PATHWAYS TO PRECISION SILVICULTURE SYMPOSIUM

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Key Existing, Emerging and Future Silviculture Technologies and Trends

A Global Perspective

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BEFORE WE START

Why should we adopt new technologies?

...and why now?

Four reasons to adopt new technologies

Key drivers creating demand



People

Fill structural labor gaps, make field work safer and move people to higher-value tasks.

Safer, scalable workforce



Productivity

Better use of land, machines and fuel, with potential MAI gains and lower cost per hectare.

Lower cost per hectare



Precision

Standardized, repeatable operations and automated tracking for compliance and accurate contractor payment.

Auditable operations



Sustainability

Right input, right place: less chemical, fertilizer and fuel, with traceable data for certification and carbon.

Fewer inputs, more sustainable

Technology is not the goal — better silviculture is.

A Global Forestry Workforce at a Crossroads

Aging populations, rural–urban migration and skills shortages are challenging the future of our forests

NORTH AMERICA
(USA & Canada)

30–45%

of forestry-critical workers are over 55 years old, with annual retirements (4–6% of workforce) exceeding new entrants in many logging and mill occupations.

Source: Forest Resources Association, 2026

SOUTH AMERICA
(LATIN AMERICA)

Rising workforce aging

Rural youth migration is reducing the availability of forestry labor, with many younger workers moving to urban centers.

Source: FAO / ILO, 2026



SOUTH AFRICA

150,000+

jobs supported by forestry, largely in rural areas, but the sector faces youth employment and skills shortages.

Source: Forestry South Africa, 2026

EUROPE

–10%

decline in forestry and logging employment between 2012–2022, with growing shortages of qualified forestry professionals.

Source: FOREST EUROPE, 2026

SOUTHEAST ASIA

50+ years

average age of farmers in many countries, with younger generations migrating to urban jobs (e.g. in Indonesia, share of agricultural workers aged ≥60 increased from 7.6% in 1971 to 21.2% in 2020).

Source: Rikolto, 2021; MDPI, 2022

What We'll Cover

Three topics, one pathway

01



Technology context

What is happening outside forestry

Mega trends · AI in business · Cost curve

02



Forestry use cases

Mechanization and digital on one pathway

Maturity pathway · Silviculture cycle · Digital & AI

03



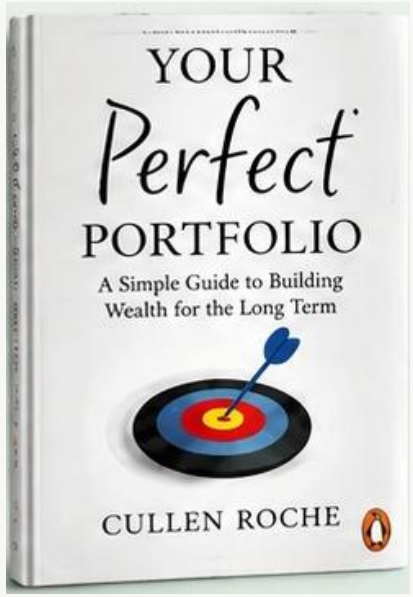
Adoption & the future

Why good technology fails, and what comes next

Kill a project · Future insights · Who controls AI

Influence of mega trends

How the global economy shapes technology adoption in forestry



Inspired by
Cullen Roche, *Your Perfect Portfolio*

1 Technology is eating the world
Digital, AI and automation reshape every industry

2 Consumption is eating the world
Rising incomes drive unprecedented demand

3 Emerging markets are eating the world
Growth and capital shift to faster economies

4 Healthcare is eating the eaters
Prosperity raises demand for health

5 Decentralization is eating centralization
Agile players take share from giants



KEY TAKEAWAY FOR SILVICULTURE

Technology drives the next wave

Falling costs of sensors, AI and automation make precise, scalable forestry a reality.

Sensors → AI & analytics → Automation → Higher productivity, lower costs

Technology evolves, but not always disrupts

Incremental gains over time

The first iPhone (2007)



3.5-inch LCD display

No front camera	CAMERA	Front camera with Center Stage
2 MP (1 rear camera)	VIDEO	4K video
No video recording	UNLOCKING	Touch ID
2G / EDGE	INTERNET	5G
No App Store at launch	APP STORE	Millions of apps
Up to 16 GB	STORAGE	Up to 1 TB
30-pin connector	CHARGING	USB-C + wireless charging
No water resistance	WATER RESISTANCE	IP68 water and dust resistance

iPhone Duo (2026)



5.4-inch cover display
7.6-inch inner foldable display

Broad AI adoption, scaled value still rare

AI in the corporate world, 2026: pilots are easy, scaling is hard

88%
of companies use AI in at least one business function
McKinsey, 2025

44%
say AI is scaling enterprise-wide, up from 38% a year ago
McKinsey, 2026

40%
of enterprise apps embed AI agents by end-2026, from under 5% in 2025
Gartner forecast

10%
call AI truly core to how their business runs
Publicis Sapient, 2026

Where companies use AI

- **Operations** — Automation, assistants
- **Customer service** — Chatbots, personalisation
- **Sales & marketing** — Forecasting, campaigns
- **Finance & risk** — Fraud, credit risk
- **HR & people** — Hiring, training
- **R&D** — Design, modelling
- **IT & cyber** — Threats, IT operations
- **Supply chain** — Planning, inventory
- **Sustainability** — Carbon, ESG reporting

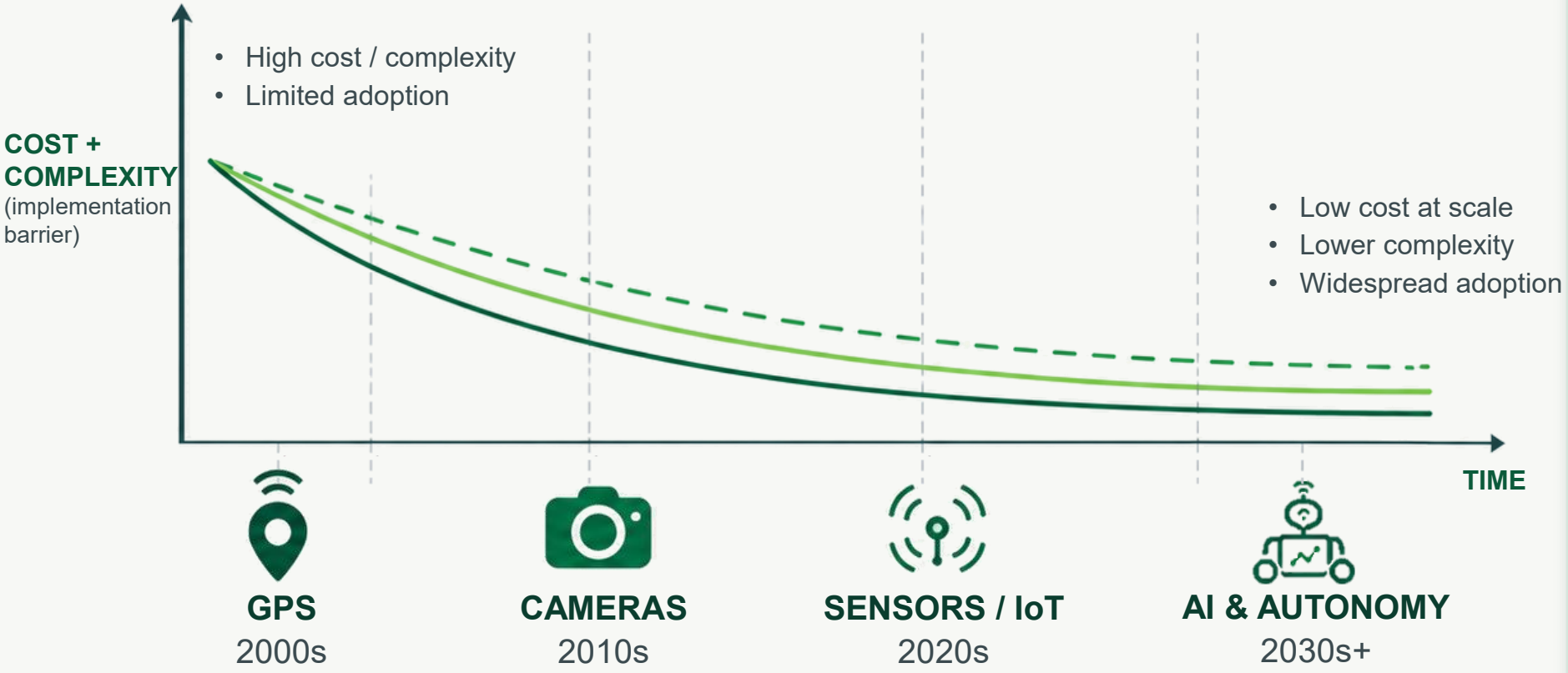
What still holds it back

- **Energy** — Data centres drive rising power demand
- **Servers & compute** — GPUs scarce; cloud bills grow with use
- **Uncertain ROI** — Many pilots never scale
- **Sensors & automation** — Field hardware: high upfront cost

Sources: McKinsey State of AI (2025, 2026); Gartner; Publicis Sapient Global Enterprise AI Report 2026

The cost curve changes everything

Capability comes first, cost comes down, adoption takes off.



Silviculture will follow the same curve.

When unit costs drop, precision becomes the standard.

SELECTED REFERENCES

1. **Zawacki et al. (2025)**
   A History of UNAVCO: Four Decades of Advancing Geodesy.
   GPS equipment costs fell rapidly, enabling broader deployment.
2. **Evolution of LiDAR (2024)**
   Nature Communications.
   LiDAR cost reported falling from >$10,000 to ~$500–1,000 over the prior decade.
3. **Agricultural drones (2025)**
   The rapid global rise of agricultural drones.
   Falling costs and outsourcing are identified as drivers of diffusion.
4. **Precision Forestry Revisited (2025)**
   Remote Sensing, 17, 3465.
   UAV and LiDAR are now dominant precision-forestry technologies; adoption still faces cost barriers.
5. **Latterini et al. (2025)**
   Remote sensing for harvesting operations.
   LiDAR enables tree-level precision forestry, road/trail mapping and operational monitoring.

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The Technology Maturity Pathway

From manual to autonomous – the evolution of silviculture operations

MANUAL



People
+ tools
+ experience

MECHANIZED



Machines increase productivity

CONNECTED



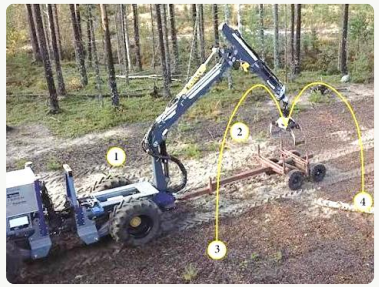
GPS, sensors & machine data in real time

DATA-DRIVEN



AI & analytics optimize planning & decisions

AUTONOMOUS



Machines execute + system learns continuously

✓ **Improving safety** • **Increasing productivity** • **Reducing cost** • **Enhancing sustainability**

Mechanizing every step of the silviculture cycle

From soil preparation to fertilizing, with embedded technology on board

Soil preparation → Planting → Watering → Weeding → Fertilizing



























Embedded technologies

- Auto-pilot (precision lining)
- Activity times registration
- Flow rate control

Digital & AI in forestry today

Every machine is a sensor: data turns operations into decisions

LiDAR inventory

DATA-DRIVEN

Drone and airborne LiDAR measure height, volume and stocking, tree by tree.

Machine telemetry

CONNECTED

On-board computers log position, activity times and output for every machine.

Precision planning

DATA-DRIVEN

GIS and AI build micro-plans for site prep, planting and fertilizing by zone.

Forest health

DATA-DRIVEN

Satellite and drone imagery flag pests, disease and drought stress early.

Fire detection

CONNECTED

Camera towers and satellite hotspots, with AI alerting crews within minutes.

Planting quality

DATA-DRIVEN

AI counts seedlings in drone images to verify survival and pay contractors accurately.

Reality check: connectivity in remote forests is still patchy and varies widely across regions and countries. Design for offline-first, store-and-forward data and satellite links.

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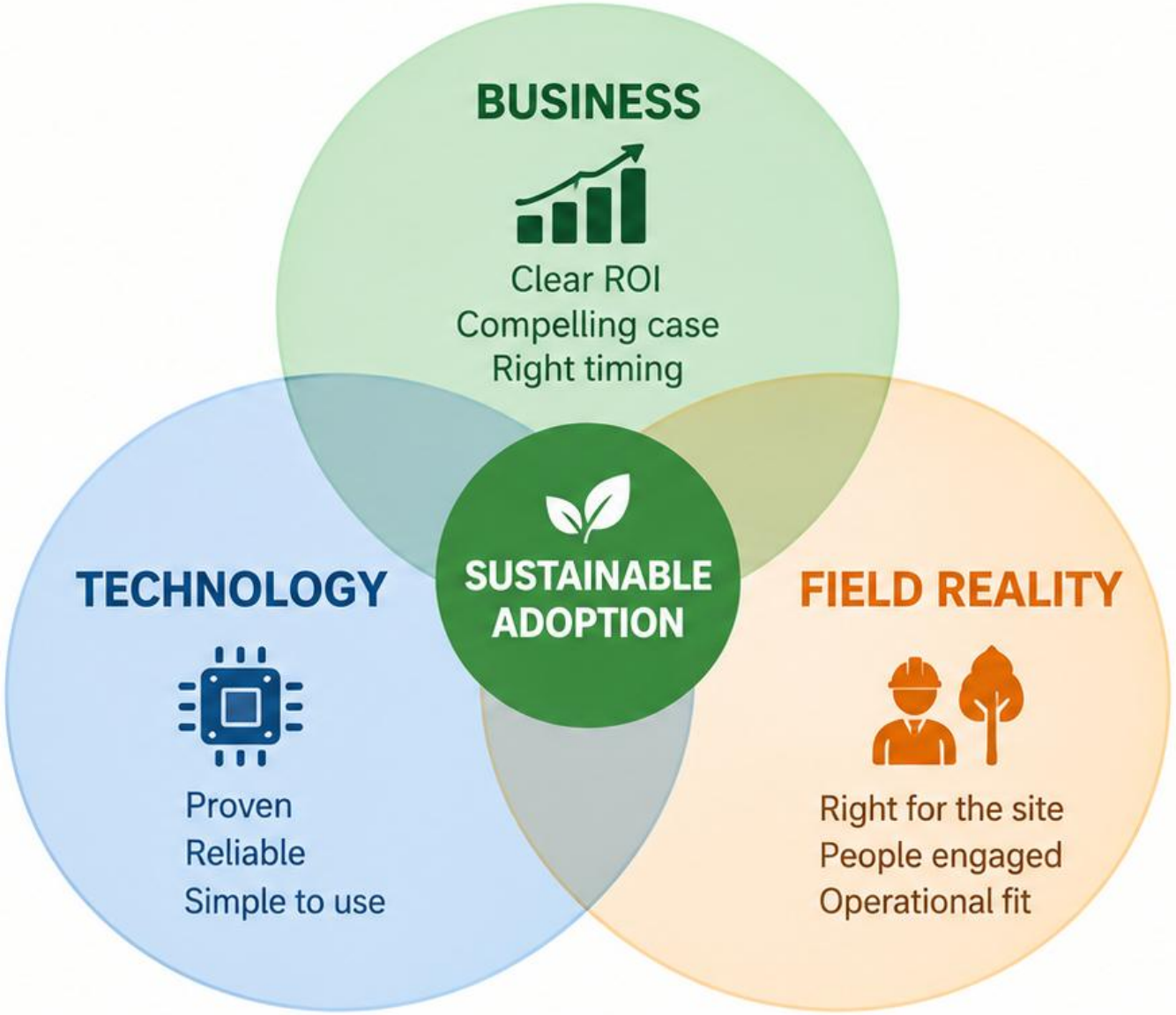
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Why good technology still fails

Success happens at the intersection



7 ways to kill a project

Common pitfalls that turn good ideas into failed initiatives



1. **Ignore the business case**
   No ROI conversation, no buy-in.
2. **Force a one-size-fits-all solution**
   Rigid = rejected.
3. **Underestimate real costs**
   Slicker price is never the total cost.
4. **Deploy without stability testing**
   It must work in real remote conditions.
5. **Skip the field team**
   No input from the people who use it daily.
6. **Chase the shiny new tool**
   Trending = solving a real need.
7. **Treat it as a one-time rollout**
   No iteration, no feedback, no improvement.

Future insights

Where new and existing technologies will expand their application



Variable-rate fertilizing

Apply nutrients by zone, based on production maps.



Spot spray

Detect weeds and spray only where needed.



Electric / laser weed control

Precision weed removal with less chemical input.



Autonomous planting & replanting

Machine vision + precision planting.



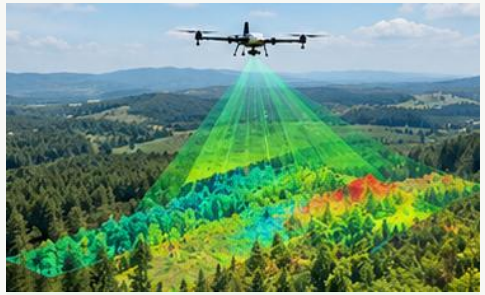
Electric machines

Battery and hybrid machines, charged by off-grid solar and storage.



Tree-level growth monitoring

Track growth, health and risk continuously.



Automatic inventory

On-demand UAV/LiDAR, tree-level inventory.



Dynamic micro-planning

AI adapts plans to weather, soil, terrain and machine status.



Autonomous drone swarms

Launch, recharge and coordinate missions.

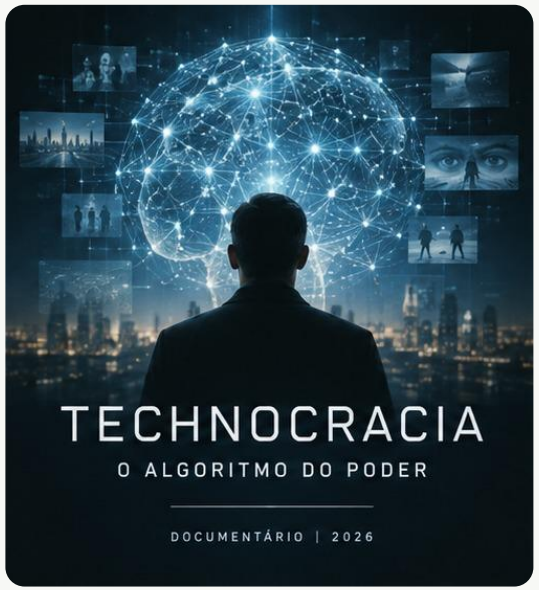


Tech-enabled firefighting

Satellite and drone detection, drones for automated suppression.

Who controls the algorithm?

As AI grows more capable, the question shifts from what it can do to who controls it, and why



Scan to watch
plataforma.brasilparalelo.com.br/playlists/technocracia

Concentration of power

Models, compute and data concentrate in a few hands.

Loss of control

Capability may advance faster than governance and understanding.

Global AI race

Nations and companies compete for strategic advantage.

Rule by algorithm

Decisions on jobs, credit and access increasingly depend on AI.

Surveillance & freedom

Profiling can enable manipulation, monitoring and censorship.

Human purpose

What remains for human judgment, skill and meaningful work?

Technology is a tool. The real question is who governs it — and to what end.

Key takeaways

Four ideas to carry from today into your own operations

01

Key drivers

People, productivity, precision and sustainability. Labor gaps are structural and global; technology keeps silviculture safe, consistent and auditable.

02

The context is ready

Technology evolves step by step, and costs are collapsing: GPS, LiDAR, drones and sensors cost a fraction of what they did a decade ago.

03

One integrated pathway

Mechanized, connected, data-driven, autonomous: each stage builds on the data captured in the one before.

04

Adoption is the real test

Good technology fails without a business case, field-team buy-in and real-condition testing. Keep human judgment at the centre.

Start small, measure, then scale.

The technology is already affordable — readiness to adopt it is now the differentiator.

Mechanization creates the data.

Digital turns it into decisions.

AI closes the loop.

Thank you!

Questions & discussion

Precision silviculture is no longer a question of if, but of how fast we learn to adopt it.



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ROLES & AFFILIATIONS

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