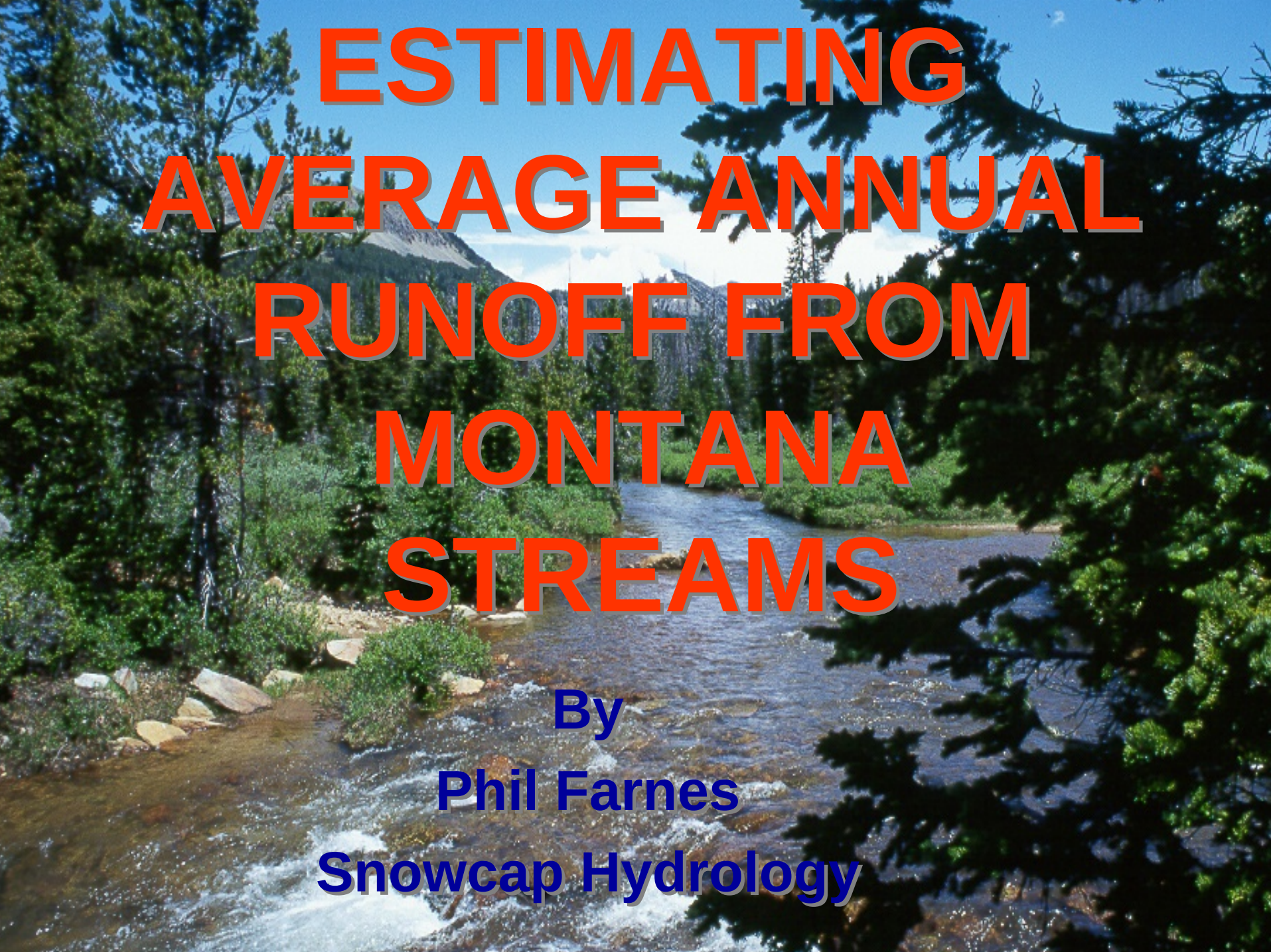


ESTIMATING AVERAGE ANNUAL RUNOFF FROM MONTANA STREAMS

By

Phil Farnes

Snowcap Hydrology

HISTORY

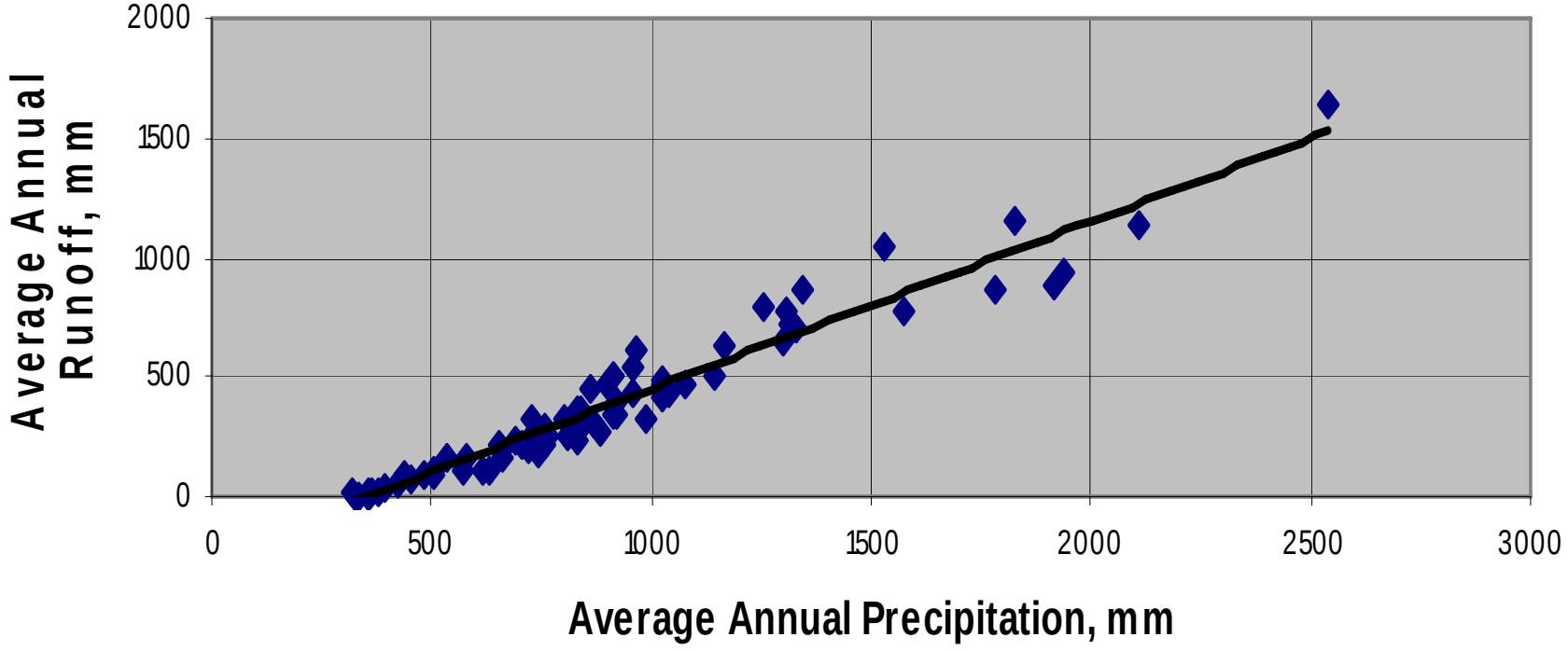
- Average Annual Precipitation Map
  - April 1 SWE More than Annual
  - Good Correlation April 1 SWE vs. Annual
  - Mountain Precipitation Map for Montana
  - Precipitation Map for Montana

CHECK PRECIPITATION MAP

- **Average Precipitation by Drainages**
  - **Planimeter by Drainages**
  - **Plot Average Annual Precipitation vs. Average Annual Runoff on Graph**

RUNOFF CURVE

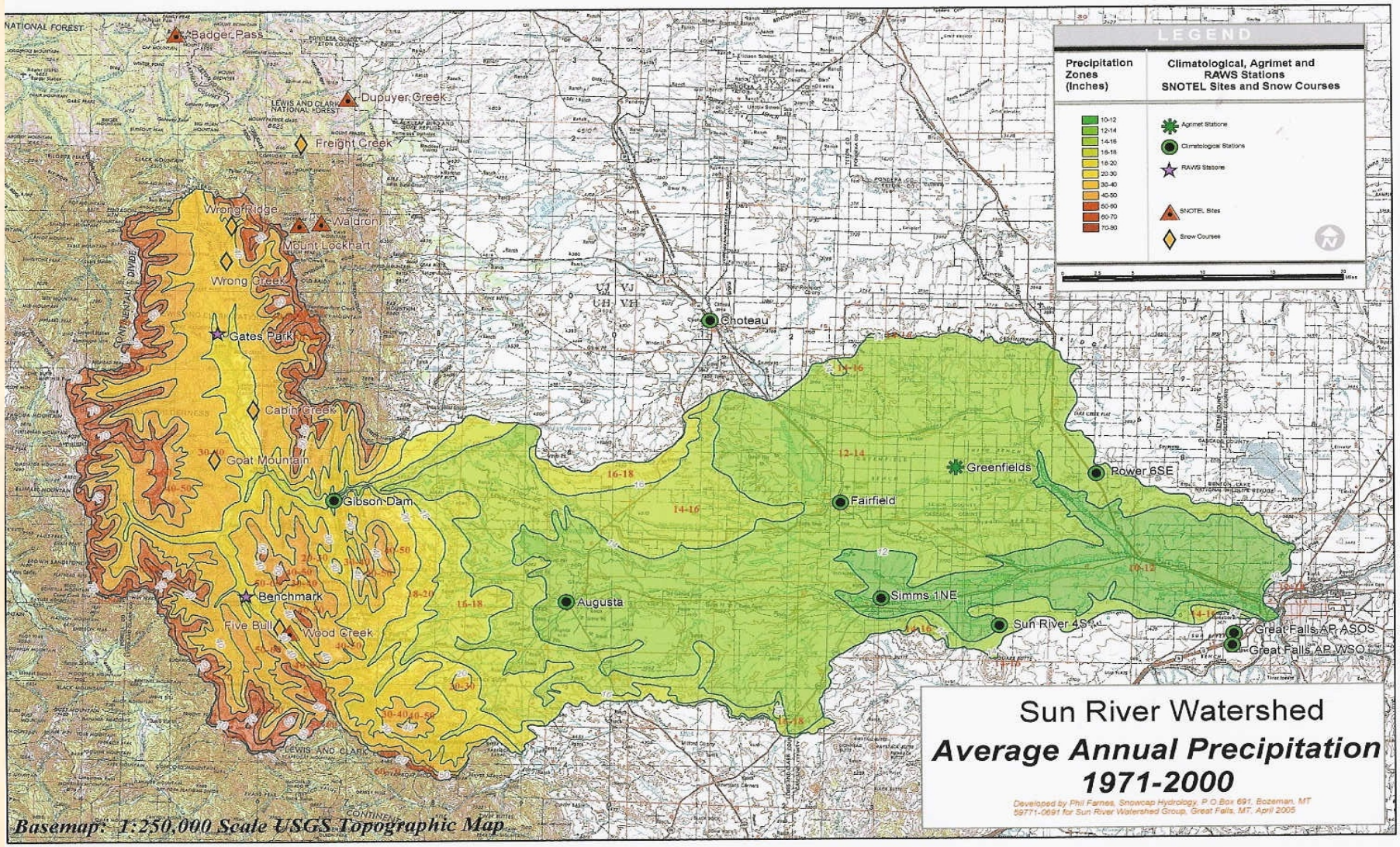
ORIGINAL MONTANA AVERAGE ANNUAL RUNOFF VS. AVERAGE ANNUAL PRECIPITATION 1953-1977



REQUIREMENTS

- Accurate Average Annual Precipitation Map
- Current Base Period
- April 1 SWE vs. Annual Precipitation
- April-July vs. Annual Precipitation
- Cover Type Map
- Interception by Forest Cover Types
- State or Regional Runoff Curve Adjusted for Forest Cover
- Fire History Maps
- GIS

AVERAGE ANNUAL PRECIPITATION MAP



COVER TYPE MAP

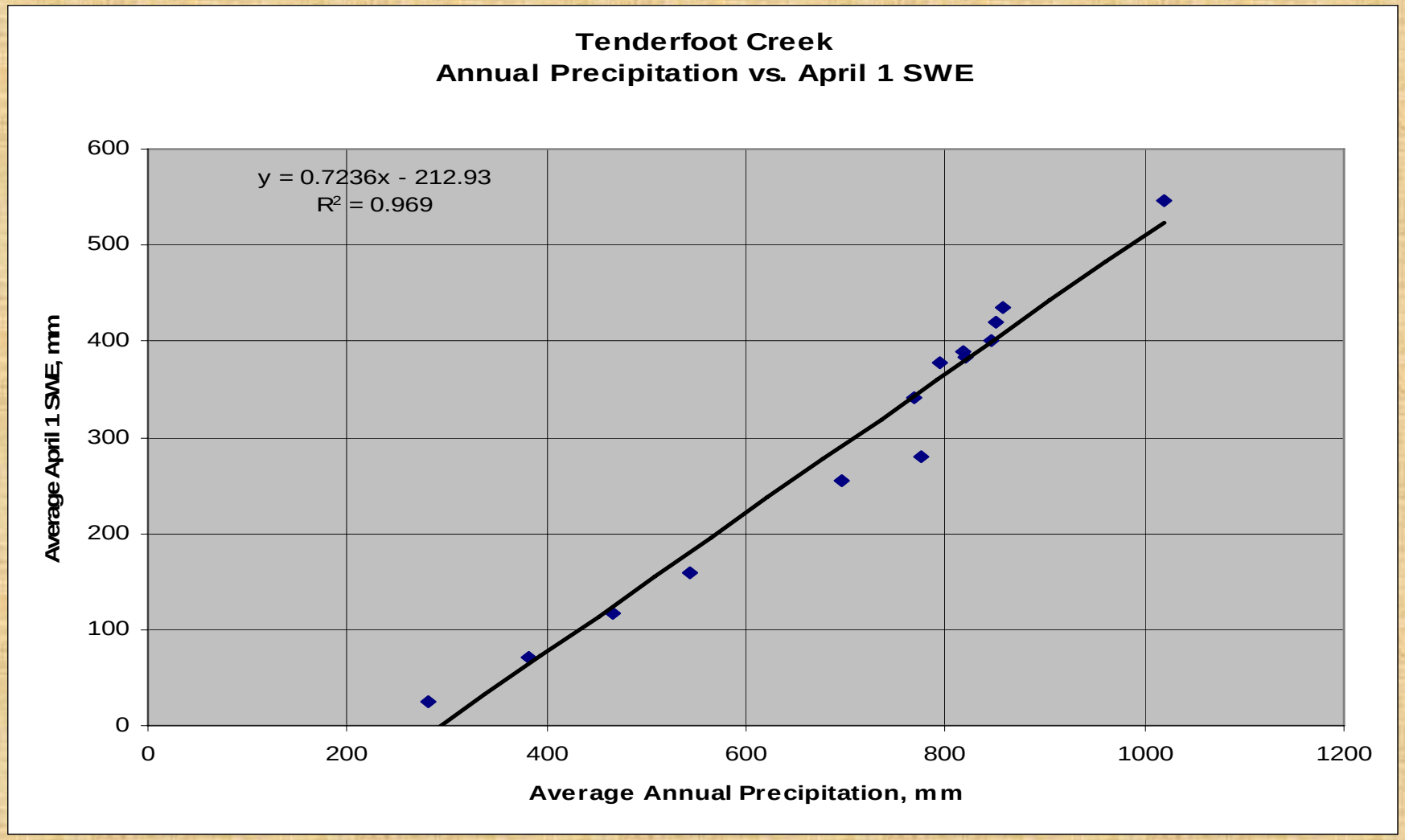
- Montana SILC3-SILC2 Land Cover Classification Database
  - ArcInfo 30 Meter Raster File
  - 36 Classifications (some may be combined for hydrologic analysis)
  - 5 Tree Size Classes (may be related to age)
  - 5 Conifer Percent Canopy Cover

GIS OVERLAY

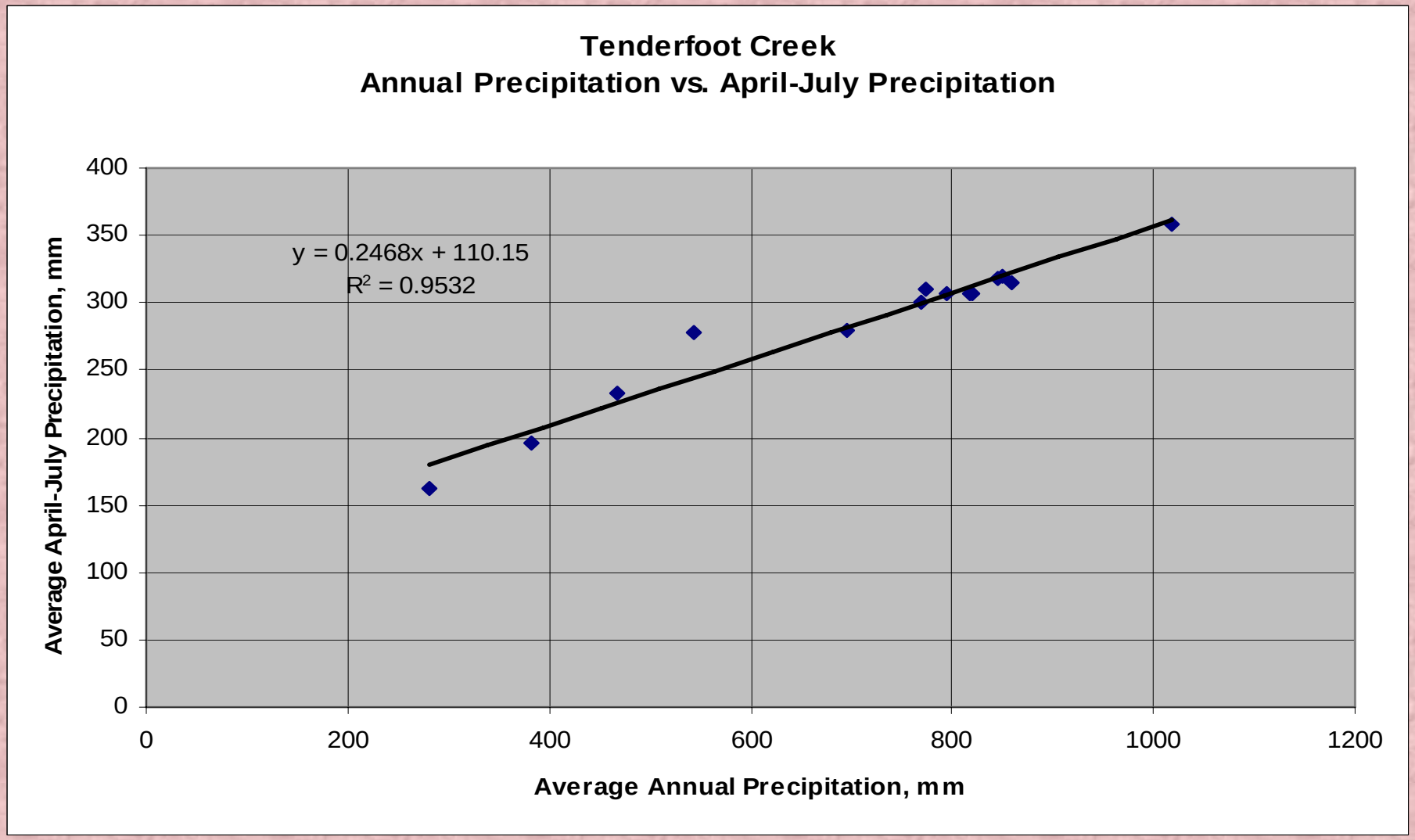
HUC 101 **Area in hectares** **Average Annual Precipitation = 1156 mm**

Precipitation Zone, mm	750-1000	1000-1250	1250-1500	1500-1750	
Cover Type					*Total, ha*
Broadleaf	15	15	15	3	48
Burns	1673	931	349	240	3193
Grass/Shrubs	188	188	177	182	735
Lodgepole	1113	386	117	117	1733
Rock/Snow	2	214	477	872	1565
Spruce/Fir	2478	2184	675	213	5550
Water	0	0	0	7	7
Whitebark	349	872	629	444	2294
Total, ha	5818	4790	2439	2078	15125
Open	190	402	654	1061	2307

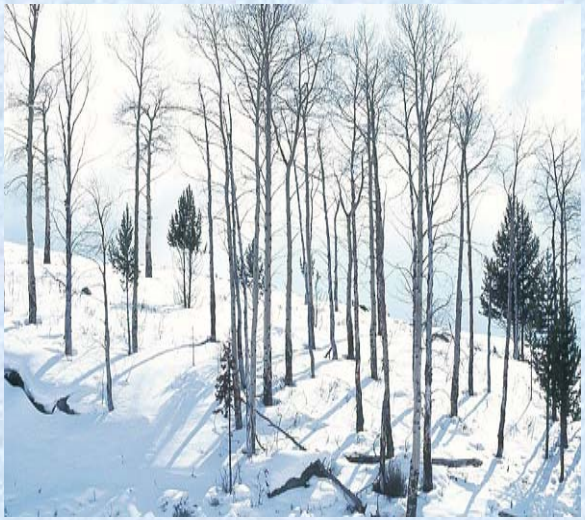
APRIL 1 SWE vs. ANNUAL PRECIPITATION



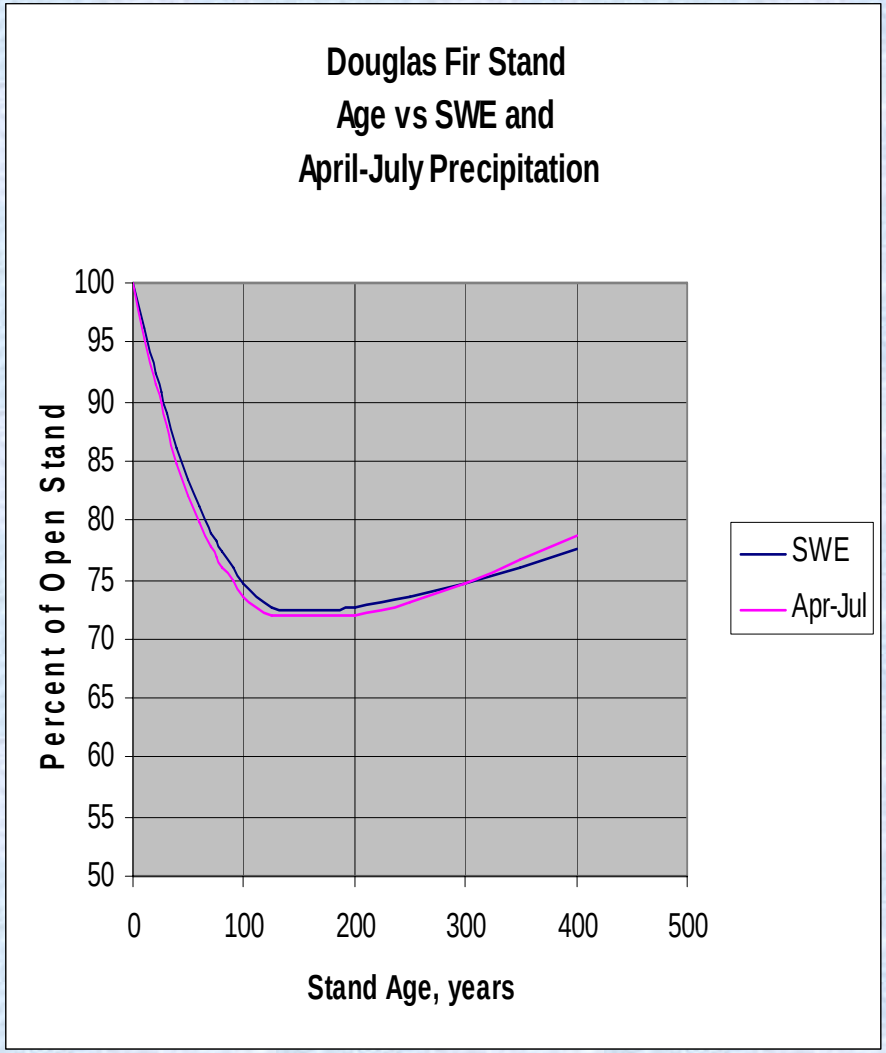
APRIL-JULY vs. ANNUAL PRECIPITATION

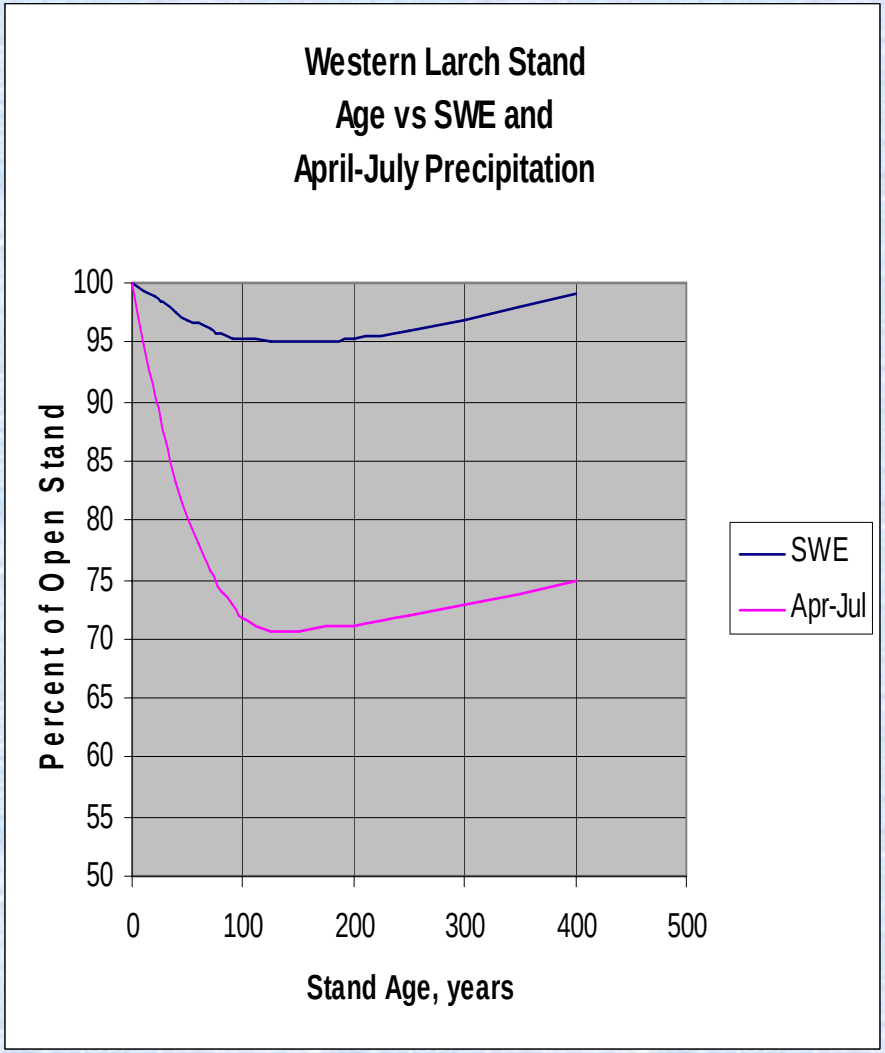


INTERCEPTION

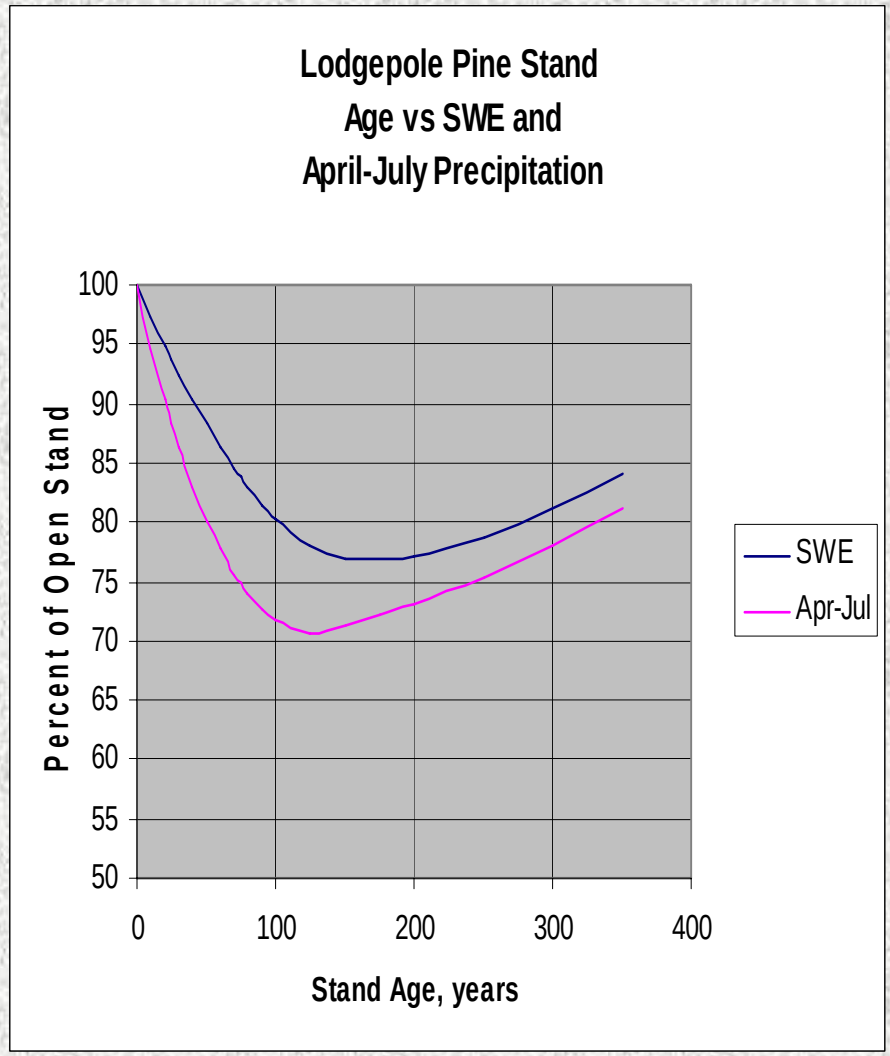


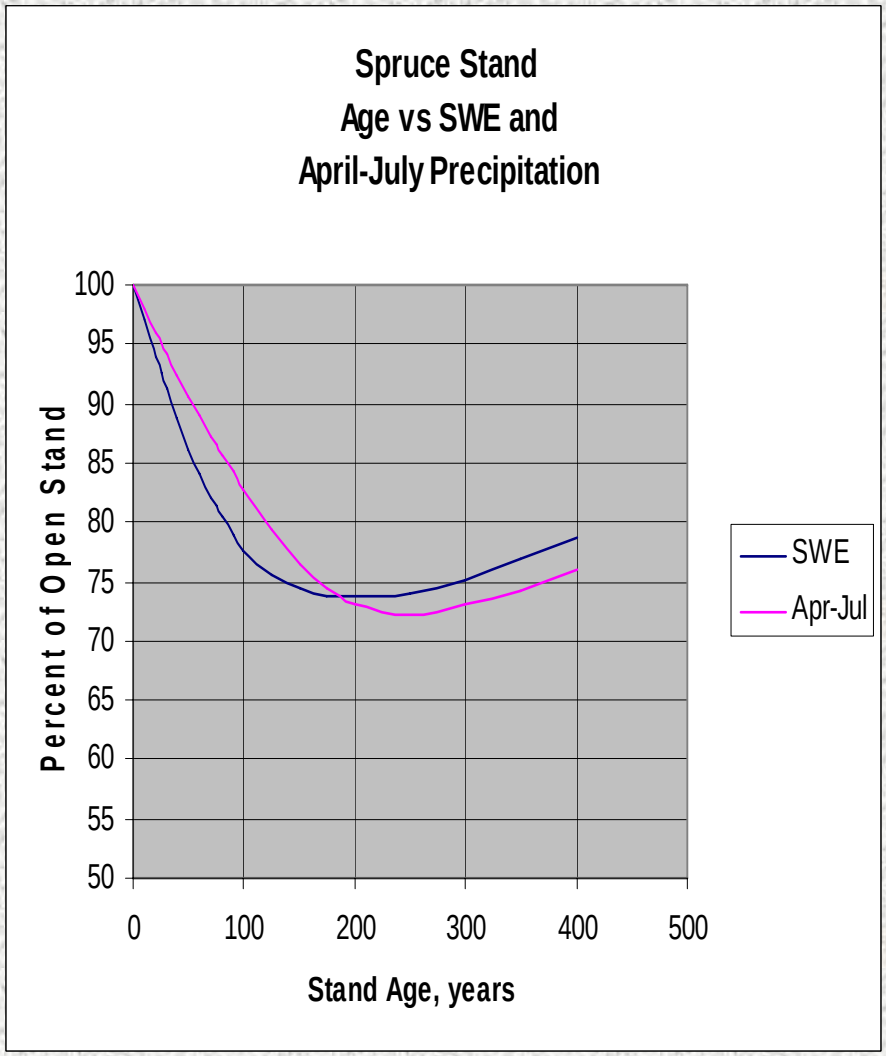
INTERCEPTION GRAPHS FOR FOREST COVER TYPES



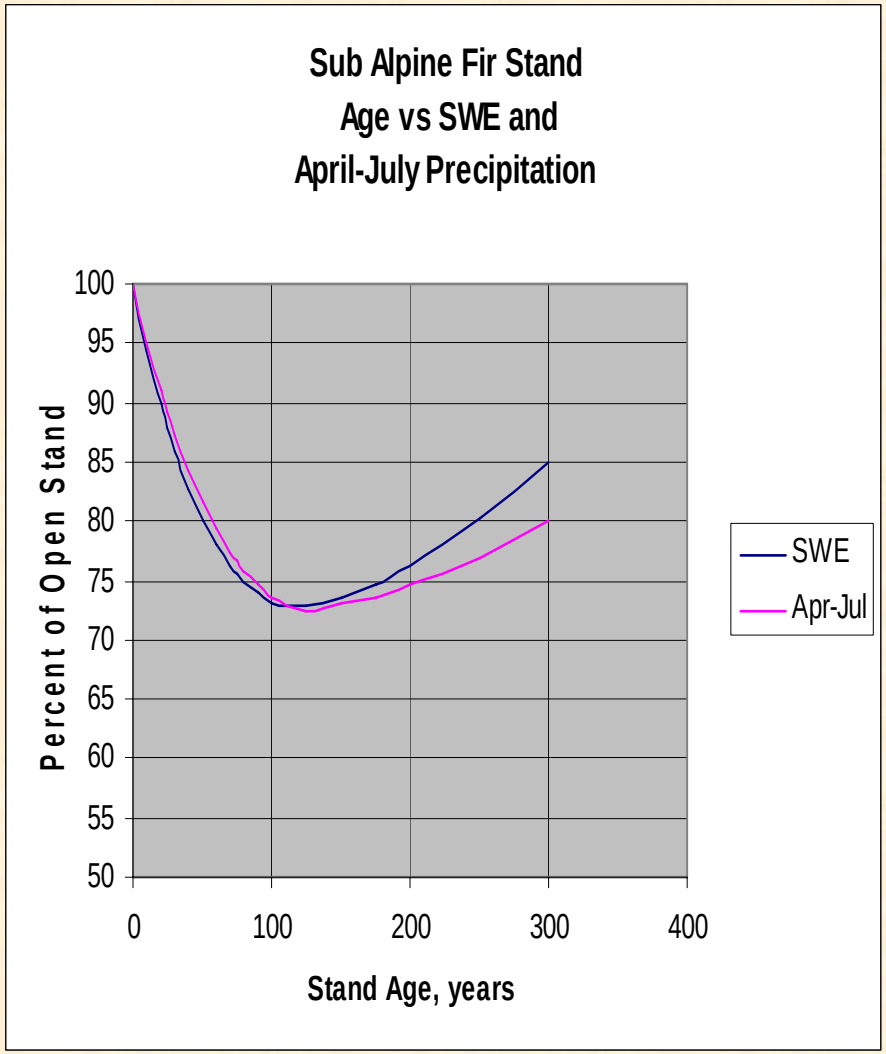


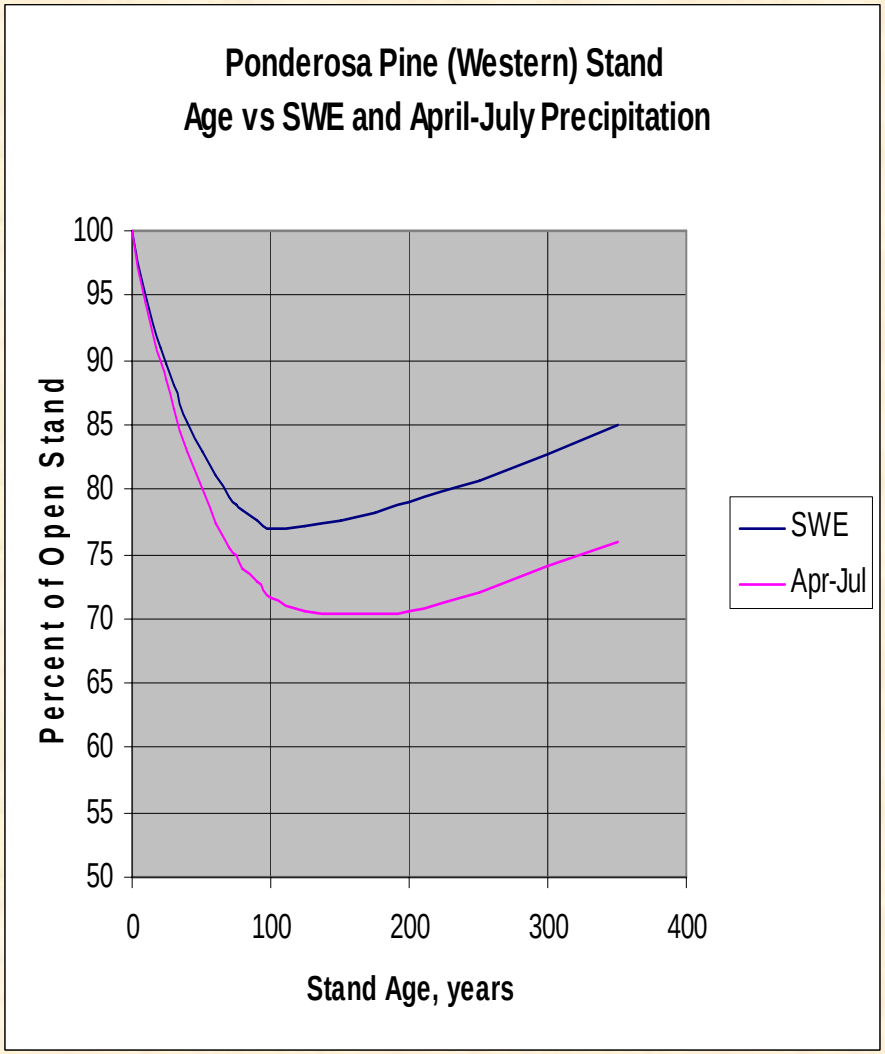
MORE COVER TYPES



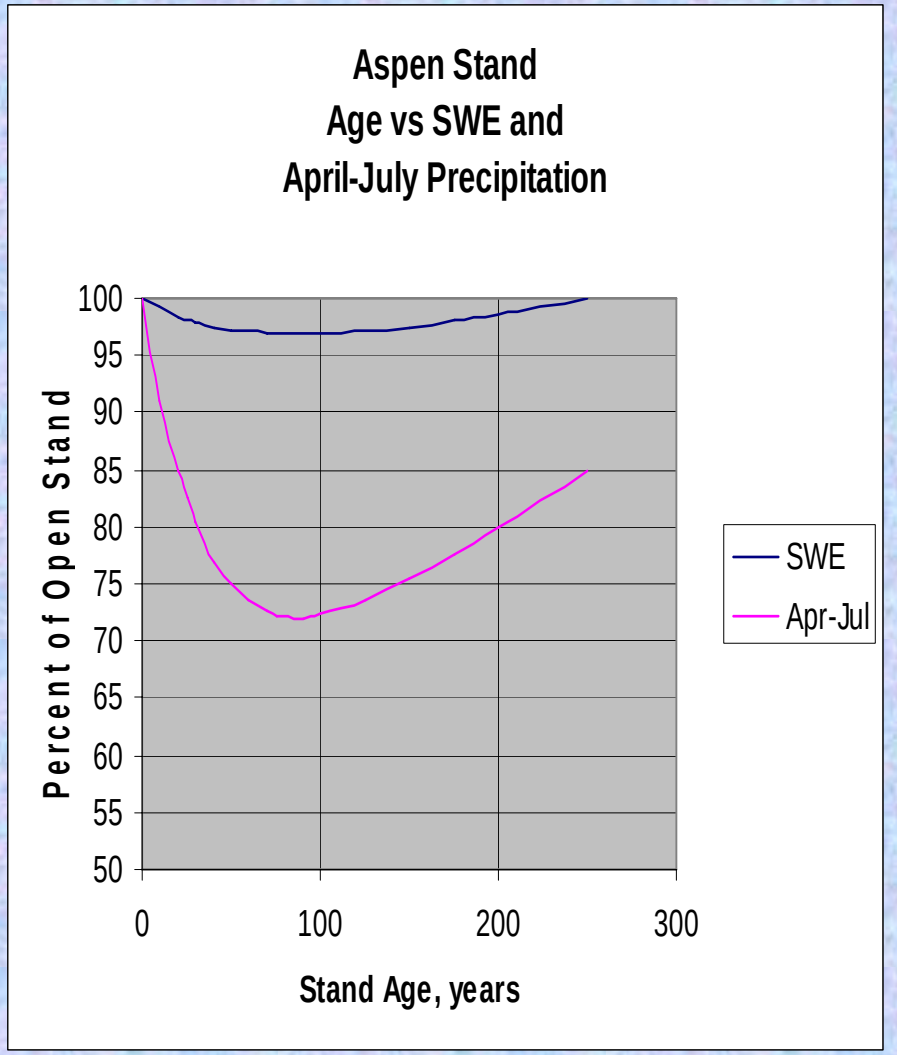


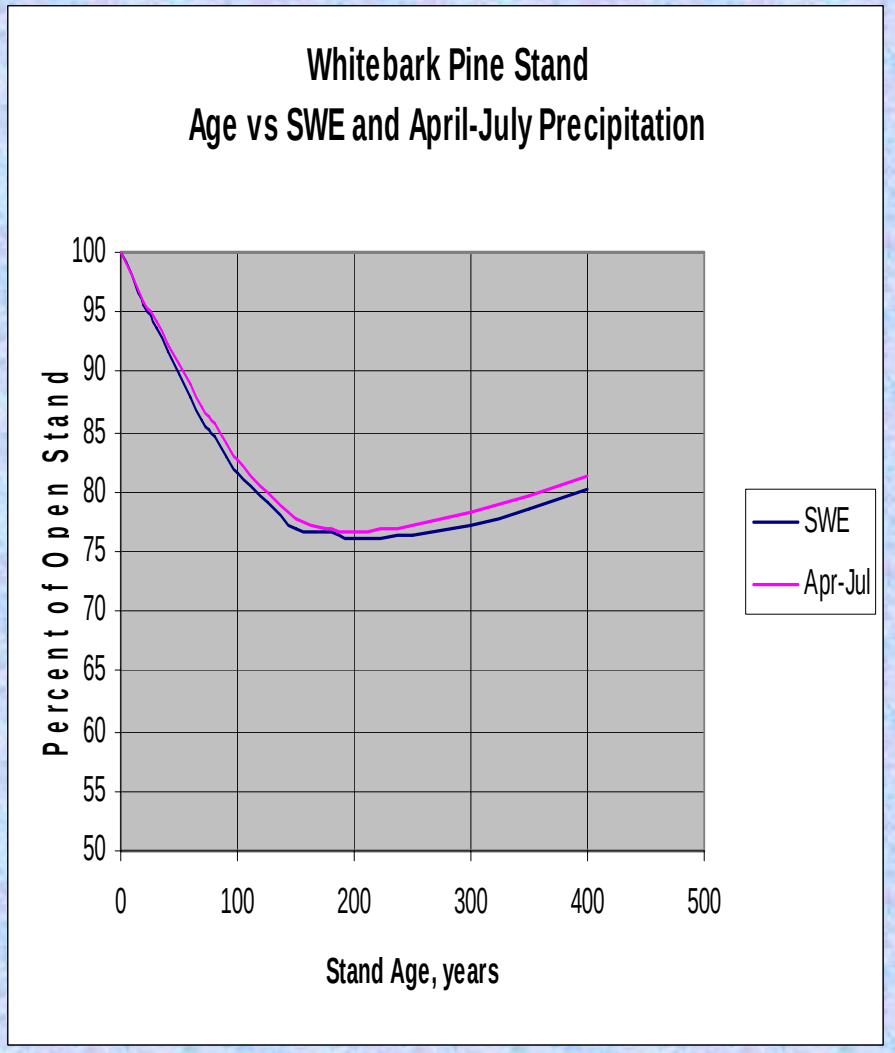
MORE COVER TYPES



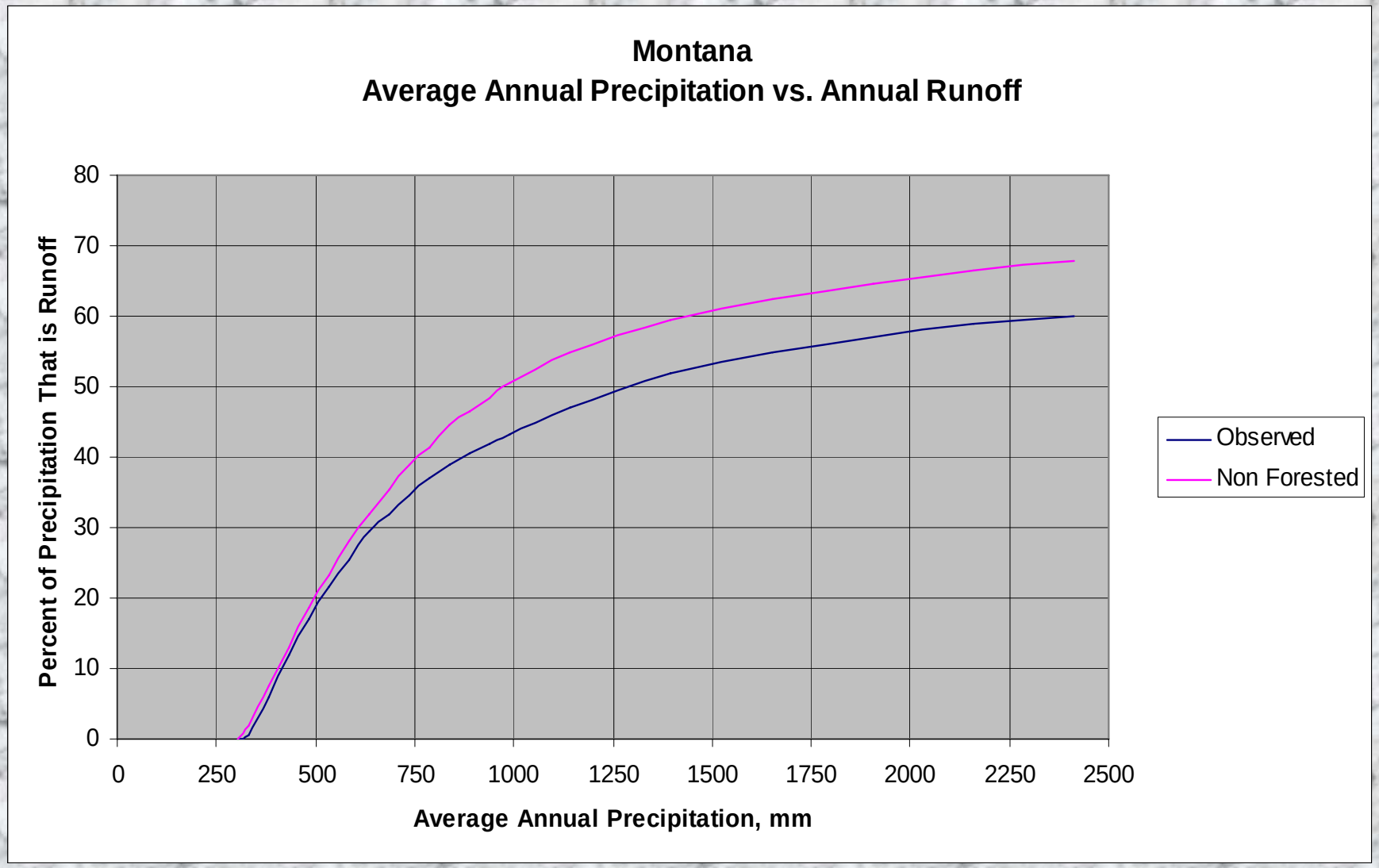


MORE COVER TYPES





MONTANA RUNOFF CURVE



RUNOFF COMPUTATION
Non Forested

Precipitation Zone Mid-Point mm	April 1 SWE mm	Apr-July Precipitation mm	Runoff Non Forest %	Runoff Non Forest mm	Effective Precipitation mm	Effective Runoff %
275	0	173	0	0	173	0
325	0	183	2	7	183	4
375	0	193	8	28	193	14
425	0	203	13	56	203	28
475	0	213	19	89	213	42
625	91	244	32	205	335	61
875	340	295	46	413	635	65
1125	589	343	55	627	932	67
1375	841	394	60	834	1235	67
1625	1090	445	63	1031	1535	67
1875	1339	495	65	1229	1834	67

RUNOFF 20 YEAR LPP

Precipitation Zone Mid-Point mm	April 1 SWE Open mm	April 1 SWE 20 year mm	SWE Loss mm	Apr-Jul Precipitation Open mm	Apr-Jul Precipitation 20 year mm	Apr-Jul Precipitation Loss mm	Loss SWE and Apr-Jul Precipitation mm	Effective Precipitation mm	Runoff mm
275	0	0	0	173	157	16	15	158	0
325	0	0	0	183	165	18	18	165	7
375	0	0	0	193	175	18	18	175	24
425	0	0	0	203	185	18	18	185	52
475	0	0	0	213	193	20	20	193	81
625	91	86	5	244	221	23	28	307	187
875	340	325	15	295	267	28	43	592	385
1125	589	561	28	343	310	33	61	871	584
1375	841	798	43	394	356	38	81	1154	773
1625	1090	1034	56	445	401	44	100	1435	961
1875	1339	1270	69	495	447	48	117	1717	1150

RUNOFF LPP

Precipitation Zone Mid-Point mm	Open	Tree Age 20 Years	60 Years	100 Years	150 Years	200 Years
			Runoff, mm			
275	0	0	0	0	0	0
325	7	7	6	5	5	5
375	28	24	21	19	19	20
425	56	52	44	41	41	41
475	89	25	69	64	64	65
625	205	187	164	152	149	152
875	413	385	340	315	307	311
1125	627	584	519	482	468	471
1375	834	773	691	642	622	628
1625	1031	961	862	801	775	782
1875	1229	1150	1033	958	927	935

RUNOFF

SUN RIVER WATERSHED MONTANA
HUC101 AVERAGE ANNUAL PRECIPITATION = 1156 mm

Precipitation Zone, mm	Cover Type	Area, ha	Yield Unit, mm	Yield $m^3 \times 10^3$
750-1000	BL	15	371	56
	Burn	1673	384	6424
	LLP	1113	311	3461
	SF	2478	302	7484
	WB	349	333	1162
	Open	190	411	781
1000-1250	BL	15	572	86
	Burn	931	582	5418
	LLP	386	471	1818
	SF	2184	457	9981
	WB	872	503	4386
	Open	402	630	2533

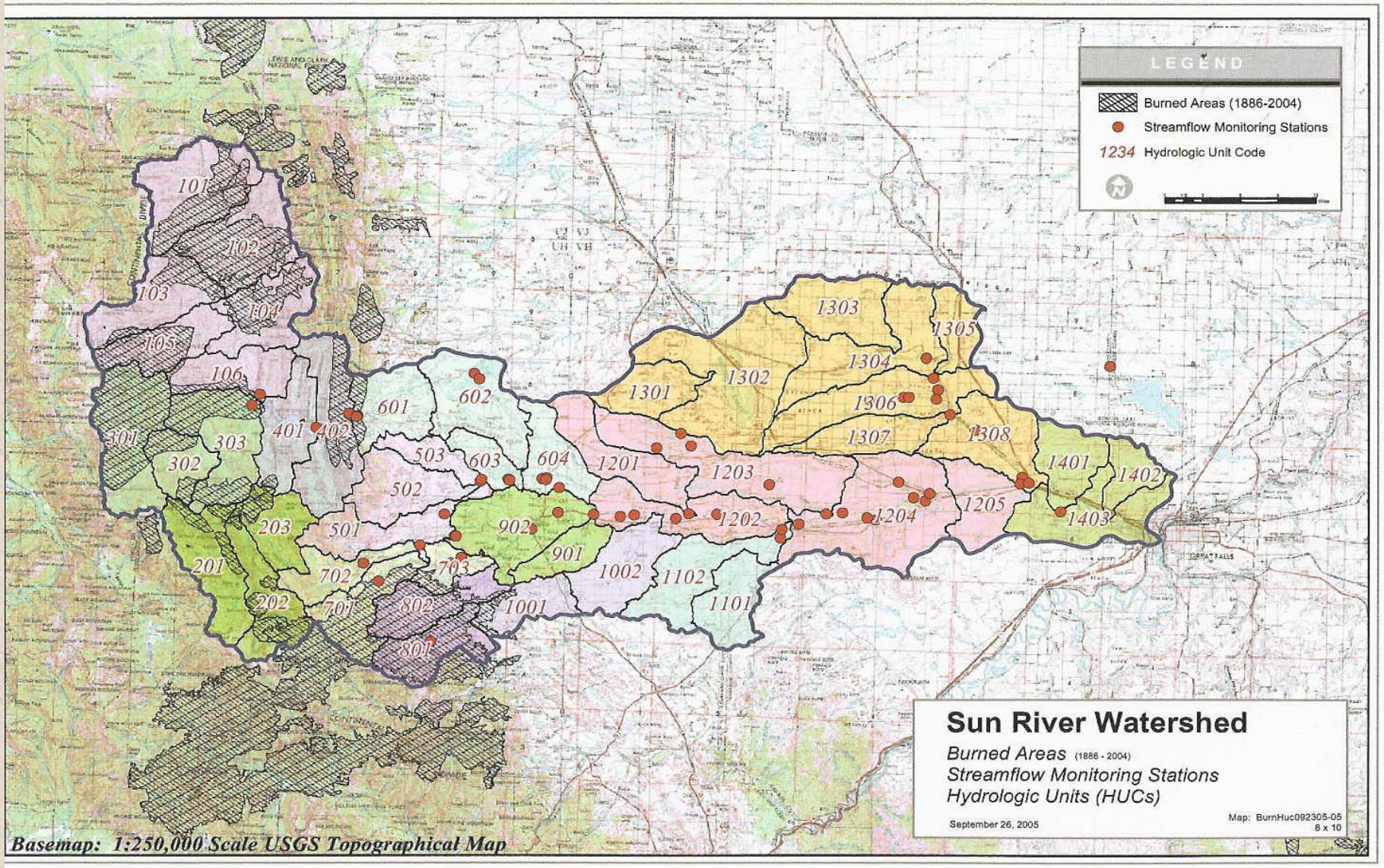
RUNOFF, cont.

Precipitation Zone, mm	Cover Type	Area, ha	Yield Unit, mm	Yield $m^3 \times 10^3$
1250-1500	BL	15	770	116
	Burn	349	777	2712
	LLP	117	628	732
	SF	675	612	4131
	WB	629	658	4139
	Open	654	833	5448
1500-1750	BL	3	960	29
	Burn	240	965	2316
	LLP	117	782	915
	SF	213	759	1617
	WB	444	833	3699
	Open	1061	1031	10939
	Total			80386

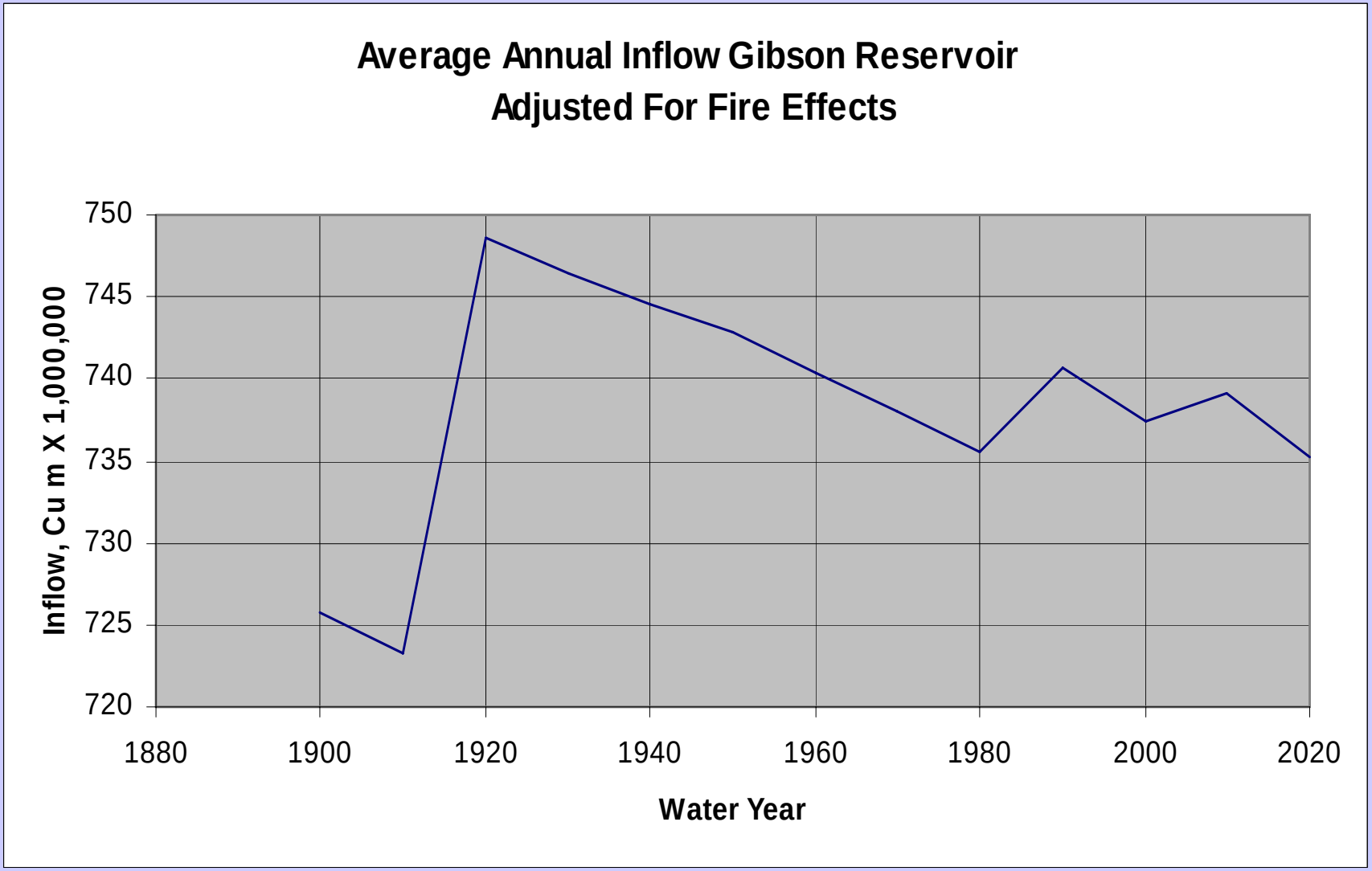
INFLOW GIBSON RESERVOIR

HUC	AREA	PRECIPITATION	YIELD	YIELD
	ha	mm	$m^3 \times 10^6$	mm
101-106 (6)	68746	1072	337	483
201-203 (3)	29945	1107	155	505
301-303 (3)	35103	1049	166	455
401-402 (2)	23742	851	79	330
TOTAL	157536	1054	737	467
ACTUAL	157472		738	

FIRE HISTORY MAPS



RUNOFF TRENDS



CONCLUSIONS

- **Accurate Estimates of Annual Runoff Are Possible If You Have an Accurate Precipitation Map**
- **Seasonal Runoff Can Be Estimated From Gaged Streams**
- **Hydrographs Can Also Be Estimated**
- **Effects of Fire, Insects, Logging, or Planned Management Activity Can be Evaluated**

CONCLUSIONS

- HYDROLOGIC MODELS SHOULD BE BASED ON EXISTING VEGETATION PATTERNS IN VARIOUS PRECIPITATION ZONES AND SHOULD BE ABLE TO ACCOUNT FOR VEGETATIVE CHANGES THROUGH TIME

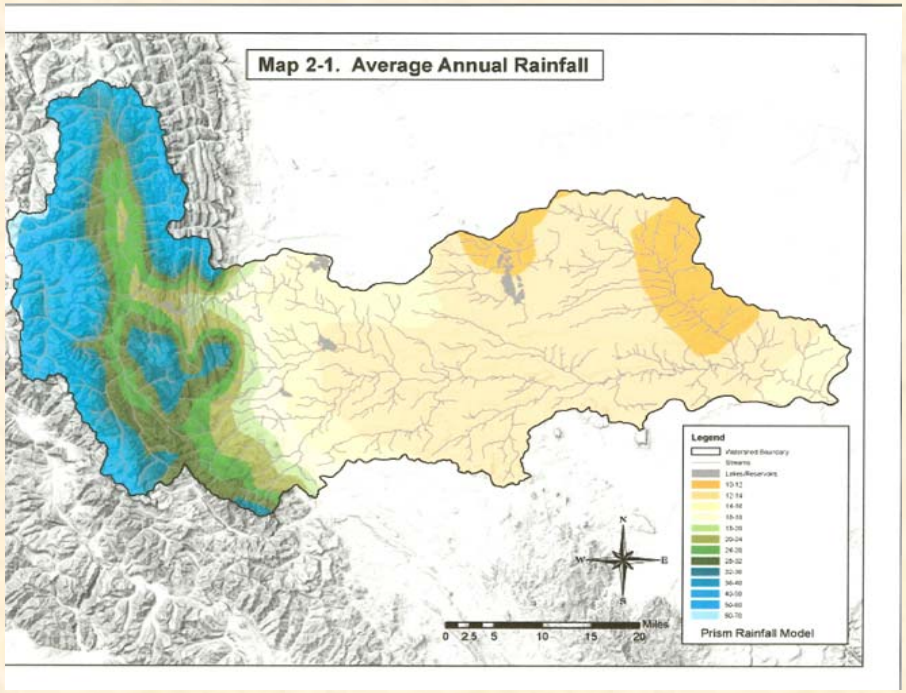
FOREST CANOPY COVER CURVES

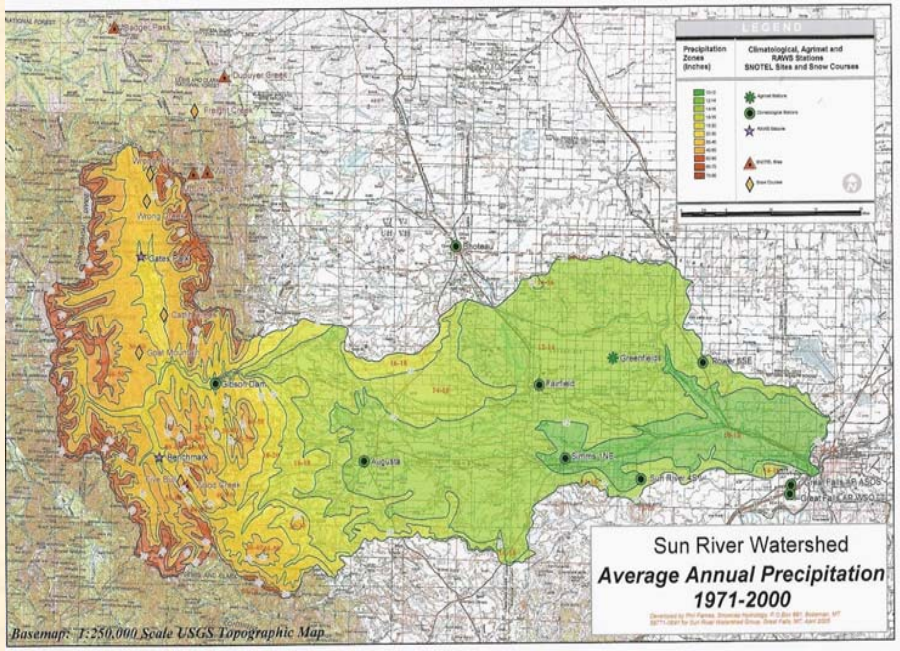
- COPIES OF PAPER WITH CURVES FOR DIFFERENT FOREST SPECIES CAN BE OBTAINED FROM THE PROCEEDINGS OF THE 2007 WESTERN SNOW CONFERENCE (WESTERNSNOWCONFERENCE.ORG -$35)
- OR BY CONTACTING ME

THE
END

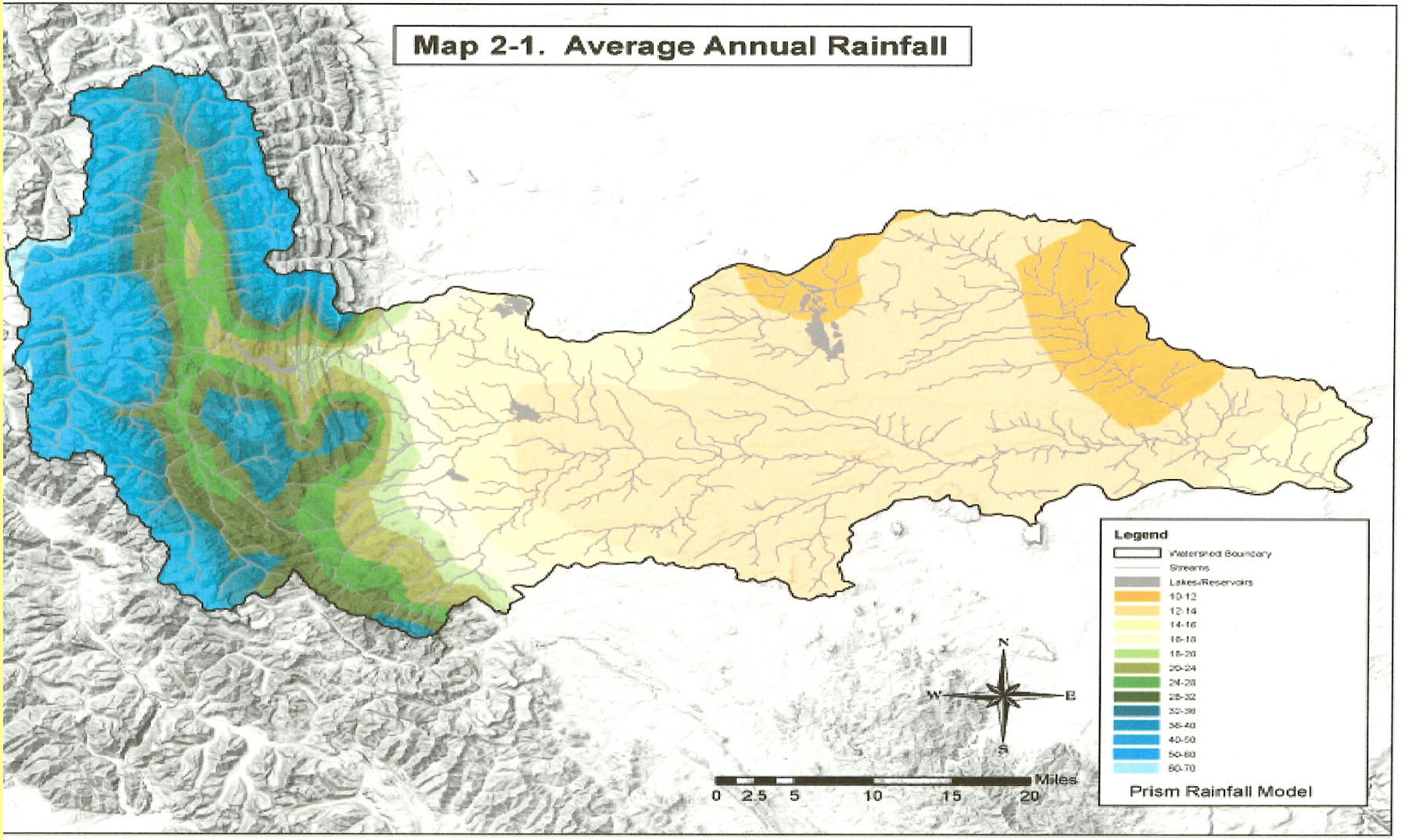
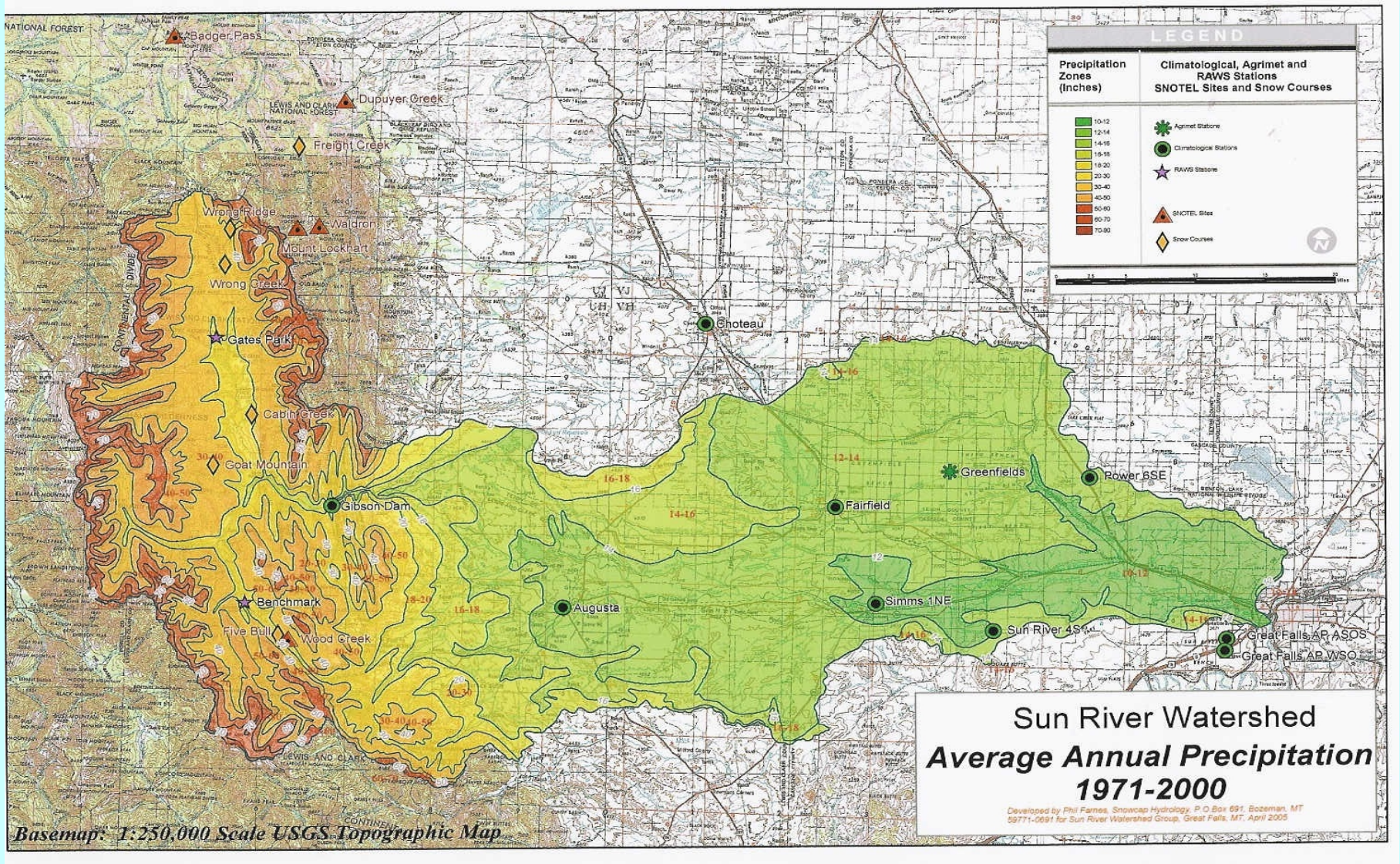
QUESTIONS?

COMPARISON BETWEEN
Prism and Farnes





1961-1990 Average Annual Precipitation-Prism



1971-2000 Average Annual Precipitation-Farnes