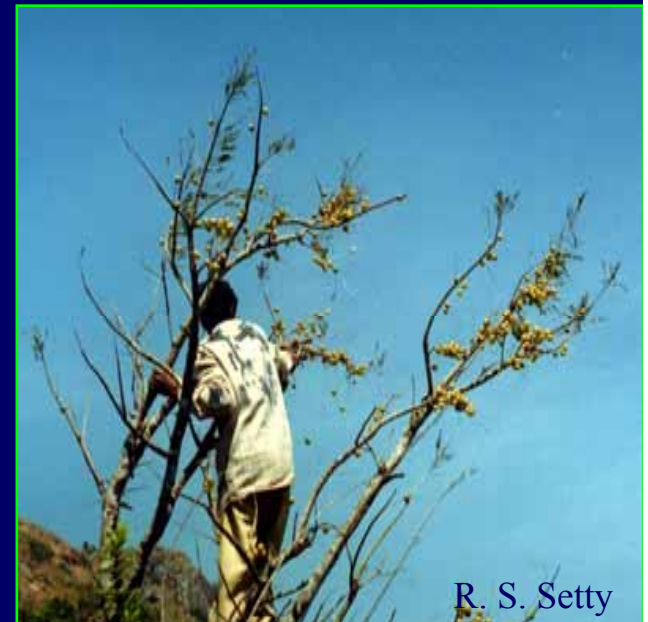


Ecological implications of collection of medicinal and aromatic plants at the individual, population, community and ecosystem levels

Tamara Ticktin
University of Hawai`i



Review and synthesis of the MAP literature:

- 1) Illustrate patterns in the ways in which MAP harvest can have impacts at different ecological scales**
- 2) Identify the range of ecological methodologies used to make these assessments**
- 3) Provide some thoughts for discussion on potential appropriate and affordable methodologies for assessing MAP harvest sustainability**

Ecological Implications of MAP Collection

- 1) Illustrate patterns in the ways in which MAP harvest can have impacts at different ecological scales**


**Review of MAP *and* NTFP literature:
quantitative ecological studies that assess the
ecological effects of harvest**

~84 case studies

Effects on Individuals and Populations

- **Most direct ecological consequence:**
 - **VITAL RATES: growth, survival, reproduction**

Effects on Individuals and Populations

- **Most direct ecological consequence:**
 - **VITAL RATES: growth, survival, reproduction**
- 
- **POPULATION DENSITY, STRUCTURE and DYNAMICS**

Focus of Studies that Assess the Ecological Implications of Harvest

Level	Type of Assessment	Number of Studies
Individual	<i>Vital rates</i>	19
Populations and Individuals	<i>Structure and dynamics</i>	51
Communities	<i>Interactions, structure, composition</i>	11
Ecosystems	<i>Nutrient, organic matter cycling</i>	3
Total		84

Part Harvested	Species	Life History	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuis 1998
	<i>Matteucia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Part Harvested	Species	Life Form	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuis 1998
	<i>Matteucia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Part Harvested	Species	Life Form	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuis 1998
	<i>Matteucia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	20	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alyarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alyarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Part Harvested	Species	Life Form	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	2+ yr rotation	Geldenhuis 1998
	<i>Sphenomeris chinensis</i>	Fern	Tropical evergreen	40	Ticktin et al. 2006
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Effects on Individuals and Populations

Effects vary with:

- Plant part harvested
- Life history
- Environment (biotic, abiotic)

Part Harvested	Species	Life Form	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuijs 1998
	<i>Mattecuia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchoy. 2002
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000	

Effects on Individuals and Populations

Sustainable harvest for any one species varies with:

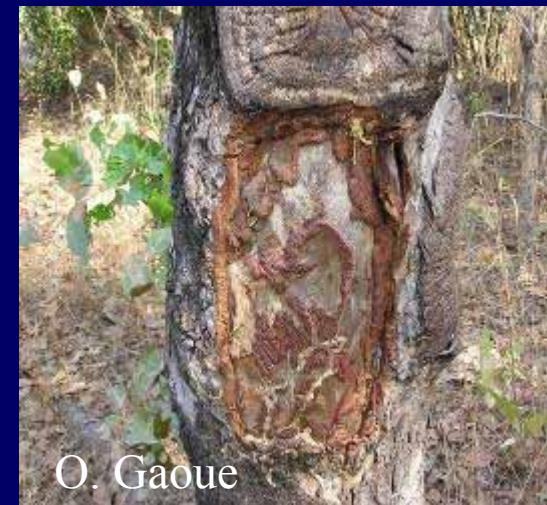
- **Environment**

Resource availability

Climatic, soil gradients (Shaankar et al. 1996; Paoli et al. 2001; Siebert 2000a; Siebert 2000b; Svenning and Macia 2002).

Plant comm (hemiparasites)

(Sinha & Bawa 2002)



O. Gaoue

Effects on Individuals and Populations

Effects vary with:

- **Plant part harvested**
- **Life history**
- **Environment**
- * **Collection practices**

Effects on Individuals and Populations

Management Practices

– Socioeconomic, political, cultural factors, landtenure

(1) Harvest methods

(2) Additional management practices

(3) Land-use context

Management Practices

(1) Harvest methods

- **Seasonal timing of harvest** (Anderson and Rowney 1999)
- **Intensity** (Price 1999; Anderson and Rowney 1999; Ghirmire et al 2005)
- **Frequency** (Geldenhuys and Merwe 1988; Nantel et al.1996; Endress et al. in Press; Zuidema 2001)
- **Size classes** (Nantel et al. 1996; Ticktin et al. 2002)
- **Type of harvest** (Flores and Ashton 2000; Ticktin, Johns, 2002)
- **Spatial pattern** (Ticktin, unpublished data)

Effects on Individuals and Populations

Management Practices

– Socioeconomic, political, cultural factors

(1) Harvest methods

(2) Additional management practices

(3) Land-use context

Management Practices that Stimulate Population Growth

Practice

Reference

Sparing

Joyal 1996, Ghirmire et al. 2006

Thinning &/or weeding

Ticktin 2002, Tickin et al. 2006

Transplanting

Ticktin 2002

Overstory mgt (light)

Ticktin 2002

Coppicing

Anderson 1991

Replanting plant propagules (Anderson and Rowney 1999;
Martinez Balleste et al. 2002)

Effects on Individuals and Populations

Management Practices

– Socioeconomic, political, cultural factors

(1) Harvest methods

(2) Additional management practices

(3) Land-use context



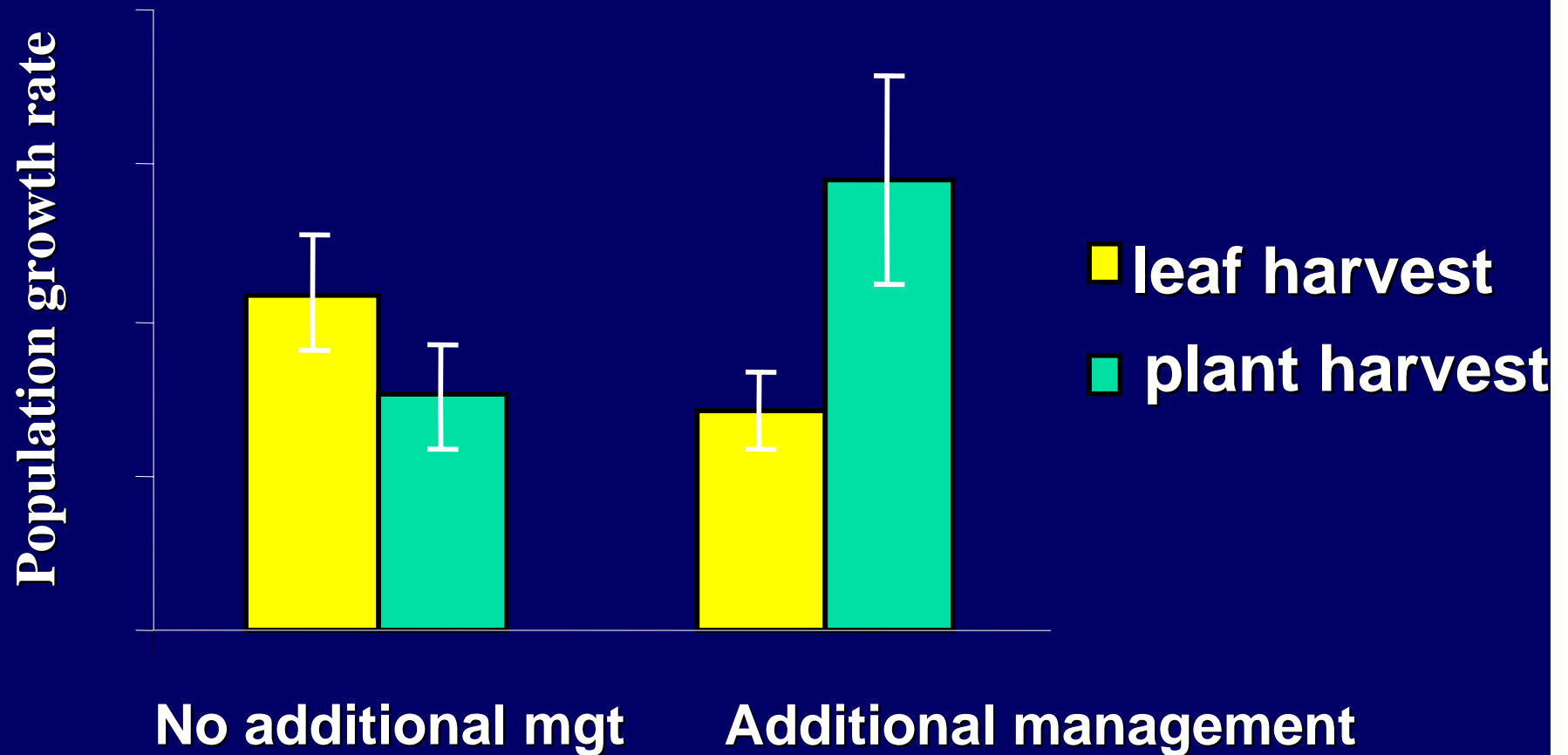
Interactions..



*Aechmea
magdalенаe*
harvest



Maximum sustainable fiber yield estimates for ixtle populations under different harvest strategies



Effects on Individuals and Populations

Management Practices

– Socioeconomic, political, cultural factors

(1) Harvest methods

(2) Additional management practices

(3) Land-use context

Management Practices

Land Use Context

- **Different stages of succession** (Svenning 2002; Siebert 2000b; Ticktin et al. 2003; Ticktin & Nantel 2004; Escalante et al. 2004)
- **Fire regime: frequency, intensity, time since** (Sinha 2001; Plowdon et al. 2003; Sinha & Bawa 2005)
- **Logging activities** (Plowdon et al. 2003)
- **Agroforestry systems** (Ticktin et al. 2003, Velazquez-Runk 1998)
- **Enhancement plantings**
- **Homegardens** (Martinez-Balleste et al. 2002, 2005)

Socio-economic and Cultural Factors

Land-tenure, Socioeconomic status

Government policies

Local institutions that govern resource use

Cultural factors and perceptions

TEK, Population pressure

Educationetc

Harvest Specific Practices

Amount harvested

Timing of harvest

Frequency of harvest

Part(s) Harvested

Spatial patterns of harvest

at local and landscape level

...etc

Land-Use Practices

Livestock Grazing

Logging

Agricultural practices

Fire management

Hunting

Agroforestry

Homegardens...etc

Additional Management Practices

Light manipulation

Thinning, Weeding

Understory clearing

Transplanting

Planting, Replanting

Coppicing, Pruning

Fire manipulation, Sparing

Fertilization...etc

Methods to assess impact of MAP collection at the individual level

- ✓ **Experimental harvests**
- ✓ **Comparisons of effects of actual harvest patterns on vital rates**

Impacts of MAP collection at the individual level

Effects vary with plant part harvested

Fruit/seed/Flower

Leaves

Resin

Roots

Bark

Whole plant



growth

reproduction

survival

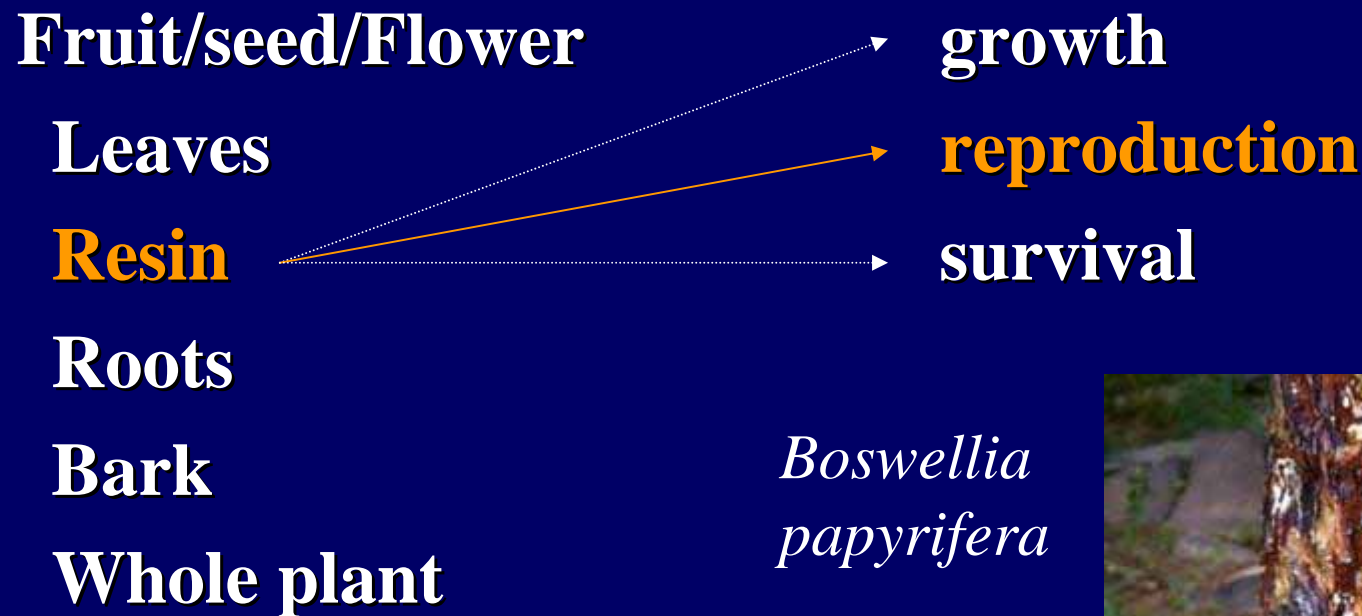
Methods to assess impact of MAP collection at the individual level

Considerations:

- **Difficulty in controlled experiments: comparing harvest vs non harvest**
- **Most studies are short term (2 yrs)**
- **Do the effects scale up?**

Impacts of MAP collection at the individual level

Effects vary with plant part harvested



Boswellia papyrifera

Rijkers et al.
2006 in Press



www.homestead.com

Methods to assess impact of MAP collection at the individual level

Considerations:

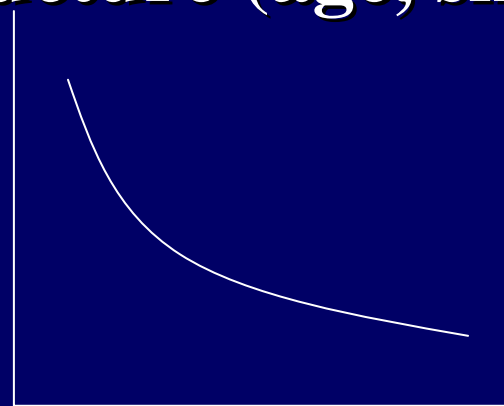
- **Difficulty in controlled experiments: comparing harvest vs non harvest**
- **Most studies are short term (< 2 yrs)**
- **Do the effects scale up?**

Part Harvested	Species	Life History	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuis 1998
	<i>Matteucia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Methods to assess effects of MAP collection on Individuals and Populations

Population structure (age, size)

No. of
individuals



Age class or size -class

Seedlings → Adults

Methods to assess effects of MAP collection on Populations

Population structure

✓ **Snapshot: low time and cost**

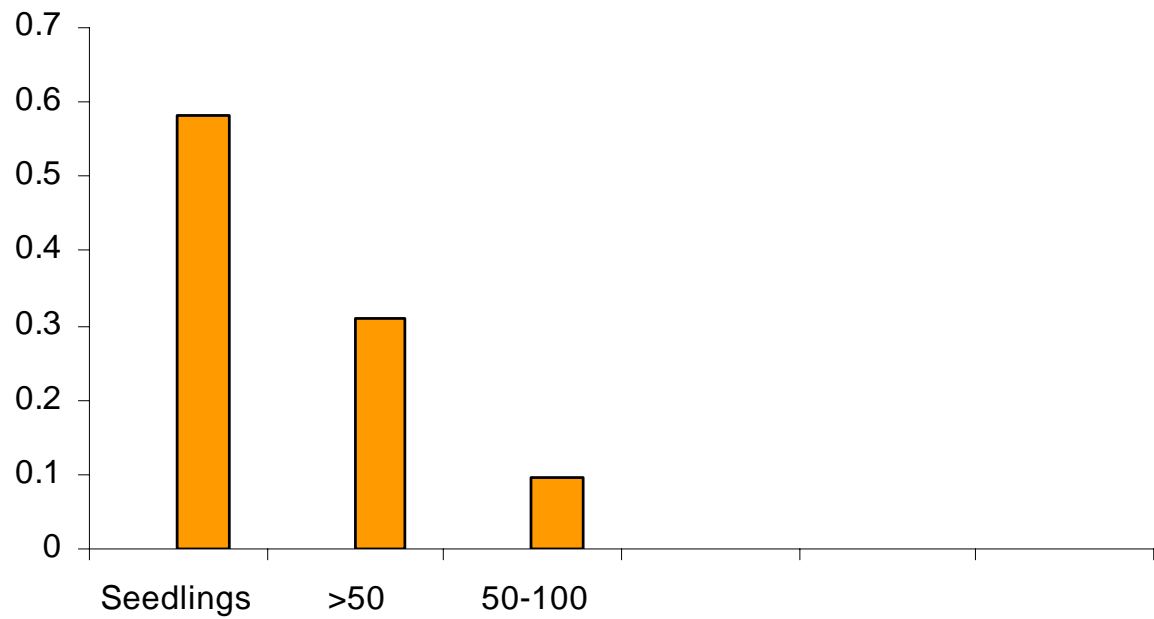
✓ **Can be hard to interpret**

without ‘unharvested’ comparisons

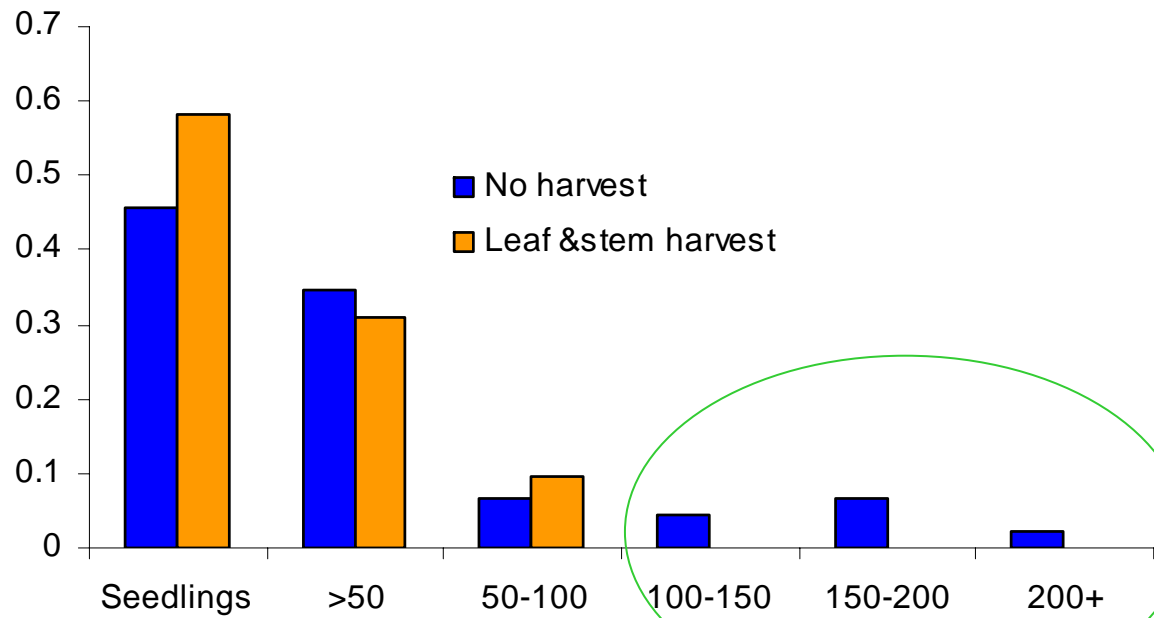
varies across life-histories

how much is sustainable?

Cycas circinalis

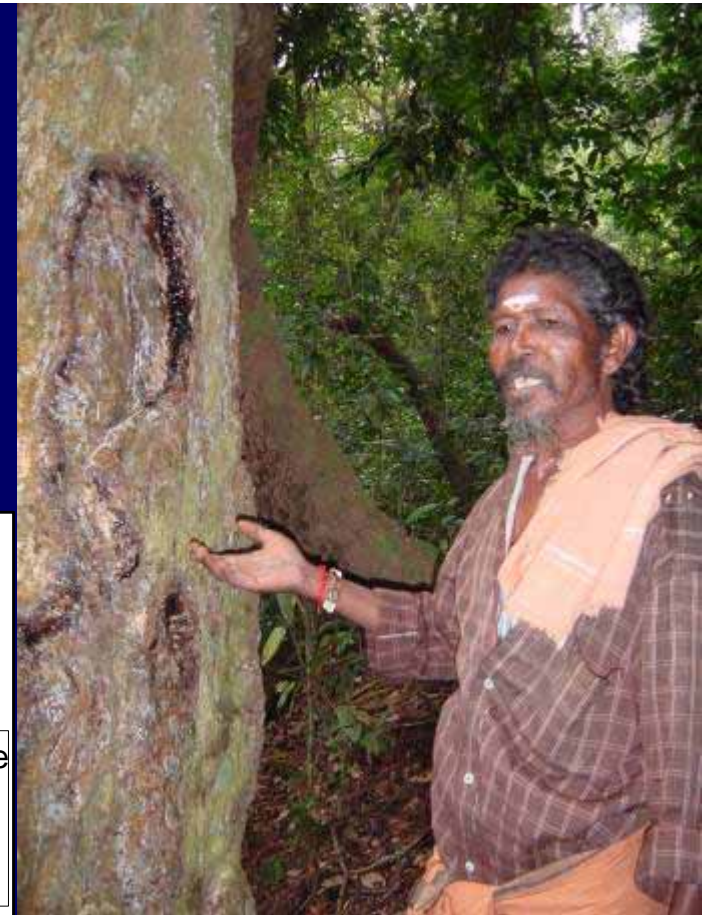
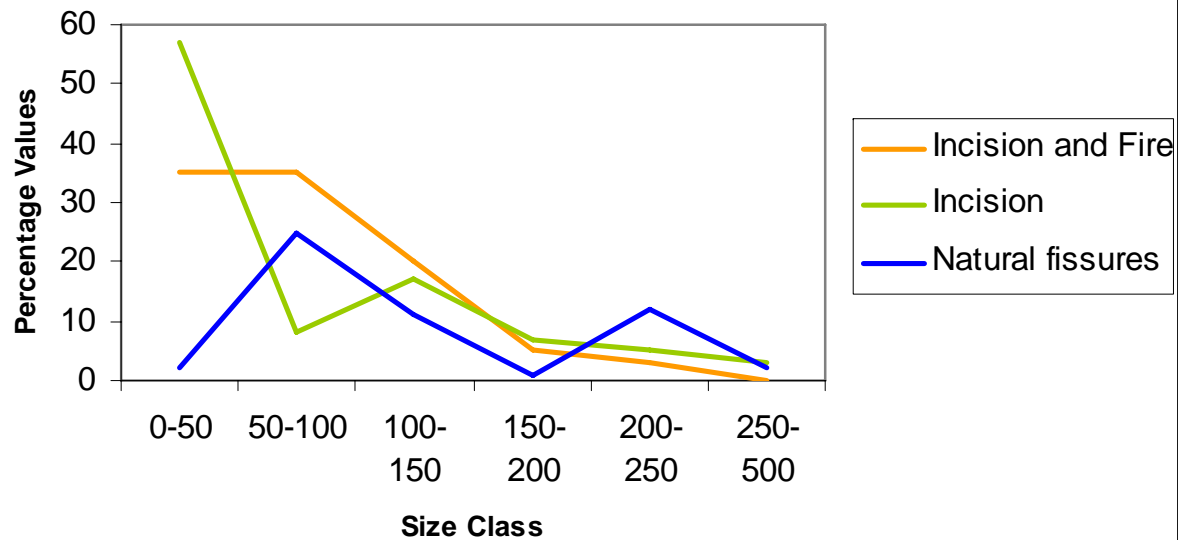


Cycas circinalis



Canarium strictum

Population under differing harvests



Methods to assess effects of MAP collection on Populations

Population structure

- ✓ Snapshot: low time and cost (one time census)
- ✓ Can be hard to interpret
- ✓ How much harvest is sustainable??
- ✓ Does not necessarily predict dynamics
(Condit et al. 1998)

Methods to assess effects of MAP collection on individuals and populations

Population structure

**Population dynamics
(matrix population models)**

Methods to assess effects of MAP collection on Individuals and Populations

Population dynamics

- ✓ **Can be powerful tools to assess sustainable harvest rates under differing contexts**
- ✓ **Large investment of time and effort**
- ✓ **Can lead to erroneous conclusions if interpreted without**
- ✓ **Can be selectively chosen to fill in gaps in current knowledge (e.g. certain life-histories and plant part combinations)**

Aechmea magdalenae



Predicted max sustainable
harvest based on
nonharvested populations

35%

Actual harvest rate

55%

POPULATION
GROWING ($\lambda > 1$)

Methods to assess effects of MAP collection on Individuals and Populations

Population dynamics

- ✓ **Can be powerful tools to assess sustainable harvest rates under differing contexts**
- ✓ **Huge investment in time and effort**
- ✓ **Can lead to erroneous conclusions if interpreted without**
- ✓ **Can be selectively chosen to fill in gaps in current knowledge (e.g. certain life-histories or plant parts)**

NTFP for which Ecological Studies have been carried out

	Palms	Trees and Shrubs	Herbs	Vines or Lianas	Bryophytes	Total
Flowers	5	3	4			7
Fruits/ seeds	16	12				14
Leaves	7		6			22
Roots/ bulbs			4	2		6
Branches		1		1		2
Bark		4				4
Resin		4				4
Whole plant	2 (1 cycad)		6		2	13
Total	30	24	20	3	2	79

Focus of Studies that Assess the Ecological Implications of Harvest

Level	Type of Assessment	Number of Studies
Individual	<i>Vital rates</i>	19
Populations and Individuals	<i>Structure and dynamics</i>	51
Communities	<i>Interactions, structure, composition</i>	11
Ecosystems	<i>Nutrient, organic matter cycling</i>	3
Total		84

Part Harvested	Species	Life History	Environment	Max. Annual Sustainable Harvest (%)	Reference
Seeds/ Fruits	<i>Phytelephas seemanii</i>	Palm, U	Tropical evergreen	86	Bernal 1998
	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	95	Ratsirarson et al. 1996
	<i>Brosiumum alicastrum</i>	Tree, C	Tropical evergreen	95	Peters 1992
	<i>Grias peruviana</i>	Tree, C?	Tropical evergreen	80	Peters 1991
	<i>Berthollia excelsa</i>	Tree, C	Tropical evergreen	93	Zuidema & Boot 2003
Leaves	<i>Neodypsis decaryi</i>	Palm, C	Tropical evergreen	25	Ratsirarson et al. 1996
	<i>Livingstonia rotundifolia</i>	Palm, C?	Tropical evergreen	<20	O'Brien & Kinnaird, 1996
	<i>Geonoma deversa</i>	Palm U	Tropical evergreen	On 16 yr rotation	Zuidema 2000
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	75	Ticktin et al. 2000
	<i>Rumohra adiantiformis</i>	Fern	Evergreen Cape forest	50	Geldenhuis 1998
	<i>Matteucia struthiopteris</i>	Fern	Temperate deciduous	<50	Bergeron 2000
Roots	<i>Echinaceae angustifolia</i>	Herb	Temperate prairie	~5	Price 1999
Flowers	<i>Banksia hookeriana</i>	Shrub	Heathland	~20 (once established after fire)	Witowski et al. 1994
Whole Plants	<i>Allium tricoccum</i>	Herb	Temperate deciduous	0-16	Nault & Gagne 1993; Nantel et. al. 1996
	<i>Panax quinquefolium</i>	Herb	Temperate deciduous	5-15	Charron & Gagne 1993; Nantel et. al. 1996
	<i>Hydrastis canadensis</i>	Herb	Temperate deciduous	<10	Christensen and Gorchov
	<i>Aechmea magdalenae</i>	Herb	Tropical evergreen	35	Ticktin et al. 2002
	<i>Prunus africanus</i>	Tree, C	Tropical evergreen	0 (on 8-10 yr rotation)	Stewart 2000
	<i>Aquilaria malaccensis</i>	Tree, C	Tropical evergreen	>10cm dbh	Soerhartano et al. 2001
	<i>Aquilaria microcarpa</i>	Tree, C	Tropical evergreen	0 (>30 cm dbh every 15 yrs)	Soerhartano et al. 2001
	<i>Thrinax radiata</i>	Palm, C	Tropical deciduous	40/ha	Olmstead & Alvarez Buylla 1996
	<i>Coccothrinax readii</i>	Palm, C	Tropical deciduous	0	Olmstead & Alvarez Buylla 1996
	<i>Euterpe precatoria</i>	Palm, SC	Tropical evergreen	0	Zuidema 2000

Ecological Sustainability

Community level effects:

- **Plant-animal interactions**
 - **Competitors with humans: frugivores, herbivores**
(Moegenburg 2002; Freckleton et al. 2003; Souyma et al. 2006)
 - **Necessary for production of desired part** (Plowdon 2002; Paoli et al. 2001; Mustart et al. 1992)
 - **Dispersors? Pollinators?**

Ecological Sustainability

Community level effects:

- Plant-animal interactions
- **Plant-plant interactions**
 - **Invasive species** (Ticktin et al. 2006a 2006b)

Ecological Sustainability

Community level effects:

- Plant-animal interactions
- Plant-plant interactions
- **Community structure and composition**

(Uma Shankar et al. 1998; Ghirmire 2005; Dovie 2006)

TABLE 1. COMPARISON OF DENSITY, BASAL AREA, AND SPECIES RICHNESS OF LARGE WOODY SPECIES AND SMALL WOODY SPECIES BETWEEN DISTANT AND PROXIMAL STANDS IN TWO VEGETATION STRATA OF BRT SCRUB.

Vegetation stratum	Large woody species		Small woody species	
	Distant stand	Proximal stand	Distant stand	Proximal stand
Tree layer				
Density (ha^{-1})	39.5 ± 30.6	20.0 ± 8.2	64.5 ± 19.4	64.0 ± 8.2
Basal area ($\text{m}^2 \text{ha}^{-1}$)	1.04 ± 0.66	0.68 ± 0.35	1.15 ± 0.39	1.37 ± 0.2
Species richness	16	11	13	13
Species (ha^{-1})	17.0 ± 6.2	10.0 ± 5.9	14.0 ± 1.6	16.5 ± 1.9
Understory				
Density (ha^{-1})	1848.5 ± 227.1	1119.5 ± 215.6	827.5 ± 426.7	1283.0 ± 107.8
Basal area ($\text{m}^2 \text{ha}^{-1}$)	4.16 ± 0.65	1.88 ± 0.51	2.32 ± 0.96	3.16 ± 0.20
Species richness	23	21	28	37
Species (ha^{-1})	19.0 ± 1.8	14.3 ± 1.7	10.8 ± 3.3	26.8 ± 1.5

Methods to assess impact of MAP harvest at community level

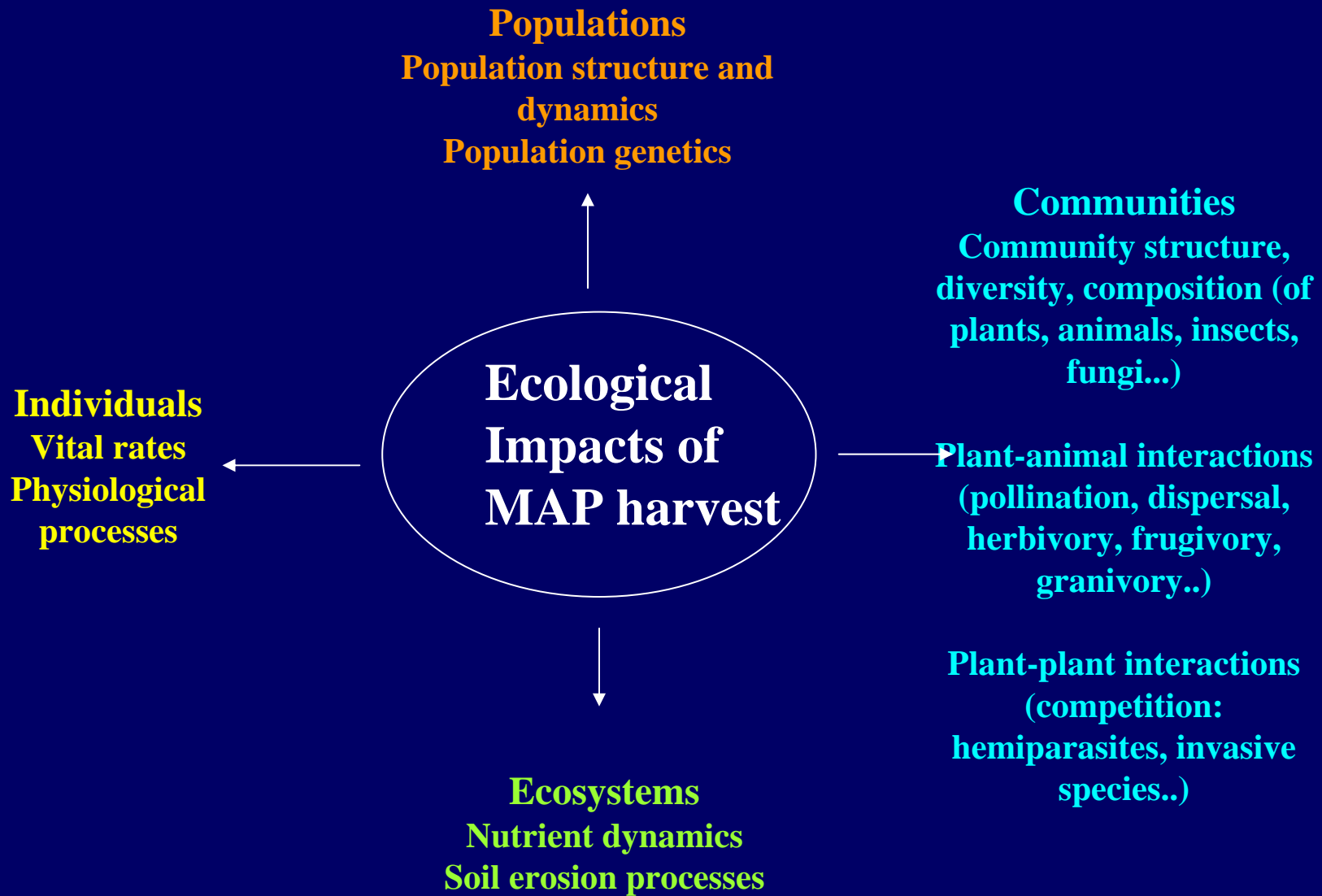
- Assess rates and patterns of herbivory/frugivory
- Quantify population size of herbivores/frugivores
- Experimental manipulations (plant-plant)
- Transects for community structure composition

Ecological Sustainability

Ecosystem level effects

- **Nutrient cycling** (Witowski & Lamont 1996, O'Hara 1999)
 - varies with part picked
 - varies over space
- **Erosion**





Ecological impacts of MAP harvest

- **MAP collection affects ecological processes from the level of the individual to the ecosystem**
- **The effects – and therefore sustainable harvest limits - for any one species can vary greatly over space and time, and according to human management practices.**



Efficient and cost-effective methods?

Efficient and cost effective monitoring?

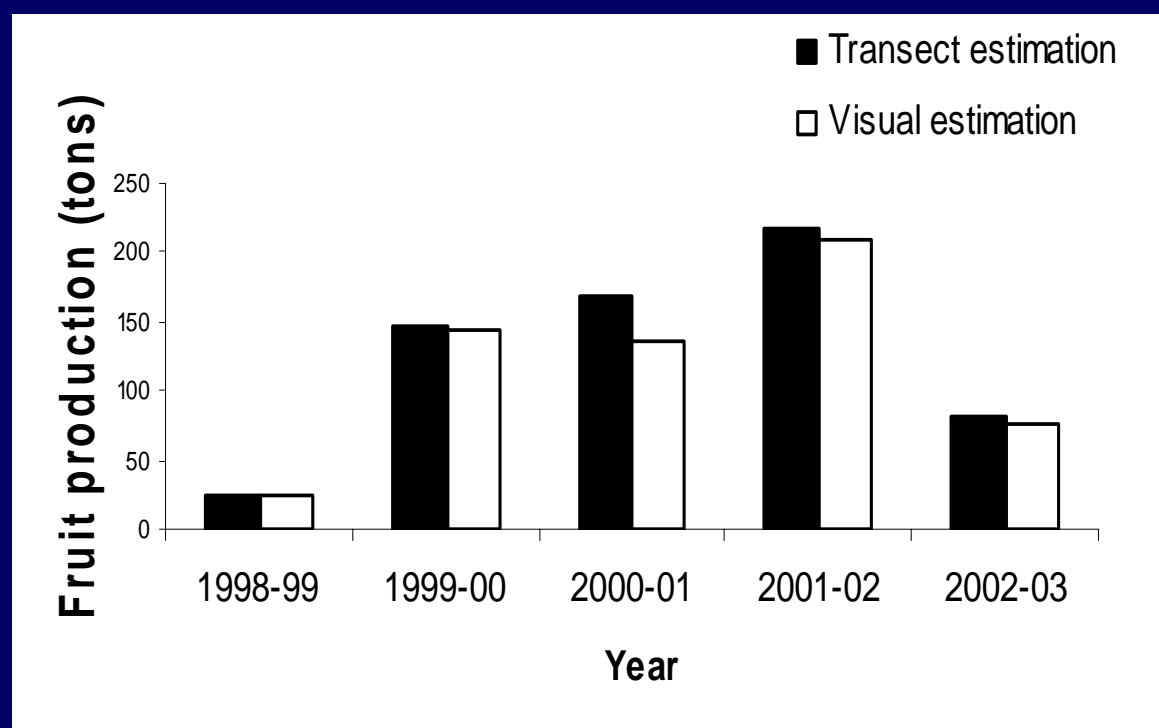
Patterns and trends from “high input” studies can help identify methods for lower cost, time effective studies

Identify the ecological, socioeconomic, cultural and political potential for sustainability first

1. Participatory monitoring with incorporation of traditional knowledge and management practices

- ✓ local measures of productivity
- ✓ local indicators of health, quality
- ✓ local experimentation
- ✓ documentation of harvest practices

Comparison of fruit production of *Phyllanthus spp.* using transects vs visual estimation of harvesters



Setty, S.R., K.S. Bawa, T. Ticktin, C. Madegowda and R. Ganesan. In prep

1. Participatory monitoring with incorporation of traditional knowledge and management practices

- ✓ local measures of productivity
- ✓ local indicators of health, quality
- ✓ local experimentation
- ✓ documentation of harvest practices



Monitoring over spatial variation & differing types of contexts

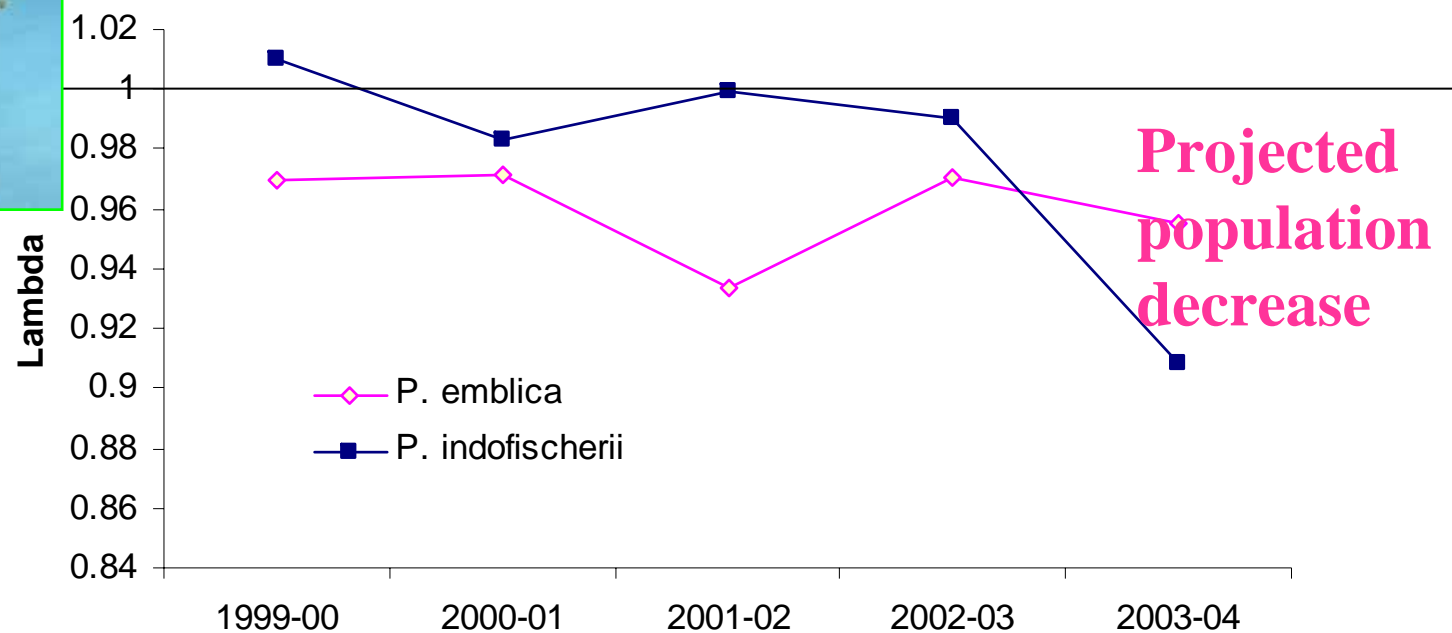
2. Monitoring at multiple ecological levels

- Qualitative monitoring at community and ecosystem levels
- Population/patch counts; presence & absence

2. Monitoring at multiple ecological levels

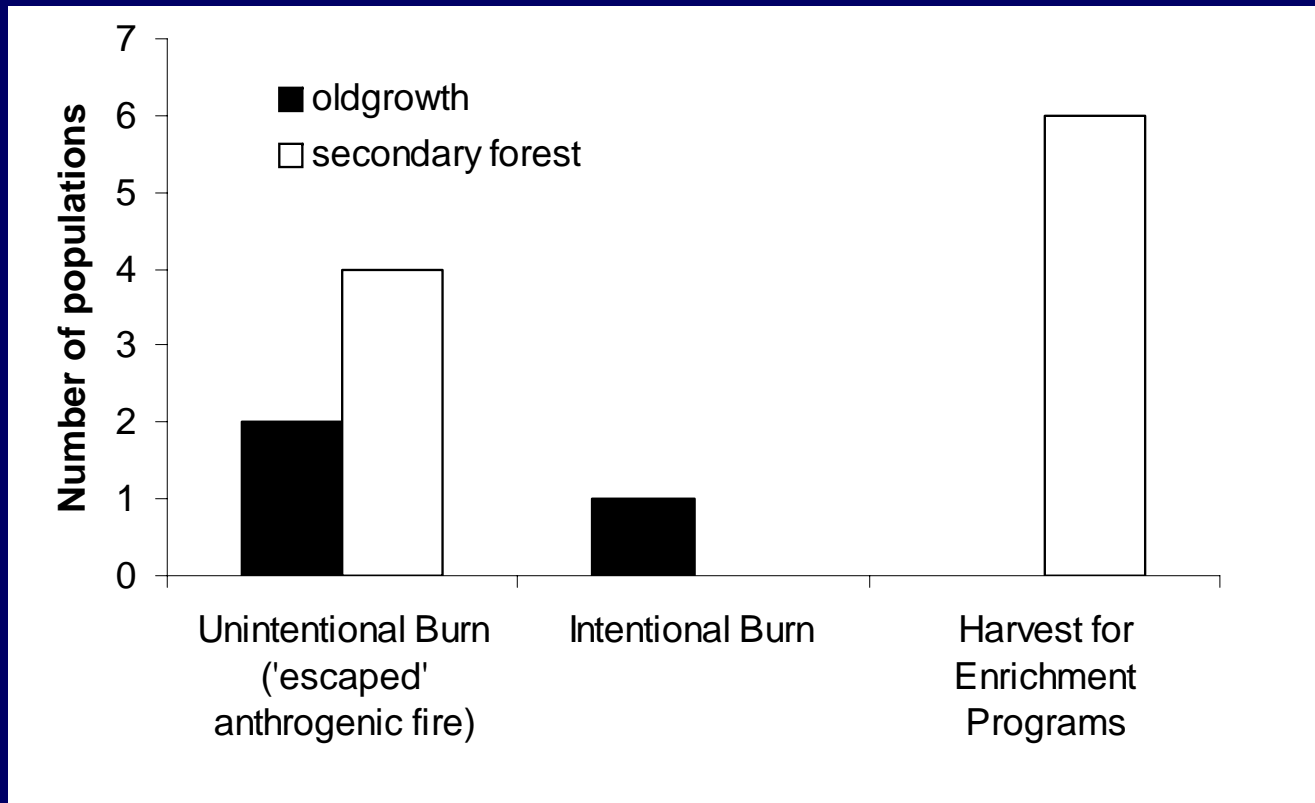
- Qualitative monitoring at community and ecosystem levels
- Population/patch counts; presence & absence

Population growth rates of harvested populations of *Phyllanthus emblica* and *P. indofischerii*



T. Ticktin, R. Ganesan, S. Setty unpublished data

Population dynamics over a landscape



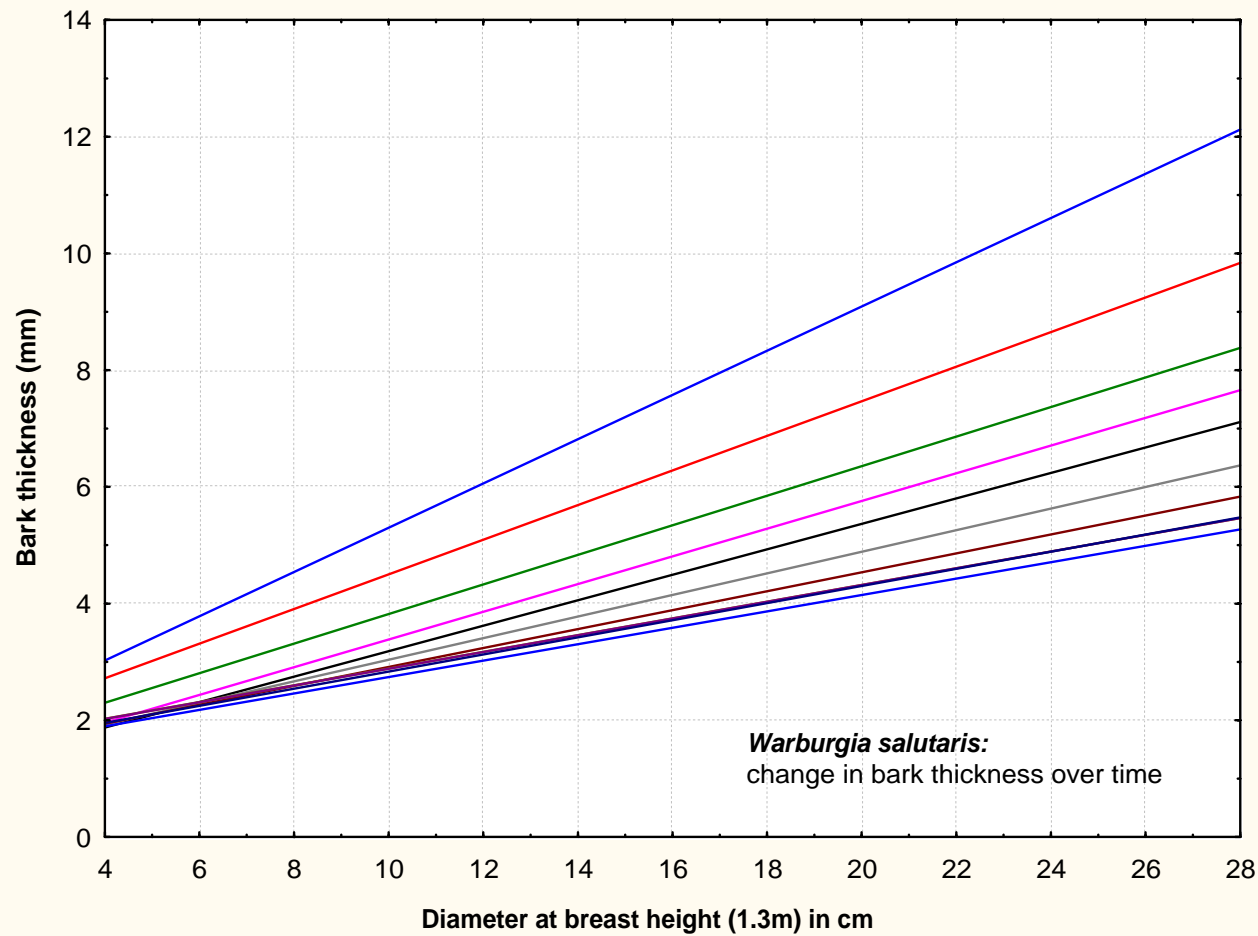
Ticktin 2005

3. Adaptive management

4. Ecological monitoring at different levels along the market chain

- Where is most cost-effective

Warburgia salutaris



Williams 2006

The most prevalent stem diameter size-classes sold in the markets in 1995 and 2001 – estimated from bark thickness records and regressions

Species	Muti shops 1995	Faraday 2001
<i>Albizia adianthifolia</i>	50 – 59 cm	20 – 29 cm
<i>Balanites maughamii</i>	60 – 69 cm	40 – 49 cm
<i>Elaeodendron transvaalense</i>	40 – 49 cm	10 – 19 cm
<i>Warburgia salutaris</i>	> 40 cm	15 – 19 cm

Adding to methods for assessing sustainable harvest...

- ID patterns and trends from literature, and the ecological, socioeconomic, political & cultural **potential** for sustainability —→ which methods?
- Include **participatory monitoring** with incorporation of **traditional knowledge and management** practices
- Assessments at **multiple ecological scales**
- **Adaptive management**
- ‘Ecological’ monitoring at different stages along the **market chain**