22 m southeast of the unprotected dual-gage site.

The summary data were taken from 5 sites unprotected by trees where dual-gage systems and Wyoming shielded gages were located together on the Reynolds Creek Watershed, which included the unprotected site described above. Elevations at the sites ranged from 1193 to 2097 m and annual precipitation varied from 288 to 944 mm. The period of record differed between sites, ranging from 2 to 7 years over the period November 1976 through June 1986.

A description of the Wyoming shielded gage was published by Rechard and Wei (1980) and the dual-gage system was described by Hamon (1973). The Wyoming shielded gage and the dual-gages were located about 50 m apart at each study site except the grove site.

Air temperature at each site was measured by a recording thermograph that was located in a standard U.S. Weather Bureau weather shelter.

Precipitation from events of 2.5 mm or more was used in this study. Events were considered separate when no measurable precipitation fell for 4 hours or more. Precipitation events were separated into three temperature groups: rain, when the mean air temperature during an event was higher than 1.7 °C; mixed, when the temperature was equal to or lower than 1.7 °C but greater than -2.2 °C; and snow, when the temperature was -2.2 °C and colder. These temperature groupings were used in this study so the results could be compared to earlier studies by Hamon (1973) and Sturges (1984).

The chi-squared test described by Freese (1960) and Reynolds (1984) was used to determine if catch was different between gage configurations at the 0.05 probability level.

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## RESULTS AND DISCUSSION

### Effect of Forest Protection on Dual-gage Catch

The results presented in Table 1 show that the protected site caught 2% more rainfall than the unprotected dual-gage site. This small difference was apparently due to catch because the ratios of unshielded to shielded catch were very nearly the same at both sites as seen in Table 2.

For the mixed and snow categories, the computed catch for the protected site was 3% higher than for the unprotected site, which indicates that the dual-gage system exhibits a slight but not a significant catch deficiency at exposed sites. The ratios of unshielded to shielded catch were lower for the exposed site than the protected site which increased the computed catch at the exposed site and therefore the difference in catch between sites was only 3%.

Table 1. Summary of precipitation gage catch at the tree site.

Type of Precipitation*	Number of Events	Dual-Gage Unprotected	Dual-Gage Protected by Trees		Wyoming Shield	
		(mm)	(mm)	Ratio†	(mm)	Ratio‡
Rain	46	496	506	1.02±.26**	502	1.01±.12
Mixed	73	1290	1333	1.03±.16	1305	1.01±.16
Snow	45	534	551	1.03±.24	528	0.99±.15
Total	164	2320	2390	1.03±.28	2335	1.01±.19

\* Rain,  $T > 1.7^{\circ}\text{C}$ ; Mixed,  $1.7^{\circ}\text{C} \geq T > -2.2^{\circ}\text{C}$ ; Snow,  $T \leq -2.2^{\circ}\text{C}$ .

† Ratio of dual-gage catch in trees to unprotected dual-gage catch.

‡ Ratio of Wyoming shielded gage catch to unprotected dual-gage catch.

\*\* Critical range.

Table 2. Precipitation catch for the unprotected and tree-protected dual-gages.

Type of Precipitation	Unprotected Site			Tree-Protected Site		
	Unshielded	Shielded	Ratio of Unshielded to Shielded	Unshielded	Shielded	Ratio of Unshielded to Shielded
	(mm)	(mm)		(mm)	(mm)	
Rain	474	486	.97	485	496	.98
Mixed	1034	1176	.88	1091	1226	.89
Snow	384	465	.83	434	498	.87
Total	1892	2127	.89	2010	2220	.91

Rainfall catch by the unshielded gages at the unprotected and protected sites was 6 and 4% less than the computed amount for the protected site (Table 2). The shielded gage catch was 4 and 2% less, which indicates that for rainfall, shielded gages could be used on the Reynolds Creek Watershed with little error.

The information in Tables 1 and 2 also show that for the mixed precipitation category unshielded gages only caught about 80% of the computed amount. The shielded gages caught about 91% of the computed amount which shows that, if only unshielded or shielded gages were used on the Reynolds Creek Watershed, recorded mixed precipitation amounts would be deficient by 10 to 20% for sites like those used in this study that were not in very windy areas (Hanson, 1988).

Snowfall catch by the unshielded gages was 30% less at the unprotected site than the computed catch for the protected site, and the shielded gage catch was 16% less which indicates that individual gages had a greater undercatch of precipitation in the snow category than in the mixed category. The undercatch of snow by the individual protected

gages was not as great as the unprotected gages, but was still in the 10 to 20% category and was also a greater undercatch than for the mixed category.

With all precipitation categories combined, the undercatch by the individual gages at the unprotected site was 10 to 20% relative to that computed for the protected site. The individual gages in the protected site had an undercatch of 16% for the unshielded gage and 7% for the shielded gage.

#### Wyoming Shielded Gage Catch at Tree Site

The Wyoming shielded gage catch for rainfall events was 1% less than that computed for the protected dual-gage site and 1% more than that computed for the unprotected dual-gage site (Table 1). For the mixed precipitation category, the Wyoming shielded gage measured 2% less than that computed for the protected site and 1% more than that computed for the unprotected site which was about the same results obtained for rainfall. The Wyoming shielded gage did not catch as much snow as was calculated for either of the other two sites. However, the undercatch was only 1% less than the unprotected site, but was 4% less than that computed for the protected site. None of the catch differences between gages was significant. The Wyoming shielded gage undercatch was not as much as reported previously by Sturges (1986) and Goodison and Metcalfe (1980, 1982) but it does indicate that under windy conditions, Wyoming shielded gages will not record as much snowfall as computed by the dual-gage system.

When all events were grouped, the Wyoming shielded gage catch was 1% more than that computed for the dual-gage unprotected site and only 2% less than that computed for the protected dual-gage site. These data indicate that Wyoming shields would be best used in areas where most of the precipitation was in either the rain or mixed precipitation categories, such as at mid to low elevations on the Reynolds Creek Watershed.

#### Dual-Gage and Wyoming Shielded Gage Catch from Other Reynolds Creek Watershed Sites

The dual-gage system and Wyoming shielded gage catch information given in Table 3 is a summary of a study reported by Hanson (1988). The Wyoming shielded gages caught 2% more rain than that computed from the dual-gage systems for all site data combined. The Wyoming shielded gages caught 1 to 5% more rainfall at 4 of the 5 sites. At the site with the highest average wind speed per rainfall event, the catch computed from the dual-gage system was 4% greater, but, as shown in Table 3, none of the differences was significant.

For the mixed precipitation category, the total catch from the dual-gage and Wyoming shielded gages at the 5 sites was the same. The Wyoming shielded gages caught from 1 to 3% more at 4 of the sites and 13% less at the site with the most wind during precipitation events.

Computed snow catch was from 2 to 29% greater than that recorded by the Wyoming shielded gages. The undercatch by the Wyoming shielded gages was 10% or less for 4 of the sites with the 29% deficit again being recorded at the site with the greatest average per storm wind speed.

When all precipitation categories were combined, the dual-gage systems caught 1% more precipitation than the Wyoming shielded gages. Overall, the Wyoming shielded gages caught 2% more rainfall, the same amount of mixed precipitation, and 10% less snow than computed from the dual-gages; however, none of the differences was significant.

Table 3. Summary of precipitation gage catch from 5 sites on Reynolds Creek Watershed, ID.

Type of Precipitation	Number of Events	Dual-Gage (mm)	Wyoming Shield (mm)	Wyoming Shield/ Dual-Gage	Average Wind Speed Per Event (m/sec)
Rain	406	3194	3263	1.02+.19	3.59
Mixed	258	2878	2879	1.00+.24	3.55
Snow	156	1910	1728	.90+.23	2.96
Total	820	7982	7870	.99+.23	3.46

## SUMMARY

The following summarizes results obtained from a study to determine how forest protection affected dual-gage system precipitation catch, and the relationship between precipitation catch by the dual-gage system and Wyoming shielded gages:

### A. Forest Protected Site;

1. For precipitation that fell at temperatures greater than  $-2.2^{\circ}\text{C}$ , the computed catch by the protected and unprotected dual-gage systems, and the Wyoming shielded gage catch were within 3%; none of the differences was significant.

2. For snowfall ( $T \leq -2.2^{\circ}\text{C}$ ), the Wyoming shielded gage catch was 1% less than the computed catch from the unprotected dual-gage system and 4% less than the protected dual-gage system; none of the differences was significant.

3. For all precipitation combined, the least precipitation was that computed from the unprotected dual-gage system which was 3% less than the protected dual-gage system's computed catch.

### B. Dual-Gage and Wyoming Shielded Sites;

1. When the data from the 5 sites on the Reynolds Creek Watershed were combined, the Wyoming shielded gages caught 2% more rainfall, the same amount of mixed precipitation, and 10% less snowfall than the companion dual-gage system's computed catch. None of the catch differences was significant.

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