EMAPI9, September 17-21, 2007, Perth, AUSTRALIA

Invasion dynamics and management of the tree *Casuarina equisetifolia* in the atoll of Moruroa (French Polynesia), a former nuclear test site in the South Pacific

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Biological invasions in islands

- One if not the main cause of biodiversity loss
- Island biota are more vulnerable to invasion
  - small population size & restricted distribution ranges
  - less competitive taxa
  - vacant ecological niches/missing functional group
- Higher risk of invasions in islands
  - alien species introduced without their natural enemies
  - dramatic increase of people and goods transportation ⇒ more alien species introductions
  - greater intensity of human impacts: land clearing, urbanization, fires, grazing or trampling by ungulates…

Disturbance and plant invasion

- A major factor affecting invasibility of native ecosystems

→ increases resource availability (e.g. light, soil nutrient…)

→ reduces species competition

- Post-disturbance plant succession

→ pioneer/light-demanding/early successional species

→ shade-tolerant/late successional species

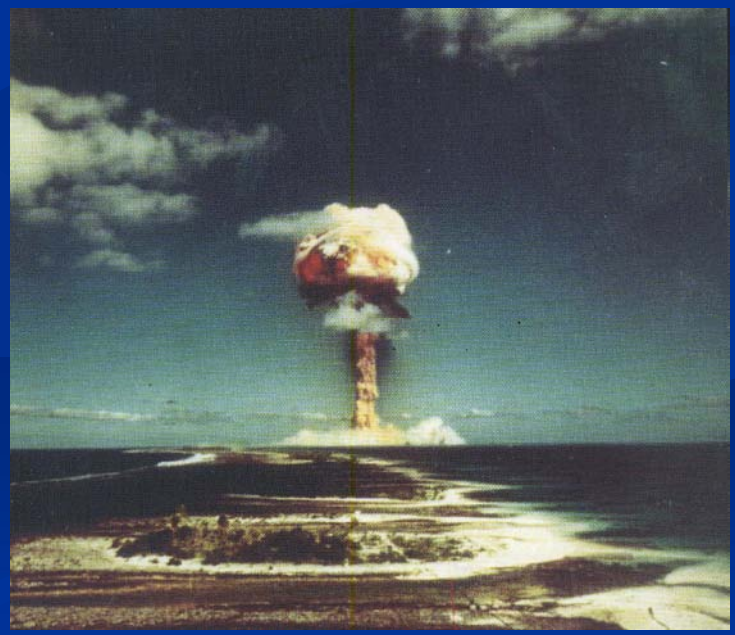
Disturbance gradient

- Importance of disturbance type, size, distribution and regime
- from micro-disturbances (local scale), macro-disturbance (landscape scale, e.g. fire, landslide, cyclone)…
- …to Mega-disturbances (ecosystem scale)

Lightning-caused fire

pig trampling

nuclear test



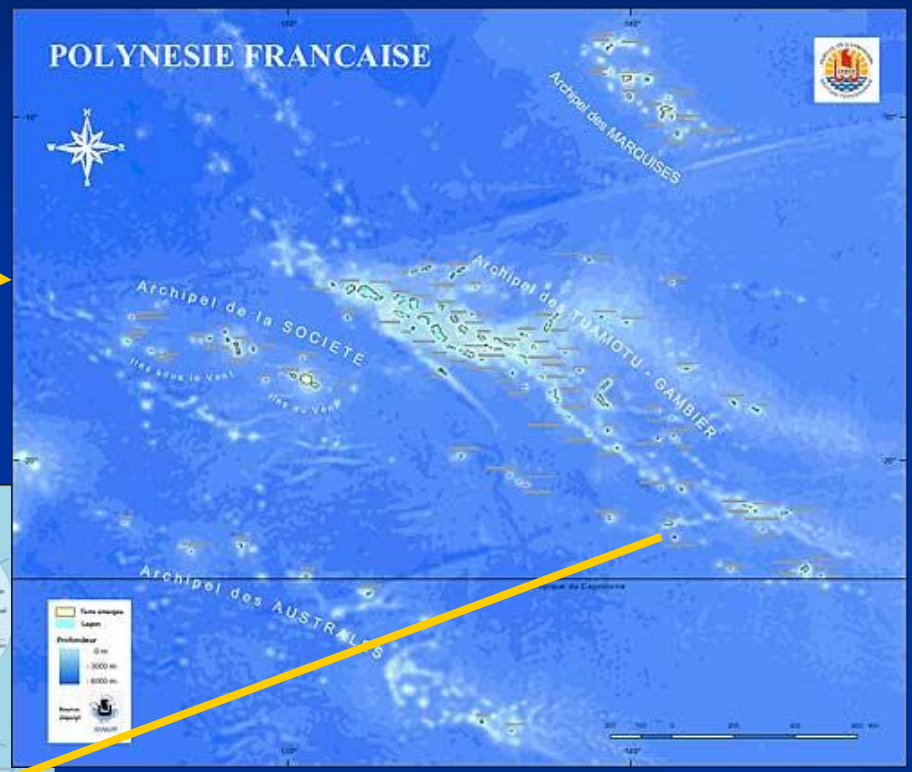
Moruroa, a National Defense Protected Zone

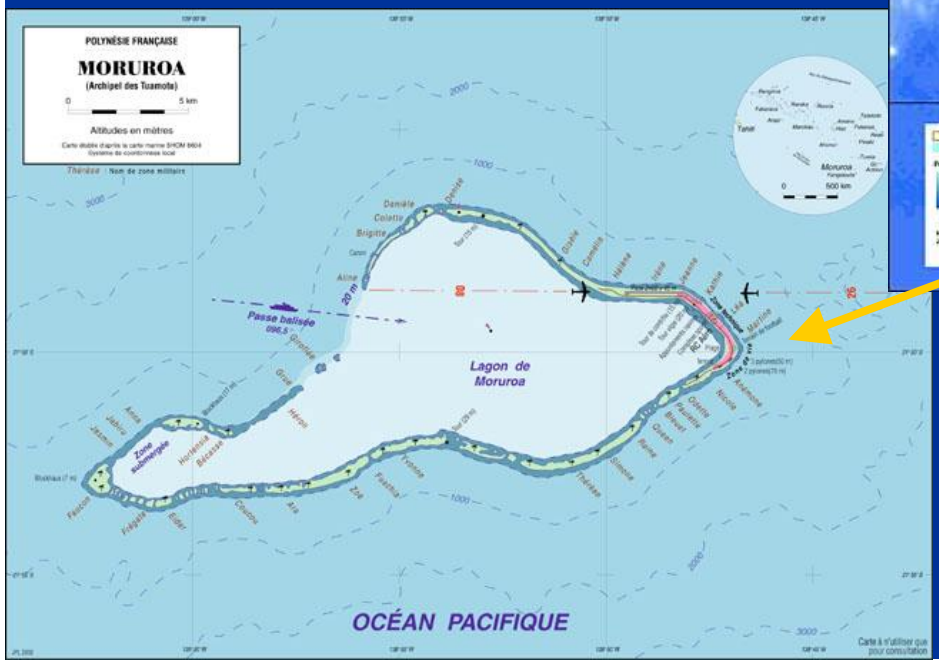
« l'atoll du grand secret »

Questions

- How to manage the *Casuarina equisetifolia* massive invasion in a coral atoll ecosystem ?
- Are the nuclear tests the triggering factor of its "demographic explosion" on Moruroa ?

Moruroa Atoll
(Tuamotu-Gambier Is., French Polynesia)





- tropical oceanic island (10-12 M yrs)
- 28 km x 10 km
- 3 km² of land area
- located at > 1,000 km from Tahiti

Human presence on Moruroa

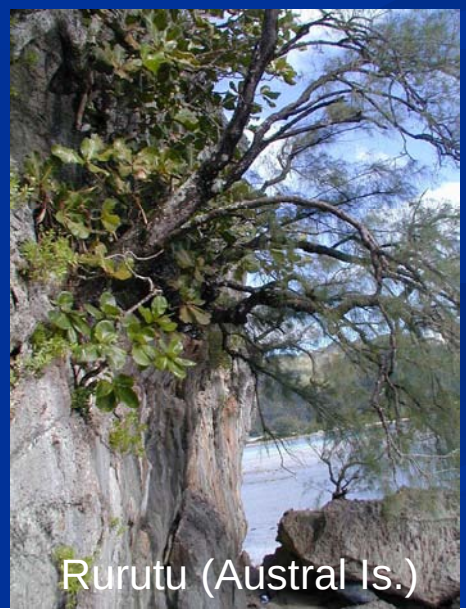
- 1792: « discovered » by the first Europeans
- 1881: a governmental land, coconut plantations
- 1904-1906: uninhabited after cyclones
- 1962: officially declared a nuclear test site
- 1966-1974 : 41 atmospheric nuclear tests
- 1976-1989 : 137 underground nuclear tests
- 1995: last nuclear test
- 1996: signature by France of the international treaty banning nuclear tests
- 1996-1998: demolition of all infrastructures
  (except the airstrip, the road, a small port, blockhouses, towers, radiological & geomechanical monitoring installations, a small military base)

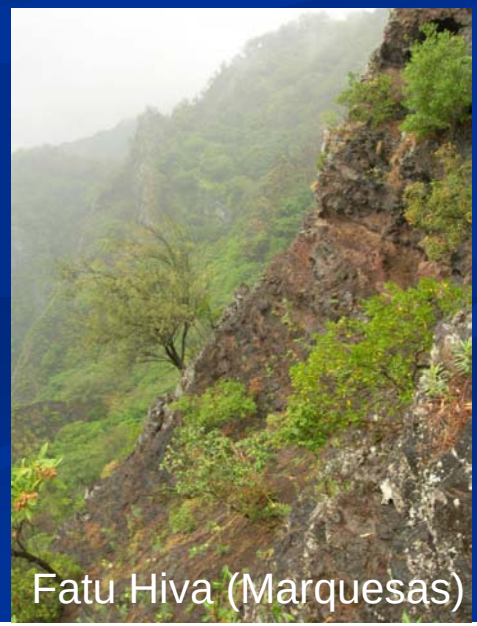
- From 1600-2500 people in 1994… to 25 soldiers in 2005

Casuarina equisetifolia L. (Casuarinaceae)

- « Pacific ironwood, beach she-oak, horsetail tree, Australian pine, filao, bois de fer, ‘aito, toa »
- Tree 5-20 m (up to 40 m)
- Native to Australia & Oceania (PNG, Solomon, Fidji, New Caledonia, Vanuatu, Tonga, Samoa…)
- Native in Eastern Polynesia ? Introduced to Hawaii in 1882
- 0-400 m (up to 800 m) elevation; rainfall 200-5,000 mm/yr
- Volcanic and calcareous substrate

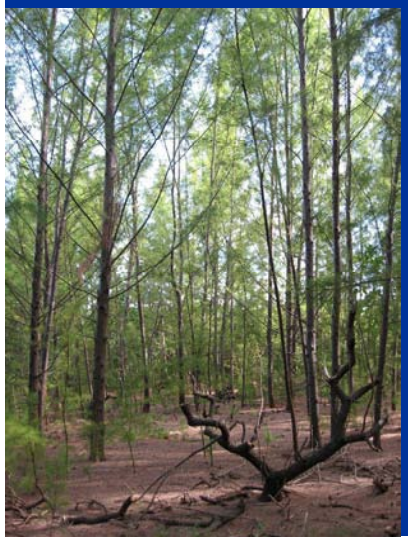

Maiao (Society Is.)


Rurutu (Austral Is.)


Fatu Hiva (Marquesas)

« Ideal » weed or agressive colonizer of open disturbed areas and poor soils ?

- Fast-growing (3 m in height/yr, 1-2 cm in diam./yr)
- Early reproduction (4-5 yrs)
- Prolific seed production
- Wind dispersed and sea-drifted
- Salt-resistant
- Drought-tolerant
- Nitrogen-fixing tree
- Forms monotypic stands with a dense leaf litter (allelopathy ?)



- Coastal dunes and sandy sea-shore in South-Africa and Florida (USA)
- New lava flows in La Réunion (Mascarenes, Indian Ocean)
- Coastal and lowland dry/mesic forests and fernlands in Hawaii
- Phosphate-mined areas in the raised limestone island of Nauru (Pacific Is.)

Casuarina equisetifolia's invasion dynamics on Moruroa

- Inroduced in 1966 (as an ornamental, shade, hedge or wind-break tree)
- Recognized as invasive in 1994
- 150 ha invaded (50% of the land area) in 2005

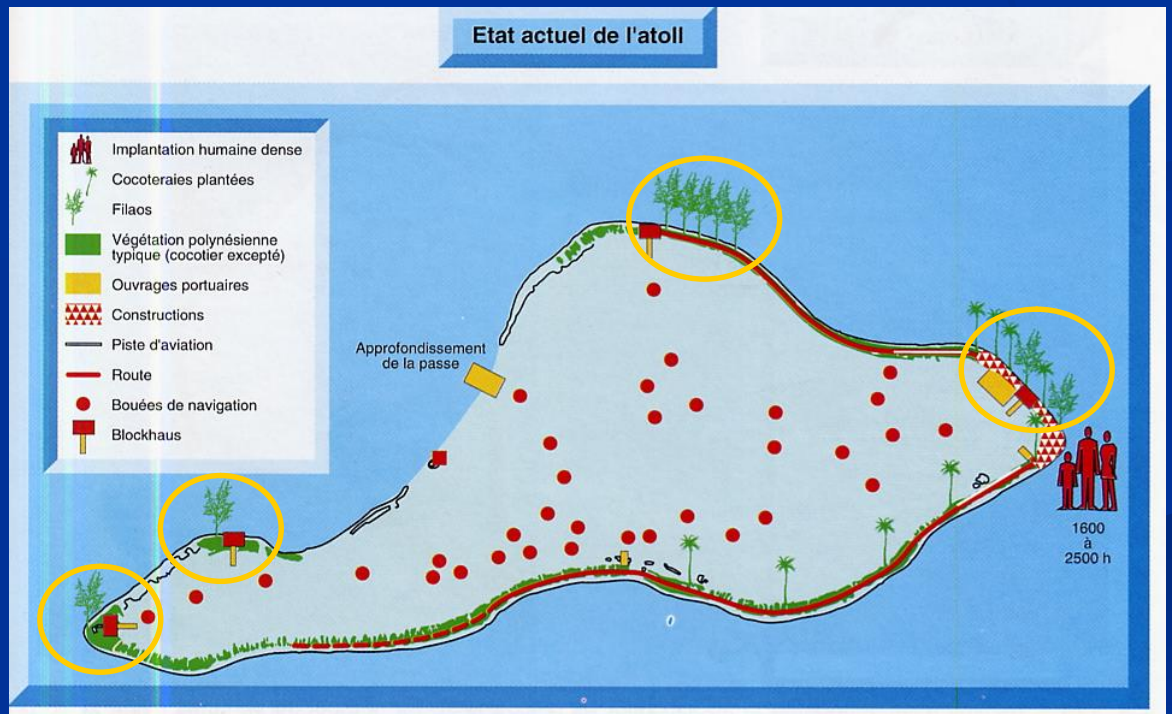


FIG. 171. - Travaux d'aménagement et modification de la flore terrestre, à Mururoa, entre 1965 et 1994.

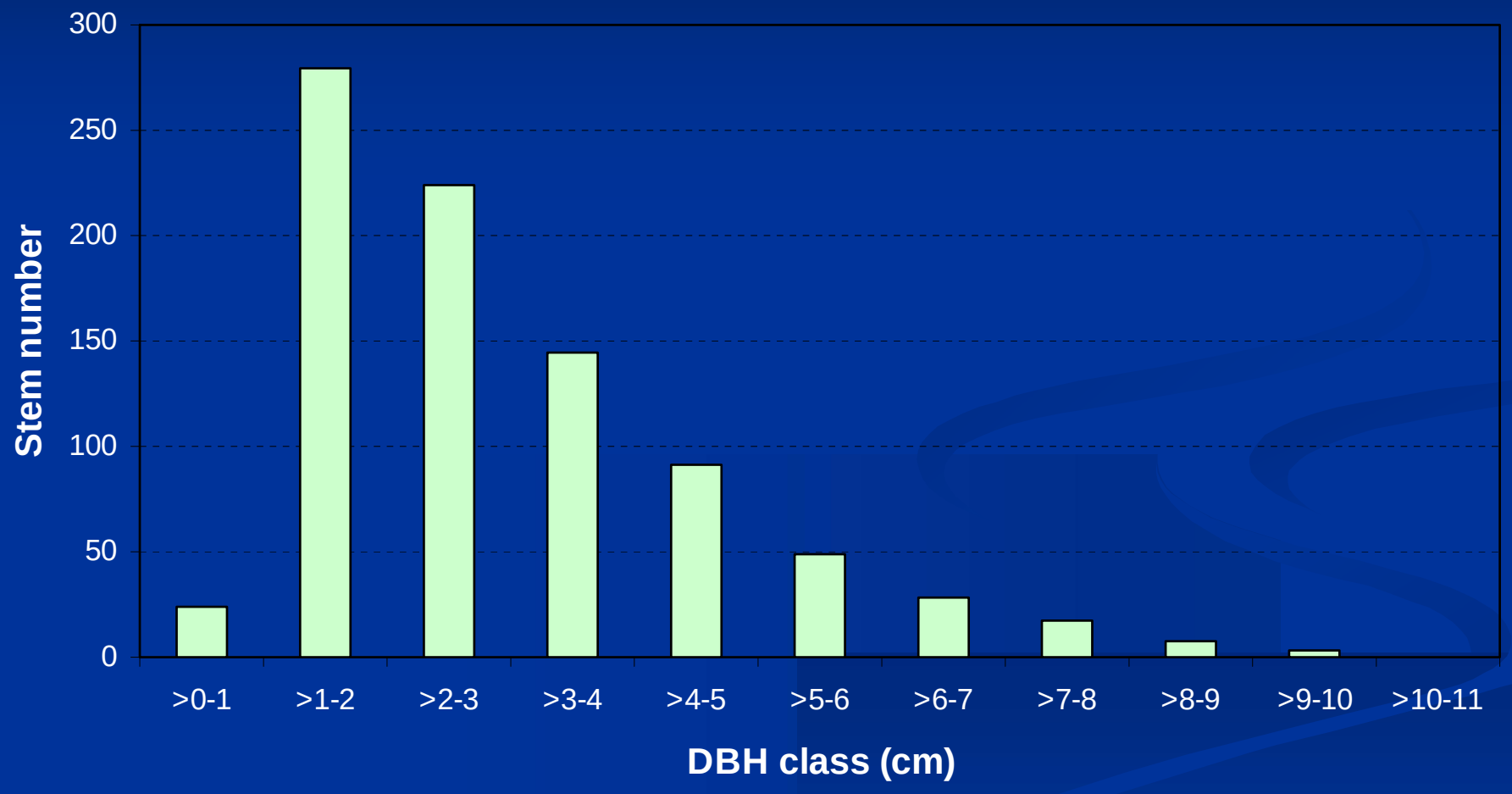
Method

- 3 short field-trips in 2005 and 2007 (4-5 days each)
- Selection of 3 dense stands with different « physionomy »
- 7 permanent plots (100 m² quadrats)
- Tree number, Stem number, DBH (measured at 1.3 m)
- Density, Mean basal area

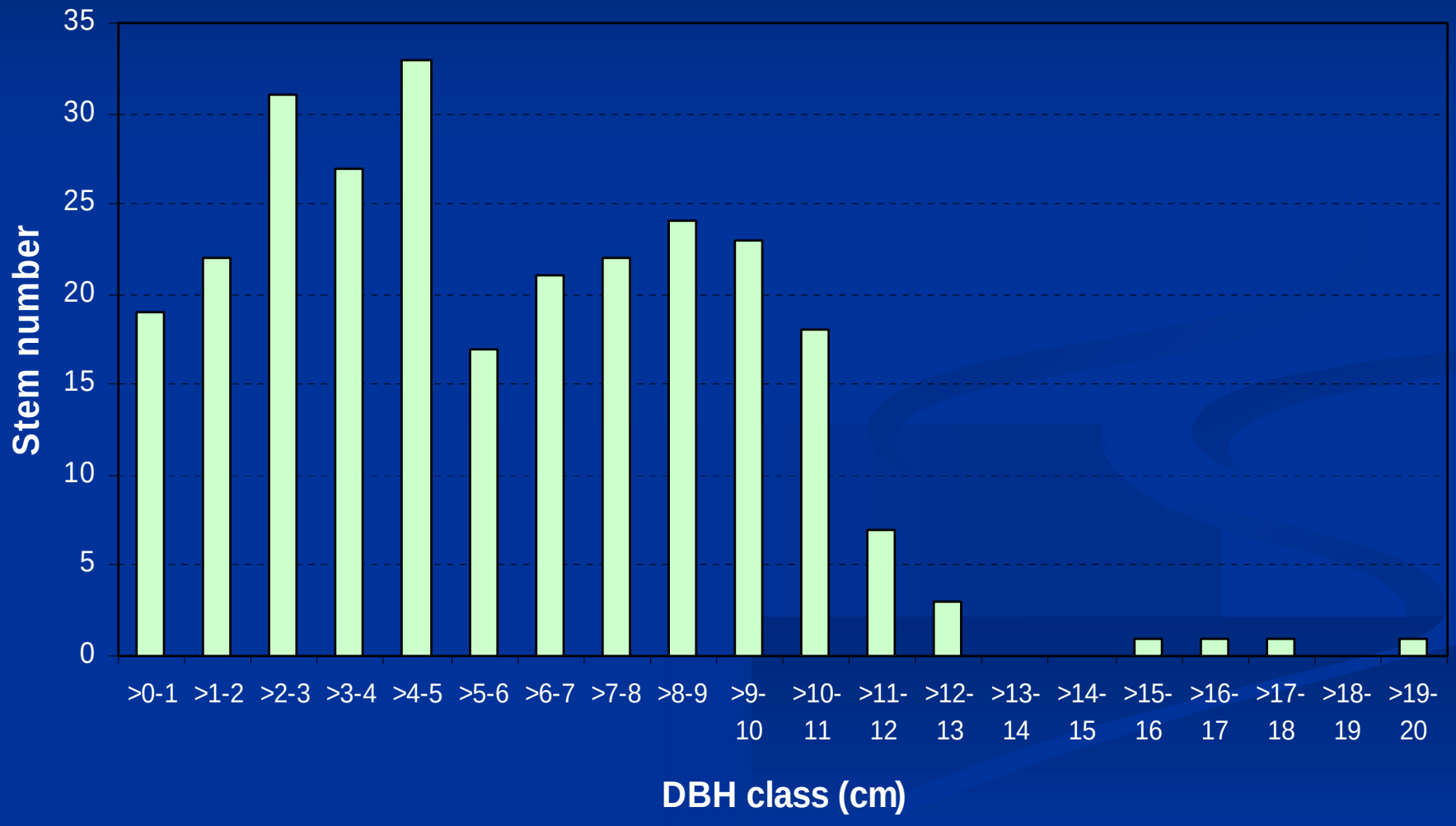
Main results

Stand/Population	Area (m^2)	Stems/m^2	Mean basal area (cm^2/m^2)	DBH max (cm)
« Very Old »	100	0.5	36.16	24.5
« Old »	300	0.9	32,3 ± 1.63	19.7
« Young »	300	2.9	27.1 ± 1.89	10

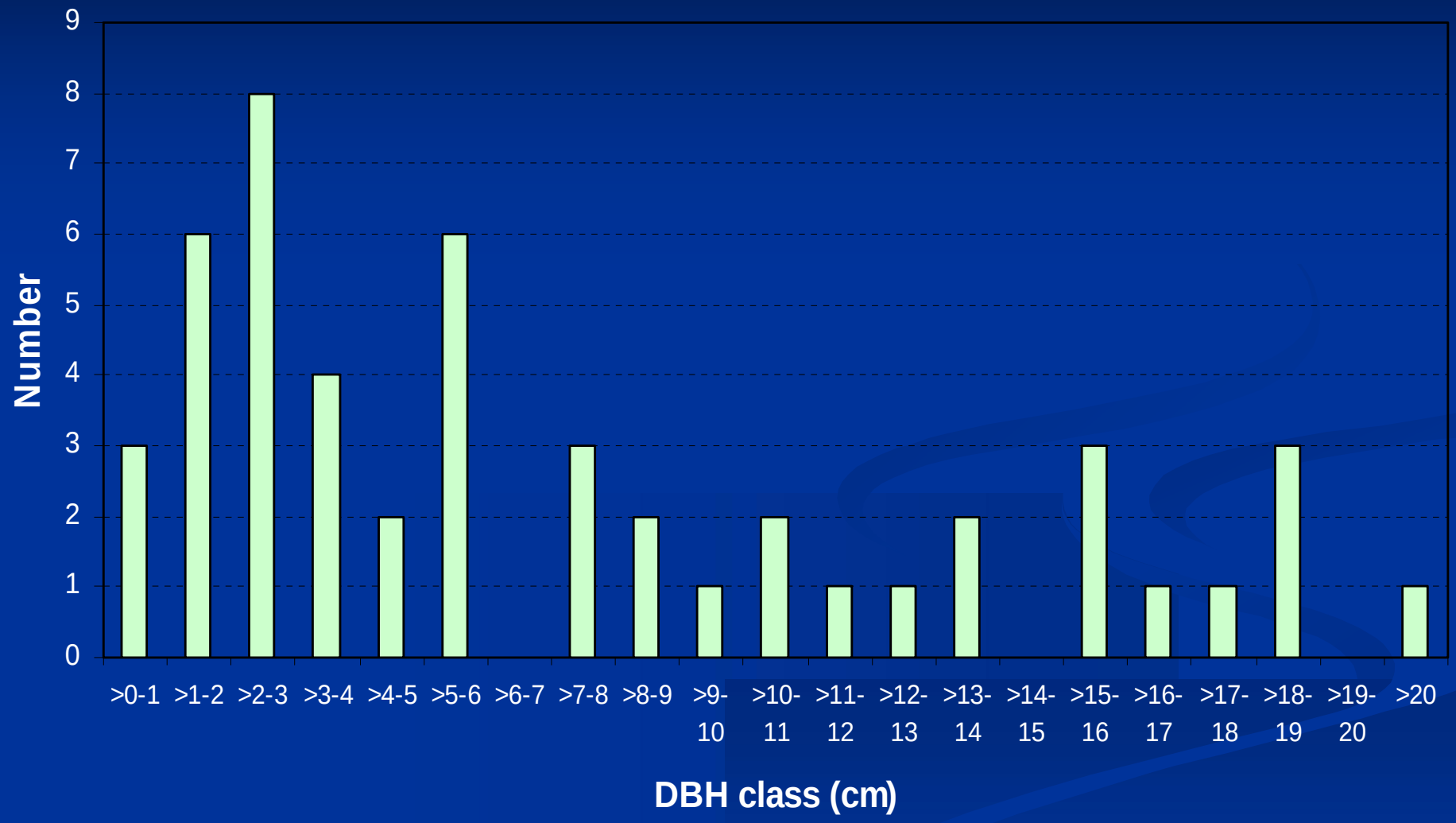
« Young » population structure (ca. 10 yrs old)



« Old » population structure (>20 yrs old)



« Very Old » population structure (>40 yrs old)



Discussion: invasion patterns and process

- Destruction of the vegetation and soil vitrification by the aerial nuclear tests (1966-1974)
- Construction and settlement period (1975-1995)
- Demolition of infrastructures and clean-up period (1996-1998)

1980's

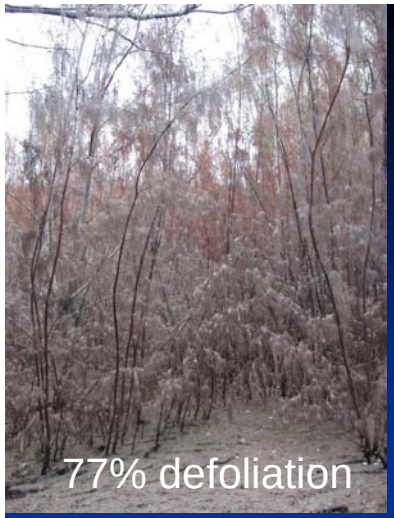
Invasion management:
testing adapted control methods

- Cut-stump treatment (+ Glyphosate "Asteroide®")
- Ring-barking/frilling (+ Glyphosate)
- Fire (low intensity)

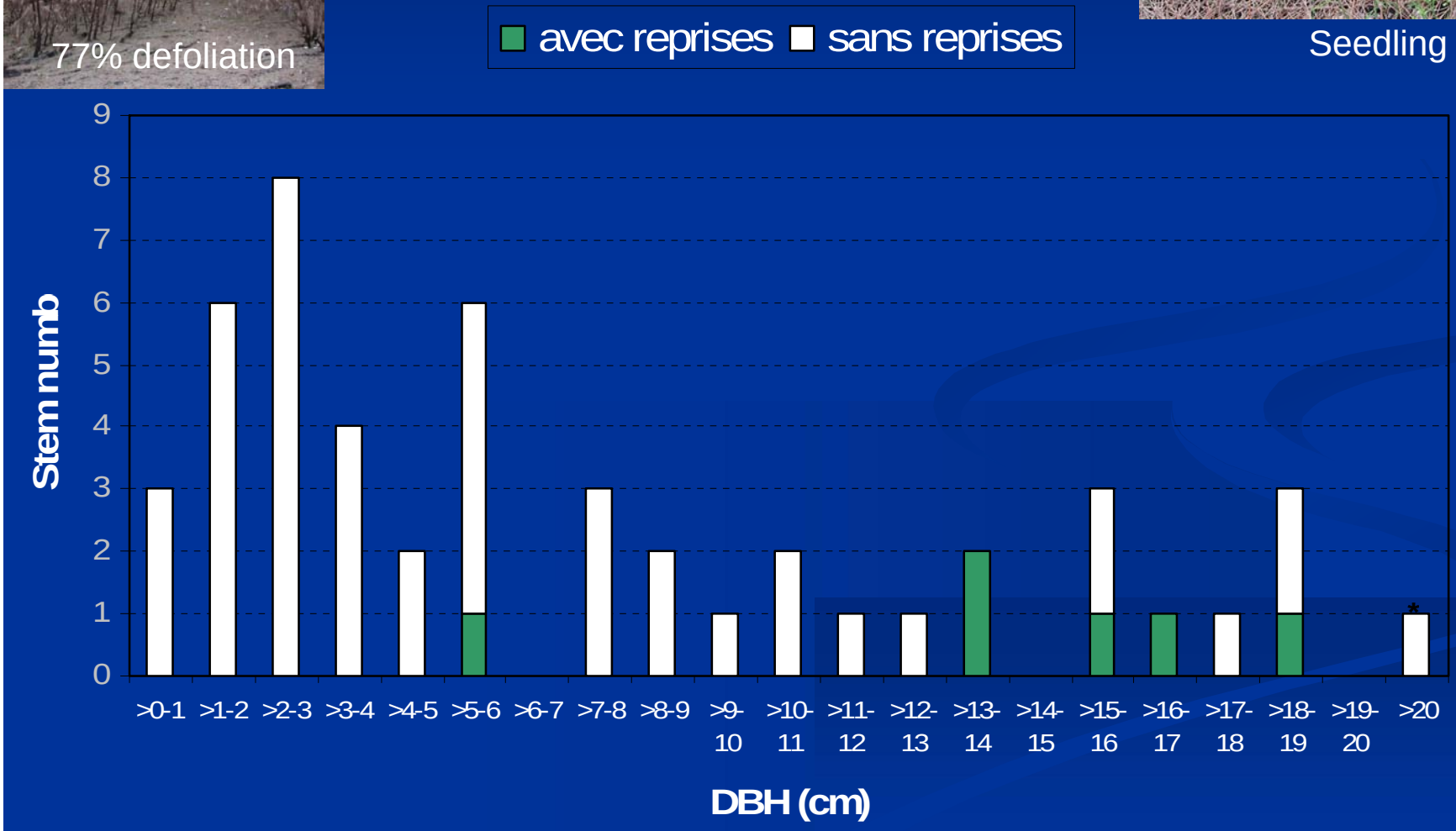
Preliminary results

% resprouting (2 months after treatment)

Treatment	« Young »	« Old »
Cut-stump	38%	28%
Ring-barking/frilling (% defoliation)	77% (83%)	56% (62%)



Fire treatment
(2 months after burning)



Future prospects: a rehabilitation project

- Inventory of native (31 spp.) and alien (110 spp.) plant species
- Early eradication of potential invaders/sleeping weeds (8 spp.)
- Plantation of native plant seedlings in treated/defoliated areas








Acknowledgements

- French Minister of Defense (DSND, DGA/DSCEN), CEA, French Army based in Tahiti (COMSUP), High-Commissioner of French Polynesia, the officers & soldiers of Moruroa

Thanks a lot for your attention, merci beaucoup, mauruuru roa

Moruroa, a natural reserve for the future ?