Some Linkages

1-8; 10; 14; 15; 18; 25; and 28!
(See Appendix A.1, page 14)

Achieving Resilient Forests Through Effective Biomass Uses[1]
(A "Thinkpiece")

Executive Summary. The intent of this paper is to provide some thoughts that can lead to a more cohesive, comprehensive investment strategy that advances higher value biomass uses as a means to help create more resilient forests across our country. There are three basic goals:

1. Address critical forest restoration needs to protect lives and property from major disturbances across the country.
2. Ensure America's forest ecosystems along a complex rural to urban land gradient remain healthy, sustainable and more resilient.
3. Diversify America's economy with targeted investments through a wide-range of commercial products.

A five year investment strategy is outlined (see Table 4, page 12) with an *average annual* total public-private investment of $82 million; $51 million in year one (designated as 2015). Appendix A.3, page 16, provides an action summary.

What's Included?

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Achieving resilient forests through effective biomass uses calls for a true public-private partnership to share investments, leadership and governance. The U.S. Endowment for Forestry and Communities is a fundamental piece of this partnership; there are others. This partnership can and must be expanded.

Forest Service leaders have consistently concluded that we shall, "…help create healthy, sustainable forests that are more resilient to disturbances so the linkage between environmental health and community stability can be more fully realized." We do this *through* a suite of restorative actions to our trees, forests and forest ecosystems along a complex rural to urban land gradient. Now is the time for a call to action as a "campaign of our campaign." A well-coordinated partnership that bands together, shares resources and avoids duplication will ensure a successful campaign that improves our forests and the economy and protects lives and property. An "Incident Commander" to ensure coordination and deployment should be considered.

> "…Our goal is to help create healthy, sustainable forests that are more resilient to disturbances so the linkage between environmental health and community stability can be more fully realized."

Introduction. A changing climate represents one of the greatest challenges we face to the management of forests and grasslands over the next century. Today, we grow about twice as much wood as we use. Our forests are getting over-crowded and stressed due, in part, to this changing climate. Hazardous fuels are increasing. Hazardous fuels lead to catastrophic fires. We have seen the devastating impacts of these fires with lives lost; homes destroyed; and, millions of acres blackened. The cost of fighting these catastrophic wildfires is enormous -- sometimes

[1] Prepared by Michael T. Rains, Director, Northern Research Station and Forest Products Laboratory, February 8, 2015 (revised).

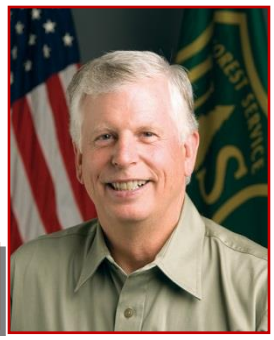
exceeding $1 million per hour. We will undoubtedly exceed $3 billion in fire suppression costs in 2014 and each year thereafter is projected to be even higher.

Forests cover about one-third of the United States – about 885 million acres, including the 138 million acres of urban forests. The Forest Service has some type of stewardship role on about 80 percent of these forests and thus has a unique role and responsibility to help address the climate change threat and create healthy, sustainable forests that are more resilient to disturbances so the linkage between environmental health and community stability can be more fully realized. America is looking to the Forest Service for help.

Finding high-value, high-volume economically-viable uses for forest biomass from hazardous fuels reduction and forest restoration activities has been identified by Forest Service land managers as one of the most important barriers to overcome to help ensure our forest are more resilient to disturbances.[2]

Restorative Actions to our Forests. The current Forest Service Chief, within his five (5) *Focus Areas*, has proclaimed "Forest Restoration" as a critical component of the agency's mission.

1. Enhanced safety.
2. Creating a culture of inclusion.
3. **Forest restoration.**
4. Fire management.
5. Community engagement.



Thomas Tidwell
17th Chief (2009 - Present)

This proclamation is not new. Other recent Chiefs have also declared the need for forest restoration. For example, the 15th Chief, Dale Bosworth declared that the Forest Service, under his leadership, should concentrate on disturbance areas that significantly threaten achieving long-term conservation outcomes. Chief Bosworth termed these the "…Four Threats."

1. Uncontrolled fires.
2. Destructive invasive species.
3. Irresponsible Use of the National Forests (with an immediate emphasis of controlling the use of off-highway vehicles).
4. Loss of open space.

Dale N. Bosworth
15th Chief (2001-2007)

Additionally, recall the "…Natural Resources Agenda" from our 14th Chief, Mike Dombeck and his focus:

1. Watershed Health and Restoration.
2. Development of a Long-Term Forest Roads Policy.
3. Sustainable Forest Management.
4. Recreation.

Michael P. Dombeck
14th Chief (1997-2001)

[2] Sundstrom, Shiloh; Nielsen-Pincus, Max; Moseley, Cassandra; and McCaffery, Sarah; "Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Mangers"; Journal of Forestry, January/February 2012; p. 16 – 24.

The primary point is: Forest Service leaders have consistently concluded that we shall, "…help create healthy, sustainable forests that are more resilient to disturbances so the linkage between environmental health and community stability can be more fully realized." We do this *through* a suite of restorative actions to our trees, forests and forest ecosystems along a complex rural to urban land gradient. Now is the time for a call to action as a "campaign of our campaign." A well-coordinated partnership that bands together, shares resources and avoids duplication will ensure a successful campaign that improves our forests and the economy and protects lives and property.

> "…Biomass uses -- by creating high-value, high-volume markets -- create cost-effective ways to enable enough hazardous fuels to be removed from America's forests so wildfires remain smaller and begin again to be a tool for improved forest health as opposed to destructive behemoths that destroy lives, communities and landscapes."

Biomass Uses. Biomass uses – for example, wood-based nanotechnology; Green Building Construction, including advanced composites; and, wood for energy -- offer pragmatic market-based solutions to help our forests become more resilient to disturbances such as wide-spread catastrophic fire loss. Biomass uses are outcomes from restorative actions.

It is estimated that a strong, *well-established* program in cost-effective biomass uses could create high-value markets from low-value wood (e.g., hazardous fuels) that could reasonably help restore up to 19 million forested-acres[3] annually (see Table 1). About one-half of the nation's 885 million acres of forestland currently requires some type of restorative action. This pace and scale of restoration could reduce future fire suppression costs in the range of 12-15 percent -- up to about $240 to $400 million annually. **Simply put**: it makes good economic sense to aggressively invest in biomass uses to help achieve more resilient forests throughout the rural to urban land gradient.

Table 1. Market Opportunities to Increase Wood Demand and Acres of Annual Forest Restoration

Market opportunity (Biomass Uses)	Wood Requirements (MM Dry Tons/Yr.)	Forest Area Treated Assuming Estimated Wood Removal Rates From Restoration Treatments (MM Acres/Yr.)
Wood-based Nanotechnology	25-100	**Low to Moderate:** 5-7 **Moderate to High:** 8-12 **High:** 13-20
Green building construction	16	**Overall:** 2
Biomass for energy	13-20	**Low to Moderate:** 1-2 **Moderate to High:** 3-4 **High:** 4-5
Totals[4]	**54-136**	**Low to Moderate: 8-11** **Moderate to High: 13-19** **High: 20-27**

[3] All lands, all ownerships.
[4] Not limited to public lands. Restoration actions limited to only to the National Forests range from about 1.5 to 9.0 million acres per year.

A Logic Sequence. In terms of healthy, sustainable forests that are more resilient to disturbances, climate change is the primary linking-pin function. And, a critical restorative action in order to achieve more resilient forests is "…effective biomass uses through high value, high volume markets." Accordingly, our "Logic Sequence" to address forest resiliency in the face of a changing climate[5] would be:

Increased Forest Resiliency *Logic Sequence*

- **A Changing Climate:**
  - Forests More Resilient to Disturbances:
    a. Restorative Actions:
      - Hazardous Fuels (or low value wood) Removal:
        - Cost-Effective Biomass Uses Through High Value Markets (Expansion and Development):
          - Wood-Based Nanotechnology
          - Green Building Construction
          - Biomass for Energy

This "Logic Sequence" is important to quickly visualize the driving forces and primary program components necessary to achieve resilient forests through effective biomass uses. Appendix A.1, page 14, illustrates a more detailed "Graphic Organizer" to show a wide array of possible connections. Appendix A.2, page 15, provides additional detail for three example biomass uses. There are other biomass uses as a result of restorative actions.

Partnerships. To address achieving resilient forests through effective biomass uses, a cohesive, comprehensive public-private partnership must be deployed. Currently, the USDA Forest Service and the U.S. Endowment for Forestry and Communities co-lead a formal partnership. Other partners active in biomass uses are being asked to join the partnership and form a coalition to ensure success. The following list of federal and non-federal partners, while not all-inclusive, represents the foundation of this **A**ccelerated **F**orest **R**estoration **C**oalition (AFRC). The National Partnership Office of the Forest Service can play a key role in securing an optimal public-private partnership. The current partnership can and must be expanded:

Federal Partners in Biomass Uses

Department of Agriculture (USDA); Department of Homeland Security; Department of Interior; Department of Defense; Department of Energy; Department of Commerce; Environmental Protection Agency (EPA); National Science Foundation; National Institute of Occupational Safety; National Institute for Science and Technology

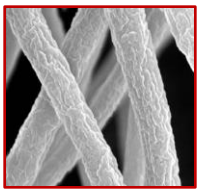
Non-Federal Partners in Biomass Uses

WoodWorks; "Agenda 2020 Technology Alliance" (forest industry); The Nature Conservancy; Penn State University; Purdue University; Georgia Tech; Oregon State University; University of Tennessee; North Carolina State University; University of Maine; NGO's (wood architectural firms); the National Forest Foundation; state and local governments; a wide-range of product manufacturers (e.g., auto; medical; IT)

[5] http://nca2014.globalchange.gov/

The AFRC provides a solid way to influence the aggressive program needed to successfully commercialize innovative new technology platforms and new products while accelerating forest restoration across America. A science committee, advancing the latest innovations, would provide input into the AFRC. This science committee has already been established.

Nanotechnology and Applications. Wood-based nanotechnology, a biomass use example, is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers[6], where unique material properties enable novel, high performance applications. Wood-based nanotechnology offers a revolutionary technology to create new jobs and strengthen America's forest-based economy through industrial development and expansion as well as providing means to enable forests to remain healthy and sustainable through accelerated restoration.



Wood-based nanotechnology applications include: packaging barrier coatings; printing paper coatings; structural composite panels for construction; flexible electronic displays; printed electronics; lightweight structural and non-structural panels and parts for aerospace; automotive applications; and, a host of industrial tools and consumer products.

Major companies and organizations including, Lockheed Martin; Pepsico; IBM; Hyundai-Kia Motor Company; Georgia Pacific; Ecolab; 3M; Ford Motor Company; General Motors; DuPont; Hewlett Packard; Procter & Gamble; and, Kimberly Clark have voiced interest in using wood-based nanomaterials in their product lines.

> "…Wood-based nanotechnology offers a revolutionary technology to create new jobs and help restore America's economy through industrial development and expansion. Wood, or cellulose, manufactured at the smallest possible level is a high-valued material that enables products to be lighter and stronger; have less embodied energy; and, come from a renewable resource."

In terms of economic impact, it is projected that cellulosic nanomaterial utilization could have a market penetration as high as 3-4 percent across target markets building to over 24 million tons of demand. This potential 24 million tons of demand could drive as many as 224,000 jobs and a potential GDP final product value of over $100 billion in the United States -- as projected by the National Nanotechnology Initiative (NNI) and National Science Foundation study.

Table 2. Jobs and GDP Projections for Wood-based Nanotechnology

Market Penetration	Production Tons	Direct Jobs	Manufacturing Jobs	GDP
1%	8 Million	16,000	64,000	$10 Billion
3%	24 Million	74,000	224,000	$100 Billion (Higher Value Products)

Sources: Future Markets, Inc.; "Nanocellulose: A Technology and Market Study, 2012; www.futuremarketsinc.com; Wegner, L. A, "Materials in the Economy: Material Flows, Scarcity and the Environment", U.S. Geological Survey Circular 1221, 2002, 34p.

[6] 1 nanometer = 0.0000000393 inches (a very small unit!).

While perhaps not as dramatic as the impacts of wood-based nanotechnology, we expect the economic impacts of other biomass uses that create high value markets from low value wood will also help drive accelerated forest restorations efforts if adequate investments in science, technology transfer and management are provided for. Green Building Construction, for example, through advanced composites using low value wood, offers an opportunity to revolutionize some aspects of commercial building construction.

Investments. The following more fully describes the investment requirements[7] for three examples of biomass uses that will create high value markets from low value wood as a way to ensure more resilient forests:

1. **Wood-based Nanotechnology.** Investments by the Forest Service and industry in wood-based nanotechnology research, development and deployment has the potential to increase demand for pulpwood type material by 25 million dry tons per year with moderate success in nanomaterial applications to 100 million dry tons with exceptionally high success. These wood amounts would be required to produce 8 million and 16 million dry tons of wood-based nano materials, respectively ("Agenda 2020 Technology Alliance 2012"). These nanomaterials will be used to enhance the properties and performance of up to 800 million tons of nonfuel, non-aggregate materials produced each year. Applications include, for example, automobile panels, packaging, electronics, and industrial composites.

   There is a high likelihood that research in wood-based nanotechnology will result in commercial production and applications that will demand about 25 million dry tons of pulpwood type material per year to produce 8 million tons of nanomaterials by 2020. At a higher risk level and sufficient levels of investments there could be production of 16 million tons nanomaterials which would require 100 million dry tons of wood. This pulpwood type material could come from any forest landowner source.

   Using estimated wood removal rates per acre for forest restoration treatments on the National Forests in the West demand for 25 million dry tons of wood would require treatment of 3-5 million acres and demand for 100 million dry tons would require treatment of 13 to 20 million acres. If we assume somewhat less than the highest level of risk and return, and only a portion of wood coming from forest health treatments acres then increased wood demand for nanomaterials could support treatment of about 10 million acres of forest health treatments.

[7] Investments can be a combination of federal and nonfederal investments. Amounts illustrated are total public-private investment requirements for science, technology and targeted management actions. In 2017, the "Wood-based nanotechnology" row includes seed funds for facility processing construction that addresses *all* biomass uses: $20 million in 2017; $45 million in 2018; and $55 million in 2019. Facilities could be used for processing cellulose nanomaterials; advanced wood for energy (*Torrefaction*); Cross Laminated Timber (CLT); etc.

2. **Green Building Construction.** Investments by the Forest Service and industry in green building science and applications can increase annual wood used in constructing low rise nonresidential buildings by 7 billion board feet (Wood Products Council). This this would require about 16 million dry tons per year of sawlog material. With support from Forest Service forest treatment programs and wood supply contracting, a significant portion of this increased wood use could be supplied to sawmills from removal of low-valued wood which would reduce fire hazard.

   Wood has documented advantages as a green building material however the market share for wood in commercial buildings, such as schools and strip malls, has been small compared with that for other materials. Today, a growing awareness of environmental sustainability and a desire on the part of consumers for quality building materials at competitive prices could boost markets for wood products. To capitalize on this growing awareness and demand Forest Service investments are needed in:

   - Research and development needed to provide life cycle impact information for wood construction products,
   - Technology transfer efforts on carbon mitigation and other environmental benefits of using wood in nonresidential building done in coordination with U.S. and Canadian companies aimed at design and building professionals,
   - Technology transfer in the form of specific demonstration products in coordination with industry, and
   - Development, application and technology transfer of cross laminated timber for use in nonresidential building construction.

   Within about 5 years there is a very high likelihood that wood demand to construct nonresidential buildings could increase by 7 billion board feet or 16 million dry tons. This wood could come from any forest landowner source. Using estimated wood removal rates per acre for forest restoration treatments on the National Forests in the West demand for 16 million dry tons of wood would require treatment of 2.1 million acres. This treated area could also, in some areas, be providing pulpwood type material for nanomaterials if nanomaterial plants are located near sawmills. With investments in research, development and deployment in nanotechnology and green building it is likely there would be a combined increase in wood demand for nanomaterials and for construction materials for nonresidential buildings that could reasonably support forest restoration treatments of 10-12 million acres per year.

3. **Biomass for Energy.** In order to attain the most value from acres treated to provide wood for construction and nanomaterials investments by the Forest Service and wood energy users are needed to support demand for biomass from forest restoration treatments (that also provide wood for construction and nanomaterials). Woody biomass feedstock necessary for conversion to a bioenergy product lies somewhere between pulp grade and hog fuel both in terms of wood quality and value. The three emerging and/or rapidly developing technologies that will consume the bulk of the available woody biomass feedstocks are liquid transportation fuels, pelletization, and co-firing to generate electricity. The acres providing wood for construction and nanomaterials could also provide 13-20 million dry tons of wood for energy.

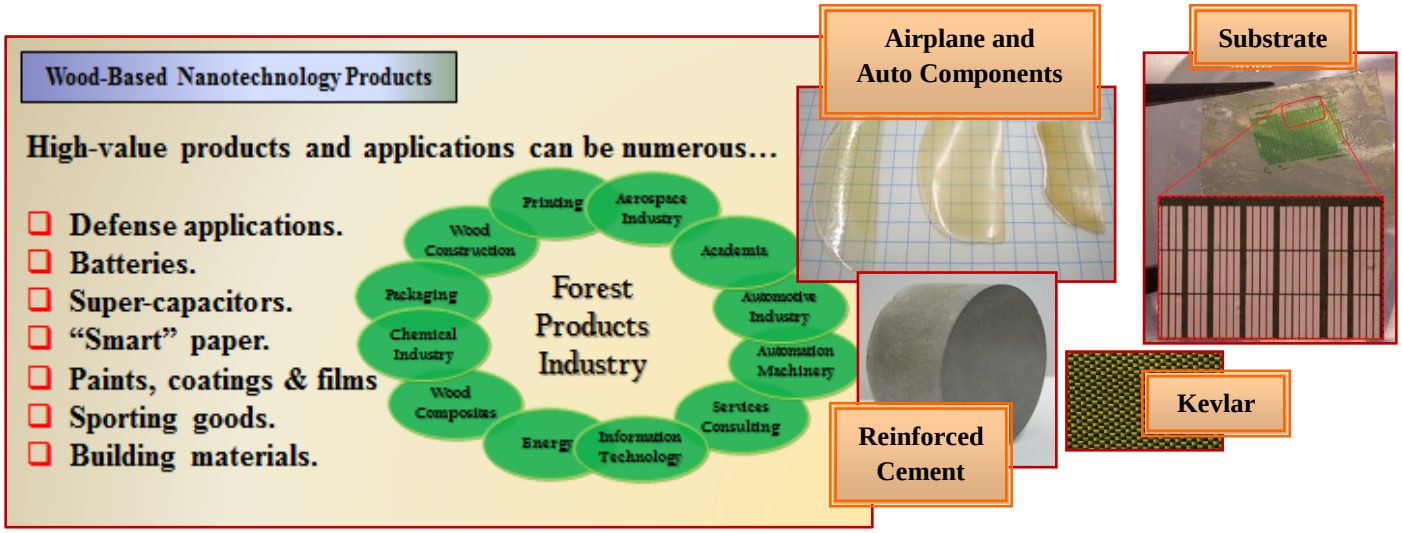


Table 3. Investments in Biomass Uses to Create Resilient Forests Through Restorative Actions

Market opportunity	Wood Requirements (MM Dry Tons/Yr.)	Forest Area Treated Assuming Estimated Wood Removal Rates From Restoration Treatments (MM Acres/Yr.)	Increased Funding Requirements[8] ($ MM/Yr.)
Wood-based Nanotechnology	25-100	**Low to Moderate:** 5-7 **Moderate to High:** 8-12 **High:** 13-20	2015 - $11[9] 2016 - $15 2017 - $35 2018 - $60 2019-2023 - $70
Green building construction	16	**Overall:** 2	2015 - $6 2016 - $8 2017 - $8 2018 - $8 2019-2023 - $8
Biomass for energy	13-20	**Low to Moderate:** 1-2 **Moderate to High:** 3-4 **High:** 4-5	2015 - $5 2016 - $6 2017 - $6 2018 - $6 2019-2023 - $6
Totals[10]	**54-136**	**Low to Moderate: 8-11** **Moderate to High: 13-19** **High: 20-27**	**Average (M-H):** 2015 - $22 2016 - $29 2017 - $49 2018 - $74 2019-2023 - $84

[8] Investment levels to achieve "moderate to high" impact levels.
[9] Includes $6 million to bring the Forest Products Laboratory back up to a "base" level of funding and $5 million to advance science and technology transfer in Wood-based nanotechnology.
[10] Not limited to public lands. Restoration actions limited to National Forests are estimated to range from about 1.5 to 9.0 million acres per year.

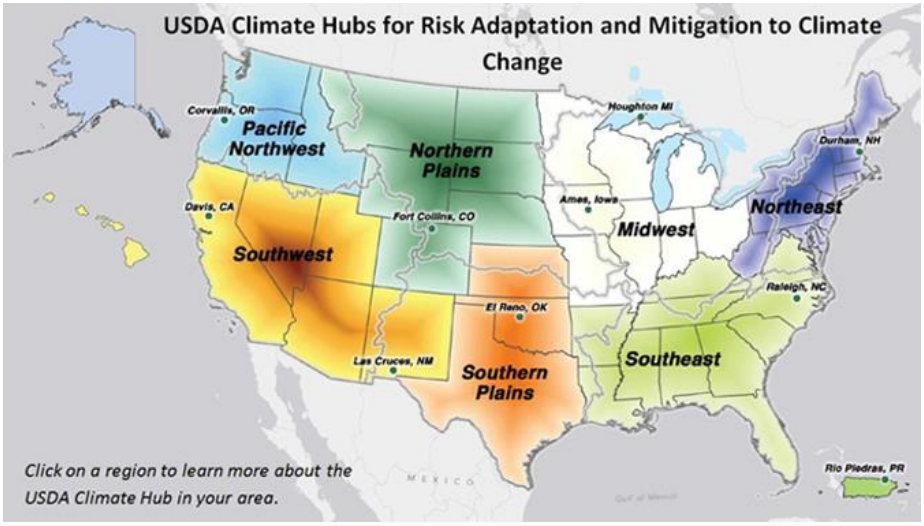
The investments shown in Table 3, page 8, can be a combination of federal and nonfederal investments. Amounts illustrated are total public-private investment requirements for science, technology and targeted management actions. In 2017, the "Wood-based nanotechnology" row includes seed funds for facility processing construction that addresses *all* biomass uses: $20 million in 2017; $45 million in 2018; and $55 million in 2019. Facilities could be used, for example, for processing cellulose nanomaterials; advanced wood for energy (*Torrefaction*); Cross Laminated Timber (CLT); etc.

Beginning in 2015, the $11 million shown for "Wood-based nanotechnology" includes $6 million to bring the Forest Products Laboratory back up to a "base" level of funding (see "Forest Products Laboratory", page 11) and $5 million to advance science and technology transfer in Wood-based nanotechnology. The additional $5 million would be used for, but not limited to, activities in program management; characterization of nanocellulosic materials; pre-competitive nanocellulosic materials production and processing technologies; and, high priority, re-competitive applications development.

Similar investment detail is available for the other biomass uses.

USDA Climate Change "Hubs" (Regional Hubs for Risk Adaptation and Mitigation). As stated before in this paper, a changing climate is solidly linked to forest health and our ability to have forests that are more resilient to disturbances so the linkage between environmental health and community stability can be more fully realized. To this end, USDA has deployed a set of Climate Change *Hubs.* The primary goal of these "Risk Adaptation and Mitigation to Climate Change" *Hubs* is to develop and disseminate science-based, regional climate change information, assessments, and tools to help farmers, ranchers, forest landowners, resource managers, and tribes in the geographic regions make climate-informed land management decisions. Simply put, the goal is to create and deliver credible information and tools to the people who need them in forms they can use. A second critical goal is to work with these people to identify gaps in the available information and tools and then encourage the science and outreach communities to fill these gaps.

Fully operational Climate Change *Hubs* will be a critical part of our ability to help create healthy, sustainable forests that are more resilient to disturbances to link environmental health with community stability.[11] It is estimated that an annual investment of about $15 million is required to ensure the goals of the Climate Change *Hubs* are realized.



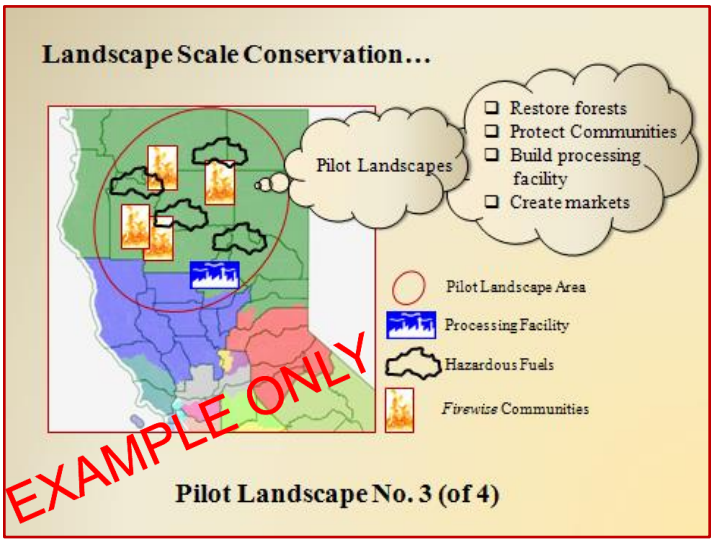
[11] http://www.usda.gov/oce/climate_change/regional_hubs.htm

Wood is Good *Literacy*. A critical feature of advancing the use of wood to improve people's lives is communication; education; market expansion and development; and, technology transfer. Units such as WoodWorks™[12]; the Forest Products Marketing Unit (FPMU) at the Forest Products Laboratory; and, the Wood Education and Resource Center (WERC) will convey the importance of biomass use to creating healthy, sustainable forests; improving the economy and adding new jobs.

The FPMU has been established to help ensure healthy, sustainable forests that are more resilient to disturbances by creating high value, high volume markets from woody biomass. The FPMU achieves success through a wide-range of cooperative working relationships, both internally and externally that strengthen technology development and applications across agency mission areas. The actions of the FPMU result in new and expanded utilization and marketing opportunities for wood products and residues. Actions are applicable across all landscapes along a complex rural to urban gradient including public, private and tribal lands and communities. While the FPMU is organizationally assigned to the Forest Products Laboratory, the FPMU has a national scope. Accordingly, to ensure an optimal program direction, broad oversight and guidance is provided by the three Deputy Chiefs of the land and science mission areas – State and Private Forestry; National Forest System; and, Research and Development. It is estimated that an annual investment of about $1 million for WoodWorks™; $3 million for the FPMU (including a new science component); and, $4 million for WERC[13] is required to ensure the concepts of *Wood is Good* are effectively advanced. Detailed budgets are available.

A Landscape Scale Approach. On August 14, 2009 in Seattle, Washington, USDA Secretary Tom Vilsack delivered a speech outlining his vision for America's forests. This national vision is characterized by an "all lands" approach to forest and rangeland stewardship and focused on programs designed to accentuate community health and wealth, such as clean and abundant water and protecting communities from wildfires.

Secretary Vilsack founded his vision on the guiding principle of conservation defined by the first Chief of the Forest Service, Gifford Pinchot. That is, we shall address the stewardship – management, protection and wise use – of our natural resources for the "the greatest good of the greatest number in the long run." A healthy, prosperous America depends on healthy forests because forests help generate wealth and enable community stability through economic opportunity. The vision includes the importance of land restoration to ensure natural resource sustainability, including adequate, clean water supplies maintained and filtered



[12] http://www.woodworks.org/about-woodworks/

[13] We believe the WERC, currently assigned to the Northeastern Area, State and Private Forestry, has the potential to be national in scope and a critical component in the advancement of biomass uses across the rural to urban land gradient. See http://www.na.fs.fed.us/werc/

from trees, forests and forest ecosystems. Climate change is stressing our forests, exacerbating the destructive effects of fire, disease and insects. The vision calls for shared leadership, taking an all-lands approach to conservation through a larger landscape scale view. Expanded stewardship makes it possible for public and private landowners to sustain America's forests and working landscapes.

Using the vision described by the Secretary as a *North Star*, four (4) pilot forest landscapes should be identified immediately across America to:

- Accelerate forest restoration by emphasizing a wide-range of biomass uses (within a designated landscape in order to focus investments).
- Create a system of integrated *Firewise* communities within these landscapes to protect people and their property.
- Expand markets and applications.
- Develop processing facility (s) within or adjacent to the pilot landscapes. This will require additional funds from USDA Rural Development and other private sources.
- Create new jobs.
- Conduct detailed science-based resource analysis, including wood supply and use; impact of fuel wood reduction on wildland fires; market expansion and development opportunities.
- Determine impact of restorative activities on watershed productivity.
- Design a suite of science-based Best Management Practices to transfer to other geographical areas.
- Link actions to the USDA Climate Change *Hubs.*

The pilot forest landscape can be existing geographic area designation (for example, a "Collaborative Forest Landscape Restoration" area) whereby investments can be focused and the results of these investments can be deployed in other nondesignated areas. In essence, the pilot landscapes are *Learning Laboratories* and are critical to the success of this campaign. It is estimated that an initial minimum investment of about $6 million -- $1.5 million of each pilot landscape – will be required to begin to meet the activities listed above. This investment will increase to about $9 million per designated landscape beginning in year three (2017) of the five year period.

Forest Products Laboratory. The section on "A Path Forward" (page 12) provides item No. 4: "…Innovations in science and technology transfer." Within the Forest Service, the Forest Products Laboratory (FPL) in Madison, WI provides a significant national program-focus for innovative science and technology transfer in biomass uses. To achieve overall success in creating more resilient forests, it will be important that the scientific capacity of this iconic unit be maintained. The current 2014 program is about $6 million less than "base" needs; about $9 million less than "base" needs in the proposed 2015 budget. See http://www.fpl.fs.fed.us/

FPL's Mission and Vision. "…To promote healthy forests and forest-based economies through the efficient, sustainable use of our wood resources. Through innovation at the highest level, we enhance the quality of life of all Americans."

The Overall Budget. The following is the overall additional investment requirements[14] to help"…achieve resilient forests through effective biomass uses." See also Appendix A.3, page 16:

Table 4. Overall Required Total Investments (Additional) from 2015-2019.

Program Component	2015 ($MM)	2016[15] ($MM)	2017 ($MM)	2018 ($MM)	2019 ($MM)	Totals ($MM)
Wood-based nanotechnology	$11	$15	$35	$60	$70	$191
Green Building Construction	6	8	8	8	8	38
Biomass for energy	5	6	6	6	6	29
USDA Climate Change *Hubs*	15	15	15	15	15	75
Wood is Good *Literacy*:						
Woodworks™	1	1	1	1	1	5
FPMU[16]	3	3	3	3	3	15
WERC[17]	4	4	4	4	4	20
Pilot Landscapes	6	6	9	9	9	39
Totals	**+$51**	**+$58**	**+$81**	**+$106**	**+$116**	**+$412**

A Path Forward. Clearly, achieving resilient forests through effective biomass uses is a Forest Service-wide initiative under the broad guidance of USDA and includes multiple partners. Depending on whom we are; the geographic region we are within; and, the social-economic climate in that region, a specific "program focus" will understandably surface. While we want to allow for regional flexibility, overall national consistency is still important. The following will be essential guides to our success:

1. A *Corporate* approach; close coordination.
2. Collaboration with a wide-range of partners.
3. Focused investments.
4. Timely, accurate resource information.
5. Innovations in science and technology transfer.
6. Forecasting capability to predict and enable "break through markets" for biomass uses.
7. Increased technical capacity in fuel wood removals and market development.
8. Share leadership (taking an all-lands approach to conservation through a larger landscape scale view).
9. Patience (make the work a "campaign of our campaign").

[14] Investments can be a combination of federal and nonfederal investments. Amounts illustrated are total public-private investment requirements for science, technology and targeted management actions. In 2017, the "Wood-based nanotechnology" row includes seed funds for facility processing construction that addresses *all* biomass uses: $20 million in 2017; $45 million in 2018; and $55 million in 2019. Facilities could be used for processing cellulose nanomaterials; advanced wood for energy (*Torrefaction*); Cross Laminated Timber (CLT); etc.

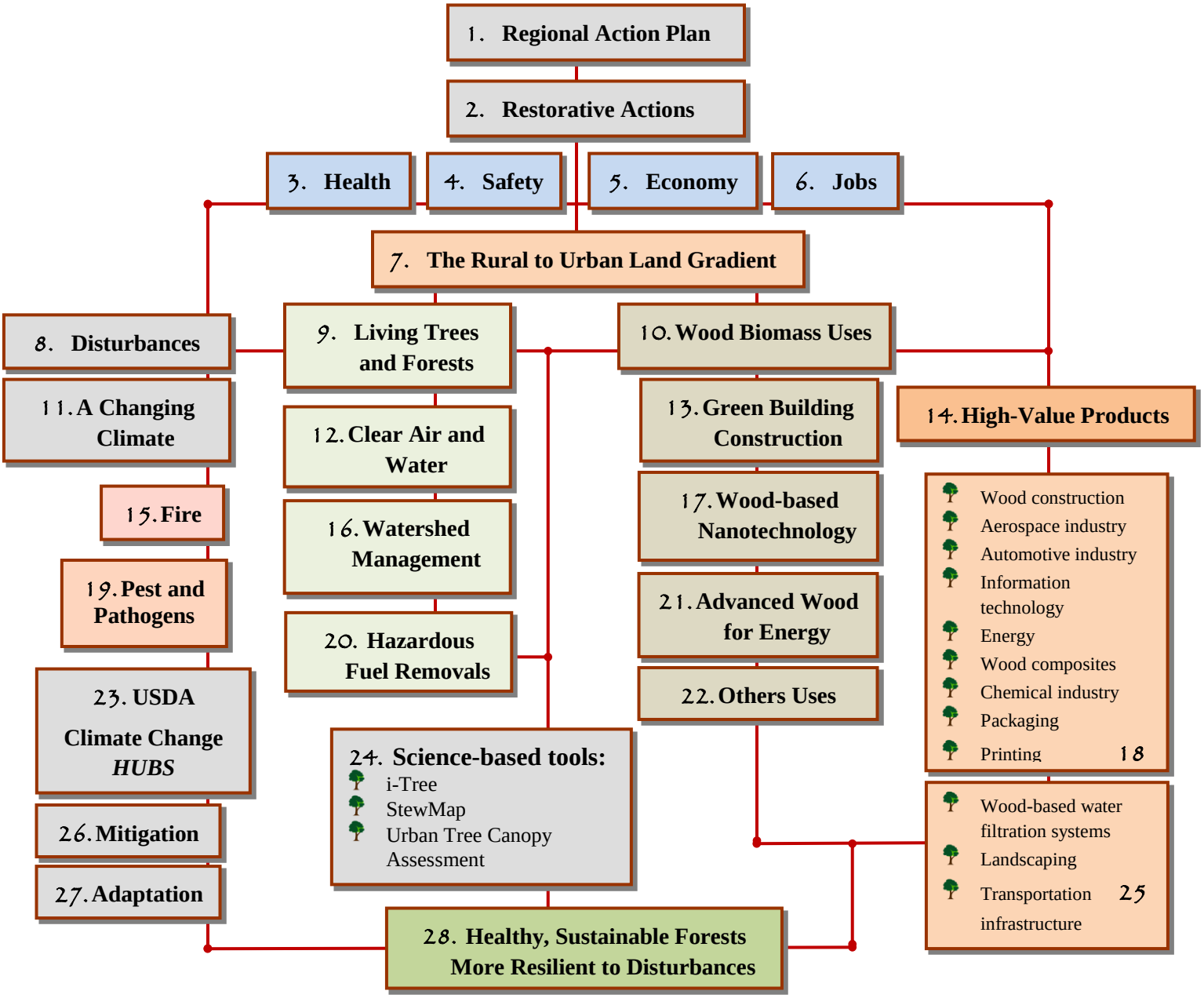
[15] Advance a "Resilient Forest Initiative" in the 2016 Agency Request.

[16] **F**orest **P**roducts **M**arketing **U**nit.

[17] **W**ood **E**ducation and **R**esource **C**enter.

Governance. A key part of the governance process will be the approvals by the three Deputy Chiefs of the Forest Service (State and Private Forestry; National Forest System; and, Research and Development) of specific program directions. While the Natural Resources and Environment (NRE) misison area of the USDA will provide the overall vision, NRE will look to the Forest Service for specific deployment in a well-coordinated manner. The agency might consider an "Incident Commander" to lead the way for "…achieving resilient forests through effective biomass uses." The **A**ccelerated **F**orest **R**estoration **C**oalition – AFRC – will be an important tactic to ensure success (see "Partnership", page 4).

Appendix A.1. Resilient Forests *Graphic Organizer* (illustrating connections)



Appendix A.2. Example Biomass Uses (descriptions)

Biomass Uses

- **Wood-based Nanomaterials.** Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers where unique material properties enable novel, high performance applications. Wood-based nanotechnology offers a revolutionary technology to create new jobs and strengthen America's forest-based economy through industrial development and expansion. Wood-based nanotechnology applications include: packaging barrier coatings; printing paper coatings; structural composite panels for construction; flexible electronic displays; printed electronics; lightweight structural and non-structural panels and parts for aerospace; automotive applications; and, a host of industrial tools and consumer products.

- **Green Building Construction**. A USDA-led program designed to advance wood, including advanced wood composites, as a green building material in appropriate commercial venues (e.g., low-rise commercial office space in urban areas). Within about 5 years there is a very high likelihood that wood demand to construct nonresidential buildings could increase by 7 billion board feet or 16 million dry tons, annually.

- **Biomass for Energy.** In order to attain the most value from acres treated to provide wood for construction and nanomaterials investments, wood energy users may also be needed to support demand for biomass from forest restoration treatments. Woody biomass feedstock necessary for conversion to a bioenergy product lies somewhere between pulp grade and hog fuel both in terms of wood quality and value. The three technologies that will consume the bulk of the available woody biomass feedstock are liquid transportation fuels, pelletization (including Torrefaction), and co-firing to generate electricity.

Appendix A.3. Actions, Achieving Resilient Forests Through Effective Biomass Uses[18]

Components	2015	2016	2017	2018	2019	$ [19]
Biomass Uses: **Wood-based Nanotechnology (W-BN)**	▪ Continue to establish the commercial production viability of cellulose nanomaterials ▪ Capture the high performance and multi-functional properties of cellulosic nanomaterials ▪ Improve process efficiency ▪ Builds connections with partners – public and private -- including leverage of funds ▪ Verify hazardous fuel use and amounts for wood-based nanomaterial	▪ Capture the high performance and multi-functional properties of cellulosic nanomaterials ▪ Designate two (2) pilot sites for demonstration facilities to produce commercial levels of cellulosic nanomaterials ▪ Develop pertinent health and safety information on cellulose nanomaterials ▪ Develop Business Plan in one (1) Pilot Landscape to construct two (2) facilities	▪ Develop commercially-viable platform technologies ▪ Designate two (2) additional pilot sites for demonstration facilities to produce commercial levels of cellulosic nanomaterials. ▪ Construct one (1) pilot facility to produce wood-based nanomaterials ▪ Continue developing applications using wood-based nanomaterials ▪ Evaluate progress ▪ Expand partnerships	▪ Develop commercially-viable platform technologies ▪ Develop codes and standards that serve as the basis for consistent/reproducible commercial cellulose nanomaterials ▪ Focus on two (2) "breakthrough" markets, advancing the use of wood-based nanomaterials ▪ Construct one (1) additional pilot facility to produce wood-based nanomaterials ▪ Continue to develop environmentally preferable ways to manufacture cellulosic nanomaterials ▪ Evaluate progress ▪ Expand partnerships to expand high value market opportunities	▪ Reduce end product producers business risks associated with incorporation of cellulose nanomaterials in their products ▪ Construct one (1) additional pilot facility to produce wood-based nanomaterials ▪ Continue to develop novel materials and further enhance multi-industry and multi-agency collaboration for new products and additional scientific discoveries	
Subtotal, W-BN	$11	$15	$35	$60	$70	$191
Green Building Construction (GBC)	▪ Formulate up-to-date life cycle information on wood products for Environmental Product Declarations	▪ Cooperatively develop software tools for the life cycle analysis of a wide range of structural assemblies	▪ Complete required research for the acceptance of Cross-Laminated Timber (CLT) in U.S building codes	▪ Evaluate progress ▪ Expand partnerships ▪ Conduct Business Plan for one (1) CLT facility to be located in Pilot Landscape; construct facility	▪ Evaluate GBC as to progress in accelerating forest restoration	
Subtotal, GBC	$6	$8	$8	$8	$8	$38
Biomass For Energy (BFE)	▪ Develop information products on bioenergy ▪ Evaluate state wood energy programs ▪ Expand *Torrefaction*	▪ Evaluate the impacts and benefits of other energy sources (oil, gas, and wind); link to WERC	▪ Conduct a "Wood-for-Energy" Congress to evaluate program success and plan for the future.	▪ Quantify impacts of biomass for energy technology transfer on the industry. ▪ Evaluate progress ▪ Expand partnerships ▪ Build on existing work	▪ Build on existing work. ▪ Work with state Governors to place "Wood-for-Energy" facilities	
Subtotal, BFE	$5	$6	$6	$6	$6	$29

[18] The Forest Service should name a national "Incident Commander" to ensure effective coordination and deployment of this initiative.
[19] Dollars in millions.

Appendix A.3. Actions, Achieving Resilient Forests Through Effective Biomass Uses (Continued)

Components	2015	2016	2017	2018	2019	$ [20]
USDA Climate Change *Hubs* (CC*Hubs*)	▪ Help deploy seven (7) *Hubs* and Sub-*Hubs* ▪ Clarify roles of different land ownerships ▪ Aligns and organize capacity in the Forest sector	▪ Assess effect of land management activities ▪ Develop decision-support tools ▪ Expand partnerships ▪ Monitor for adaptation ▪ Link to Climate Science Centers	▪ Conduct landscape assessments on Pilot Landscapes ▪ Assess Climate Scorecards with land disturbances ▪ Expand technology transfer capacity	▪ Build on existing work ▪ Monitor and evaluate *Hub* performance ▪ Evaluate linkage of a changing climate with forest resiliency	▪ Build on existing work	
Subtotal, (CC*Hubs*)	$15	$15	$15	$15		$75
Wood is Good *Literacy* (WIG:*L*): **WoodWorks™** **FPMU*** **WERC**** ***Forest Products Marketing Unit, Madison, WI** ****Wood Education and Resource Center, Gardner, WV**	▪ Develop educational campaign for "Wood is Good." ▪ Fully deploy the FPMU; link with nontraditional partners and markets; emphasize tribes ▪ Establish the WERC as a national program	▪ Provides strategic opportunities to deliver science findings ▪ Design and construct two (2) Forest Facilities increasing the use of cutting-edge wood utilization technology ▪ Expand use of urban wood	▪ Expand partnerships ▪ Monitor and evaluate performance of FPMU and WERC ▪ Conduct a "Wood is Good" Congress, advancing wood for expanded commercial building construction	▪ Build on existing work ▪ Construct two (2) commercial building using wood in 2 major metropolitan areas ▪ Fully expand WERC into softwood markets.	▪ Build on existing work	
Subtotal, WIG:*L*	$8	$8	$8	$8	$8	$40
Pilot Landscapes (PL)	▪ Designate the four (4) pilot landscapes ▪ Conduct detailed resource analysis ▪ **Advance a "Resilient Forest Initiative" in the 2016 Agency Request (+$51-$58 million)**	▪ Expand markets and applications. ▪ Conduct detailed resource analysis ▪ Determine impact of restorative activities on watershed productivity. ▪ Design a suite of science-based BMP's	▪ Build on existing work ▪ Monitor and evaluate performance within Pilot Landscapes ▪ Expand Pilot Landscapes as a feature of accelerated forest restoration, as needed – up to eight (8)	▪ Build on existing work ▪ Monitor and evaluate performance within Pilot Landscapes ▪ Conduct a science-based evaluation of restorative actions on fire behavior and occurrence	▪ Build on existing work ▪ Monitor and evaluate impacts of actions; link low value biomass use to fire rates and size	
Subtotal, PL	$6	$6	$9	$9	$9	$39
Increment (+)	+$51	+$58	+$81	+$106	+$116	+$412
Cumulative Increment (+)	+$51	+$109	+$190	+$296	+$412	
Base Estimate (2014)	$12	$12	$12	$12	$12	$60
Total, (Increment + Base)	**$63**	**$70**	**$93**	**$118**	**$128**	**$472**

[20] Dollars in millions.