The Surface Water Supply Index: History and Issues

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Overview

- Purpose and history of SWSI
- Formulation – original and revised
- Nuances of numerical behavior and meaning
- General index issues

Purpose of SWSI

- Original purpose: "... be an indicator of basinwide water availability..., be predictive, and permit comparison of water supply conditions between basins..." (Shafer and Dezman, 1982)
- Used where Palmer Drought Index does not adequately reflect conditions in snow-dominated regions
- Used where primary source of agricultural water supply for irrigation is surface water
- Used as monitoring and triggering index for state drought plans

History of SWSI

- Originally developed in early 1980s in Colorado (Shafer and Dezman, 1982)
- Original formulation, with variations, also adopted in Montana and Oregon
- Procedure reviewed by NRCS in cooperation with Colorado Climate Center in early 1990s
- Revised formulation based on streamflow volume forecasts published by Garen (1993)
- New formulation, with variations, adopted in Idaho, New Mexico, Utah, Wyoming and later in Montana and Colorado

Original Formulation

$$SWSI = \frac{aP_{snow} + bP_{prec} + cP_{strm} + dP_{resv} - 50}{12}$$

- Based on probability distributions of monthly time series of individual component indices
- Rescaled weighted sum of non-exceedance probabilities (in percent) from individual components
- Ranges from -4.2 to +4.2 (to have similar values as the Palmer index)
- Weights determined subjectively or from normalizing procedure but not optimized to predict a certain variable

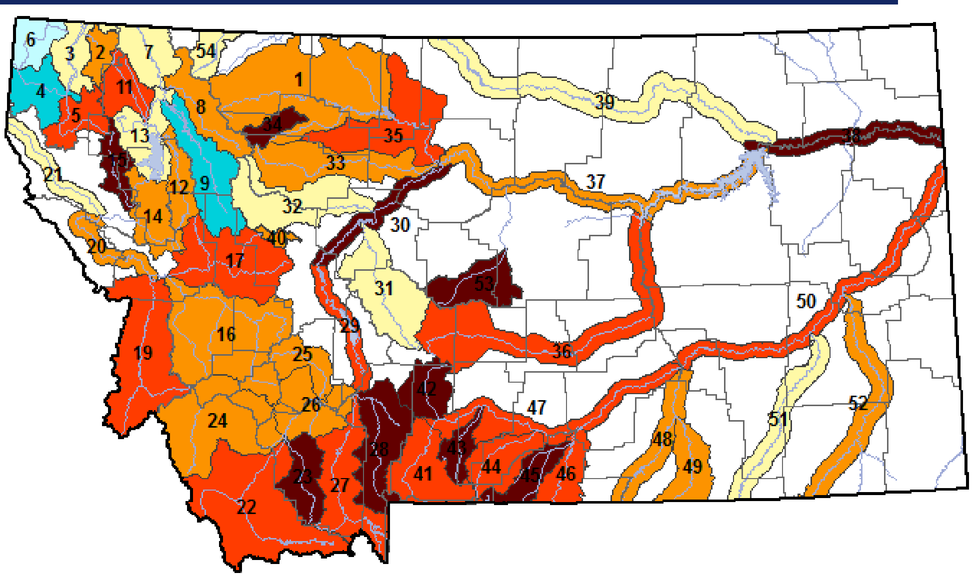
Revised Formulation

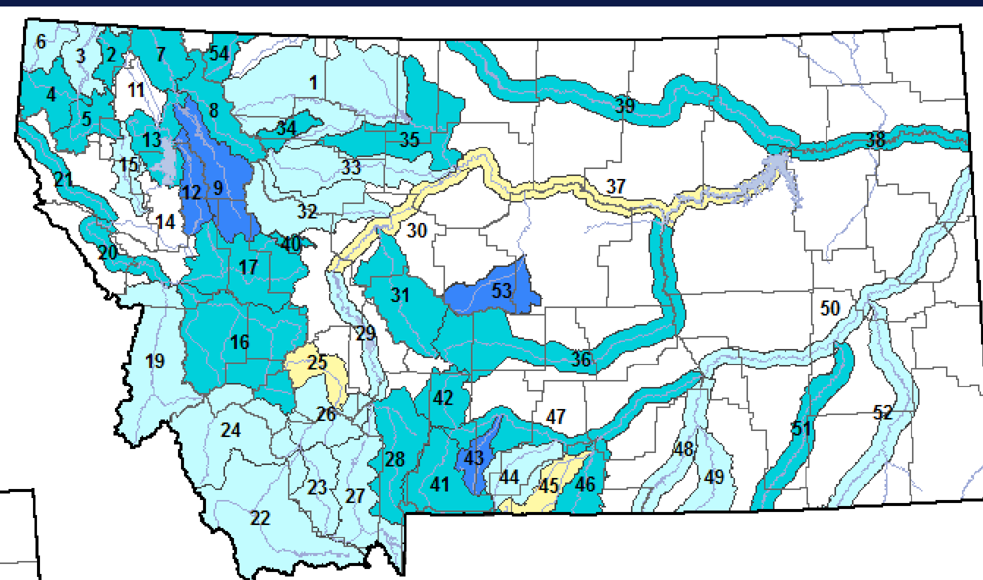
$$SWSI = \frac{P_{fcst+resv} - 50}{12}$$

- Single probability of summed expected streamflow (over an appropriate time horizon) and current reservoir storage
- Component weightings are done implicitly within the streamflow forecast
- Streamflow forecast component varies throughout the year and switches to upcoming year at beginning of water year

Map Display of SWSI -- Montana

April 2007





April 2011

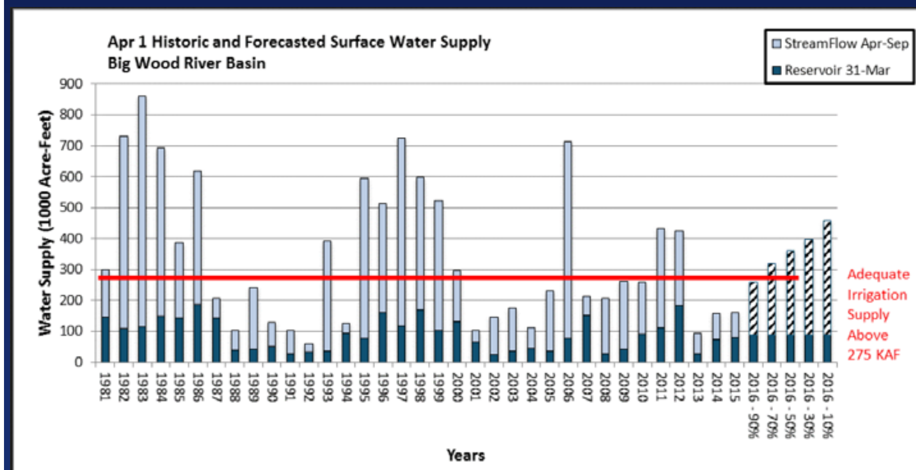
Tabular and Graphical Display of SWSI -- Idaho

Big Wood River Basin SWSI — Adequate Water Supply Greater than 0.2 SWSI or 275 KAF

Station ID	Station Name	Period	Data Type	Years	# of Years	
13142500	Big Wood R blw Magic Reservoir	Apr-Sep	strm	1981-2015	35	Units KAF
13142000	Magic Reservoir	31-Mar	resv	1981-2015	35	Units KAF

ENSO Classification
SE Strong El Nino - EN Mild El Nino - N Neutral - LN Mild La Nina - SL Strong La Nina

Rank	Year	Enso	Stream Flow Apr-Sep	Reservoir 31-Mar	Streamflow + Reservoir Sum	Non-Exceedance Probability	SWSI
1	1983	SE	747	114	861	97%	3.9
2	1982	N	622	108	729	94%	3.7
3	1997	N	605	118	724	92%	3.5
4	2006	N	636	78	714	89%	3.2
5	1984	N	545	149	694	86%	3.0
6	1986	N	432	186	618	83%	2.8
7	1998	SE	427	170	597	81%	2.5
8	1995	SE	518	77	595	78%	2.3
9	1999	SL	420	102	522	75%	2.1
10	1996	N	351	161	512	72%	1.9
2016 10% Chance Exceedance Forcast		SE	370	89	459	71%	1.7
11	2011	SL	322	111	433	69%	1.6
12	2012	LN	238	185	423	67%	1.4
2016 30% Chance Exceedance Forcast		SE	310	89	399	65%	1.3
13	1993	EN	355	38	393	64%	1.2
14	1985	N	242	144	386	61%	0.9
2016 50% Chance Exceedance Forcast		SE	270	89	359	60%	0.8
2016 70% Chance Exceedance Forcast		SE	230	89	319	59%	0.8
15	1981	N	153	146	299	58%	0.7
16	2000	N	165	132	298	56%	0.5
17	2009	N	219	42	261	53%	0.2
18	2010	EN	167	92	259	50%	0.0
2016 90% Chance Exceedance Forcast		SE	170	89	259	49%	-0.1
19	1989	SL	200	42	242	47%	-0.2
20	2005	EN	194	36	230	44%	-0.5
21	2007	EN	60	153	213	42%	-0.7



SWSI Issues

- Criterion variable
- Statistical formulation
- "Forecast" vs. "current conditions"
- Seasonal or year-around
- Numerical behavior
- Reservoir storage
- Individual components vs. combined variable

Criterion Variable Issues

- Do we need an explicit definition of "surface water supply"? That is, do we know what we mean by this term?
- Do the changes in the criterion variable as the year progresses make sense?
- Is it necessary that the same criterion variable be used throughout the region or country?

Original Formulation Issues

$$SWSI = \frac{aP_{snow} + bP_{prec} + cP_{strm} + dP_{resv} - 50}{12}$$

- Weights determined subjectively or from normalizing procedure but not optimized to predict a certain variable
- Probability properties not maintained
- No explicit criterion variable
- Discontinuity when snow enters and leaves

Revised Formulation Issues

$$SWSI = \frac{P_{fcst+resv} - 50}{12}$$

- Dependent on streamflow forecasts
- Requires unofficial forecasts or redefinition of criterion variable during non-forecast season (July-December) to compute year-around
- Discontinuities when criterion variable changes, such as summer and at beginning of water year

"Forecast" vs. "Current Conditions"

- What does "current conditions" mean with respect to surface water supply?
- Snowpack has an inherent lag therefore is implicitly predictive
- Three of the four components are typical predictor variables for streamflow forecasts
- Does previous month's or current streamflow mean anything?
- Diagnostic components vs. prognostic forecast

Seasonal vs. Year-Around

- What does "surface water supply" mean at each time of the year? This determines the criterion variable.
- Should we make unofficial forecasts during the summer and fall, or should we redefine the criterion variable?

Numerical Behavior Issues

- Statistical properties -- distribution of index in general and seasonally
- Forecast-based SWSI will not reach extreme values if streamflow forecast is highly uncertain
- Discontinuities: original SWSI when snow enters and leaves; revised SWSI at new water year and during summer months
- Setting of trigger levels -- should be based on frequency of occurrence
- Large changes in SWSI can result from small volume changes for low-variance distributions

Numerical Behavior Issues (cont.)

- Expression as rescaled non-exceedance probability, number of standard deviations, or non-exceedance probability itself (i.e., is frequency information inherent or obscured in index value?)
- Should SWSI formula denominator be 10 instead of 12 so that the range is -5 to +5, and the frequency of the value is transparent? (e.g., -3.0 → 20% non-exceedance probability)
- Should SPI be rescaled to do the same?
- People think linearly, even if index is nonlinear

Reservoir Storage Issues

- Large vs. small
- Newer reservoirs with short period of record
- Changing management over the years
- Can we even apply a probability-based index to reservoirs?
- Reservoir purpose -- some are not for "water supply" (e.g., flood control)

Separate Component Indices

	Feb 1974	Apr 1977	Jan 1988
Snowpack	2.9	-3.2	-3.9
Precipitation	2.7	-4.0	-3.6
Ant. streamflow	2.8	-3.5	-3.9
Reservoir	1.4	0.0	-3.7
Fcst. streamflow	3.6	-3.5	-3.1
SWSI	3.7	-3.4	-3.4

General Index Issues

- Combining very different and noncommensurate variables is highly problematic
- Need a clearly defined quantity to be indexed (e.g., SPI)
- Numerical behavior and statistical properties of index need to be clear and well-understood
- Meaning of index needs to be clear
- Needs to be a well-conceived rationale for connecting specific values of index to decisions and responses (e.g., taking into account frequencies of occurrence, etc.)

Final Remarks

- Many questions, many issues, many discussions over the years -- some things have been clarified, and some things are still unclear and unresolved, or at least no general consensus has been reached
- Sometimes there is a mismatch between (naïve?) expectations and technical realities of an index's behavior
- How much understanding should we expect of people for them to use a drought index appropriately?

References

Garen, D. C. (1993). Revised surface water supply index for western United States. Journal of Water Resources Planning and Management, 119(4):437-454.

Shafer, B. A. and L. E. Dezman (1982). Development of a surface water supply index (SWSI) to assess the severity of drought conditions in snowpack runoff areas. Proceedings of the Western Snow Conference, 164-175.

Conclusion

Questions?

Comments?