Methods for Calculating Economic Value of Earth System Predictions

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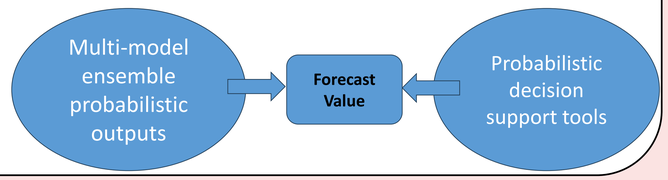
Goal: Assess Economic Value of ESPs

We develop and test methods for estimating the economic value of weather, climate, and water forecasts (aka Earth System Prediction, ESP). Improved numerical predictions and ability to deliver a full range of probabilistic uncertainty, MATCHED with sophisticated yet accessible decision-making tools, promises a new era of forecast-informed decision making (FIDM).

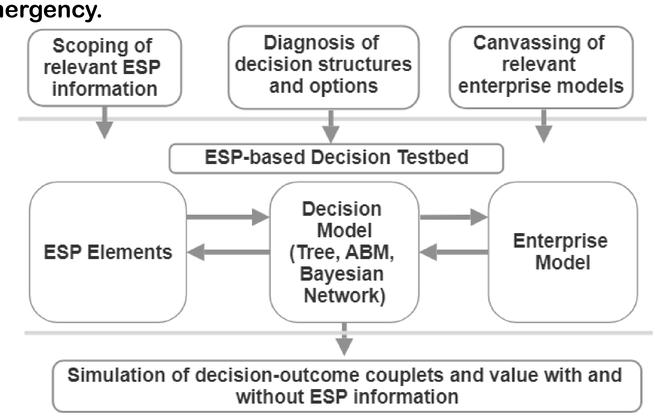


A combination of forecast elements & decision structure set economic value

While forecast skill is obviously important to its value, so is the skill in decision-making and the risk/reward structure of the weather- or climate-sensitive decision. Decision structures are not all idiosyncratic—with classes that can be defined and matched with ESP types:

- Short-term, short-fuse decisions (e.g., road de-icing)
- Multi-day choices with thresholds (e.g., hurricane evacuation, riverine flood preparation)
- Cumulative & predicted seasonal conditions (Case 1: cattle grazing in the face of drought).
- Probabilistic future arrival times matched to alternative choices and probabilistic impact thresholds (Case 2: stormwater management).

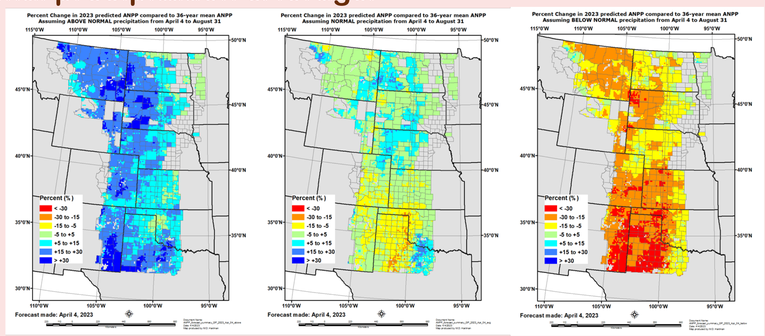
We focus on decision options available and how forecast-informed choices can best be made. A **forecast value testbed** thus combines forecast elements (skill, specificity, lead-time) with decision structure in a process that can be applied to a wide variety of forecast products and decision settings, from routine to emergency.



- How does forecast skill and user sophistication interact to increase or decrease value added?
- What is the cost of risk aversion, and can it be relaxed by forecast informed decision-making?
- What's the marginal economic value of a unit of improved forecast skill?

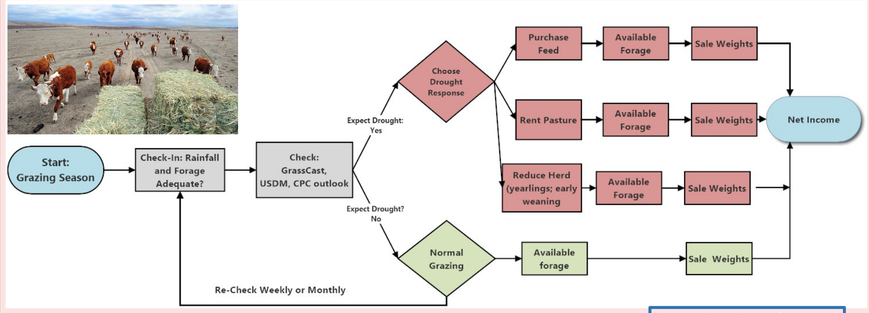
Decision: Prepare for drought on a cattle ranch?

The forecast information: Likelihood of achieving normal precipitation & forage.



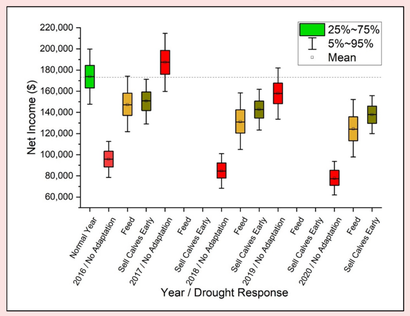
- Earth system indicator: "Grass-Cast", predicted growing season Above-ground Net Primary Production (ANPP) in terciles based on historical values and current cumulative conditions.
- The forecast gives departures from normal forage (ANPP) every two weeks. Ranchers must choose a tercile map best suits the current season and get their location for predicted end-of-season forage factor.
- Users advised to consult NOAA/CPC's monthly and seasonal outlooks to choose among the three maps, but have other sources, in our study area INE Colo) we think 8-16-day precipitation forecast have best skill & lead-time.

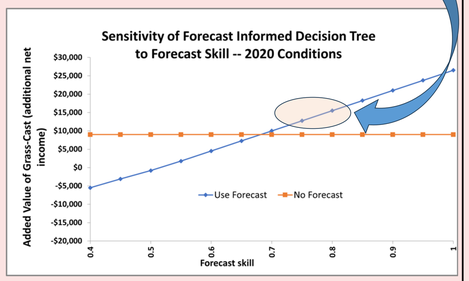
The decision structure



Economic value to a typical 600-head ranch

Current Grass-Cast/sub-seasonal forecast skill can add $15,000 during droughts to a 600-head ranch that averages $173,000 annual income.



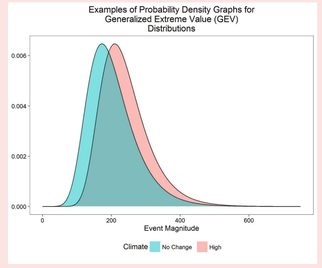


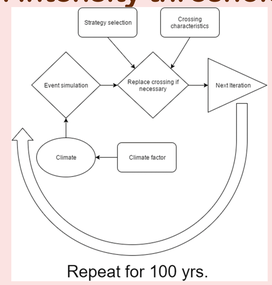
Year	Mid-Season Site Forage Factor	Mid-Season Grass-Cast	Precipitation 6-10 day / 8-14 day	Initiate Drought Response?
2017	1.04	+5 to +15	Below / Below	NO
2018	.94	-5 to +5	Below / Below	MAYBE
2019	1.38	+5 to +15	Above / Above	NO
2020	.93	-15 to -5	Below / Below	YES
2021	1.17	-5 to +5	Below / Below	NO
2022	.52	-30 to -15	Normal / Normal	YES
2023	1.32	+15 to +30	Above / Normal	NO

A decision dashboard for drought response on a ranch near Ault, Colo.

Decision: When to replace & upgrade culverts in a changing climate

The forecast information: Probabilistic decadal arrival times at precipitation intensity thresholds.





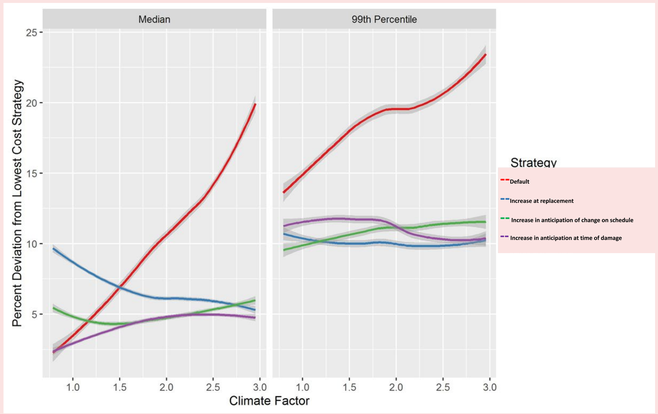
- Earth system indicator: Rate of increase in precipitation event frequency/ intensity/inundation(left).
- Simulate random damage events over culvert lifetime with changing probabilities (right)

The decision structure

Decision strategy:

- **Default: Replace as necessary with same sized crossings.** Typically at end of useful life.
- **Increase culvert capacity at replacement**, assuming climate is changing and damaging events are indicators of that change
- **Anticipatory: Increase culvert capacity prior to normal replacement** in anticipation of future increase in flood events
- **Reactive: Switch from the default to anticipatory when a crossing is destroyed** by and extreme event, used as a pacemaker for adaptation

Economic value to a highway culvert replacement program



Deviation from lowest cost culvert replacement strategy (perfect information) plotted against rate of increase in precipitation event frequency/intensity/ inundation.

- Higher values are more costly over the lifetime of the program (e.g., 100 years).