FOREST CARBON OFFSETS – MARKET EXPANSION, RESEARCH GAPS AND MODELING NEEDS

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Presented at: Southern Forest Assessment Consortium 2022 Annual Meeting
August 10. Durham, NC
What is Driving Market Participation?

Corporations

Airlines

State/Regional
Types of Projects

1. California Air Resources Board (CARB or ARB)
   - Program: Regulatory program in the state of California

2. Climate Action Reserve (CAR)
   - Registry with Programs: Biggest movement lately is Mexico

3. American Carbon Registry (ACR)
   - Registry with Programs: Biggest US non-ARB improved forest management (IFM) program

4. Verified Carbon Standard (VCS or Verra)
   - Registry with Programs: Biggest international registry – not much in terms of US IFM
Where are these projects - ARB?
Where are these projects?
Where are these projects - ARB?

ACR209 – Weyco project not on map

It was listed in 2014, but never a project

Alabama – 3 projects
1) ARB - TCT Birmingham IFM Project
2) ARB - Finite Carbon – Stevenson AL IFM
3) ACR - Bluesource – Sharp Bingham
Following CARBON and MONEY through an Offset Market

**Forest Land Owner**
- Provides land base and additional carbon storage

**Project Developer**
- Provides interaction with registry

**Reserve Pool**
- Provides insurance against reversal

**Verifiers**
- Provide independent confirmation of account

**Discounts**
- For cruise error, leakage, risk of reversal, etc.

**Registry**
- Provides protocol, tracking and accounting of account

**Brokers**
- Facilitate deals between buyers and Registry accounts

**Offset Buyers**
- Corporation
- Individual

**Offset Market**
How ARB IFM (Improved Forest Management) Works

1. Conduct forest inventory
2. Determine CAR Common Practice for your region/forest type (legal and economically viable of course)
3. Conduct a 100 year harvest schedule
4. Average the 100 year live carbon stock value
5. Landowner gets one-time allocation for carbon above Common Practice Line
6. Annual carbon payments same as base year
How ARB IFM (Improved Forest Management) Works

1. When you conduct this 100-year harvest schedule

2. You also average the removals for use in the Harvested Wood Products determination
   - Average of storage in wood products over a 100 year timeframe

3. If you harvest less than this amount in a reporting period, you will be assessed a penalty (reduction in offsets) due to leakage
Stand Type 1

Carbon Stock based on this number

<table>
<thead>
<tr>
<th>Stand=Type_1 Year=2009 Inventory conditions</th>
<th>Wood_001.svs</th>
</tr>
</thead>
</table>

5194 Total Cubic ft / acre

Accumulating 7.3 tons / acre of CO₂ per year

Carbon Flux is what we care about
Stand Type 2

740 Total Cubic ft / acre

Accumulating 19.21 tons / acre of CO₂ per year

Lower Stock

Higher Flux
Types of Projects

Avoided Conversion (AC)
- Forests prevented from being converted to non-forested land

Improved Forest Management (IFM)
- Forest management that increases and maintains a certain level of carbon stocking

Reforestation (R)
- Converting non-forested land into forested land
**Issued credits:**
represents one metric ton of CO2 from the atmosphere

**Retired credits:**
purchased credits that are taken off the market, so the purchaser can claim to have reduced emissions

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**ARB Issued and Retired Credits**

ARB is California Air Resources Board

- **Credits Issued**
- **Retired Credits**

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**US FOREST CARBON OFFSET CREDITING**
To the State of California requires the reduction or avoidance of any air or water pollutant that could negatively affect the state of California (Assembly Bill 398 (AB 398; Chapter 135, Statutes of 2017)).

DIRECT ENVIRONMENTAL BENEFITS (DEBS)

ARB DEBs Issued and Retired

- Credits Issued
- Retired Credits

Prior slide (all ARB credits) for reference
Could be projects that just began (or are in the verification process)

Or

Could be projects that monetized avoided emissions credits only.
US FOREST CARBON OFFSET STOCKING

Percent Increase from Baseline to Actual Stocking

Avoided removals

Projects

Percent Increase from Baseline to Actual Stocking

ARB only here *(yet again)*

This graph shows the percent increase from the projected stocking to the actual stocking recorded.

(not including early action)
AVOIDED EMISSIONS VERSUS REMOVALS BY CREDITS

**Avoided Emission Offsets:** Initial credits issued, usually larger number because of previously established timber.

**Removal Offsets:** Credits that are issued yearly due to yearly growth of the project area.
Looking just at ARB

- 37% of all projects
  - *That is 56 projects harvesting*
- 38.6% of IFM *(Improved Forest Management)*
- 45% of AC *(Avoided Conversion)*
- 0% of R *(Reforestation)*

Leakage

- 20% in ARB – not assessed on avoided emissions at time of crediting
- 40% on most ACR – assessed against all crediting

The risk rating represents...

- Financial risks
- Natural disaster risks
- Social risks
- Management risks.

Average Risk Rating is 17.5%
Looking Back

2018

Research Gaps And Modeling Needs

University of Idaho
College of Natural Resources

REFLECTIONS/EXPERIENCES IN FOREST CARBON OFFSET MARKETS

Greg Latta
Research Assistant Professor Of Forest Economics
University of Idaho
glatta@uidaho.edu

Presented at: WFE Annual Meeting
Olympia, WA, 5 June 2018
CARBON MARKET PROCESS SIMPLIFICATION

- Reliability (aka Verification)
  - Too many “These go to 11” moments
  - In other words – no room for common sense

- Do all projects need to go through an onerous verification process
  - What about sampling projects (verify only some)

- What role do small woodland owners have in the market?
  - Is there a way to monetize activities known to improve the carbon balance of a forest property?
CARBON MARKET RESEARCH NEEDS

• There appears to be a lack of coordination/collaboration between the carbon researchers and carbon practitioners.
  • There is even a communication gap (Example BC Forest Carbon SSP, vs IPCC SSP)

What can the research community do to help?

• Leakage
  • The Brian Murray 20% in entrenched, but not necessarily appropriate
  • We can do better *(hint: the leakage is not constant, it depends on carbon market participation)*

• Permanence
  • Do we need permanence? *(is forestry the problem we are trying to solve?)*
  • Why 100 years anyway? *(would you get better participation and thus emissions reductions with shorter contracts?)*
**CARBON MARKET PROCESS JUSTIFICATION**

- Why are the rules what the rules are?

- **Additionality**
  - Should NGOs, Industry, and family owners have the same baseline?
  - Should outside money have a non-forestry baseline? (invest instead in equipment upgrades at poorly performing facilities)
Fast Forward to Now

Same old story:

• But worse----

• Now we have NCX, FFCP, ACR Canada, CAR Mexico...
  • Landowners are confused
  • Academia is confused
  • Project developers are confused
  • Worse yet – offset buyers are confused

• Market “watchdogs” are popping up all over
  • And they are confused too

Can we simplify
Simplify

• Don’t focus on stocks – they don’t matter
  • Only the interaction with the atmosphere matter

• Only 2 Concepts
  1. **Reliability** – the emissions reduction (or sequestration) must be additional and that includes onsite and offsite effects (so leakage)
  2. **Durability** – they also need to stick around (or we need to account for the project timeframe) through reserve pools or discounting
Forest Carbon Quantification Consortium

2022 Summer Workshop
May 17, 2022
Raleigh, NC
Stateview Hotel and Conference Center*
Send participation inquiries to: glatta@uidaho.edu

Workshop Agenda:

Report Results from Year 1 Leakage and Permanence Studies
Discuss Priorities for Year 2 and Beyond

The Forest Carbon Quantification Consortium (FCQC) is a collaborative focused on economic approaches to evaluate market and policy issues that affect forest carbon offsets. FCQC leverages research capabilities at multiple research institutions and provides a flexible funding mechanism to accomplish research objectives targeted at bolstering scientific credibility to a rapidly developing voluntary forest carbon offset (FCO) market.

*This will be a hybrid meeting—call-in information will be provided to meeting participants.

1. FCQC – Forest Carbon Quantification Consortium (Greg Latta (Univ. of Idaho), Adam Daigneault (Univ. of Maine), Christopher Galik and Justin Baker (North Carolina State Univ.))
1) Initial onsite reduction in emissions when harvest delayed on 5000 acres.

2) Offsite response in same period.

3) Second period we cut the stand and therefore there is an increase in onsite emissions.

4) And reduction offsite as the harvest displaced offsite harvesting.

Same compensating harvests occur when the regenerated stand is harvested again.

Not much going on outside of the harvest shifting periods (because no payment for sequestration (only avoided emissions)).
Note: the “leaked” harvest in the reserve was higher than that in the 3 cases where harvest was just delayed.
Issues with that approach – focus on the old stuff

- There is a lot of harvestable material on private forest land in the US
  - Most actively managed land in 0-80 acre classes (fairly evenly distributed)

80 years plus land –
- 17% of the area and 24% of the volume
- That’s 4.1 billion cubic meters
- Annual harvest on all land in US is 0.35 billion cubic meters
- So close to 12 years of volume on those older forest land
- Only 2% of that land (and volume) shows up in the Protected Lands Database (so it would appear harvestable)

So: There is a lot of Slack in the system

We don’t know how much of this land is not really part of the manageable land base (riparian, inaccessible, or otherwise encumbered)
Basic FASOM Stand Dynamics

Live Bole Biomass – this is what we think of as yield in logs. It does not include small tree, tops, branches, or stump biomass
- Sigmoidal – so increasing growth rate when young and then decreasing growth when older

Periodic Annual Increment (PAI) – this is what we think of annual growth rate
- Peaks when the stand growth rate changes from increasing to decreasing (yield curve inflection point)

Mean Annual Increment (MAI) – this is what we think of average growth rate
- The peaks is often defined as the biological rotation age (where PAI crosses MAI)
Basic FASOM Stand Dynamics

Defining Merchantability Limits in FASOM
- We have always had a minimum harvest age
- What if we add a maximum harvest age?

Pre-merch – defined as younger than 2/3 of biological rotation (here biological rotation is 50 so pre-merch limit is 33). Can’t harvest stands younger than this age.

Merch Zone – defined as a range of rotations most likely used in a working forest (so not a reserve). Where harvesting will occur.

Post-merch – defined as younger than 2 time pre-merch age (here biological rotation is 50 so pre-merch limit is 33 and post-merch is 66). We will experiment with harvesting stands older than this age. Remember, we don’t know how many of them are actually not harvestable.
Basic FASOM Stand Dynamics

Pre-merch
Post-merch

Not additional - Too young to do anything but grow (not exactly true as there are other management options possible outside of FASOM)

Not additional? – Possible reason for not harvesting (not exactly true as there are other management options possible outside of FASOM)
Harvest Probability

Increases as stand volume increases or as stand ages

Decreases as stand volume increases or as stand continues to age
So can we Delay Harvest in FASOM (and get meaningful output)

Not Currently – even with maximum harvest ages determined at the Region / Forest Type / Site Class level

<table>
<thead>
<tr>
<th>Owner</th>
<th>Pre-Merch</th>
<th>Merch</th>
<th>Post-Merch</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLM</td>
<td>6,739,735</td>
<td>11,411,837</td>
<td>12,906,422</td>
</tr>
<tr>
<td>Ofederal</td>
<td>4,541,396</td>
<td>7,506,631</td>
<td>7,444,887</td>
</tr>
<tr>
<td>Private</td>
<td>142,388,578</td>
<td>207,167,584</td>
<td>77,169,087</td>
</tr>
<tr>
<td>State</td>
<td>15,213,991</td>
<td>27,394,858</td>
<td>14,284,514</td>
</tr>
<tr>
<td>USFS</td>
<td>27,614,011</td>
<td>55,296,615</td>
<td>52,531,503</td>
</tr>
</tbody>
</table>

We’ve been focusing on this as a concern (slack in the model)

There are 207 million acres of harvestable (merchantable) private forest acres. Assuming 9 million acres harvested each year, that would be about 23 years worth.

So: When we move 5 thousand acres or even 1 million acres, a model like FASOM has plenty of other harvestable acres available it can replace it with

100% Leakage for Harvest Delay pretty much every time with current model formulation
Using a market mechanism *(a carbon price)* in a market model *(FASOM-GHG)*

- Use the strength of the model to inform the leakage analysis
  - In other words: use a carbon price and observe the market/resource response
  - This will be like the Wade et al. (2020) model with the Latta et al. (2011) additions allowing voluntary participation
    - So private forest owners can:
      - choose to participate in the offset market and get paid for sequestration (while also paying for emissions)
      - Or choose not to participate and not get paid or pay for sequestration and emissions.
    - To flush out that was not participating in the market anyway (non-additional) I will use $1/tCO_2$ as the base level against which to measure additionality

- Scenarios
  - 0, 1, 5, 10, 15, 20, 25, 30, 40, 50, 75, 100 $/tCO_2$ for offset market participants *(and $0 for non-participants)*
  - Carbon Price paid only on above and below-ground live tree carbon *(so not soils, litter, or dead wood)*
  - No Harvest in Post-Merch private acres
  - Allow harvest in Post-Merch private acres


Using a market mechanism \textit{(a carbon price)} in a market model \textit{(FASOM-GHG)}

Allowing Harvest in Post-Merch private acres

Marginal Abatement Cost Curve (MACC)

Steps:
1. Run the Carbon Price Scenarios through 2090 in 5-year time periods
2. Calculate additional sequestration in each time period
3. Discount the additional carbon using 4% (similar to Murray et al (2004))
4. Calculate the annual annuity value that would equal the sum of the first 40 years of discounted additional carbon

\[ V_0 = \frac{a \times [(1+i)^t-1]}{i \times (1+i)^t} \]

- \( V_0 \) is the sum of the discounted additional carbon over the first 40 years
- \( i \) is the discount rate (here 4%)
- \( t \) is the time period over which the annuity is calculated (here 40 years)
- \( a \) is the annuity value (or a single value that could be applied annually for 40 years and give us the discounted sum of additional sequestration – it basically makes it so we have one value for each carbon price)

Offset Participants – additional sequestration at each carbon price

Non-Participants – additional emissions at each carbon price

Note: the blue line (participants) is only the above and below ground carbon. Gains in other carbon pools are part of the non-participating total.

Using a market mechanism \((a \text{ carbon price})\) in a market model \((\text{FASOM-GHG})\)

- Allowing Harvest in Post-Merch private acres

Marginal Abatement Cost Curve (MACC)

Steps:
1. Run the Carbon Price Scenarios through 2090 in 5-year time periods
2. Calculate additional sequestration in each time period
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4. Calculate the annual annuity value that would equal the sum of the first 40 years of discounted additional carbon

\[
L^T = \left[ (PV_P - PV_T) / PV_P \right] * 100. \tag{12}
\]

\(PV_P\) is the time-discounted present value of carbon sequestration increment on lands targeted by the policy. \(PV_T\) is the corresponding discounted value of carbon increments on all lands (targeted and non-targeted).
No Harvest in Post-Merch private acres

Offset Participants – additional sequestration at each carbon price
Non-Participants – additional emissions at each carbon price

Total Sequestration

MACC - With and without harvest in Post-Merch stands

Solid lines are “No harvest in post-merch stands”
Dashed lines are “With harvest allowed in post-merch stands”

Without harvest allowed in post-merch stands

<table>
<thead>
<tr>
<th>CO₂ Price</th>
<th>Participants PVₚ</th>
<th>Non-Participants PVₚ</th>
<th>Total PVₜ</th>
<th>Leakage Lᵀ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2,976</td>
<td>-543</td>
<td>2,433</td>
<td>18%</td>
</tr>
<tr>
<td>10</td>
<td>6,078</td>
<td>-1,022</td>
<td>5,056</td>
<td>17%</td>
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<tr>
<td>15</td>
<td>8,168</td>
<td>-1,164</td>
<td>7,003</td>
<td>14%</td>
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<tr>
<td>20</td>
<td>11,282</td>
<td>-1,877</td>
<td>9,405</td>
<td>17%</td>
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<tr>
<td>25</td>
<td>13,398</td>
<td>-2,836</td>
<td>10,563</td>
<td>21%</td>
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<tr>
<td>30</td>
<td>16,213</td>
<td>-4,532</td>
<td>11,681</td>
<td>28%</td>
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<tr>
<td>40</td>
<td>20,964</td>
<td>-6,639</td>
<td>14,325</td>
<td>32%</td>
</tr>
<tr>
<td>50</td>
<td>24,006</td>
<td>-7,802</td>
<td>16,204</td>
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</tr>
<tr>
<td>75</td>
<td>31,103</td>
<td>-7,982</td>
<td>23,121</td>
<td>26%</td>
</tr>
<tr>
<td>100</td>
<td>37,561</td>
<td>-5,796</td>
<td>31,765</td>
<td>15%</td>
</tr>
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</table>

With harvest allowed in post-merch stands

<table>
<thead>
<tr>
<th>CO₂ Price</th>
<th>Participants PVₚ</th>
<th>Non-Participants PVₚ</th>
<th>Total PVₜ</th>
<th>Leakage Lᵀ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>7,565</td>
<td>-5,990</td>
<td>1,574</td>
<td>18%</td>
</tr>
<tr>
<td>10</td>
<td>14,417</td>
<td>-9,412</td>
<td>5,056</td>
<td>17%</td>
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<tr>
<td>15</td>
<td>21,255</td>
<td>-12,134</td>
<td>8,121</td>
<td>62%</td>
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<tr>
<td>20</td>
<td>29,604</td>
<td>-16,720</td>
<td>12,883</td>
<td>56%</td>
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<td>25</td>
<td>34,317</td>
<td>-18,119</td>
<td>16,199</td>
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<td>18,620</td>
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<tr>
<td>40</td>
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<td>24,077</td>
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<tr>
<td>50</td>
<td>51,176</td>
<td>-24,720</td>
<td>26,456</td>
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<td>75</td>
<td>63,817</td>
<td>-34,374</td>
<td>29,443</td>
<td>54%</td>
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<tr>
<td>100</td>
<td>74,816</td>
<td>-38,797</td>
<td>36,019</td>
<td>52%</td>
</tr>
</tbody>
</table>
Ever-declining mitigation expectations
(or comparison with past studies)

Offset Participants – additional sequestration at each carbon price
Non-Participants – additional emissions at each carbon price
Total Sequestration

MACC - With and without harvest in Post-Merch stands

Solid lines are “No harvest in post-merch stands”
Dashed lines are “With harvest allowed in post-merch stands”
Single Region C-Price Scenarios

North 15 – offers option for Northeast and Lake States to enroll in carbon market for $15/tCO2
South 15 – offers option for Southeast and South Central to enroll in carbon market for $15/tCO2
(in each case there is no cost or penalty associated with carbon in other regions)
US 15 – all private forest landowners in US can enroll in carbon market for $15/tCO2

<table>
<thead>
<tr>
<th>CO₂ Price Scenario</th>
<th>Participants PVₚ</th>
<th>Non-Participants In Region</th>
<th>Other</th>
<th>Total PVₜ</th>
<th>Leakage within Reg</th>
<th>Lₜ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>North 15</td>
<td>3,997</td>
<td>234</td>
<td>-2,879</td>
<td>1,353</td>
<td>-6%</td>
<td>66%</td>
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<tr>
<td>South 15</td>
<td>2,986</td>
<td>1,419</td>
<td>-2,477</td>
<td>1,928</td>
<td>-48%</td>
<td>35%</td>
</tr>
<tr>
<td>US 15</td>
<td>8,168</td>
<td>-1,164</td>
<td>7,003</td>
<td></td>
<td>14%</td>
<td></td>
</tr>
</tbody>
</table>

Preliminary – in each case, there is negative leakage (more sequestration in non live tree and unenrolled lands) within the regions and higher leakage when adding in other US regions as the industry expands there and contracts in the program region
This is the part where you roll your eyes and curse “models”

- I knew this was all BS

Remember models don’t provide answers, rather they inform the decision space

- What did we learn?
  1. Leakage is not an easy issue
     - We didn’t really learn this, but we know it is a market response
  2. Leakage depends on how the credits are quantified (how much you take to market Methodology matters)
  3. Leakage depends on market penetration (how much of the market is affected)
  4. Leakage may be different for methodologies that target removals as opposed to those that target maintenance of stocks
  5. Leakage is not constant over time (future markets are affected by current market effects)
FCQC Forest Offset Leakage Update

Leakage Option B

• Elasticity Route:

  \[ L' = \frac{100*e*\gamma*C_N}{[e - E*(1 + \gamma*\Phi)]C_R} \]

• Pros
  • elegant, equation-based approach
• Handles

• Cons
  • Requires elasticities we don’t have
  • Methodology doesn’t affect it

\( \theta \) is the supply price elasticity
\( E \) is the price elasticity of demand
\( C_N \) is the carbon sequestration per unit of non-reserved forest
\( C_R \) is the carbon sequestration per unit of (foregone) harvest gained by preserving the reserved forest
\( \Phi \) preservation parameter
\( \gamma \) substitutability

Murray et al. (2004) - Why go through the paper and 2005 EPA Mitigation Report scenarios if the equation was enough?
FCQC Research Priorities *(short-term after we finish the leakage work of course)*

**Harvest Probability Equations**
- utilizing some localized regression techniques
  - so either GWR *(betas vary across map)* or SAR *(error varies across map)* —or hopefully not both
- Problem is we would need FIA cooperation *(location and private owner type)*
- These could be applied both within an NCX-type program as well as within a ARB-CAR-ACR-VCS-type program *(don’t need it for VCS_FFCP)*

**Risk in Buffer (Reserve) Pool**
- First focus on fire
- What have the actual, project emissions
- Maybe next hurricanes
**U.S. FOREST CARBON MARKET PRIMER**

### Carbon Registries

**Compliance**
- Project: 192
- Acres: 5,794,736
- Credits: 192,754,683

**Voluntary**

<table>
<thead>
<tr>
<th>CAR</th>
<th>AC-R</th>
<th>VCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Acres</td>
<td>43,965</td>
<td>330,799</td>
</tr>
<tr>
<td>Credits</td>
<td>3,966,334</td>
<td>8,715,040</td>
</tr>
</tbody>
</table>

**Principles of Offset Projects**

- **ADDITIONALLY** Project must demonstrate how it is going to increase carbon stocks in the project area.
- **VERIFIABILITY** Projects must be verified through a third-party, sites are visited every six years, and inventory reports are verified.
- **LEAKAGE** Occurs when the GHG reductions in one area result in the increase of GHG reductions in another area.
- **PERMANENCE** Must show project maintains benefits for a period of time.

One Carbon Credit is equivalent to one metric ton of CO2e from the atmosphere.

**Steps for a Forest Offset Project**

1. **Landowner**
   - Provides project area and management of site.

2. **Developer**
   - Project: Initial project carbon inventory, quantification and documentation.

3. **Verifier**
   - Received through an independent third party.

4. **Registry**
   - Registry verifies the offset project externally.

5. **Verified Again**
   - If all previous steps were approved then credits are issued to the landowner.

**Carbon Offset Types**

- **AVOIED EMISSION OFFSETS**: Initial credits issued, usually larger number because of previously established timber.
- **REMOVED OFFSETS**: Credits that are issued yearly due to yearly growth of the project area.

**Forest Project Types**

- **AVOIED CONVERSION (AC)**: Forests prevented from being converted to non-forested land.
- **AFFORESTATION/REFORESTATION (IFM)**: Converting non-forested land into forested land.
- **IMPROVED FOREST MANAGEMENT (IFM)**: Forest management that increases/maintains a certain level of carbon stock.

**ARB HARVESTING**
- 37.6% (All projects 50 projects of 140)
- IFM: 38.5% AC: 45% R: 0%
Greg Latta
Director, Policy Analysis Group
glatta@uidaho.edu

e-newsletter and reports
http://www.uidaho.edu/cnr/pag
For those of you who muttered "you cherry-picked your past studies" Greg