I'm happy to share with you today about our project. I am Johna Boulafentis with the Nez Perce Tribe Air Quality Program. As shown in these pictures, we studied older model and new EPA certified stoves in our study. The project took place between Jan 2007 and March 2009. We received EPA funding and worked with Dr. Tony Ward at the University of Montana to conduct the study.
**Study Overview**

- 16 participating households
- Sampling before/after changeout
  - Ambient PM$_{2.5}$ mass
  - Indoor PM$_{2.5}$ levels and chemical markers of woodsmoke
- Woodstove change out
- Outreach and education

The Hypothesis was: Wood stove replacement will reduce indoor levels of PM and associated wood smoke chemical markers from domestic wood burning? This slide lists the components of the project.

**In order to participate, the 16 homes had to** Use an old woodstove as primary source of heat, and had to be non-smoking, tribal member homes with an asthmatic child between the ages of 6 and 17.

**We sampled outdoor and indoor air before and after change out:** For this presentation, I will discuss our findings for indoor PM2.5 and chemical markers of woodsmoke. Our data will be presented with pre and post woodstove change out values.

**Woodstove Changeout**
- Replace with an EPA certified stove
- Oct ’07-5 homes, Mar ’08—11 homes

**Outreach and Education**
- Was a large component of the project and we'll talk about that in greater length today.
- Homeowner training with new stove shortly after installation. And further education as owners used their stove.

**Sampling during winter months:**
- Baseline: Jan-Mar ’07 and Dec ’07-Mar ’08
- Post changeout: Dec ’07-Mar ’08 and Nov ’08-Mar ’09
Ambient PM2.5 levels vary widely by season in Lapwai and Kamiah. Before the project began, we had intended to compare the ambient and indoor mass to determine if ambient PM2.5 influenced indoor PM2.5 concentrations. After reviewing both the indoor and ambient PM2.5 data sets, it is likely that the ambient PM2.5 had an insignificant influence on the indoor PM2.5 measured in this study. As shown in Appendix C, the indoor levels are far more elevated when compared to the ambient levels during the same time periods. The results from this study suggest that indoor sources (i.e. cooking, cleaning, and woodstove use) dominate the indoor PM2.5 levels within each of the 16 homes.
Indoor Sampling

- **Equipment**
  - DustTrak (Model 8520)
  - Leland Sampler / Personal Environmental Monitor (PEM) with a quartz filter

- **Data Collection**
  - Sampled for 24-hour period, one to five sample days
  - Intern sampling duties
  - Participant responsibilities

**Equipment:**
We used two pieces of equipment to do the indoor sampling, the Dusttrak which measured continuous PM2.5 mass averaged over 60-second intervals and the Leland that measured Organic and Elemental Carbon along with 7 chemical markers of wood smoke on a filter.

**Data Collection:**
- Our Goal was to collect as many samples as possible pre and post changeout. Depending on the home and for various reasons (equipment failures, homeowner issues) some homes only had 24 hour while others had up to five, 24-hour samples collected.
- This picture shows one our college interns calibrating and setting up the equipment before taking to a home. They worked directly with the homes directly and sent data to the University.
- Participants also completed datasheets during the sampling about their home activities such as cooking, cleaning, candle/incense or cultural burning along with a wood burning log of when they loaded their stove, type of wood used.
PEM and filter showing collected particulate matter
• The Change out included everything the homeowner needed: Hearth pads, piping & flashing, and the EPA certified stove.

• Following the installation of the new stove, Jerry Marquez who worked on the Libby, MT changeout inspected the installation and gave the homeowners an initial introduction to their new stove. He provided them with a handout on best burn practices.

• Also, my office provided each home with a packet of information (DVD, wood smoke information, asthma information, materials for kids, and manual for the stove). Although important, this outreach and education strategy did not work for every home, and additional strategies were later needed. I'll go in further detail towards the end of the presentation.
Results
Overall, there was a 52% reduction in indoor PM2.5 when comparing the median pre- and post-changeout results. As there is a large standard deviation when looking at the PM2.5 results (because of high PM2.5 levels in some of the sample runs), results are presented in median concentrations (instead of averages) when evaluating the impact of the changeout.

In looking at the Graph,
• The average of the 24-hour pre- AND post-changeout PM2.5 concentrations were used when comparing the pre- and post-change in indoor concentrations within each of the homes. Levels are in ug/m3.
• As there are no indoor air standards, I will refer to the National Ambient Air Quality Standards (NAAQS).
• Prior to the changeout, eight of the homes had 24-hour average concentrations above the NAAQS 35 µg/m3, with the maximum 24-hour average of 188.0 measured in Home 16.
• Following the changeouts, four homes still had 24-hour average concentrations above 35 µg/m3. Specifically
  • H2 (post sample)-I will discuss in greater detail in a few slides
  • H4&5 had low pre-changeout PM2.5 concentrations, 10.2 and 8.2 respectively, making it difficult to achieve an overall reduction when comparing with the post-changeout sampling events.
  • H9 (post)-Many factors may have led to their increased values. Their home activity log identified burning “wet wood, some dry” Also had incense burning, smudging, and boiling of koush koush. Highest spike of 4000 ug/m3 correlates when the home had windows open and door propped open.
PM2.5 and OC/EC/TC
(Homes with Complete Datasets)

<table>
<thead>
<tr>
<th></th>
<th>Median PM$_{2.5}$ ($\mu$g/m$^3$)</th>
<th>Minimum PM$_{2.5}$ ($\mu$g/m$^3$)</th>
<th>Maximum PM$_{2.5}$ ($\mu$g/m$^3$)</th>
<th>OC ($\mu$g/m$^3$)</th>
<th>EC ($\mu$g/m$^3$)</th>
<th>TC ($\mu$g/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Changeout</td>
<td>21.6±57.5</td>
<td>5.0±6.6</td>
<td>254.0±731.1</td>
<td>16.9±15.3</td>
<td>0.3±0.4</td>
<td>17.2±15.5</td>
</tr>
<tr>
<td>Post Changeout</td>
<td>18.4±54.1</td>
<td>4.0±13.4</td>
<td>145.0±278.3</td>
<td>13.4±11.0</td>
<td>0.7±0.4</td>
<td>14.0±11.3</td>
</tr>
<tr>
<td>Difference</td>
<td>-15%</td>
<td>-20%</td>
<td>-43%</td>
<td>-21%</td>
<td>+120%</td>
<td>-19%</td>
</tr>
</tbody>
</table>

**Graph**
Organic Carbon / Elemental Carbon (OC/EC) were collected on the filters connected to the Leland. OC is volatile and is made up of thousands of compounds. EC is stuff remains on the filter-black carbon soot. Stuff in pencil/graphite. (During analysis, first the OC is analyzed.)

- When looking at the PM2.5 mass results in those homes with complete data sets, there was a 15% reduction in indoor PM2.5, while maximum spike concentrations were reduced by 43%.
- OC/EC results show that the PM2.5 mass measured within the homes is heavily enriched with the OC fraction, with a minimal contribution from the EC fraction.
- The 21% reduction in OC correlates with the 15% reduction in PM2.5 mass, suggesting that the introduction of the EPA certified woodstoves directly impacts the OC fraction of PM2.5.
- Even though there was an overall increase in EC following the changeout, levels were still extremely low when compared to OC. (EC: When making a relative comparison-the increase from 0.3 to 0.7 $\mu$g/m$^3$ is very small.)

**Additional Information**
As the DustTrak was often set to run for 48-hours (while the Leland samplers ran for 24 hours), the DustTrak data had to be formatted in an effort to make the applicable comparisons. Therefore, during data analysis, the 48-hour DustTrak runs were separated out into individual 24-hour events so they could be directly compared with the 24-hour OC/EC and chemical markers of woodsmoke concentrations.
Chemical Markers of Woodsmoke
(Homes with Complete Datasets)

<table>
<thead>
<tr>
<th></th>
<th>Levoglucosan (ng/m³)</th>
<th>Dehydroabietic acid (ng/m³)</th>
<th>Abietic acid (ng/m³)</th>
<th>Vanillin (ng/m³)</th>
<th>Acetovanillone (ng/m³)</th>
<th>Guaiacol (ng/m³)</th>
<th>4-Ethylguaiacol (ng/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Changeout</td>
<td>645.1±1315.3</td>
<td>113.0±147.7</td>
<td>11.3±18.7</td>
<td>0.5±2.3</td>
<td>0.3±9.2</td>
<td>0.9±256.0</td>
<td>0.8±0.8</td>
</tr>
<tr>
<td>Post Changeout</td>
<td>238.1±310.1</td>
<td>0.3±37.1</td>
<td>41.5±40.3</td>
<td>0.5±4.4</td>
<td>0.3±0.0</td>
<td>0.3±0.4</td>
<td>0.1±0.4</td>
</tr>
<tr>
<td>Difference</td>
<td>-63%</td>
<td>-100%</td>
<td>+267.0%</td>
<td>No Change</td>
<td>No Change</td>
<td>-62%</td>
<td>-92%</td>
</tr>
</tbody>
</table>

**Chemical Markers**

- Out of the seven chemical markers of woodsmoke tracked in this study, levoglucosan was found in the highest concentrations. It is generally a major organic component of biomass combustion related PM. The 63% reduction in concentrations confirms that woodsmoke related PM2.5 was reduced within the homes as a result of the changeout.
- In addition, dehydroabietic acid had a nearly 100% reduction.
- Abietic acid actually increased following the changeout, which is a trend the University of Montana observed in the Libby woodstove changeout. The University is looking into this increase.

- 7 Chemical markers of woodsmoke (vanillin, acetovanillone, guaiacol, 4-ethylguaiacol, levoglucosan, abietic acid, dehydroabietic acid)
Graph

• As shown in a previous graph, some homes had higher PM2.5 concentrations after the changeout when compared to pre-changeout levels.

• The Bar chart shows four homes’ pre-changeout results, initial post-changeout measurements referred to as Post 1, and then measurements following additional targeted outreach/education provided to the homeowner shown as Post 2.

Additional training

• After collecting post-samples at a few homes, we noticed elevated levels.

• After determining the causes of these elevated concentrations, we provided additional training, we called “new stove refresher” to homeowners.
  
  - H2: pitch on stove;
  - H6: wasn’t burning stove hot enough-build-up of creosote in pipe
  - H11: leaving door on the stove open when using. We explained that this type of technology had to have the door closed.
  - H13 chimney full of creosote, got chimney cleaned. And levels were reduced. You can see that H13 had very high Post 1 avg.

• Seeing the benefits of the refresher for a few homes, we decided to provide a “new stove refresher” to each home.

• As a result of this education/outreach effort, PM2.5 concentrations were lowered within four homes as demonstrated by follow-up post sampling events.
Outreach and Education
Lessons Learned

- New stove learning curve
- Less is more
- Be specific. Step by step directions

- We learned that there is a learning curve for homes when operating a new stove. Multiple visits may need to be made to the home to ensure that residents learn best burn practices for their new stoves.
- We learned that providing too much educational material can overwhelm a homeowner. During the initial visit with Jerry Marquez we gave everyone a large packet of information. We learned it’s better to discuss the most important topics and show the material rather than briefly reviewing and leaving a packet.
- Thus, homeowners need to be given specific instructions on how to operate their new stove. Directions need to be clearly spoken and written down, reviewed in detail with the homeowner during the visit.
- Each home received a specific, step-by-step protocol.
- Since not every homeowner will refer to their stove’s manual, this direction sheet was a quick and easy to read reference tool for them to keep.
- During a few of the “refreshers” we watched a portion of the Environment Canada film on burning techniques.
- This targeted outreach and education was a critical component of the overall success of the project.

After some of the post-changeout measurements showed an increase in PM2.5 levels, we decided to provide a “new stove refresher” to each home.
Challenges

- Sampling equipment malfunctions
- Distance to Kamiah from Lapwai
- Homeowner
  - Learning curve with new stove
  - Paperwork, no shows
  - Selecting 4 new homes mid-study
- Woodstove business & installer
  - Distance (~200 miles away)
  - 2nd round of installations delayed two months due to snow
  - Attitude/not vested in the community

• Equip: faulty wires

• Distance to Kamiah: meeting with homeowners and children who are available late afternoon. Challenging to supervisor and check in with intern.

• Homeowners:
  - getting to fill-out questionnaire each day, no phone, don’t return calls, no show for appointments, one homeowner was moving, wood stove shared a chimney with a wood cook stove.
  - Having to select 4 new participants during the study.
  - Lesson Learned: Clear directions when giving stove; multiple interactions; Written agreement about removing old stove

• Installer: Only saw stove when they arrived for the installation. Pictures could only help so much.

  • Lesson Learned:
    - Purchase stoves from a local business
    - In a written agreement or in the bid (New stoves “burned off” pre-change out, Old stoves hauled to a recycler)
Outcomes/Successes

- Partnerships & intern participation
- Reduced ambient PM2.5 in each community
- Reduced indoor levels
  - PM$_{2.5}$ levels by 52%
  - Levoglucosan by 63%
- 16 tribal homes with EPA certified stoves
- Outreach and Education

Partnerships and interns
We worked with many agencies and organizations tribal and non-tribal to complete this study. Their shared experiences and support aided in our success.

Reduced Ambient
Main Partners:
• EPA
• University of Montana
• Northwest Indian College, Nez Perce Tribe Distance Learning Centers
• Institute for Tribal Environmental Professionals
Other partners:
• Washington State University Extension Energy Program
• Swinomish Tribe
• Nimiipuu Health
• Nez Perce Tribe Housing Authority, Nez Perce Tribe Forestry & Fire Division, Nez Perce Tribe Safety Program
• Contacted State and other tribes that completed changeouts

16 Tribal homes with EPA Certified Stoves
• New stoves “burned off” before change out, Old stoves recycled, Installation inspection and training
Thank You!

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