Soil Carbon Confab
13-14th January 2014
What is the best management can do to improve rangeland social-ecological systems and contribute significantly to sequestering carbon in rangeland soils?

The Confab funded by the Walton Institutional Collaboration Fund was a great success and starting point for our future endeavors. This report outlines the main outcomes of the meeting and future plans, before presenting a compilation of the notes taken during the Confab.

Main Outcomes

Bringing together the group for the first time led to lively and productive discussions regarding our overall theme: can using adaptive grazing methods - managing cattle with high stock density and short rotational grazing, on forage made up of a polyculture of grasses, forbs, and legumes - potentially sequester huge amounts of carbon back in the soils, while increasing the quality of grasslands and our resilience to climate change? The multi-institution consortium of scientists was selected due to their activities on the leading edge of this field. The scientists came from ASU, New Mexico St., Michigan St., Brown University, Texas A&M, USDA and independent companies. The participants are listed below with their specialties. Gary Dirks and Rob Melnick, Director and Executive Director of GIOS respectively, also attended.

Name	Affiliation	Area of expertise
Steven I. Apfelbaum	Applied Ecological Services Inc.; The Earth Partners	Soil carbon consultant
Peter Byck	Arizona State University	Communications
Russ Conser	Retired - Shell Game Changer	Business models; carbon sequestration
Jennifer Hodbod	Arizona State University	Social-ecological systems; resilience; food systems
Christine Jones	Amazing Carbon	Soil carbon
David Johnson	New Mexico State University	Carbon sequestration; agricultural systems; microbial biodiversity
Urs Kreuter	Texas A&M University	Human dimensions of rangeland ecosystem management
Michael Lehman	USDA - Agricultural Research Services	Agricultural systems; microbial biodiversity
Jonathan Lundgren	USDA	Entomology
Jason Rowntree	Michigan State University	Grazing systems; methane
Rebecca Ryals	Brown University and The Ecosystems Center at Marine Biological Laboratory	Greenhouse gas fluxes; agricultural systems
Wendy Taheri	TerraNimbus	Mycorrhizal Ecologist (Microbiologist, fungi)
Richard Teague	Texas A&M AgriLife Research	Grazing management

Heather Wilkinson	Arizona State University	Communications
Jingle Wu	Arizona State University	Grasslands; Mongolia

The Confab started with brief introductions of the members of the group, highlighting their research priorities and activities so far in the area of adaptive grazing, or potential application to adaptive grazing. We agreed that the overall research intention was to first prove 'what is the best management can do?' for soil carbon sequestration in grazing systems. Our hypothesis is that adaptive grazing will produce more co-benefits for the social-ecological system than conventional grazing, but we are open to the possibility that there may be conventional grazing methods that lead to beneficial impacts as well. Therefore, our field studies need to be in areas where management practices are the only difference, so to isolate the impacts of management choices.

We then discussed the necessary scale to achieve robust results. It was concluded that a landscape perspective is necessary, to demonstrate repeatability. To compare conventional and adaptive grazing in a statistically robust manner, paired comparison tests are required. As conventional grazing (CG) incorporates many different management strategies and impacts on the environment, we envisage finding sets of three ranches for paired comparisons – best case CG, worst case CG and adaptive grazing, all of which are on the same soil type, aspect and slope (as demonstrated in Teague et al. (2013)). The intention is to find ranches that have been operating under the same methods for at least 8 years, so to study established systems with less variability. We propose that the best-practice would be to carry out 3x3 matrix for each soil type, and to repeat this over two different transects: wet to dry and north to south within the US. Therefore, this research design demands 9 observation sites at multiple locations, with multiple types of data collection at each site. A summary of the data to be collected is summarized below.

Element	Data required	Relevant consortium members
Soil carbon	Total carbon; sequestration at multiple depths down to 1m; carbon stocks	Steve Apfelbaum; Christine Jones; David Johnson; Richard Teague
Entomology	Insect community composition; dietary diversity; predation rates; pollination rates; pat removal rates	Jonathan Lundgren
Plant	Plant community composition; ground cover; photosynthetic capacities	David Johnson; Wendy Taheri
Microbial function	Microbe and bacteria concentrations and biomass; community structure; activity	David Johnson; Michael Lehman
Arbuscular mycorrhizal fungi	AMF diversity in plant soil and roots; glomalin; phytate; spore counts; water stable aggregates; penetration resistance	Wendy Taheri
Nematodes		*Jonathan Lundgren; David Johnson*
Water	Infiltration; absorption; retention.	Steve Apfelbaum; Christine Jones; David Johnson; Richard Teague
Greenhouse	Soil fluxes – methane, nitrous oxide, carbon dioxide.	Jason Rowntree; Rebecca

gas fluxes	Animal response variables (methane)	Ryals;
General – ecological	Meteorology; soil temperatures; soil moisture; soil type and texture; aspect; slope; bulk density; cation exchange capacity	Steve Apfelbaum; Christine Jones; Jason Rowntree; Rebecca Ryals; Richard Teague
General – social	Management practices of the farm	Jennifer Hodbod; Urs Kreuter
Socio-economics	Life cycle assessment of financial inputs and outputs	Russ Conser; Jennifer Hodbod; Urs Kreuter
Management decisions	Why they own the land; knowledge; attitudes; risk perceptions; social networks; demographics	Jennifer Hodbod; Urs Kreuter
Well-being	Time availability	Jennifer Hodbod; Urs Kreuter

Main outputs from the Confab

We feel that the Confab achieved the goals we set out with:

1) We have initiated a long-term multi-institution collaboration.
2) We aim to bring in substantial funding to further this collaboration and have highlighted potential funding bodies and calls.
3) We disseminated our work to 85 people at ASU during the 'Carbon Nation Conversation' #4 (CNC #4) hosted as part of the Confab. A further group of people listened to the CNC online.

Next Steps

What was quickly established was that this scale of operation, looking via a systems-perspective is novel research and there are lots of research gaps to be filled. Also apparent was that the robust research design constructed is such a large-scale project that one grant is not likely to be sufficient for funding. The overall research aims will probably have to be modularized so the group can apply for different pots of funding to look at different aspects of the research, but that can be carried out concurrently on the same sites. The NSF Coupled Nature-Human systems call for 2014 is still a main target for the group, and other funding opportunities include large foundations and other NSF grants. One of the outcomes of the confab that could be particularly productive was a potential linkage within ASU with the Complex Adaptive Systems Group, as a keystone project within their application for NSF Science Technology Center – a $25 million grant. During the Confab the group also discussed less-traditional funding methods. For example, the consortium has already been funded by Shell ($200,000) to explore new business models to see if they could achieve their goals of carbon sequestration in a much more reliable and inexpensive way by simply helping ranchers and farmers switch to smarter land use practices. If Shell finds this grant's findings compelling, we will approach them for funding for this soil carbon research. We are also in conversations with the World Bank about continuing our ASU/Carbon Nation 2.0 film work – they helped to fund the first film in this series, about adaptive grazing. We hope these conversations also lead to funding for our field research as well.

Further confabs will be necessary to continue outlining research design and to complete proposal preparation. Our long term intention is to apply for a Research Coordination Network grant from the NSF, so to allow 'on-site' confabs where the consortium members can learn about methods used by the other members. We hope that we may continue working with the Walton Institutional Collaboration Fund in the short term to maintain the enthusiasm and productivity of our initial confab.

Confab Notes

Morning Session – 13th January

Russ Conser

- Grass fed supply & demand
    - Market prices compared to feed lot producers
    - Hypothetical
        - Can we feed the world?
            - We would saturate beef – can we eat enough meat
    - How broadly can we apply this?
- Compilation of data – for Shell GameChanger program?
    - Good basis of data available

Jonathan Lundgren

Studies how microorganisms fit into the system

- 20% agriculture
- Food webs having trouble adapting to these new environments
- Synthetic chemical and genetic – supporting the system – not adapting
- How does mother nature attain these systems
    - Food webs
    - Fertilizers – return plant-based nutrients to the soil
- Herbicides
- Insecticides
    - Natural enemies
- Future of farming
    - Simplicity
        - Reduce disturbance
        - Increase diversity
    - They cant/difficult
        - Farmers are using sustainable practices
        - Diversifying crop rotations
            - Feeding the soil
            - Combining crops in certain patterns
        - Complex polycultures
            - New crops
            - Intercropping
        - Manage field margins

                - Supporting spill over effects
            - Integrating Livestock
                - Key mechanism to getting these cropping systems to be productive
    - What do these farmers need
        - Farmers already using agronomical viable methods:
            - Managing field margins
            - Integrating livestock
        - Encourage innovation
            - We need to provide tools/policies that support new ideas
        - Help from ecologists
            - Trained to work in natural systems and get into agriculture systems
        - Communicate science to end users
            - Practice
            - School of hard knocks
    - Hope for the future
        - It's already happening and makes us available!
    - For every bad insect there's 1500 good insects
    - Pumping unnecessary pesticides

David Johnson

- Composting Technology
    - Developed a composting process
        - 6X less water
- Growth test
    - Compared 8 other different to his
        - More fungi because of no turning so the fungi is allowed to proliferate
    - Took a suite of inorganic
        - Fungi to
        - Increased composition
        - New soil carbon
        - Latest experiment
            - Tracking carbon and nitrogen – where is all this energy being shuttled to
            - Higher concentrations of nitrogen and carbon
                - Has started going more into the plant than into the soil
                - Seeing a change in how that soil operates (farmers)
- Does this work in the field
    - Changes in soil nutrients over a 20-month application period
    - Once you start to restore – you get microbes back into your soil
- Planted
    - Irrigated same time – observed 5 to 1 ratio
- Getting the energy back into these systems
- Soil carbon respiration – most interesting
    - Compared to other productive systems
- Comparisons to the rest of the world assuming the climate is the same as NM
- Manure
    - (1/3:woodchips:yard trash (leaves) (1 year old)) –

    - Desert climate too dry to compost well
- Produces highly fungal, no turning to fungal community proliferates.
    - 80-90% C going into the soil – reverses at 3% soil organic matter, change in how soil operates
- Developed strategy that requires less water
- David – if everybody practices the same techniques – how to move soils based on a metagenome analysis
- Russ – relationship between the guts of an herbivore
    - David only looks at the relationship in the soil
- Urs – compare the maps
- Restore soil microbes get soil nutrients back into the soil – 20 month study
    - 5:1 ratio of above ground biomass with David's compost vs. normal (none?)
    - No till - irrigated
    - Bring the biology back to the soil
        - Changing the soil carbon content
            - Fungal to bacterial ratio
    - Creating the compost and getting it in there – Peter
        - 1st test – organic matter to the growth – it's all about biology and it's all about the fungal community

Jason Rowntree

- We are not really resilient as we like to think
    - It altered his thought process
- Get his hands on anything that he could read to further his studies and to change his thinking
- Apply holistic management to his research
- Do systems research
- Goals
    - Improve energy efficiency
    - Understanding the impact of grazing systems
    - Slide
- He doesn't spray or till
- How do we take advantage of the photosynthetic process
- Interface the molecular biology pieces
- Funding
    - In-state
    - Federal
        - Helps do the work
        - Grad students
- Systems based approach
- Diversified income – keep ranchers in business
- Understand triple bottom line
    - Financial
    - Ecological and;
    - Social
- Lake City Research Center – 300+ ha
    - Managed by university
- Low (high stock density) and high (taller grass) intensity grazing
    - Put chambers on and tap gases
    - Run through GC

        - Nitrous oxide emissions lower than anticipated
        - Carbon begins to be reabsorbed post-graze (3-4 days)
    - How do we develop the soil microbiology that can keep the C in for longer?
    - Following carbon through these systems
    - Using chambers to monitor
    - Seeing in our work
        - Grazing livestock is not a source to nitrous oxide
        - Carbon sink as post graze
            - Important to establish that through communities
    - WE need to take from David – how do we establish the soil microbiology for sustainability and pull the carbon back into the topsoil
    - Mike – how do you know you are slowing the methane?
        - Variation in methane - prolonged dry period
        - When you see the numbers bouncing around presume 0 not negative growth
            - Looks at longer time frames and comes out to 0.
            - i.e. they produce methane when grazing
        - Jason – it's capped – sampled intensively for a two-week period
    - Peter – does grass fed versus feedlot produce more or less methane?
        - JR: enteric methane - grass-fed will produce more
        - But if you look at entire picture on system base - including fossil fuel use - grass-fed is three-times more productive
        - Organic matter has risen 0.5% on his land since 3y of HPG.
        - Grass fed does produce more but when you compare to the feed lot processes – fossil fuels
        - Quietly following organic matter and it has increased

Christine Jones

- Grassland ecologist – native grassland interest
- More desired plants
    - Were appearing on properties managed holistically
    - Even plants that were claimed to be instinct plants and most desirable
    - Why would a change in grazing management result in the reappearance of desirable plants?
        - Knew they were deteriorating
            - Started taking routine soil tests – over a couple years
                - Carbon increased about 2%
                - Soils were softer
    - Coming from an ecological perspective – how she became interested in soil carbon
    - Penetration resistant studies and all were going off the page
    - Traditional science was rejecting her findings about nutrient availability etc.
    - Started running soil carbon conferences – 2005
        - First conference on soil C
        - Done around eight
        - One funded by World Bank
    - Australian government – said it was impossible to change the soils with these methods
        - Put in research grant application
        - Can't give her money – fall from grace
        - Talking about restoring the damage was done – she was shunned

        - Indirect conflict with Australian Government – against their advice to farmers
        - Why should method be working in Australia when Australia has no history of ruminants?
        - Persona non grata – can't get funding anymore
        - No lag time curve from early adopters – not taken up by general population
        - Huge resistance to change - against Govt. advice
    - Interest has moved from grazing – majority is still resisting these methods
    - Had early adopters – hasn't seen increase
        - Conventional science and government saying that it doesn't work
    - Interest in cropping
        - Monoculture – 5 years and then 7 months left bare
            - Resulting in soil carbon depleting and nutrient based soil
            - Can't buy seed without having fungicide
                - Destroys micro organisms
                - Being used routinely
                - Causing more problems
                - Being caused to think if you don't use these seeds you will lose crops
                - Cover cropping is being cast as not working
            - A long hard road to bring about change
                - More open discussion about what is happening in our soils – more scientific community to get involved
        - Prophylactic approach rather than specific approach
        - Now seeing more fungal diseases
        - Hard to move away from this because of perceived risk
        - Christine trying to show microbes increase when chemical applications stop
        - Diversity of cover crops etc. "won't work" – spray weeds three times, so must be enough moisture for something!
            - Linkage between all elements
        - Need wider conversation rather than rejection of what innovative farmers are doing differently
    - Peter – droughts
        - Desertification throughout croplands – in management that is designed to increase photosynthetic capacity of plants
        - Channel more C to soil
        - Get better porosity - water holding capacity etc. –
            - Do better in times of drought
            - Changing their crop management makes it through droughts
        - No real data to support this because it needs funding – but anecdotally
    - Huge response in farms doing HPG when it finally rained (8-9 months without) because roots still there
        - Get 4 inches of grass within 3 days
        - Those who do CG got much less growth.

Wendy Taheri

- Research in coal mines – found that AM Fungi:
    - Increased biomass function

- Mycorrhizae in native and agricultural systems – tipping balance of parasitism vs. benefits
- Keystone species - play a huge role
  - Cant' be created and have to have a plant host
  - Provide all the minerals and nutrients
  - Mediate what other species are doing
  - Double to triple amount of water under drought conditions
    - Smaller than roots so can break water tensions roots can't
  - Take in C
  - Want microbial to grow on their roots
  - Traverse all the gaps – shortcut to the plant roots
  - Help plants colonize land
- Rock prices are more volatile than oil prices
- Phosphate reserves are depleting
  - Becoming dependent on high produced systems
  - Will run out – limited supply
  - Increase our dependence on foreign phosphate
  - Depletion by 2041
  - Challenges – act now!!
    - Longer we wait the bigger the disaster
  - Recycle P
  - More efficient use of our phosphate reserves
    - How much phosphate should we be using on our crops
    - Putting too much phosphate and killing the microbiology
    - This is removing carbon from the carbon cycle
    - Diversity matters!!
      - Influences plant diversity
      - Hyphal length
      - Shoot biomass
      - Root biomass
      - Plant tissue P
        - (Van der Heijden et al. 1998 – prairies/grasses) – soil P decreased because going into plant tissue P
      - AMF diversity being re-written by German guy in last few years – polymorphic DNA – difficult to measure
      - Tools still in development but getting better
      - Wendy has written them for USDA
      - Concept of species doesn't apply very well to AMF
- IPNI – fertilizer industry put out recommendations and people use their recs BUT:
  - Ignore organic P
    - "Too difficult to measure"
    - Glomalin sequesters C
    - Helps soil structure
    - Losing AMF on huge basis

- Urs – what type of system
  - It was a constructed grassland – added and took away species
- Peter – how many varieties of mycorrhizal fungi

        - Interesting question
        - Multiple genomes in a single spore
            - There are the tools to measure this
        - 250 roughly described species
    - Russ – is the issue not enough phosphorus in the soils – a study
        - Soil type
        - CEC inorganic form plays a role and because the amount of phosphorus – breaking the link and depending on exporting – wide range of factors – 20% less reaches the plant
    - Christine – phosphorus being added to the soils and you kill the plants
    - Peter – a transition time to ensure these systems work
    - Christine – three years seems to be the magical number
    - Once you make the change – how long will they see 15 years in their yield
        - Peter – 20 years, first 3 years but you have to tell the farmers in advance

Jenny Hodbod

- Grad School – 2008-2013
- How to tie all the elements into the social science and long-term impacts
- Biofuel expansion
    - Rapidly changing system
        - Land use change
        - Infrastructure changes across the country
- Coupled systems– everything feeds into each other
    - Resilience framework
        - Dynamics
        - Cross-scale
        - Interactions
        - Thresholds
- SES Dynamics
    - There are natural cycles in these systems – these things change throughout – shift, changes,
        - Who was winning
        - Who was losing
- What's changing
    - How does it have effects on other systems
- Theoretical themes
    - What is a resilient food system – main focus
- Main themes – see slide
    - How does her work fit into this work?
    - She is an interdisciplinary scientist – looking to see how all these things fit together

Richard Teague

- Mitigation and adaptation to climate change – the whole ecosystem – work in a systems framework
    - Soil - hydrological components etc.
- Got to use your resources sustainability
    - Research down to way these are done – fundamentally different
- Need to look at landscape impacts not reductionist samples - can miss whole story

- No even impact by keeping cattle on large area over whole year – presumed to be even impact
- Why need to study context-specific areas
    - Holistic management is cognizant of this
        - Reverse trends of degradation
        - Provide relief
- Animals graze more of the whole landscape - select a wider variety of plant species
    - Manager can control how much is grazed
        - The period of grazing
        - The length and time of recovery
- Followed Alan Savory
    - Provide relief from grazing - can get better growth than fallow land that hasn't had stock on for 30 years – what are the causal mechanisms?
        - Causing degradation
        - How to reverse
        - How good is HPG as a restoration and management tool
        - Where does it work – where doesn't it work
            - Need the data
        - How does it need to be managed
        - Possible sample sites
            - Does it work with the same principles everywhere
                - Work with the right people to make sure these systems work
        - Build a framework but lack the funding – that's why Peter brought the team and the research can be done here at ASU
    - Richard's fieldwork that ties into what David's work
- Identifying the right grazing systems
- Key things
    - You have to address causal mechanisms
        - Need good science
- Jason – are grasslands bacterial dominated
    - Both forest and grasslands are bacterial and fungially dominated
- Jason – do you think we need to look at the same type of methodologies
    - Yes. What treatments? What is driving the fertility? How do we change
- Christine – see in fungially dominated in native grasslands
- Over 8 years (6-inch measurement) in Bermuda grass lands – improved up to 4% carbon increase – it all relates to the fungi
- Which functional groups do you have?
    - Wendy - everything readjusts to what's going on
- Start the compost from the area that you're working on – and you need the right environment – need carbon for the energy
    - Jason – reluctant to advise farmers to augment
    - You need to have the habitat ready
- Birds are more natural transporters – robins
- Peter - the more diverse the area the better the chances
- Wendy - Management has to been in place first
- Seen it work from 10-80 inches/year but no consistent data
    - Possible sample sites on maps
        - Dry axis (MT down to NM) and;
        - Wet axis (ND down to TX)

Urs Kreuter

- Comparing grazing systems since Masters
- Ecologist → Economist
- What stops uptake?
  - Marketing problem – scientists not good at thinking about how to get it out there and applied
- Social issues key:
  - Changing population structures in Texas
  - Managing systems from integrative SES approach – necessary especially for CNH
  - Has to be fully integrated
- Voluntary and collaborative management approaches to sustainability practices at watershed scales
- Sustainability thought about from a capital perspective
  - Capital building applied at numerous levels – social capital key
  - If you can build social capital you'll get management strategies to be applied more easily
- ISEEC framework – SRR focus – Kreuter et al. 2012
- Fox et al. 2009- an ISEEC framework for considering rangeland sustainability
- Our system diagram – add linkages.
- Put ESS at center of integrated model
  - Then how does the biophysical and social interact?
- ISEEC Figure 2 also integrates time
- Systematic way of thinking
  - Identify indicators - then can compare across systems
- Table of linkages
  - Hypothesis building approach
  - Positive/negative consequences
  - Link to criteria and indicators for monitoring change in key linkages to measure change in ESS
- Way of building integrated model and linkages and explore how to measure them.
- Already got a proposal into CNH – slowing expansion of woodlands and increasing resilience to…
- Need figure linking hypotheses to see how whole system interacted
- ABM to model social element - as well as ecol modeling → scaling up both to regional component so can figure out how to measure impacts on landscape

Becca Ryals

- Climate change focus
- "Where are opportunities from a biogeochemistry side to increase soil storage?"
- Multiple tools
  - Controlled field and lab studies → ecosystem modeling & footprint modeling & LCA → policy development - rangeland management guidelines → better understand ecosystem C storage
    - N transformations and;
    - GHG emissions.
- Carbon ranching – rangeland managements as a climate protection strategy
- What to do with all that poo – manure application to intensively managed corn

- Chicken tracks
    - Pasture raised - N
- Turn manure into compost or biochar
    - More stable less likely to leach nitrate/NOx
- GHG – soil N2O, CO2, CH4, and NOx fluxes measured simultaneously using chambers and laser-based gas analyzers
    - Get real-time data - no GC required
    - Advisor has published on laser stuff
        - Not developed by team so some backing by producers own work
- "Mob" grazing
    - Moved everyday - 65 chickens in moveable coop
- Graze with cows before chickens
- Measuring GHG impacts of a herd of chickens
- California work – active adding compost creates big benefits for a few years
- Measured bulk carbon and C chemistry and physical protection of the C
- Multiple ways of measuring C all have issues:
    - Net ecosystem production
    - Directly measure
    - Ecosystem modeling
    - Full GHG LCA
- Higher soil respiration rates but didn't offset C gains
    - Increased forage production by 40-50% for 4 years
    - One time ½ inch dusting of compost
    - Increase of C storage of 0.5<1.2 Mg C/ha/y (Mg = metric ton)
        - Doesn't include the C from the compost - just the ecosystem response
        - Yard waste compost from commercial producer
        - Compost applied at beginning of wet season and then cycled fast because of rains
- LCA- source materials + production, management, transportation + ecosystem & grazer impacts
    - Avoided emissions (methane in landfill) = net GHG savings
- Up scaling reveals large-scale potential
    - Mainly from offset from methane in landfill (DeLonge et al. 2013)
- Carbon fractions can tell us about the lifetimes of C in soils
    - Free light vs. occluded light vs. heavy fractions
        - Accounting light net plus as long as management practices are continued
        - Heavy fraction will stay longer than management practices
- Microbes drive it into more heavy pools
- UK - Are there management tools for incorporating more into the heavy fraction?
- CJ - Liquid pathway paper – humus – long chain polymer and occluded with minerals
    - Polymerization is a microbial process
    - Need fungal metabolites
- DJ - able to distinguish between plant based and microbial based C?
- RR - need good isotope differentiation, looked at FTIR – ratio of labile: not C, indicates some coming from compost, some from soil, but only assess qualitatively.
- CJ - ties a lot of things together
    - Increasing soil C is the theme
    - David mentioned the free-living N fixing bacteria
- RC - how to fix C in soil

        - Nitrogen gets into aggregates via bacteria
        - When you add compost or change management - change aggregation
            - How to get over the 3 year decline - supports the biology in the soil that supports aggregation
                - Bacteria transforms N into humus form - because need low-partial pressure of oxygen - can't be in soil
                    - Need to be in an aggregate roughly 2mm
                    - Aggregates are sticking to the roots - inside that aggregate there'll be a higher level of moisture and lower level of O than in general soil environment
- PB - cost of composting over vast acres?
    - RR - not practical to spread compost everywhere
        - Steepness is one restraint - availability another
        - But LCA shows don't have to spread it everywhere
            - Has a big effect on specific areas where there'll be a valid ecosystem impact
- PB - maybe rangelands near cities so can divert from landfill?
    - RR - Marin County has smaller ranches - Marin composting project = centralized - collect manure and food waste
- PB - better to leave manure where it is and use other sources of compost?
    - RC - energy-wise makes no sense to move it
    - RR - maybe from high intensity situations – feedlots etc.

Mike Lehman

- Benefits from soil microbes
    - Documented in reductionist studies
    - Some extrapolated to field but very difficult
    - META-ANALYSIS
    - Nutrient retention one benefit
        - Can we reduce P applied by optimizing soil microbial benefits?
    - Others =
        - Soil aggregation
        - Weed retention
        - Glomalin production
        - N fixation
        - Plant growth promoters
        - Nutrient availability - soil C
- Soil microbiology is critical to sustainable Ag – intuitive (Barjett studies)
- What to measure? How?
- Lab methods are not the most rigorous lab methods
    - Would like to be apart of a smaller group that's doing some innovative measures rather than off-the-shelf methods
    - Establish the soil C health methods
- Uses quantitative VCR to measure gene copies in bacterial systems
    - Some criticism but iterations above direct observation in Elaine L's lab
- How to relate to practical values ($)?
    - Farmers want to know what the benefits are
- "I want a dipstick to test for soil biological quality" heard at stakeholder workshop.
- "Do I need to add an amendment?

- How can I tell if it's good or bad?
  - "Wendy's work with mycorrhizae has been one part of that
  - Also using DNA based methods to process soils
- Opportunity to examine paired practices (+/- best management practices) at replicated sites over broad geographic area over time
  - Need:
    - Multiple microbiological measures
    - Contemporary methods
    - Need other measures to interpret
      - Physical
      - Insects
      - Below ground roots etc.
  - Want to be part of a group doing this
- Acknowledgements:
  - Relationships not 100%
  - Site specific effects
  - Interactive effects
  - Weather/climate
  - Spatial
  - Temporal
- Expectations
  - Determine most appropriate indicators
  - Define relationship with other measures
  - Establish link with practical values
- Improving sustainability with soil microbes
  - Lower the inputs - increase relative deposition of CO2 vs. emissions
  - Keep your yield up - tightly coupling the nutrient cycling
  - Lower outputs
    - Less leaching of nitrate
    - Less erosion of soil particles P etc.
    - Less hormones that all comes out the other end
    - Increase soil C
- American Academy of Biotechnology
  - How microbes can help feed the world -2013 report
- RT - need to give ranchers clues of visible things they can manage on
- ML - problem is they're microbial and invisible to the naked eye!
- Indicators?
  - Fungal: bacteria ratio
    - Smaller more significant groups like the mycorrhizae
- DJ - meta-genomic approach
  - Go in - disrupt every organism in the sample
  - Take DNA into multiple pieces - splice in - put back together
- PB - Thermopile?
  - RR - Yes, working with that at the Lawrence Berkeley lab
    - Use metagenomics to look at process of composting different types of waste
      - Look at pathogens
      - Medical waste decomposed etc.
- ML - Geochip was the original one – microarray
  - Chip that extracts RNA/DNA – hybrids it
  - Looks at relevant abundance of genes

        - 10-12 years ago
        - Offered on a commercial basis by Berkeley
        - V specific
            - Has to be on chip
    - WT - database connected physical spores to dna - analyzed data for mycorrhizae
        - Changed 75% of results (?) overlap likelihood gets higher and higher
        - Need shorter piece
        - Have to be careful what conclusions you draw
    - MG Rast – collects data is the best we have right now
    - RT - if looking at fence lines - when do you have to sample to differentiate effects between samples:
        - DJ: at peak biological activity - not when completely dry
        - Gives you a bar chart of abundance
        - 16S is a good tool for specifics but usually use 22 base layer primer -can get totally different structure of ecosystem
    - RT - sample according to what you're looking for – is this a more precise measure for general stuff? Use nematodes for specific landscape?
    - CJ - Scale a good question
        - Landscape or what's happening in the land? i.e. rainfall will switch on different genes, give different answers.
    - UK - $800 per sample
        - If did areas on Richard's map - what's one sample?
            - One specific soil core?
    - DJ - need a reference
        - Look at metagenome
            - Where are our indicators (from heat map)?
            - Will give diffs then:
                - Set up specific primer set - create dipsticks maybe?
    - ML - concern about taking enough samples
        - Propose a stratified sampling approach
            - At least for the micro-biology
        - Do cheaper things at a higher frequency - i.e. soil respiration at 1000 samples
        - Not meta-genomes
        - Other indicators: Diversity of mycorrhizae – not trivial
        - Specific genes to do with C/N cycle.
    - JL - our group understands how linked the microbial community is with C -but that's still too limited a view
        - Biodiversity is connected to everything else that's living in that system
        - Can't just look at one component without considering how it effects the rest of the ecosystem
        - Tie in links
            - Maybe there are specific bio-indicators for farmers
        - But think about biodiversity in general
            - RT - ability to study in different climates will help that

Jingle Wu– ASU

- Landscape ecology
- Urban ecology
- Biodiversity and ecosystem functioning

- Sustainability science
- Lost plateau in China
  - Potential to sequester C there because so huge
- 1000 island lake

  Formed 1959 by damming

  Look at multiple impacts on biodiversity - ecosystem functioning

- Inner Mongolia
  - Huge part of Eurasian steppe
- N.Am
  - Two rainy seasons
  - MP = only one - when temperatures are hot
  - So receive less precipitation but the grasslands are as/more productive
- Flora
  - Multiple studies comparing prairies and steppe
- Trade-offs-
  - C sequestration
  - Productivity
  - ESS
- Nature paper in 2004
  - Long-term dataset
  - Do not have to be trade-offs all the time
  - Productive and diverse
- Pattern of productivity-diversity relationship in IMGR. Bai et al. 2007 J of Applied Ecology
- Now understand that we have to solve problems
  - Priority is sustainable grassland
  - Effects of grazing on productivity/diversity relationship
- Scaling up to entire world
- Inner Mongolia Grassland Removal Experiment
  - C sequestration a key part
  - 6 year project
  - Had to manipulate ecosystem
  - Exciting results are expected
  - Grazing element not finished yet - started in 3rd year
- Integrated systems
  - Landscape sustainability science framework – Wu, J 2013
    - Landscape Sustainability Science: ecosystem services and human well-being in changing landscapes
    - Landscape ecology 28:999-1023
    - Only at landscape scale can we make changes to make sustainable
- PB - way of rejuvenating land is to remove the animals?
  - JW - no one-size fits all methods
  - Must think on multiple scales
    - Regional scale planning for removing/condensing animals
    - Grassland already been degraded so not much for animals to eat
    - Need feeding lots
    - Need to learn from the west
      - Feeding lots if well designed can save land

        - Concentrate in a smaller amount of grassland – i.e. increasing density and allow longer rest periods
        - Change the way the people live
        - Lot more people and animals on this ecosystem now
        - Dramatic to see the historical numbers of change in last 200 years.
- WT - feedlot – not what we mean as feedlot, i.e. area covered in cement where food hauled to animals and waste has to be processed differently?
    - JW - feedlot more vaguely
        - Ecological feedlot – don't have in IMG yet
        - First step is artificial grasslands
            - Highly managed
            - Lot of livestock in very small area
            - 90-95% of grassland left alone
- Traditional herbivores
    - Antelope
    - Yak
    - Camels
- CJ - 200 year perspective compared to Australian story
    - No 'livestock' in Australia traditionally - so introduction of livestock has gone from 0→massive
    - Accompanied by massive degradation
    - Common response is saying if it's the livestock's fault
        - Remove the animals as they caused the degradation
    - What we're seeing in Australia is it's the way the animals move through the landscape
        - So change their movement and recovery periods - regenerate
        - About the management of the animals not the animals per se
- JW - David Kemp, Australia - how many years it takes to recover
    - Could recover in 3-10 years no matter how long had been degraded for
    - Rotational grazing not possible with so many animals?
    - Before 1960 Inner Mongolia livelihoods were nomadic - controlled by the climate
    - Since 1960 grassland controlled by management practices – no movement
- JR - production levels?
    - JW - eastern IM = meadow steppe
        - Higher productivity
    - Western = desert
        - Minimal productivity.
- PB - Test ideas in the Mongolian plateau
- JW - Has funding for same meeting type in China

Steve Apfelbaum – API

- Why isn't the 2nd largest living carbon sink on earth not being talked about in CC adaptation/mitigation?
- USDA say 60-90% soil C depleted from land use practices
- SOC is highly durable
    - Regrows quickly
        - 3-4 inches or 1-5% per decade
    - Linked to water supply

    - Linked to food/forage quality and yields
- Why are we not measuring soil C?
    - Practical
    - Easy
    - Cost-effective
    - But if you can't see it… there are no measurement standards accepted by marketplace/policy arena
    - Business community (McKinsey) identified soil restoration with large potential
        - All about soil C but verbally articulated.
- AES – New standard soil C Measurement Method
    - TEP standard method to measure C stocks/GHG emissions
    - Tested on 90 projects in NAm/CAm/SAm and elsewhere
    - Method approved by the Verified Carbon Standard (VCS)
- Method built on modules
    - Long and complicated for non-scientists but straight forward for scientists
    - Modularizes every part of the soil C/Climate market conversation
    - Define a baseline
    - Investigate future emissions
    - Cost of high-tech methods means do back-of-envelope for NOx modeling
        - Buffer as what proportion of C you can sell in the markets based on variance in modeling
        - Calibrate with continuous gas chamber measurements etc.
        - Wildlife and livestock emissions
        - GHG pools
        - Displacement and leakage
        - Monitoring plan
        - Estimate of litter pools
        - Market leakage
- Fungi/entomology/bacteria
    - Rolled into organic soil C measurements - not individually
    - Marketplace doesn't care – just want to know change in soil C
    - Include as additional modules
- Repackaged USDA standard methods
    - Not 1200 page volume - 70 pages but standardization demanded by the marketplace
- RT - Grasslands module?
    - SA – no - umbrella method
        - Applicable to multiple ecosystems
        - Adding in specific modules for wetlands/peat etc.
    - SA - no module for it but it wouldn't be difficult to translate what we have
- WT - draining a wetland - take into account the C in biomass that's lost/potential that's lost?
- SA - How do we measure at large landscapes?
    - What technologies can we use?
        - Military in the 60s - very high resolution imaging
            - 1-2 inch on ground pixel size
            - One of three civilian businesses with that technology
            - 2"x2" up to 36"x30"
            - Use to measure C3/C4 grasses, woody vegetation
- RT - cross-referenced?
    - SA – yes - Satellite cross-walk imagery
        - Landsat

- UK - Species level?
    - SA - 28,000 acres
        - Measuring to decimeter and species level - looking at eco-toxicology across landscapes
- PB - computers to scan through it?
    - SA - field training using GPS - get signature from 50 examples of a plant species
        - Get the spectral signature - then develop a statistical test for that
        - Speed is huge computer processing power
        - Been using the Centre for Advanced Computation at Illinois
- End up with plan form- use that to help refine the plan
- Map their fence lines accurately etc.
- Palouse – tried to take to scale
    - Scaling and market play - preparing for market place
    - Stratified the physical/meteorological/human land use in the Palouse
    - Stratified random allocations of sample points against the strata and the key variables
        - Primarily agricultural- CRP - no till etc.
- Sampled 7 million acres
- 95% confidence levels in soil accrual rates (soil C levels increasing)
    - Sampling to 1m deep - every 10cm do a subsample
    - At statistically allocated (randomly) over landscape but paired samples about 1m apart
    - Some blind samples sent elsewhere → R^2 of 98%
- JR - what's going on in the bottom third of that meter core?
    - SA - did sampling down to 5m - soil soluble C down to 3m - less and less as you went down but accounting for 1-3% of SOC
    - Depends on soil type and management
    - Soil scientists told me to sample 30cm down
        - You'd get 99% of C
        - But knew needed to go deeper
        - 40-60% of SOC was below the 30/50cm zone
        - Depends on the ecosystem
- PB - Group consensus that we need to go 1m down?
    - Everyone - yes
- RC - at least – side cut at Gabe's ranch it'll be expensive but necessary
- PB - project model could be rolled out to crops too?
- SA - need to go interview for Shell piece
    - Sustainable _ _ _ - main representative of Ag companies – i.e. PepsiCo
- Links to carbon markets – from just no-till average 5000 acre farm could gain $500,000< over 20 years at $10/ton C
- RT - we were talking about 3x3 on wet dry & north/south axes
    - Very different sampling strategy to what Steve's proposing on a grid.
- SA - dropping VCS method down over the cluster of ranches in each location
    - Still have three (HG/CGH/CGL) – i.e. over 30-mile radius - then can scale up and look at benefits over landscape
    - What if 80% ranches came over to HG – what would the impacts be then?
- UK - Voluntary markets?
- SA - through Social responsibility actions
- UK - needs to translate into something with economic teeth
- RC - Peter Donovan told Peter… indicators of economics

- SL - 1m issue – understand the criteria we're setting
    - 1m is reasonable but need to recognize if we're talking about global C in the ground
    - Not true that 99% of C is in the top 30cm
    - SA - Standard method recognizes that
- SL - 200m down sediments/salt beds will have C
    - But land use management won't affect that
    - Need to be explicit about why choose 1m. I.e. the C we can effect is in the top 1m
- SA - marketplace methods for accountability – more rigorous than scientific methods
- CJ - we're not verifying C stocks in the landscape – we're looking at differential stocks
- RC - 90% of differential load is in the top 1m
- CJ - anything that occurs below that is a bonus
- WT - 2m down roots
- SA - 1/2m long earth worm in the Palouse
    - Lots of mobility between horizons
- JR - when we monitor/measure – soil to anestra loam - 6-8 inches of top soil then clay layer ('impenetrable') – is it?
    - How do we make the biggest impacts on changing soil C?
        - Have to get deeper than the topsoil but is it possible to impact that next layer in climates like I'm referring to?
    - SA - in some places you won't be able to core but we've been sampling 1m deep in associating with some of the mines
        - 1m not been a problem but not everywhere
- JR - Do you have farms making improvements in that lower horizon?
    - SA – yes but savannah originally
- JR - not swamp like UP.
- SA - podzolic layers can be punched through but is it worth it?
    - Just build on top
    - Cool season grass environment - not going to punch root systems 2m deep - all 1-2 feet
- Meta-data analysis/lit review
- *Dropbox – and spreadsheet*
- Find base level of knowledge about HPG Vs CG.
- Find holes in research – i.e. bio → will be indirect evidence of benefits but not directly linked to HPG.
- Terminology
    - Multi-paddock grazing – fine reaction
        - Strategic grazing?
        - Adaptive grazing?
        - Adaptive multi-paddock grazing?
- RT - core elements, i.e. adaptive
- JR - but needs qualifying
    - How many paddocks?
- RC - Who are we communicating with?
    - Ranchers different language than to policy makers
    - SA - start with receivers you want to communicate with
        - Create language around that
- RC - ranchers have no aversion to holistic management
- RT - but small part of population - we have to be without bias.
- SA - last week TNC ten year report on language of conservation
    - There are terms that no one understands and yet we use them regularly

        - Restoration for example
        - Conservation & protection – yes
    - Environmental benefits - yes
        - Use instead of ESS. ESS, adaptive management - no.
- PB - NSF don't want wonky stuff in proposals – not a lot of jargon
    - They want something entertaining with a good story
- Don't use holistic
    - Grazing and ranching good
- JR - Carbon?
    - PB - Carbon not important
- UK - need a term that will make people excited not depressed
    - Don't tell people what they were doing before was wrong
- CJ - regenerative grazing
    - Doesn't matter what method but if it's better than it was before – based on an outcome.
- UK - constructive grazing – opposite of destructive?
- PB - regenerating the right flavor
- RT - can't be misunderstood
- WT - renewal?
- SA - is what's most easily understandable something wider – 'healthy land' – can be adapted into cropping system later
- WT - soil health is the main interest of farmers
- CJ - regenerative land management
- JR - regenerative agriculture
- PB - climate smart Ag and smart Ag turns people off
- CJ - don't talk about climate – don't use the word holistic
- UK – acronyms? Proposal name?

Afternoon Session – 13th January

We need to understand what happens at the landscape level

- Landscape perspective necessary - show repeatability. When you find the same differences in different locations your argument is watertight, don't need 100% coverage
-

Application of prescribed fire and building social capital

- How do you get people to adopt?
    - People getting engaged – kinetic learning
- System in good condition with high concentration of herbaceous plants, don't need fire
- Flip it back into an open system, fire not necessary, or necessary at long intervals
- Steve has a company to take down mesquite (mechanically) - turn into pellets - sell to Europe - economic because of premiums
- Scale is important
    - Ranch scale is different to prairie - where fire is part of the landscape historically
    - Entomologists finding you lose a lot of rare species by burning, i.e. one patch burning
    - Drive out rare (killing) species
        - If it was all connected, they'd find their way back
- Same thing happens underground – kill off everything and set system back
    - Depth depends on heat of fire

- **Negative results**
    - Three good seasons to recover from fire - 5-8 years to have three good seasons
    - Gets rid of woodies etc., but there are negatives (ecosystem function)
    - Water limited system – need ground cover to maximize water infiltration
        - Fire immediately creates bare ground
- **Positive Results**
    - Heavily infested – the only alternative is fire and puts it back to a starting point
        - If you have woodland (juniper) suppressing herbaceous plants, fire is the most economic method to remove the woody plants
        - Within a year the herbaceous life would come up from a very intense burn
        - Recycles the mineral held up in plants
        - Prescription burning to reach a particular goal
    - Has to be used in context of the holistic goal - if you can't get any green stuff growing it has a role
    - Frequency
        - Cooler burns may happen more frequently
    - Research in Canada
        - Has an important role because the movement of the ecosystem
- How does this relate to the work
    - Issue is (Russ) or the question: Could the tool of fire be an important place for people to come together and interact with the landscape?
    - Are there other parallels to ranching with carbon
        - Defend that loss of carbon through the fire
    - If you don't burn there is little to no carbon sequestration
    - Integrate trees into grazing lands
    - Should there be some metadata in phase one regarding fire?
        - Keep it broad enough to give enough flexibility at the management level – working with producers through a holistic concept
        - This may bring up some opportunities for burn
        - Keep it broader and could include these different management type of tools
        - What is the management that gets carbon in the soil?
        - What is the best that is being achieved in these environments but the primary focus is on the grazing component?
        - What happens in a cool season grasses versus warm season grasses?
- Fire needs to be used in a productive manner
- Look at scale – kill off a species usually at a smaller scale when dealing with a patch and could prohibit the species returning
    - The connectivity is compromised when you are dealing with smaller patches versus
    - Same as grazing management – depends on management and scale
- Patch burning versus rotational grazing
- Difference between a cool burn and hot burn
    - Cool burn method used by Aboriginal tribes at 3a because of the heavy dew
        - Just took top of grass – like light grazing
            - Small patch burn (3x side of room max)
        - Didn't touch litter - just removed some of the biomass
    - Hot burns
        - Totally obliterates life above land
        - Some of microbial life below
        - Burns 6 inches into the top soil and will be like that for 20-50 years
        - Creates a capped surface

        - Hot burns destroy the whole biome and the regeneration is longer
        - Natural fires – the thermal effect is really important. Try to mimic a natural fire
    - California burn in Fall to get green spring
    - California suppresses fires
        - Eventually end up with out-of-control fire
        - Natural prairie fires move very quickly and don't stay put
            - i.e. tortoise goes in shell, fire goes over, tortoise comes out ok
            - Low-intensity fires used to keep invasive species out because not adapted to fire –but need management
    - Hot natural fires – cool fires
        - Herbaceous plants came up within a year, no difference in biodiversity between hot and cold fire
        - Hot fire
            - Three years + good rain - all herbaceous plants came back
        - Cooler burns would have been set frequently - 3-5 years. But don't need a hot fire because weeds/woodies in the herbaceous canopy
    - Fire and grazing work together – fire would blow through grazed areas (by bison)
    - Movement of animals important in the landscape for regeneration
    - How does fire relate to soil C? Do we want to have it?
    - How do we get it to scale on human systems?
    - Could the tool of fire be an important place where people come together to build social capital?
        - If there's a resistance to fire you don't want to force it down people's throats – is there a parallel?
    - C balance of fire
    - Need some woody vegetation
        - Shade
        - Protection in storms - protects grass and C sequestration.
    - Would we say not touching it in phase 1?
        - Vast geography - such that anything in Eastern realm you're not going to burn
        - Keep it broad enough at the management level to say we're working with ranchers - not our own facilities and the system will be managed holistically
        - So there could be opportunities where burning is necessary, but the goal is to burn or not to burn but to manage holistically
        - Primary focus is what is the management that gets soil C in the ground best
        - Grazing is our focus. – let's focus on that and let others work on fire
        - It's an option of a tool - not the focus - but may be valid in some cases
        - If someone using best practices uses fire we don't exclude them
        - We're looking at how to change management to make it even better
        - Looking down the road - wetter vs. drier
        - Only brought it up because we learned some interests lesson about how people adopt new ideas - about how to build social capital and build soil C
        - Might find it advantageous to bring in the fire unit later on

Talking points

- The prime area – does grazing have a place in taking carbon out of the air?
- What is the potential of grazing rangelands in sequestering carbon?
- Biodiversity improvements is one of the elements of the proposal
- Take out reference as a silver bullet to remove more than emit – don't know potential
- Key is to establish the social side and data accumulation

- Point is to monitor
- Biodiversity in the top line - interlinked with soil C
    - Drive each other
- Keep topline simple but biodiversity is important for fixing C

Fence Line Test

- What does the fence line test give us
    - Need at least 8 years in mesic environment - 15 years in a dry climate
        - Buying time at least 3 per environment gives you the precision
    - Cut right through that landscape and have a clear distinction
        - People who want controlled experiments will query them
        - There is nothing more compelling to show the relative differences
    - Compare with neighbors that are doing things differently - is the same thing happening to treatments in both places?
        - Normal grazing practices – commonly used and;
        - Best (holistic grazing)
        - Trying to find some consistency between two cadres of management – if management is the only difference can explain whether HPG is better
    - Sound science needs to be reflected
    - Varies from one place to another – prove that it is possible to get large concentrations of carbon
    - The NRCS has to pick the best managed places – they have produced good ecosystems
    - What are we trying to get?
        - Put boundaries on what's possible
    - Do not use "we believe"
    - To keep it simple – pick one fence line over one fence line
    - Which is the best managed property and then take it from there
    - Find HPG - say these are the mechanisms - find CG – high and low level of stocking
        - Some parameters in there that are comparable
        - Why you need multiple locations with same combinations?
        - Ask whether same things are happening in different geographic locations
        - If we find CG with 25% soil C – then we assess his best practices
        - Do we mention each type of system in the proposal?
            - Have to say we've found these best management areas and here are their practices
        - Define best practices – has these sort of elements and put those against common practices
    - Two audiences
        - Rancher and;
        - Publications
    - Need example of the normal situation
        - 3 ranches right next to each other - not fence lines but in the same county
            - One HPG
            - One light CG
            - One heavy CG
    - Not a parametric approach – looking for best practice and default
        - Here's type a and b
        - Here's the ratio of response of multiple variables
            - Non-parametric stats

        - Multiple reps at a particular location
    - Then what particular fence line you use isn't key
    - May need a statistician to look at it but I think its ok
    - Producers respond to pictures of fence line comparisons
    - But to publish needs to be statistically robust
- We need six spots of heavy and light HPG – 12 altogether that will beneficial
- Three systems by three reps - for a completely balanced experimental design
    - Best practices versus continuous grazing heavy
    - Best practices versus continuous grazing light
    - Continuance grazing heavy versus continuing grazing light
    - Then need to duplicate
        - One wet
        - One dry
        - One warm
        - One wet
- 2011 – Compare in light and heavy stocking rates in Richard's paper
    - What is the best management to getting biodiversity into the ground
    - If method's been published and not negatively commented on -build on it
    - If we could get the unbiased information a different way happy to do that
    - Simplifies it to just compare to one other 'normal grazing' i..e light CG, but leaves space for questioning
    - Best management involves multi-paddock systems and recovery
        - But David Briskey will say that light CG could do same - so can't just compare Heavy CG and HPG because leaves question
- Nine observation sites at multiple location over multiple years
- Three types – peak standing crop in year one and peak standing crop in year two – samples one a year over a course of two years
    - HPG
        - 2 samples – A & B
    - CG – light
        - 2 samples – A & B
    - CG – heavy
        - 2 samples – A & B
- Are heavy and light CG normal American ranching techniques?
    - Yes
- Got to analyze the landscape as a landscape as well as sample plots to test the hypotheses
- If you take the 9 as your unit
    - Wet/dry = 2 units of 9
    - N/s as well = 4*9
- Three reps along one fence – how far apart physically?
    - **RT** - counties were adjacent - 10-15 mins drive - stratified on two major soils with a combination of:
        - Slope
        - Cantonal position and;
        - Aspect so they were comparable
- Actually looking at 9 operations?
    - Stratification within each ranch
    - Sample points within each ranch just once

- At each parallel have one or three points?
  - Compared same two soil typographies in three ranches - did that in three different counties
  - 18 sample sites - for statistical measure of variability need three examples in same climate setting:
    - i.e. nine ranches in Texas
      - Did nine ranches - 18 sites for $35,000 with two staff members
    - Did soil physic parameters
      - Ag stability
      - Impact & infiltration
      - Full spectrum of chem, soil C and vegetation - functional groups
      - Sugars
      - Soil microbes, fungi – functional groups
    - Did measurements twice in two consecutive years
      - Peak standing crop in Year 1, year 2
      - Soil phys in winter when less workload
      - Soil chem
- Won't be able to do in just one snapshot – biological communities etc.
  - Steve's company can do this in one day
  - Needs several time points throughout the year
  - Peak expression – when system most productive
  - Ok for some - but others not that static
- Don't have to be comparing every site for everything we need to address
  - Peak biological production doesn't even occur same time in different places – twice in California!
- Do we need to do everything at all sites?
- What are the individual things we want to measure?
- As soon as bring in extra disciplines - the bill goes up a lot
  - $3.5 million to Shell originally
    - 1/3 of that was aerial photography
- When you do systems level research it becomes time and cost intensive
  - Otherwise its always criticized for being not enough replications
  - Firm advocate for replicating but also in keeping as simple as possible
- Dream big – and the priorities start to shine out
- What is more difficult to manage?
  - Depends on overall question – which grazing method is going to give you the best
    - Across ranch variation with in treatment?
    - Or in-treatment?
    - At the same ranch?
- Comparison between ranches is key
  - Is it more important to measure in depth at one ranch than three ranches in the same location?
  - To show superior outcomes of HPG - have to show it works well in multiple locations
  - If just have one ranch - get negative reaction
  - Need to show everyone using it is different to his neighbor

- If you want to convince people of HM – you have to sell it without showing all the differences

BIG PICTURE! Measurements

- If our expertise can be put into a document we have something substantial that can be brought together

Jon - no headaches with links to USDA

- Plant community composition
- Insect community composition broken up functional guilds – what is the function of the insect, predators, herbivores
  - 3x times per year
- Dietary diversity of each of these groups based on:
  - Stomach analyses
  - Pollination rates
  - Predation rates
  - Dung pats removal rates
  - Parasites/fly counts on the cows
- How?
  - Multiple collection methods to describe communities
    - Quadrats and lines
    - Sweep samples
    - Ground samples
    - Collect critters – look inside their stomach - using genetic technique to see diet
    - Sentinel prey items
      - How many are removed over time - same with dung pat
        - How quickly is it degraded?
    - Exclusion techniques – exclude insect community from a certain area
      - Look at soil quality over time
- Where?
  - Sample a large area from every farm - insects move so need large area to study
    - 5 locations on each ranch three times a year
    - Gut analysis is done in the lab and;
    - Predation rates etc. done in the field

- **David**
  - Microbial fungi and bacteria/whole community
    - Protozoic
    - Amoeba
    - Siliates
    - Flagilates
  - Elaine Ingham's lab
  - Visual microscopy
  - How many sample sites – seasonal metagenomal lab analysis – self selecting
    - Seasonal collections – collect at peak opportunities

- Look at what represents that community – establishing a type of grid at each site and use that to spatially compare
    - Compare apples to apples
- Makes sense to sample to where RT samples
    - At exact same spot?
        - Look at map - look at what's representative
        - Put out 30m transect and subsample along that – 20 cores
        - Steve has 100x100m grid – very expensive
- If 100m transect could do biodiversity sampling along that
- True bio inventory probably needs Steve's method

***SAMPLING GEOGRAPHY A DISCUSSION TO BE CONTINUED**

- **Jason**
    - Animal response variables
        - Stocking rates and density
        - Pounds sold
        - BCS
        - Income
        - Rest periods
        - Soil GHG fluxes
            - Laser vs. chambers – do laser in each location if not confounded by time
            - Monitoring methane – using green feed – mobile monitoring system
        - Purchasing enteric methane (methane & burping)
            - Green Feed enteric methane monitoring vs. SO6 mobile monitoring system that downloads into a computer –
                - Put EID in cow's ear and gate will only open when that cow goes by - bait cow - let eat half alfalfa pellet and measure breath
                - Monitors in real time whereas SO6 is messy
        - Soil parameter ongoing
            - Weather station
            - Continuous soil temps
            - Moisture
            - Weather variable
                - Year round so as covariate in model
            - Botanical compositions
                - Change throughout grazing season and across parallels
        - *Methane is just one piece/nitrous oxide
        - HOW
            - For methane:
                - Put out ten static chambers - move them around - three reps
                - In one time frame - three areas with ten static chambers each
                - But with laser beam - what you buy in technology you get back in field/lab time
                - Per sand type – three – more gross management monitoring areas
            - Have to have areas that were never grazed – so that you can compare – fenced off plot that you could measure

- Need 90 chambers for three fence line ranches
- Laser technologies better for low fluxes, i.e. background levels
    - Do more samples in-situ - get real-time measurements and no lab work
    - Costs about $95,000 (best) – would need a few, i.e. different latitudes, $25,000 in future.
    - Becca could do a 100 samples a day – takes about 4 minutes to capture the flux unless very low
- Backgrounds necessary:
    - i.e. areas that were never grazed – during the study - annual exposure
    - Tells you background noise from wind etc.
- CG side needs more inputs:
    - Sprays
    - Medicines
    - Pesticides fed to cattle etc.

- **Christine**
    - *How much can we increase the carbon by*?
        - *Do the same principles apply?*
            - *Yes – they are the same ecosystem processes.*
            - *Do the same principles apply to carbon sequestration?*
        - Brix levels (photosynthetic capacity + rate)
        - Total carbon – inorganic and organic
            - Depends on the activity of the soil
    - Termites produce enteric methane – methane in atmosphere around 1m from mound = lower than extent methane → methanotrophs
        - Nature has figured it out as an energy source
    - So focus is about soil C sequestration – measure soil C - rather than other things.
    - Botanical composition
    - Transect based
    - Moisture/temp based differences in locations
        - So even if I measure change over time still difficult to compare
        - More of a case study approach
    - Is the question what is happening to the plants or the soil C?
        - Say what change was and how it relates to management
    - How to prove diversity?
        - Need fence line tests
    - Can show if you increase C it has impacts on x, y, z
    - Isn't the question we're asking how much you can increase the soil C by?
        - If you set out to collect all the information it might be difficult to distill anything out of it
        - How to link between locations if different suit of conditions
    - Aren't we asking **DO** the same principles that lead to the same increases in soil C
    - Same ecosystem processes – question is do the same principles apply to soil C - not the rest of the ESS
    - What are the principles?
    - Diagram with C at the central

- Do we have to prove the linkages with other elements?
- Aren't other people working on that and have proven it?

General discussion

- Theme = what management creates the best soil C?
- What are you going to pull out as the key management principles of HOW you get the C in the soil?
- The problem is mainstream science doesn't believe what we class as the principles ARE the principles.
- Correlation between management principles and C – management creates condition that increases microbes etc. that then creates C
- Mediation process
- So causal effects produced by all other elements
- The more detail I study in one place - the more different it'll be to the same measurements in a different place
- Ecosystem processes will be the same anywhere but the species will differ
- The principles will be the same and we haven't mentioned processes that will build soil C:
    - Photosynthetic capacities
    - Primary productivity (NPP not necessarily the same)- biomass could be the same but if photosynthetic rate is diff it'll be sequestering a diff amount of C
    - Photosynthetic rate
    - *Measure above and below ground biomass?*
    - Brix levels of the plants
- Cause and effect confusion – do the other elements lead to soil C or does soil C lead to the elements?
- Soil C comes first.
- Total Carbon
    - Cheap to measure and if TC1>TC2 it must have come from the atmosphere - simplistic but ok
- Further fractionation – more recent lit found those fractions no longer apply
    - Depends on soils
- Dynamic systems
    - The more measurements - the more difficult it becomes to distill conclusions
    - Is C so dynamic it would need different measurements?
        - Not total C
- Causal mechanism of degradation: over-use of one plant → bare ground→downward spiral
- Need functional groups of plant species and bring together so someone somewhere else can see what the functional groups are where they are
- Ground cover % by functional groups
- Photosynthetic rate
- Need leading examples:
    - Neil Dennis
        - What's the best possible?
        - Doesn't need to be replicable
        - Principles are the same
- Difference between mechanics and principles

- Need the principles - can compare management cadre then
    - Local application of principles is fine
- Need to know mechanics
- Need to seek best CG's to compare to best 'other'
- NRCS will have to help us:
    - 1) Who are conservation award winners
    - 2) Who's best CG and;
    - 3) Who's norm
- Best economic against HPG
- Heavy CG will be making the most money but will also be degrading their environment
- Total C = $5 per measurement every 10 cm
- Do that at many sites purely funded by kick starter
- Do that before proposal – seed funding – "we know there's this extremes of total C" and now we go look at the causal mechanisms
    - USDA/NRCS – soil C measurement campaign – could we use that?
- GRACENet. Started by ARS 12 years ago
    - 20 locations around the country
    - Take Soil C measurements under multiple conditions - mostly cropping but some grazing
    - Download report
    - Push to get database up and publically accessible
    - Duplicated by REAPNet
        - Subset looking at corn/soy systems where stover removed for cellulosic ethanol production
        - Replicated plots with different levels of residue.
        - Could gracenet be our baseline?
- If Russ does his Kick starter campaign could we use the same methodology to just measure on our HPG
- Measures:
    - Brix definitely - massive differences in brix - depends when you measure it (i.e. how long sun's been out/time of year) but finding if he (?) measures what's happening on his farm compared to his brothers (same management prior) brix =20<25, whereas brother is 3<5.
    - Photosynthetic rate measured with brix
    - Welch's grape = 18
    - Can add N and get a lot of biomass but "empty" biomass – no nutrients
    - Fence line tests – real fence lines or
    - Try and find to get the same soil/aspect/slope for different management → can't call it a fence line, call apples-apples = **paired comparison**
- Are we looking to see how much carbon the other managers sequester with different methods?
- OR what is the difference between HPG and CG?
- 80% of prize winners for conservation are HPG managers
- Management comparisons
    - Need to be 10 years or longer
- Paired comparison takes a lot of work to find
- As long as it's replicated it will hold up in peer-reviewed literature

- **Wendy**

- Glomalin and fungi
  - Plant soil
  - Roots
- Mycorrhizal diversity
  - Plant soil
  - Roots
- Phytate
  - Proxy for organic P
- Spore counts
  - Found that spores all tend to be different – the ratio between the good the bad and the ugly have completely reversed
- Water stable aggregates
  - Jeff Herricks aggregate stability measure – dip in water and see how much stays together - do in the field
- Penetration resistance – to measure compaction. Small variability in those measures
  - HPG less dense - higher soil C

- **Richard**
  - Estimate of bare ground
  - Total composition by species of fords and grasses and compiled into functional groups
  - Soil measurements including:
    - Bulk density
    - CEC
  - Fungi
  - Bacteria
  - Nematodes
    - Different functional groups and how they are in relation to each tells you the health of the ecosystem
    - In the visual test by Elaine's lab
    - In every trophic level and therefore good indicator species
  - ***Modeling***
    - Both Richard and Steve have STELLA models
    - Using model to triangulate
    - Point model turned into spatial model - simulate whether it predicts the distribution of results
    - Century only goes down 20mm.
    - Dayson (?)
    - SWAT hydrology models presume animals graze over whole landscape
      - Why developed spatial models
      - HPG protocols put into model - should come out similar to field measurements
  - Photographs
    - Where are the degradation points?
    - Shouldn't be any on HPG photos
    - Gives different scale of looking at the website
- Becca
  - Modeling -DAYCENT
  - Extrapolate through time
  - Different scenarios
  - Couple the systems

        - Meteorological Data – use data logger
            - Precipitation
            - Maximum air temperature
            - Soil temp/moisture
        - Carbon stocks of the whole ecosystem
            - Above/below ground
            - Manure/animal urine
                - Deposition rates
        - GHGs – N_2O, CH_4, CO_2
            - Measure through the laser or;
            - Through using a chamber
                - Limited how many places you could sample from
                - Cow proof!
                - Increasing soil C stocks could lead to increase N_2O emissions which is important to know for trade-offs
        - Management practices of the farm –
            - Inputs/outputs – LCA
                - May need a separate phase for LCA?
        - Snapshot strategy
            - Gives a good indication of what happens over time but its not an accrual rate
            - C often expressed per year - probably not linear - so if we're picking one point its not easy to say where we are in the process
            - Gives us idea of accretion rates
            - Could do older/newer farms?
                - i.e. with Army plots
    - Also a good place for modeling

- **Mike**
    - Microbial biomass
    - Community structure that is DNA based
    - Activity measure in addition to what Wendy's proposed
    - HOW
        - Measure some things in the lab and bring in collaborators to measure other things – work out the specifics with Wendy and David
        - Alternative is to send samples to Elaine Ingram's lab – but no personal experience. We're bumping against the glass ceiling of knowledge – I think we can do better than her methods
        - Lots we don't know – changing DNA between eukaryotes/archea - changing function
        - Smallest unit would be nine ranches in one county in Texas (eg) would be fine – scale up from there and price will scale too

- **Urs**
    - More dynamic in how you develop it – depends on primary question but only becomes evident after everything else is ironed out
    - Think about ramifications
    - Need to be clear on feedback effects

        - i.e. acceptability of new ideas determines management determines soil C
- Different phases
    - Socio-economic benefits
    - EIA: what's the proportion of farmers who'll adopt the best-management practices. What's the best C savings we'll get?
    - How would we encourage farmers to adopt?
        - Potential
- Is our goal to educate ranchers to
        - adopt?
- HM – is going to make ranchers more successful?
- Environmental impact statement
    - What 's the portion – who are willing to adopt
    - What extent are the land owners willing to change and adopt strategies?
    - Self assessment is apart of the strategy
- Need a general survey and how do you reach those people?
    - Mail surveys – technique for setting it up is extremely important – using that approach you can ask a series of questions but not too many
        - When aiming for a higher response rate – you need to be very careful about how you frame the question
        - Good sample size
        - Use Nadine Marshall's surveys
            - Resource dependency
        - Interview wives & husbands
            - Novel – how they perceive the quality of their life
        - Interview farmers who are in fence line tests
            - Do a broader survey
- Needs to be two phases or more
- Focus groups – one of each of the primary locations – grab their views of the problems
    - Build the survey off the focus group
- Get detailed information from the ranchers of the chosen sites
- Sample size will depend on the area
    - Size
    - Population are the dependents
- Ranching households within the county or sample size
- What are the fundamental questions
    - Why do you own the land?
    - Different attitude questions
        - Questions about fire
    - Demographic questions
    - Management practices
    - Knowledge
    - Attitudes
    - Risk perceptions
    - Social networks
- Finding farming households – STATSCo from USDA
    - All farming households in counties
    - Courthouse records
        - Cut-off of acreage – presume larger farms are grazing etc.

- Well-being assessment
- Uniqueness to this proposal
    - Social networks – knowledge and learning through this vehicle
        - Feed ecological elements into social assessment
        - What information do people need?
- Social Side
    - Their approaches to change
    - Looking at resource dependency
    - Speak to the wives to look at the well-being of their husbands?
    - How on the family level do they see the quality of their life?
    - Perceptions of climate change? (Yale)
    - Maybe use climate variability
    - Health indicators for the livestock (relevant to human health)
    - CLAs
    - Omega balances etc.
        - Creates pull- what's in it for me
    - Pesticide residues/antibiotics
        - i.e. elements we think are linked to human health
    - Novelty = difference between CG and HG
    - Beef piece – sustainable/health for humans
    - Consumer side as well
    - Lots of research on it – novelty of HPG in grass-fed scenario.
    - Health of ranchers – perceived
    - Verity group – all chemical free
        - Sociological value to knowing where their food comes from
        - CC views on grass-fed/corn fed beef

- **Jenny**
    - Socio-economic judgment of the grazing systems
    - Willingness to take up new methods
    - Ties all those in to the ecology side of things

Tuesday 14th January

General Proposal Points

- Richard brings the modeling to the table
    - Landscape analysis
        - Where are the degradation points and where they are not
    - Once you do HM there should be no real degradation points comparative to continuous grazing
- Drought conditions channel more carbon – Christine found with their research
- Get energy to the microbes
- Need to use 10-15 years – get with the Savory Institute and NRCS
- Understanding science instead of industry driven science
- Show the differences and use that as the starting point – citizen science
- Push to get a database up and publicly accessible – measurements of carbon
- Need to be sensitive to 'agenda-driven' claim

- Prices
    - 16S is $60 by the lab David's using

- STATISTICS
    - What does it take to get published?
    - Continuous measurements?

APPROACHES

AGREED UPON TO SAMPLE ONE METER DEEP – using the surface management to affect the carbon – make sure that point is clear when establishing the standards for why it is one meter deep sampling

- Grasslands - rangeland study
- Then can go right to crops
- Need to go interview the PepsiCo group
- Big pockets are starting to listen to us

Discussion to include Steve:

- Voluntary market because there is no compliance market and under social responsibility
- Higher productivity of the biomass
- We are looking to see what change can be made (differentials) – the one meter sampling can be influenced by land management
- Can we penetrate the clay type loams?
    - It's not been a problem but not sure it's worth it to go further than one meter –
- Metadata analysis needed
    - Set up a Dropbox
        - Within the Dropbox an Excel spreadsheet would be set-up for everyone to reference literature about HM/conventional grazing
- What are we calling it?
    - Multi Paddock Grazing
    - Adaptive Grazing
    - Strategic Grazing
    - Protective Grazing
    - Conservation
    - Environmental Benefits as the new language – Steve to send around the document that identifies what the lay person
    - We like a good story – we have to be rigorous
    - Smart Grazing
    - Get people excited!!
    - Regenerative grazing – doesn't matter what method but if its better than it was before – based on an outcome
    - Healthy Land – healthy soil – healthy crops
    - Regenerative Agriculture

- Who are we trying to communicate with?
    - The best phrase will communicate across the board
    - Start with the receiver and create the language around that
    - Is it adaptive or is it regenerative?
    -

Barriers/Strategies

- JL – Agro industry has a lot of say in the science that is conducted and if they feel threatened then it causes problem – we are off in left field – as the industries start to feel threatened with their bottom line – we need to confront – stakeholders become important
- DJ – Stays under the radar as part of his strategy – his approach is not accepted – he has to be careful because of his intake of soft money – he's funded his work
- RC – Be open and never hide anything – from the very beginning to invite the big guys to be apart of the conversation. Be tactical – be objective and use this opportunity as a start up venture – be transparent and stay below the radar – take the entrepreneurial approach - not to make a crisis – stay practical – let's plug into people we know are interested - John Hoffmeister would work with us he's faculty here at ASU. Former President of Shell America. Trying to find common ground. Can shape a policy conversation
- PB – have a point person – keep everyone in the loop – let's talk. Let's be transparent – big picture thinking – show the big companies what we are doing – showing – I'll be making films along the way
- BR – press talking points – how to speak to a journalist – may reference to communication specialist – personal barrier is being able to do the research in a temporary position as a post-doc – funding is a big issue – it's important to look at non-traditional funding
- SA – Need a communication strategy and plan – don't think centralizing does the movement any good – important to have a plan and message. Using GameChanger to open conversations – this conversation is about the WHOLE system and ground that conversation with key people – put a peer review group together
- JR – ten talking points available that we all agree on – pro active – talk about the efforts not against others – has dealt with threats from the EPA – get coordinated – be intentional – get some papers written – get a paper out by April – preparation also – just need to roll and no belly aching
- UK – maybe have a point person for press contacts but not necessarily for all communication or events – being able to get funding to do this work – resistance to supporting this work and the scientists and people don't understand systems approach – not a lot of support from an institutional level at Texas A&M – top down not successful
- WT – should we not mention the work? – RT – create commonality, talking points – coming from the bottom up – aligning with your needs – created a central hub for marketing carbon credits?
- UK – The way you word it is critical – learn to ask questions and not to attack anyone
- JR - Many of my friends work for Cargill, Monsanto – I don't want to hurt their livelihoods. I may not agree.
- RT – all your research has to be structured – how important the management and the science – policy driven and management science - our organization is very traditional and linked to agri-business – but we've got to round it by showing that 90% of conservation award winners – I'm researching why. So don't say stop using chemicals, say yes they use less but they probably can't use none until the management is fully established. Ask questions so other guy fills in the dots, you don't push it into his face.
- ML – THEM (stakeholders, customers) want more information than what is provided – publicity – have limited methods to publish their results
- JR – don't wait on the front line for a government grant
- PB - Cronkite have an award annually – when the award winner comes they visit and meet people

- RT - we have evidence that this is damaging towards that – what do you think?
- RC - take people on a journey where they come to the conclusion themselves
- RT - wording of papers makes conclusions and say 'this calls into question x, y, z'
- SA - 99% of people won't read the paper, so its how you push that out.
- SA - unique time, GMO being flipped over in the marketplace. Monsanto changing their business plan – similar to 'no smoking'. GM announced that they're going to remove all GMO from Cheerios – one product, one company. Positive response from consumers.
- SA - Soybean market said their market was china – we are not going to produce GMO soybeans. What's really happening is Monsanto is not getting where they thought they were getting to with GE/breeding drought resistance through GE → look at the soil! Key people in these organizations are starting to realize it's about soil health.
- WT - Labeling plays a role. Defeated labeling because people who were against it put GMO free, so now if you can't put that on your product your losing out.
- SA - but now, what were barriers 6 months ago are not any more. Shell – we should meet with Cargill etc. and say 'it's the system stupid'!
- RT - if we stick to rangelands right now, there's a strategy to handle those things later
- RC - CISCO – new grass fed beef transport system
- SA - idealistic – we're at a point where this conversation isn't about GMO/food security – it's about the whole system. We're closer to a tipping point.
- CJ - that's what I feel – this is the right time to be doing something.
- SA - need to be bold.
- PB - lots of criticism in Australia – why? Big businesses being threatened?
- CJ - Yes, projects have been stopped – funding gets cut. Letter from Dept. of Ag. And then they go back and delete all reference to you on their website. CSIRO have deleted all the biological references from their website, not just Christine's – i.e. all mycorrhizal fungi pages. 70% of CSIRO comes from Beijer Crop Science – 1998<. CSIRO say "we see no future in soil biology". Removed all references to Legacy P. Christine worked as extension worker with Dept. of X & X –CJ said salinity was a soil biology problem, they had just implemented tree planting campaign and so Christine got sacked.
- JR - threatening letters because talked about grass-finished beef left outside. Bosses have been supportive. People saying we're hurting the animals to the press. EPA has been out. Need coordination, commodity groups have somebody to do the science and PR arm. Have data that can be crunched out in paper by April (LCA) – strength in this group – let's coordinate and prepare.
- SA - is it worth putting our compendium together – use our group as a first level of peer-review. Towards setting up a journal/society.
- RT - don't think we need a new journal but hugely important to have the ability to bounce off each other
- UK - Solutions journal (Robert Constanza). Big effort and may not be best use of time.
- WT - opposite response to all of you – hired by the farmers, funded by farmers, then went to Senate and said we want you to make a position for her. Probably main difference is I'm bottom up –
- SOCIAL SCIENCE – having us do conversations with farmers could be a way of building that bottom-up demand.
- PB - curious to see how Shell thing goes = big ally. McDonalds. Boeing. Need to show to big companies that we're necessary.
- WT - lots of groups get together and form own institutions. What if we created a central hub for marketing carbon credits? How much research would that support?
- SA - already out there, Ecosystem Marketplace. Run by NGOs/scientists
- JH - Emails, categories of power relations upset people.

- UK - being able to get funding – funders don't understand systems perspective.
- RT - word it well from a scientific angle. Have counter hypotheses. Stick to good science and you'll be ok.
- UK - but NRCS are different to NSF. There's no question that some publications won't be picked up by top journals – not sexy enough. Texas A&M 10 m contract – need funding to do the research in the summer. Not a lot of support for management related things, dept. strength is merging science with management but changing perspective – not interacting with farmers any more and viewed as becoming irrelevant. Need ground up perspective.
- RT - leading conservation ranchers have achieved something differently and I'm studying why. Quiet elements from Briskey etc. just blocking, suspect that goes into the funding arena too. Reductionist science bias preventing action on the ground – asked to write white paper by higher levels, who now want to fund it and put it into Texas legislature in 2015. Been looked after.
- RR - barrier is that I'm a postdoc and its temporary, hard to build research program. Funding across the board is just harder and harder to get. Have to have non-risky science to promote tenure. Non-traditional sources of funding are important. NSF/NRCA funding always rejected, but competitive, and management focus isn't appealing to NSF.
- JR - Small Farm grants – USDA
- CJ - disconnect between management and science – National Rangelands Policy in Australia is to remove livestock. Can get carbon credits for removing livestock, increase woody vegetation and carbon stored.
- ML - customers want to know about soil biology, but we're at the maximum the science can tell them – that's the biggest challenge. "Where's my dipstick". Everything we're doing will advance that. Foil for Wendy's discussion – people who are responsive are a small proportion of the rancher population. Plus we're not selling stuff- we're going to compete with those who are. Some of big agribusiness companies may be embracing soil biology, but it'll be with the intention to create another product to sell. Some may be valid, some won't be.
- PB - test of products?
- ML - very little peer-reviewed lit because ARS told not to study that.
- WT - will be offering product testing. Monsanto's buying up biological companies but with a limited scope.
- ML - lot of confusion about these products – management creates the environment to grow indigenous plants that benefit soil C – no magic potion. There is a certain application for amendments but the bigger question is how can we create the environment where it's present already.
- SA - soil pro-biotics as Montsanto's next move – **Noah Fryer, Science paper.** Microbe profiles of prairie soils.
- JR - GMO – cherry trees resistant to bug, spliced gene – so have to be careful going down that road. Don't take it on.
- 80% of time grant writer. Always going to be 50% IDC that gov will take – need a lot of money to fund 12 people. Don't wait on a federal grant line to come to us. We write what we want do and go to NGOS. Need $10 million to cover all.
- ASU Foundation – Foundation money is open source. Shell money runs through ASUF not OKED – only 2%.
- UK - depends on source of funding

Funding Strategy

- SA – waste of time chasing NSF – doesn't align the federal funding strategy – work with NGO's and corporate America and gain their interest
    - Blue Moon Fund
    - Caterpillar foundation
    - Try an ASU donor's forum – help us put a plan together – and they will give us a short list – PB – write a report from this Confab and get this to Crow
        - Clearinghouse for philanthropic dollars - make an appointment – ASU/MSU/Harvard etc.
    - A good link to the Walton Family Foundation
- Who else is doing what we are doing
- Who else can we convince – maybe John Deere?
- Howard G. Buffett – top of the list
    - Be careful with Buffett- UK and RT suggests to be careful
    - Just find out where he is at – AG research or livestock research – understand his passions/commitments
- Bring Tim LaSalle – SA – maybe bring him in as an advisor (PB)?
- RR – feels that we shouldn't discount NSF and also continue to go after any available funds
- WT – to share the list of celebrities that have interest in sustainability/microbial efforts
- Soil carbon concert
    - Soil Aid!!
- Ed Norton Junior
    - Father was with TNC
    - Now with TPG as token caretaker of the world
- Biodiversity ambassador with the UN
- Knows about CN – would be a great voice
    - Disney/Pixar

Next Steps

- Create a more specific document – bring together all the points to refine
- CCEMC – managed by a company in Cleveland – SA shared a one paragraph of the work
- SA – the proposal written before nails it and he feels we need to add
- PB – feels there is a benefit to doing the whole picture story
- RC – make a map of potential funding sources – RC to gather that data
- RR – Build a better graphic – needs to show linkages and establish specific component
    - UK – tail the graphic to this
        - Then get to a graphic designer here at ASU
        - SA – can also talk to his graphic people
    - PB – feed back the wish list to what everyone wants to do
    - PB – wants a budget
        - Cost of one location and then scale it up
        - Look at four at this stage
        - Develop a budget per location?
    - Everybody work on your cost per unit (3)
        - 3 CG's light
        - 3 CG's heavy
        - 3 HPG

- SA – brief description (hypotheses) with budget breakdown – has experienced spreadsheet guys that can pull this together
- PB – give bullet points of the goals
    - The why's
    - The how's
    - Focused section
        - Introduce strata
    - Give everyone wish lists and then can pull together and remove any overlay