DRAFT Memo

To: Maine Department Of Environmental Protection (ME DEP)
From: Thomas D. Peterson LLC
Re: Cost Estimates For Forestry Greenhouse Gas Options
Date: September 28, 2004

This memo provides background and data to characterize the potential costs and cost ranges of forestry greenhouse gas options developed by the Maine Agriculture and Forestry-Working group under guidance from the Stakeholder Advisory Group and ME DEP.

The Maine greenhouse gas process provides new policy development and data in support of state level climate mitigation related to forests and pre harvest biomass, as well as post harvest biomass in the energy and wood products markets. The opportunities that drive this interest include the potential for protection and expansion of forest acreage, methods for increasing forest carbon sinks, biomass energy and related fossil fuel displacement, and wood products and related energy displacement of building materials.

In response to your report needs, I have provided general background and specific cost estimates to the extent possible. Our stakeholder process focused on a select set of options applicable to Maine at this point, but other options may be of future interest in the state and region, and I have included this broader framework to support future planning.

This document provides the following sections:

1. Specific Maine forestry options and descriptions, with cost estimates and or characterization of Maine options
2. Categories of greenhouse gas emissions impacts from the forestry sector
3. Potential ancillary benefits of greenhouse gas actions
4. Forest carbon accounts needed for full life cycle analysis
5. Accounting issues and principles for forestry policy

MAINE FORESTRY GREENHOUSE GAS OPTIONS AND DESCRIPTION		
Proposed Policy	**Estimated Low Cost***	**Estimated High Cost***
Protection Of Forestland From Conversion To Nonforested Land Uses *Through Growth Management and/or Permanent Easements or Acquisition*	Negative (profit) to zero (no cost)	$0.21 - $5.97 per MT CO2 $0.75 - $21.85 per MT carbon
Protection Of Forestland From Conversion To Nonforested Land Uses *Through Forest Retention During Development*	-$5.89-$6.49 MT CO2 -$21.94-23.75 MT carbon ($2000 per acre baseline)	-$11.96-$12.98 MT CO2 -$43.88-47.50 MT carbon ($4000 per acre baseline)
Increased Stocking Of Poorly Stocked Stands With Fast Growing Trees	$1.02 per ton CO2 $3.72 per ton carbon	$1.02 per ton CO2 $3.72 per ton carbon
Early Commercial Thinning	$0.60 per MT CO2 $2.20 per MT carbon	$0.83 per MT CO2 $3.04 per MT carbon
More Regular, Lighter Harvests	$2.36 per MT CO2 $8.63 per MT carbon	$3.25 per MT CO2 $11.88 per MT carbon
Active Management To Maintain And Increase The Softwood Component Of Forest Stands	$2.26 per MT CO2 $8.27 per MT carbon	$3.11 per MT CO2 $11.38 per MT carbon
Increased Biomass Electricity Feedstocks	$0	TBD
Increased Use Of Wood Products	$0.60 per MT CO2 $2.20 per MT carbon	$3.25 per MT CO2 $11.88 per MT carbon
Afforestation Of Nonforested Lands	$1.72 per MT CO2 $6.31 per MT carbon	$1.72 per MT CO2 $6.31 per MT carbon
Increased Age Of Forest Stands	TBD	TBD

Stands		
Development And Use Of Short Rotation Woody Crops	TBD	TBD
* Costs are calculated as the cost of producing a greenhouse gas reduction credit, both in units of carbon dioxide and carbon. Ranges are provided where applicable. Cost analysis focuses on key parameters. All options are implemented as-annual programs over the 15-year budget period.		

PROPOSED POLICIES:

1. Protection Of Forestland From Conversion To Nonforested Land Uses

- **Policy Description:** Preservation of forestland may reduce or avoid the loss of carbon sequestered in forestlands. It may also have the effect of directing growth to more efficient locations and reduce transportation emissions. The working group agreed to an option that would reduce 10 percent of projected forestland conversion by 2010, and 20 percent by 2020 (against a baseline rate of 141,600 acres projected loss from 2005-2020). This is equivalent to a goal of protecting 2,832 acres of forest cover per year that otherwise would have been lost to development. No geographic targets were included. The group did not recommend an implementation program for this option.

- **Cost Issues:** The cost of this option is highly dependent on the specific implementation tool, and the degree to which full costs and benefits are included. For instance, some approaches alter the location and lot size of new development (and the amount of land clearing) by redirecting public funds that support development. In the process they may save money at a public level. General implementation approaches include:

  1. **Locating residential development on smaller lots (higher density) with a lower proportionate impact on forestland clearing per lot.** This often is implemented with programs that encourage development closer to existing service areas (location efficiency) or cluster development to allow greater preservation of open space. Programs include zoning restrictions, conditions on building permits, redirection of public funds for infrastructure and services, and easements and acquisitions. Program costs include the need for planning and evaluation of programs and, potentially, individual projects.

     - **Cost of producing a carbon credit:**

- Zoning restrictions and conditions on building permits. The American Farmland Trust estimates that single-family homes nationwide require more cash outlay for infrastructure and public services than cash inflow through property tax payments; new homes typically require deficit spending.[1] In contrast, forest, farm and ranch lands generate a surplus of revenues.[2] One reason is the relatively high cost of infrastructure and services to homes located far from existing service areas. To the extent that working lands are protected from development and growth is relocated to existing communities, cost deficits can be avoided. The alternate cost of locating development within or near existing service areas and communities varies, and is probably equal or less than that of new homes in rural, forested areas. While rural construction costs are often lower (due to lower building codes and zoning standards), the larger lot sizes and public infrastructure and service costs likely outweigh these savings. A full comparative analysis of these two alternatives is beyond the scope of this report. Zoning can be an effective approach to relocating development or reducing land clearing associated with new lots. <u>We assume that the full (public and private) cost of reducing lot size and or locating new growth away from forestlands is negative to zero per ton of carbon saved.</u>
- Redirection of public funds for infrastructure and services. Cost issues are the same as those noted under zoning above. Because the location of growth size of lots are largely determined by public funding for infrastructure and services, forestland development can be reduced by targeting these funds more carefully. With potential cost savings. <u>We assume that the full (public and private) cost of reducing lot size and or locating new growth away from forestlands is negative to zero per ton of carbon saved.</u>
- Easements and acquisitions: Farmland protection programs in MD, PA and NY are estimated to cost $1,164 per acre for permanent acquisition or easement.[3] Maine data from The Nature Conservancy shows actual costs of permanent protection of forestland acquisition ranging from $39.42 per acre to $462.00 per

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[1] American Farmland Trust, *Cost of Community Services Studies: Making the Case for Conservation*, Washington, DC, 2003. This study compiles results of 80 studies that assessed the costs and benefits of alternative land uses for working lands, including residential development.
[2] AFT, Cost of Community Services.
[3] American Farmland Trust, Farmland Information Center, *Status of PACE Programs, Fact Sheet*, Washington, DC, June 1999. Data includes total program costs and program acres under farmland protection programs. These include woodlots.

acre.[4] Russ Libby estimates forestland protection at $750 per acre, and farmland easements at $5,000 - $15,000 per acre.

- Each acre of forestland in Maine that is protected saves an estimated net[5] 195 pounds CO2 (53.28 pounds carbon).[6] Program costs range from $0.75 - $21.85 per ton carbon, or $0.21 - $5.97 per ton CO2.

2. **Retaining a higher percent of forest cover on new lots during the development process, or during home ownership.** This is often implemented through conditions on zoning, building permits, land-clearing permits, incentives payments, and education. Program costs include the need for planning and evaluation of programs and, potentially, individual projects.

    - **Cost of producing a carbon credit:**

        - Zoning restrictions and conditions on building and land clearing permits that require higher forest retention. Land clearing is expensive. Costs can be reduced significantly through cluster development or conservation design. A recent study by NOAA identified cost savings of reduced land clearing in coastal zones for a traditional development scenario, and two reduced impact scenarios: new urbanism and conservation design.[7] All three approaches accommodated the same number of dwelling units on the total acreage, but the percent of forest retention was about half for new urbanist design, and about one quarter of the site for conservation design. Costs of land clearing per acre dropped from $2,000 per acre in the traditional case, to $821 per acre for new urbanism, and $726 per acre for conservation design. These latter two options can be mandated by zoning and permit restrictions, or implemented through incentives. Sales prices for homes were equal or higher in the nontraditional cases. Cost savings for

[4] Data provided by Kate Dempsey for recent permanent easements and acquisitions.
[5] Some of the biomass harvested during land clearing is used for durable wood products and electricity generation and results in displacement of fossil emissions associated with energy supply or manufacturing emissions. Specific percentages and coefficients are included in the full technical report on forestry and agriculture. The net greenhouse gas savings from protecting forested stands is 24 percent less due to these positive displacement effects associated with harvested biomass. Unlike sustainable forests, however, none of the harvest biomass (merchantable or non merchantable) will grow back and sequester carbon in the future.
[6] Peterson, Tom and Jim Smith, *Maine FORCARB Analysis*, Maine Agriculture and Forestry Working Group, 2004.
[7] NOAA Coastal Services Center. *Alternatives for Coastal Development: One Site, Three Scenarios*, 2004. Available at: http://www.csc.noaa.gov/alternatives/clearingCosts.html

nontraditional versus conventional development ranged from $1170 per acre to $1271 per acre. Carbon savings from avoided land clearing are estimated at 53.35 tons carbon per acre. The direct cost of greenhouse gas ***savings*** is equal to a gain of $21.89-23.75 per ton carbon, or $5.98-6.49 per ton CO2 when conventional land clearing costs are $2000 per acre. The NRCS Maine field office estimates that land clearing costs in Maine range between $2000-4000 per acre. At the high end of this range the economic savings associated with new urbanist or conservation design would be twice as high as the low range, at $43.88-47.50 per ton carbon, or $11.96-$12.98 per ton CO2 when conventional land clearing costs are $4000 per acre.

- Easements and acquisitions may also be used to create cluster development. See the above note and calculation. Program costs range from $0.75 - $21.85 per ton carbon, or $0.21 - $5.97 per ton CO2.
- Education. It is beyond the scope of this report to identify carbon cost savings associated with education, but acknowledged that it has a positive effect.

2. Increased Stocking Of Poorly Stocked Stands With Fast Growing Trees

- **Policy Description:** This measure focuses on increasing overall stand stocking with faster growing trees by management practices that promote current Poorly Stocked Stands (10% - 34% stocked) into Moderately Stocked Class Stands (35% - 64% stocked), an effective increase of 30 percent. Goal: Manage and promote 25,000 acres per year from the Poorly Stocked Class to Moderately Stocked Class over the next 15 years. Apply to all forest type groups, focusing on desirable species, and available to all landowner classes. Program costs include the need for planning and evaluation of programs and, potentially, individual projects. Projects may require site visits and plan approvals.

- **Cost Issues:** Tree planting and reforestation programs are well understood.

  - **Cost of producing a carbon credit:** The Maine Woods WISE program estimates tree planting costs for enrichment and inter planting at $100 per acre.[8] Total future carbon sequestration from increased stocking of faster growing trees on poorly stocked sites is estimated at 26.90 MT carbon per acre. This translates into a cost of saved carbon equal to $3.72 per ton carbon, or $1.02 per ton CO2 saved.

[8] Guidelines and data from the Woods Wise program to support private forestland owners are available at: http://www.maine.gov/doc/mfs/woodswise/steward.html

3. Early Commercial Thinning

- **Policy Description:** Over the next 15 years, treat 50% to 100% of the 400,000 acres (40,000 – 80,000 acres per year) estimated to be available for ECT. Apply to all forest types and all landowner classes. Estimated Forest Product Output: 20% durable wood products; 60% pulp/OSB ("oriented strand board"), and 20% biomass energy. Assume 8 cords per acre per year harvest.

- **Cost Issues:** By definition this option meets market criteria and does not involve new costs to producers beyond planning and evaluation expenses that may include site visits and plan approvals by a certified forester.

- **Cost of producing a carbon credit:**

  - Federal cost share programs support the development of forest and harvest management plans for Maine woodlot owners on acreages of 10-9999 acres include the Forest Incentives Program (FIP; the Stewardship Incentives Program (SIP); and Forest Stewardship Assistance Program (FSA). Cost share percentages and maximum prices for forest management plans are specified, and range from $5.00 to $6.88 per acre (table 2). This additional investment to support new biomass harvest options would yield 8.29 MT carbon per acre. Costs are estimated at $2.20-3.04 per MT carbon, or $0.60-0.83 per MT CO_2.

Table 2. Federal cost shares for forest management plans.

Acres (minimum of 10, maximum of 999)	**Maximum price that will be cost-shared**	**Cost per acre**
10-40	$275	$6.88
41-70	$360	$5.14
71+	$5/acre	$5.00

4. More Regular, Lighter Harvests

- **Policy Description:** This option is intended to remove standing biomass from the forest with minimal impact on the forest floor and soils, and to apply biomass to energy saving uses to reduce carbon dioxide emissions. Apply to all forest types and all landowner classes on 1,700,000 total acres over a 15-year period (113,333 acres per year). Goal: within 15 years capture 50% of biomass that otherwise is thinned by natural mortality and becomes decay on forest floors. This would yield approximately 4,000 cords of wood annually, or 3 cubic feet of wood per acre per year. Estimated Forest Product Output: 45% saw logs; 48% pulpwood and 7% biomass chips (the average mix of the reported harvest of forest products over the past 7 years).

- **Cost Issues:** By definition this option meets market criteria and does not involve new costs to producers. Producers will expand selective biomass removal if it is more profitable than alternative management of the stand. This program will potentially require new administration and program costs associated with technical assistance to landowners, and removal of any regulatory or institutional barriers to expanded biomass removal from private and public lands. Program costs include the need for planning and evaluation of programs and, potentially, individual projects. Projects may require site visits and plan approvals.

- **Cost of producing a carbon credit:**

    - Federal cost share programs that support the development of forest and harvest management plans for Maine woodlot owners on acreages of 10-9999 acres include the Forest Incentives Program (FIP; the Stewardship Incentives Program (SIP); and Forest Stewardship Assistance Program (FSA). Cost share percentages and maximum prices for forest management plans are specified, and range from \$5.00 to \$6.88 per acre (table 2). This additional investment to support new biomass harvest options would yield 2.12 MT carbon dioxide per acre. Costs are estimated at \$2.36-3.25 per MT CO2, or \$8.63-11.88 per MT carbon.

5. Active Management To Maintain And Increase The Softwood Component Of Forest Stands

- The working group proposed implementing a structured conversion process back to an assignment as a softwood forest type will increase the soil sequestration values of a substantial portion of Maine timberlands. Goal: transition 33,333 acres per year over 15 years currently classified as a hardwood forest type on native softwood sites to a softwood forest type by 2020. This includes removal of two cords of harvested biomass per acre through one-time removals over the 15-year period from ten percent of these stands, with restocking of softwood species. It also includes application of herbicides to 3,000 acres of hardwood to promote natural stand release and regeneration of softwoods.

- **Cost Issues:** By definition this option meets market criteria for the acreage involved in biomass harvest, and does not involve new costs to producers. Herbicide acreages do involve costs without immediate market return. This program will potentially require new administration and program costs associated with technical assistance to landowners, and removal of any regulatory or institutional barriers to expanded biomass removal from private and public lands. Program costs include the need for planning and evaluation of programs and, potentially, individual projects. Projects may require site visits and plan approvals.

- **Cost of producing a carbon credit:**

    - Federal cost share programs that support the development of forest and harvest management plans for Maine woodlot owners on acreages of 10-9999 acres include the Forest Incentives Program (FIP; the Stewardship Incentives Program (SIP); and Forest Stewardship Assistance Program (FSA). Cost share percentages and maximum prices for forest management plans are specified, and range from $5.00 to $6.88 per acre (table 2). This additional investment to support new biomass harvest options would yield 2.12 MT carbon dioxide per acre. Costs are estimated at $2.26-3.11 per MT CO2, or $8.27-11.38 per MT carbon.
    - Per acre herbicide costs are estimated at $200 per acre by the Maine NRCS field office. Per acre carbon sequestration responses from herbicide release are estimated at 0.05 MT CO2 per acre (Note: the effect of herbicide treatment is to convert live biomass to dead and decaying biomass, with new biomass growing in response. Long term biomass growth replaces biomass killed with herbicide, but does not provide emissions displacement benefits through use wood products or bioenergy). Costs are estimated at $4,295 per MT CO2, or $15,718 per MT carbon.

6. Increased Biomass Electricity Feedstocks

- **Policy Description:** This option is the simple addition of biomass energy sub options evaluated under forest management options, including: early commercial thins, more lighter harvests, and active management of stands for softwood reestablishment.

- **Cost Issues:** The GHG production credit cost of expanded biomass use is the additional cost of production divided by the GHG savings per Kwh of biomass energy. Biomass energy under current capacity and technology is marketable, but new capacity and new technology (biomass gasification and combined cycle) may require market intervention.

    - **Cost of producing a carbon credit:** Expanded use of current and projected capacity does not require additional cost and is estimated at $0. The cost of new capacity and BGCC technology is beyond the scope of this report, and important for future research.

7. Increased Use Of Wood Products

- **Policy Description:** This option is the simple addition of biomass to wood products sub options evaluated under forest management options, including: early commercial thins, more lighter harvests, and active management of stands for softwood reestablishment.

- **Cost Issues:** The policy options that contribute to expanded wood products use assume marketable harvests of biomass and no additional costs of market penetration. The only additional costs are those associated with stewardship and harvest planning by landowners.

    - **Cost of producing a carbon credit:** Management and planning costs range from \$0.60-3.25 per ton CO2, and \$2.20-11.88 per ton for carbon.

8. Afforestation Of Nonforested Lands

- **Policy Description:** This option calls for establishment of forests on cropland and pastureland. Note declining baseline.

- **Cost Issues:** Tree planting and reforestation programs are well understood.

    - **Cost of producing a carbon credit:** The Maine Woods WISE program estimates tree planting costs for afforestation at \$170 per acre.[9] Total future carbon sequestration from increased stocking of faster growing trees on poorly stocked sites is estimated at 26.90 MT carbon per acre. <u>This translates into a cost of saved carbon equal to \$6.31 per ton carbon, or \$1.72 per ton CO2 saved.</u>

9. Increased Age Of Forest Stands

- **Policy Description:** Over the next 15 years, identify hardwood stands under relatively short pulpwood rotations that can be shifted to significantly longer saw timber rotations. Target lands that are financially marginal for pulpwood and feasible for saw timber, as well as sites with high environmental attributes. Support development of durable wood products markets targeted to hardwood saw timber. In addition, identify marginal economic sites for all stands that can be removed from production and maintained in permanent forest cover, particularly in areas with high environmental attributes. Focus forest preservation programs on mature timber stands to reverse the disproportionate clearing of this land, and reduce disease and pest risks as possible to maintain continuous growth of existing stands.

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[9] Guidelines and data from the Woods Wise program to support private forestland owners are available at: http://www.maine.gov/doc/mfs/woodswise/steward.html

- **Cost Issues:** Program costs include the need for planning and evaluation of programs and, potentially, individual projects. Projects may require site visits and plan approvals. Projects may involve opportunity costs of foregone pulpwood revenues.
    - **Cost of producing a carbon credit:** Estimates have not yet been developed.

10. Increased Cultivation Of Short Rotation Woody Crops

- **Policy Description:** Over the next 15 years, explore the use of short rotation woody crops using hybrid willow or poplar species on non forested sites, including cropland, riparian zones, eroded lands, rights of ways, and pasture. Manage crops for wood products and bioenergy to displace fossil energy emissions. Use waste manure where possible for fertilization to minimize nitrous oxide emissions from synthetic fertilizers.

- **Cost Issues:** Additional research and development and commercialization programs may be needed.
    - **Cost of producing a carbon credit:** Estimates have not yet been developed.

Potential Greenhouse Gas Benefits Forest Biomass Management: Direct And Indirect Impacts Of Pre Harvest And Post Harvest Biomass

1. CARBON DIOXIDE REDUCTION
    a. Increased carbon storage (stocks)
        i. Ecosystem biomass (pre harvest)
        ii. Wood products (post harvest) (indirect – manufacturing, energy supply)
    b. Reduced carbon dioxide emissions (flows)
        i. Reduced combustion and release of ecosystem biomass (pre harvest)
            1. Combustion (fires)
            2. Decay
        ii. Fossil fuel displacement (post harvest)
            1. Heat and power production/substitution (indirect – energy supply)
            2. Building materials production/substitution (indirect – manufacturing)
2. METHANE EMISSIONS REDUCTION (flows) (post harvest)
    a. Reduced direct landfill methane flow (indirect – solid waste)
    b. Methane conversion to carbon dioxide (combustion by flaring) (indirect – solid waste)
    c. Methane conversion to carbon dioxide (flaring) plus carbon dioxide reduction by energy recovery and fuel switching (indirect – solid waste, energy supply)

Ancillary Costs And Benefits Of Biomass And Forestland Management And Conservation

1. ENVIRONMENTAL POLICY
    a. Wildlife conservation (terrestrial and aquatic)
        i. Long term habitat supply
        ii. Seasonal disruption
    b. Water supply and management (watersheds)
        i. Flow levels
        ii. Flow timing
    c. Water quality
        i. Soil erosion
        ii. Chemical contamination
    d. Air quality
        i. Biomass combustion
        ii. Air pollutant absorption
    e. Soil conservation
        i. Forestland conversion

      ii. Harvest impacts

2. ENERGY POLICY
   a. Renewable Energy Supply
      i. Direct biomass (live chips)
         1. Natural lands
         2. Plantations
      ii. Indirect waste conversion
         1. Logging and mill residue
         2. Landfill methane
         3. Construction and demolition
   b. Indigenous Energy Supply And Energy Security
      i. Import reduction (natural gas, petroleum)
      ii. Diversification
   c. Energy Reliability
      i. Supply continuity
      ii. Supply timing

3. ECONOMIC POLICY
   a. Economic Development
      i. Expanded wood products and biomass energy markets
         1. Working lands
         2. Manufacturing of wood products
         3. Power providers
         4. Technology providers
            a. Energy industry
            b. Wood products
      ii. Expanded/protected tourism and recreation
         1. Working lands (landowners)
         2. Rural communities (services)
         3. Manufacturing (equipment)
   b. Economic Policy (And Tax) Reform
      i. Tax and budget shifts (growth management)
      ii. Budget savings
         1. Environmental services (water supply)
         2. Infrastructure and services investments (growth management)
   c. Economic Transition And Hardship
      i. Green jobs
         1. Products
         2. Services
      ii. Enhanced prices for forest products and services
      iii. Depressed rural areas

State Greenhouse Gas Emissions Accounting Principles And Issues:

1. Full life cycle accounting = comprehensive tabulation of debits (increased emissions flows or reductions in carbon storage) and credits (reduced emissions flows or increased carbon storage) across sectors, time periods, gases, actions. It includes:
    a. All positive and negative emissions impacts
    b. Direct and indirect effects (indirect displacement may be counted in other sectors, including manufacturing, waste management, energy supply; double counting should be avoided)
    c. Emissions impacts during and beyond the compliance (budget) period for impacts that occur as a result of the compliance action and are otherwise measurable (long term carbon storage is included)
    d. Emissions effects of imports and excludes effects of exports for post harvest biomass (to avoid double counting across jurisdictions)
2. Discounting
    a. Optional, depending on circumstance and use of information
    b. Should be symmetrical for both debits and credits when used
    c. Can be used for monetized and non monetized costs and benefits

Potential Implementation Mechanisms For Forestry Greenhouse Gas Reductions

1. Goals And Targets
    a. Quantitative
    b. Qualitative
    c. Binding
    d. Nonbinding
2. Mandatory Actions
    a. Codes and standards
        i. Regulatory
        ii. Market based
    b. Funding requirements (eligibility and targeting)
    c. Negotiated agreements and covenants
    d. Reporting and disclosure
3. Voluntary Actions
    a. Technical assistance
    b. Funding assistance
    c. Information and education
    d. Voluntary agreements and covenants
4. Monitoring And Reporting
    a. Programmatic plans and evaluation
    b. Project Based eligibility and evaluation

Framework Of Potential Forestry Greenhouse Gas Mitigation Options:

1. PRE-HARVEST BIOMASS
    a. Protection Of Forestland From Conversion To Nonforest Conditions
        i. Relocation of development to non forested/less forested areas
        ii. Increased forest retention during development
            1. Reduced lot size
            2. Increased forest retention (reduced land clearing) on site
        iii. Protection of forest health
            1. Disease and pests
            2. Storm and ice damage
            3. Drought
            4. Floods
            5. Prevention and control of invasive species
    b. Afforestation Of Nonforested Lands
        i. Urban Communities
        ii. Institutions
        iii. Commercial Areas
        iv. Suburban, Rural And Resource Lands
    c. Restoration of forestlands
        i. Crop and pasture lands
        ii. Wetlands and riparian zones
        iii. Abandoned or eroded lands
    d. Reforestation Of Forestlands
        i. Stand regeneration
        ii. Increased Stocking
    e. Better Harvest Methods
        i. Selection
        ii. Felling
        iii. Extraction
    f. Modification Of Rotation Age
        i. Short rotation woody crops (fiber and energy)
        ii. Long rotation saw timber
        iii. Mixed rotation systems
    g. Density Management
        i. Selective shelter wood harvest
        ii. More regular, light harvests
        iii. Stand tending
            1. Thinning
                a. Precommercial
                b. Commercial
                    i. Natural stands
                    ii. Plantations

2. Herbicides

h. Species Selection
   i. Selective Thinning
   ii. Selective Reforestation
   iii. Stand Replacement
   iv. Intensive Management

i. Increased Fertilization Of Forests
   i. Bio solids and waste recycling
   ii. Commercial fertilization

j. Modification Of Fire Suppression Of Forests
   i. Removal of biomass at risk
   ii. Forest fire containment

2. POST HARVEST BIOMASS
   a. Substitution of biomass for fossil energy (fuel switching)
      i. Electricity feedstocks
         1. Existing technology
         2. Advanced technology
         3. Waste recovery
      ii. Direct heating
         1. Existing technology
         2. Advanced technology
         3. Waste recovery
   b. Substitution of wood products for other building materials
      i. Building materials
      ii. Furnishings
   c. Biomass waste management
      i. Source reduction
      ii. Recycling
      iii. Conversion to energy (fuel switching)

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