The Value of Uncertainty through Time

E.S. Marland, Appalachian State University

16 November 2012

Acknowledgements:

Dr. Kevin Shirley (Director, Actuarial Science Program)
Dr. Gregg Marland (Research Faculty, RIEEE)

Ms. Jenna Cantrell (Graduated, Mathematics and Economics)
Ms. Kimberly Kiser (Senior, Actuarial Science)
Ms. Meredith Branham (Junior, Mathematics and Biology)
Ms. Dawn Woodard (Junior, Mathematics and Biology)

Dr. Matthias Jonas (Project Leader, IIASA)

Uncertainty in Carbon Emissions

- Evaluating the current climate
- Setting a climate target
- Translating to an emissions target
- Assessing current emissions
- Following the emissions path
- Meeting chosen targets

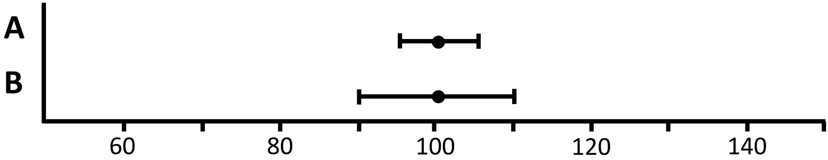
Paying the cost of emissions.

- Mitigation.
- Adaptation.

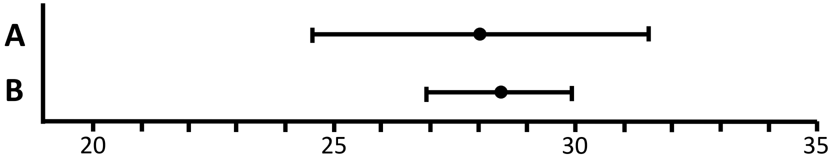
Emissions and offsets need to be valued accurately and fairly to inform all accounting activities and transactions.

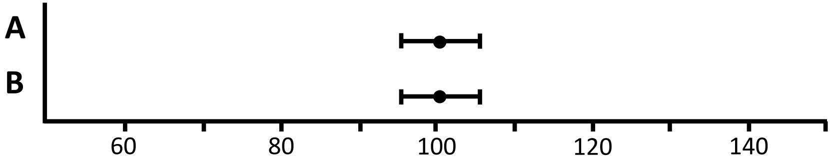
Suppose we enter into a trade agreement with another party ...

If A represents emissions and B represents sequestrations, do they offset each other?



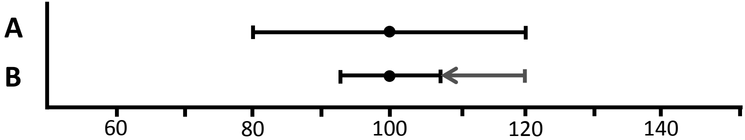
How about these?



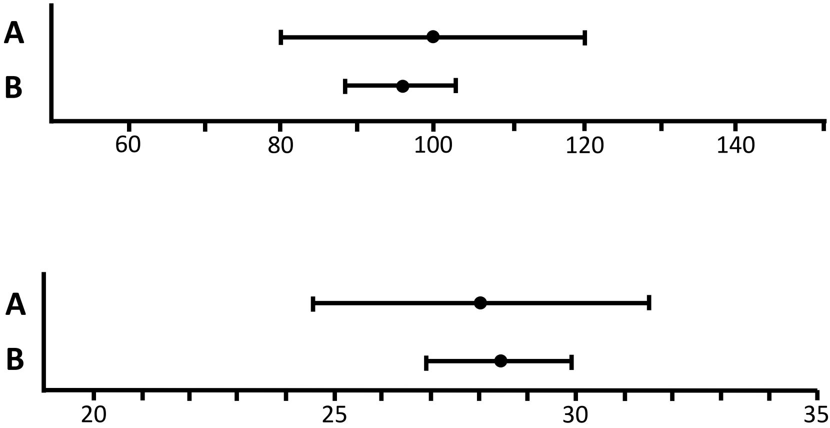


Suppose we agree to reduce our emissions ...

If A shows emissions at time zero and B at time t, have emissions been reduced?

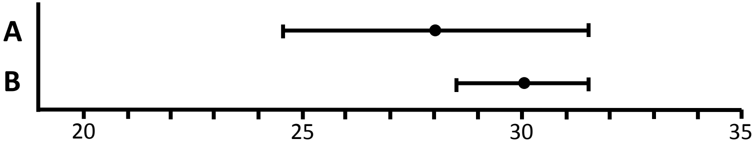


Have these?

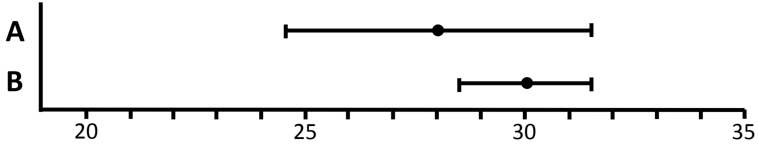


Suppose we are required to pay for our emissions ...

If A and B are emissions from two companies, should the emissions have the same value?



If A and B are emissions from two companies, should the emissions have the same value?



If they shouldn't, were would you have to shift the center of B for them to be the same?

- What is the value of uncertainty?
- How do we value changes in uncertainty?
- How do we compare uncertainty in sequestrations and uncertainty in emissions?

It turns out someone has thought about these types of questions before ...

Insurance Companies

A risk charge: insurance for the insurance company.

Emissions

Cost = Present Value of Emissions + Risk Charge

where the risk charge reflects the level of uncertainty.

- Err on the "safe" side: above on emissions, below on sequestrations.

Lots of possibilities on how, but the specific method must be clear and consistent.

Two Possible Criteria

1. Agreements must be met at 95th percent confidence levels. (less conservative)
2. Valuations are made at 95th percentile confidence levels. (easier)

Risk charges quantify and value uncertainty in a clear, consistent manner.

Transparency, clarity, and ease of use help to ensure objective decisions and comparisons.

Implications on Time

- Emissions are spread out over time.
- Contractual and Agreement Lengths.
- Time Horizons.
- Permanence.
- Trading Time for Space.

Emissions over time

$$\overline{C} = E[b_T e^{-\delta T}] = E[be^{(r-\delta)T}] = \int_0^{\infty} be^{(r-\delta)t} P(t)dt$$

What are the implications?

There are problems with:

- Predicting accurate discounting rates.
- Having accurate probability distributions.
- Understanding the costs of emissions

Shorter time frames produce smaller uncertainty, but we still want to set long term goals.

Time horizons - what about the emissions that occur after the horizon?

$$\overline{C} = \int_0^\infty b e^{(r-\delta)t} P(t) dt$$

$$\int_0^\infty b e^{(r-\delta)t} P(t) dt = \int_0^{100} b e^{(r-\delta)t} P(t) dt + b e^{(r-\delta)100} \int_{100}^\infty P(t) dt$$

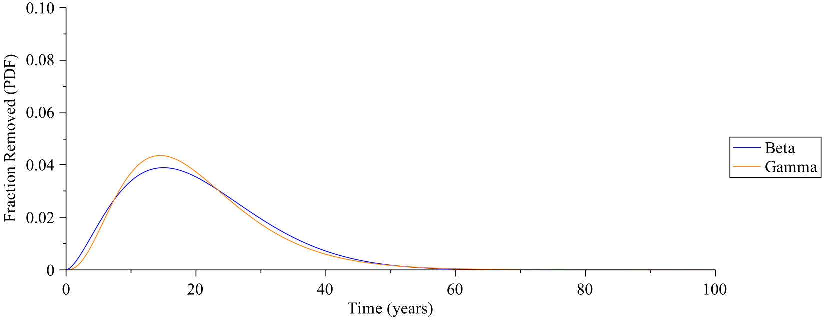
$$\int_0^\infty b e^{(r-\delta)t} P(t) dt = \int_0^{100} b e^{(r-\delta)t} P(t) dt + \text{risk charge}$$

Permanence - how sure are we?

$$\overline{C} = \int_0^\infty be^{(r-\delta)t}P(t)dt$$

$$\int_0^\infty be^{(r-\delta)t}P(t)dt = be^{(r-\delta)100}$$

$$\int_0^\infty be^{(r-\delta)t}P(t)dt = \text{risk charge}$$



Distributions fit based on data on particleboard from Forest Research, UK which assumes a year of maximum decay of 15 years and a year of 95% decay at 40 years.

Calculating the risk charge for distributions

Oxidative pressure as a proxy of sensitivity for risk determination
Defining a PAD (Provision for Adverse Deviation)

The force of oxidation defined as $\mu(t) = \frac{P(t)}{\int_t^\infty P(\tau)d\tau}$ where $P(t)$ is the oxidation distribution.

$\mu(t)dt$ represents the expected proportion of the remaining material that will oxidize in the time interval $(t, t + dt)$.

The expected present value is calculated by adjusting a factor k in $k\mu(t)$ to determine the PAD associated with the increased oxidation rate.

The resulting distribution is $S(t) = exp(-\int_0^t k\mu(\tau)d\tau)$ which yields

$$P_{mod}(t) = k\mu(t)S(t)$$

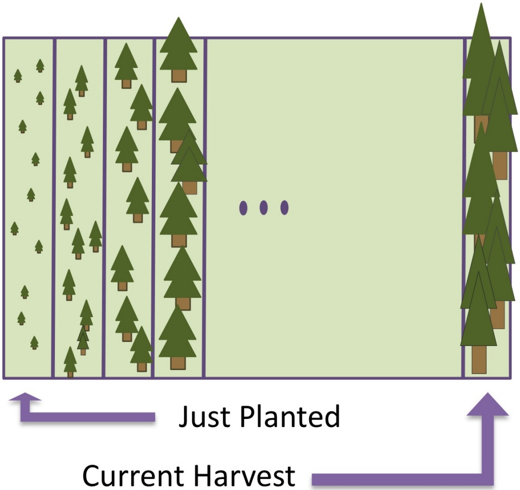
Therefore $\overline{C}$ after the PAD is given by

$$\overline{C} = 50 \int_0^\infty e^{\delta t} P_{mod}(t)dt.$$

	Beta Distr. Model	Gamma Distr. Model
Present Value ($\overline{C}$)	\$34.08	\$34.25
Parameter Sensitivity ($\pm 5\%$)	\$1.02	\$1.26
Oxidative Pressure Uncertainty ($\pm 5\%$)	\$0.32	\$0.33

Based on 1 ton of CO_2 released at \$50 per ton with 2% discounting.

Averaging over space can reduce uncertainty in time by decreasing magnitudes.



Conclusions

- Uncertainty has value.

- Risk charges provide a clear and consistent method.
- Risk charges generalize across greenhouse gases and sources.
- Risk charges generalize to address uncertainty over time.
- Risk charges encourage improved accounting.

A final note: risk charges do not need to be related to money ...