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Creating forest sector solutions

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From forests to products: building the linkage

Tony Zhang, Senior Scientist & Group Leader, FPInnovations

From forests to product recovery

Growth data (e.g. tree-, stand- and forest-level) as input

↓

Development of a series of models

↓

Product recovery as output

From forests to product recovery

1. **Stem taper modelling (S-P-F species)**
2. Tree diameter-height relationship modelling
3. DBH distribution modelling
4. Product recovery models
5. Lumber recovery correction models for stem deformations
6. Wood/product quality modelling

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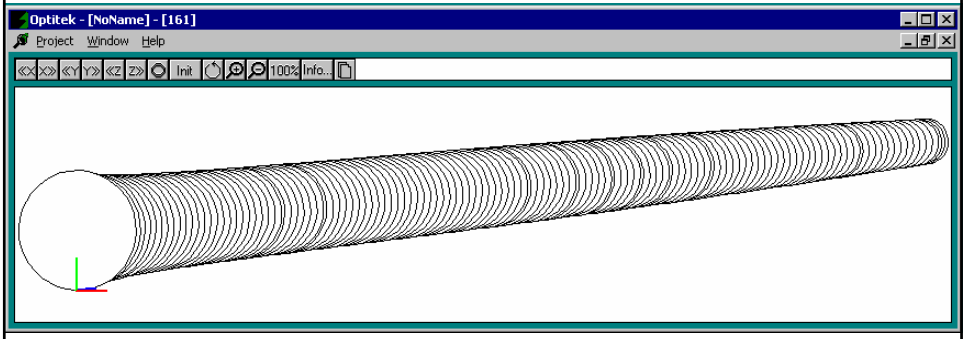
Virtual stem reconstructed from the taper model



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From forests to product recovery

1. Stem taper modelling
2. **Tree diameter-height relationship modelling (S-P-F species)**

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From forests to product recovery

1. Stem taper modelling (S-P-F species)
2. Tree diameter-height relationship modelling
3. **DBH distribution modelling using 4 stand level variables (age, density, site index, tree height): models developed for**

   Sb (3 stand types)

   Pj (2 stand types)

   Sw (plantations)

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From forests to product recovery

1. Stem taper modelling (S-P-F species)
2. Tree diameter-height relationship modelling
3. DBH distribution modelling
4. **Tree-level product recovery models (Sb, Pj)**

$ = f (DBH, tree height, etc.)

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From forests to product recovery

1. Stem taper modelling (S-P-F species)
2. Tree diameter-height relationship modelling
3. DBH distribution modelling
4. Product recovery models
5. **Lumber recovery correction models for stem deformations**

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Stem deformations in jack pine

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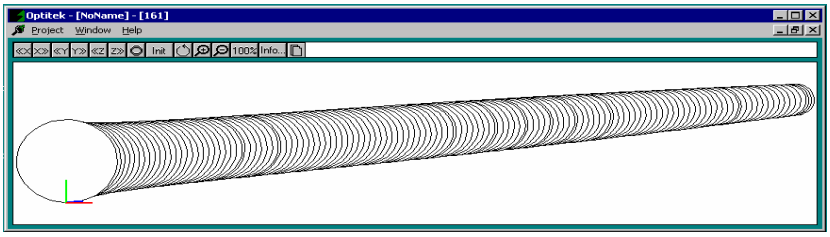
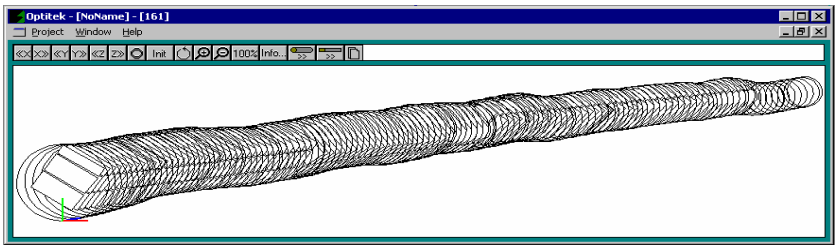
True-shape stem vs virtual stem





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Lumber recovery correction factors for stem deformations at different mills

- Dimension Mill:

$$V_{real} = f(V_{virtual})$$

$$R^2 = 0.958$$

- Stud Mill:

$$V_{real} = f(V_{virtual})$$

$$R^2 = 0.946$$

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From forests to product recovery

1. Stem taper modelling (S-P-F species)
2. Tree diameter-height relationship modelling
3. DBH distribution modelling
4. Product recovery models
5. Lumber recovery correction models for stem deformations
6. **Wood/product quality modelling (empirical models in S-P-F speices)**

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Correlations of lumber properties and total tree value with tree characteristics in black Spruce

Tree characteristic	Correlation coefficient			
	MOR	MOE	SS Grade Yield	Tree Value
DBH	-0.633	-0.457	+0.112 NS	+0.944
Tree height	-0.438	-0.279	+0.157 NS	+0.828
Stem taper	-0.552	-0.497	-0.011 NS	+0.630
Crown length	-0.230	-0.089 NS	+0.162 NS	+0.652
Crown width	-0.375	-0.243	+0.127 NS	+0.636
Branch diameter	-0.486	-0.369	+0.069 NS	+0.649
Wood density	+0.699	+0.762	+0.059 NS	-0.473

Note: NS = no significant ($p < 5\%$)

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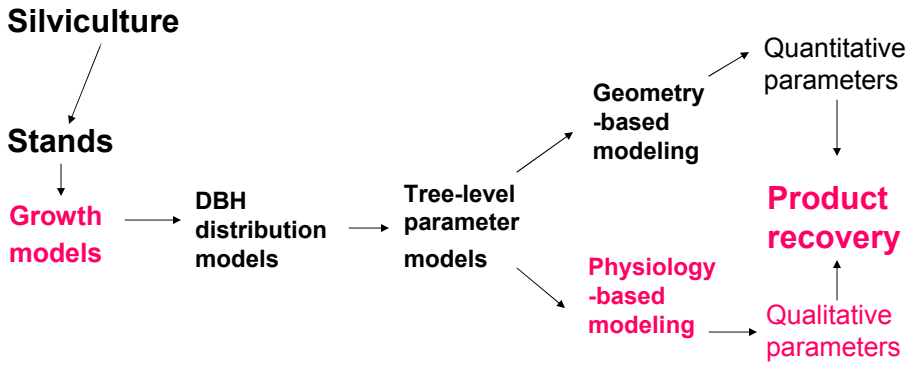
Development of integrated decision-support systems



Further research is needed

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The ForValueNet Project – NSERC Strategic Network

- **Overall objective**

  To develop a series of new and integrated models to simulate and optimize the forest-wood value chain from the Canadian boreal forest.

- **Research themes**

  1. Stand and tree growth modelling;

  2. Three-dimensional stem quality modelling;

  3. Sawmilling products recovery modelling;

  4. Value-added wood products recovery modelling;

  5. Development of integrated decision-support systems;

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The ForValueNet Project - team

- Co-applicants: 32 professors from 10 Canadian universities
- Collaborators: over 30 scientists from CFS-CWFC, FPInnovations and provincial governments
- International collaborators: US, Finland, Germany, France
- Led by Prof. Alain Cloutier (PI, Director) and Dr. Tony Zhang (Co-PI, co-Director)

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The ForValueNet Project - partners

- **Industry and government partners (11):**
  - **Abitibi-Consolidated**
  - **Bowater Canadian Forest Products Inc.**
  - **Tembec**
  - **Association des entrepreneurs en travaux sylvicoles du Québec**
  - **FPInnovations**
  - **Natural Resources Canada – Canadian Wood Fibre Centre**
  - **Ministère des ressources naturelles et de la faune du Québec**
  - **Saskatchewan Forest Centre**
  - **British Columbia Ministry of Forests and Range**
  - **New Brunswick Natural Resources**
  - **Ontario Ministry of Natural Resources**

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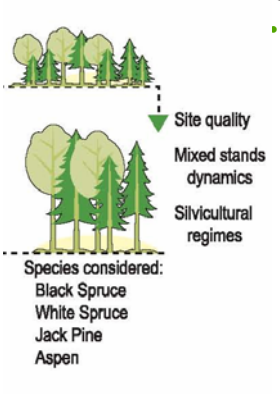
Theme 1. Stand and tree growth modelling



Objective

- Develop stand and tree growth model to obtain/predict:
  - Species composition
  - DBH distribution
  - Tree age and height
  - Live-crown size
  - Stem taper
  - Bark thickness
  - Branchiness
  - Sapwood/Heartwood distribution
  - Biomass and carbon

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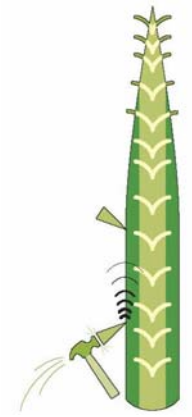
Theme 2. Three-dimensional stem quality modelling



Objectives

- Develop a 3D stem quality model:
  - Knottiness
  - Juvenile wood distribution
  - Fibre length distribution
  - Microfibril angle distribution
  - Wood density distribution
  - Mechanical properties
  - Dimensional stability
- Evaluate the performance of non-destructive tools to determine wood properties in standing trees.

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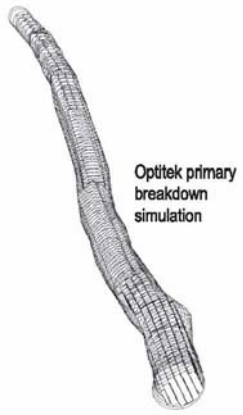
Theme 3. Sawmilling products recovery modelling



Objectives

- Développer a primary breakdown recovery model considering wood properties within the stem:
  - Lumber recovery
  - Lumber properties
  - Chip volume and quality
  - Residue volume
- Evaluate the performance of non-destructive tools to determine wood properties in the logs.

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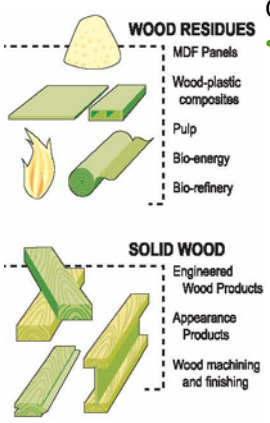
Theme 4. Value-added wood products recovery modelling



Objectives

- Develop a model of value-added wood products that could potentially be obtained from the boreal forest:
  - MDF panels
  - Wood-plastic composites
  - Pulp
  - Bioenergy
  - Appearance wood products
  - Engineered wood products

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Theme 5. Development of integrated decision-support

Objectives

- Integrate the information generated in the four previous themes;
- Develop a decision-support system for forest management taking into account the potential products, their manufacturing cost and market value.

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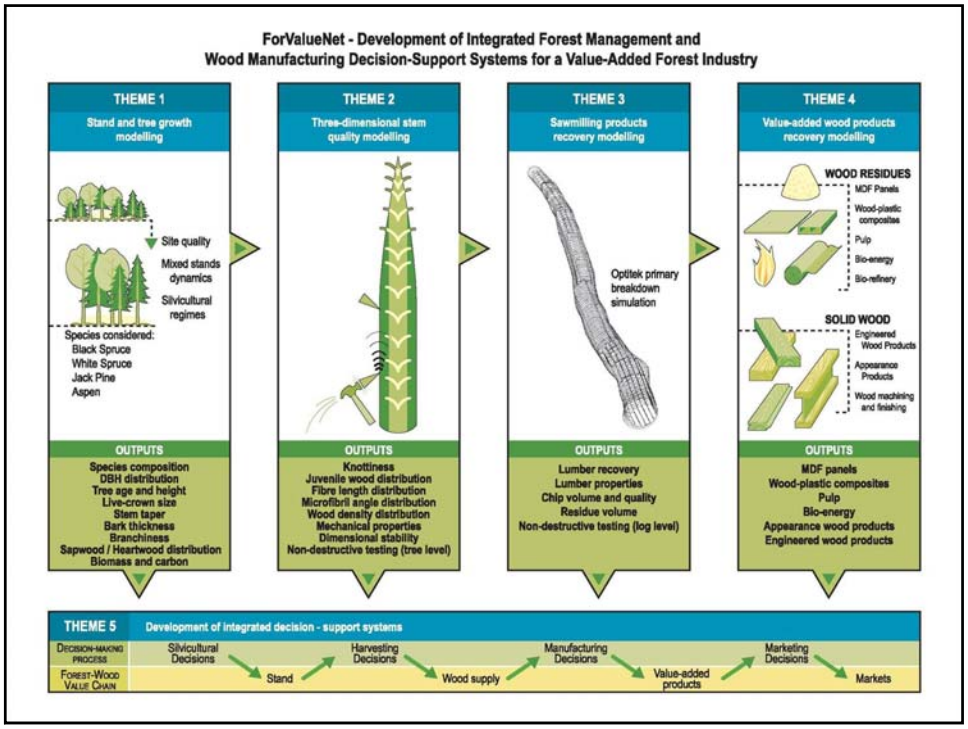
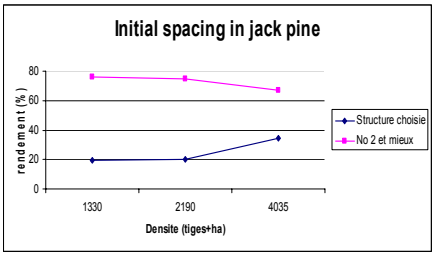
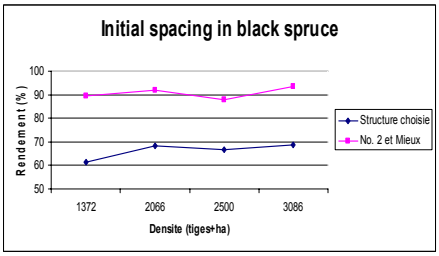


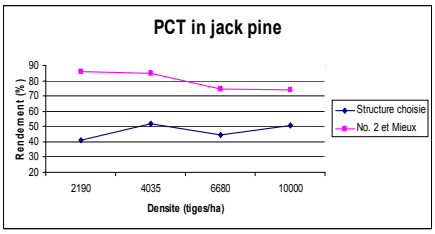
Impact of stand density management on forest-wood value chain

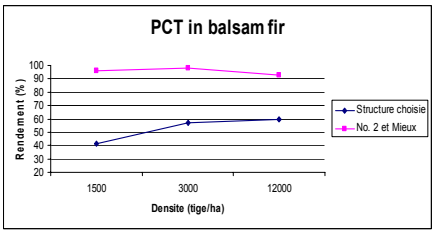
1. Initial spacing in black spruce
2. Initial spacing in jack pine
3. Precommercial thinning in balsam fir
4. Precommercial thinning in jack pine
5. Precommercial thinning in black spruce
6. Commercial thinning in jack pine
7. Commercial thinning in black spruce
8. Commercial thinning in white spruce (new project)

Lumber quality (visual grading) in relation to stand density









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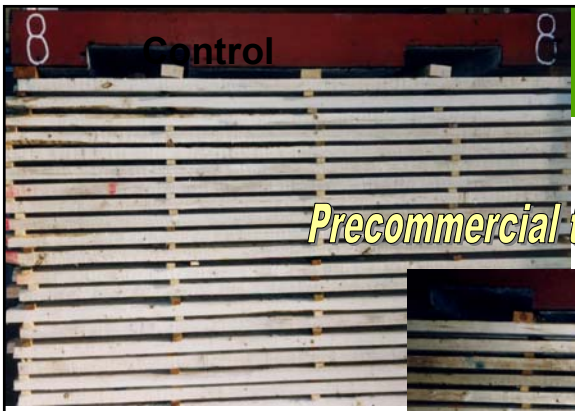

Precommercial thinning in balsam fir

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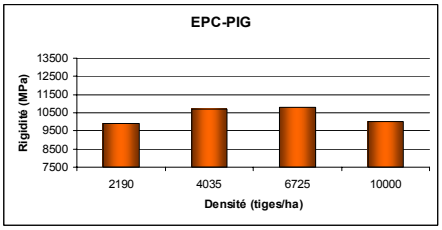
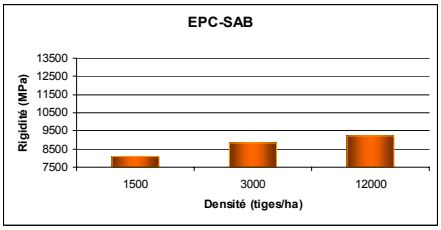
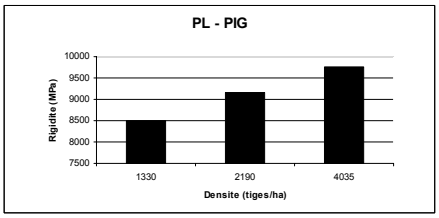
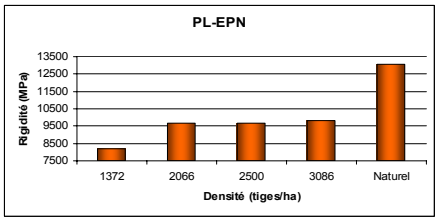
Lumber stiffness (MOE) in relation to stand density









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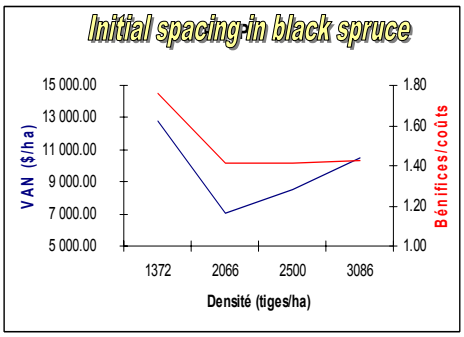
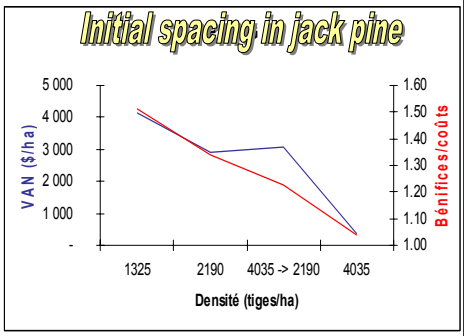
Net stand value & Benefit/Cost ratio in relation to initial spacing





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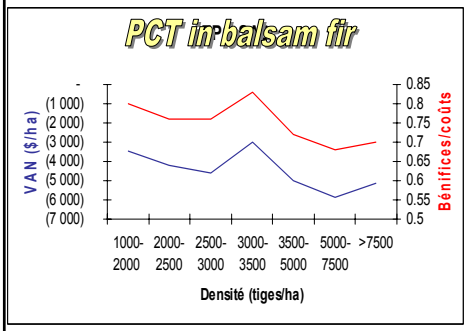
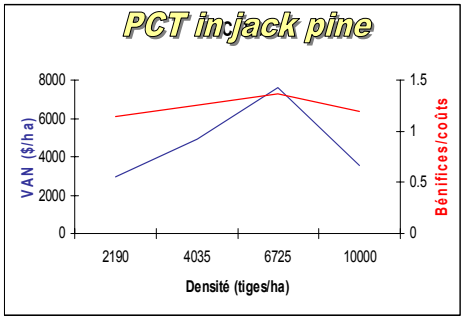
Net stand value & Benefit/Cost ratio in relation to Precommercial commercial thinning (PCT)





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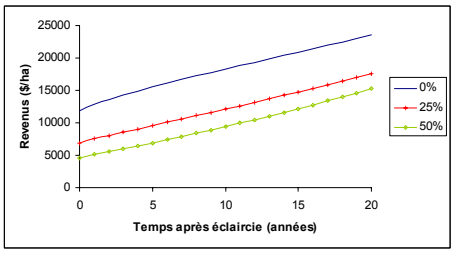
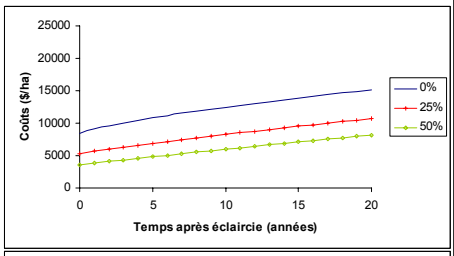
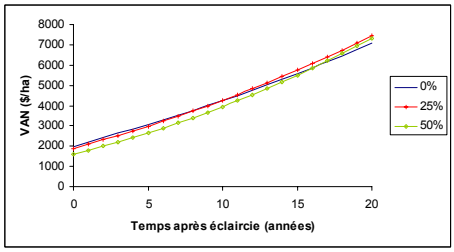
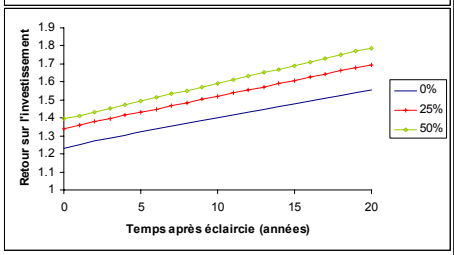
Economic analysis for commercial thinning in jack pine









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Modelling Diameter Distribution and Stand Value for Three Types of Jack Pine Stands in Ontario

Team: Forintek, OMNR (Mahadev Sharma, John Parton, Murray Woods), CFS (Peter Newton), Tembec/FRP (Al Stinson), Co-op (Dave Wood), Forest Analysis Ltd (Margaret Penner)

Partners: AbitiBowater, CFS, Co-op. Neenah Paper, OMNR, Tembec/FRP, OMNR, Weyerhaeuser.

Funding: EFPSP, Forintek, partners

Results: Models developed for plantations and natural stands

Maximizing the Value of Black Spruce Resource Through Development of An Integrated IFM Strategy

Team: Forintek, CFS (Rob Fleming), Tembec/FRP (Jeff Leach/Al Stinson), OMNR (John Parton), Co-op (Dave Wood)

Partners: CFS, AbitibiBowater, Co-op, Lakehead University, OMNR, Tembec/FRP,

Funding: EFPSP, Forintek, partners

Results: PCT, CT

Other ongoing projects

1. Impact of thinning on stand structure, biomass, carbon sequestration and economic value in Pj
2. Impact of partial cutting on wood quality, product recovery and economics in mixed S-P-F stands
3. Predicting product recovery using forest inventory data
4. Development of wood quality/product recovery models
5. Development of economic weight-based selection strategy

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