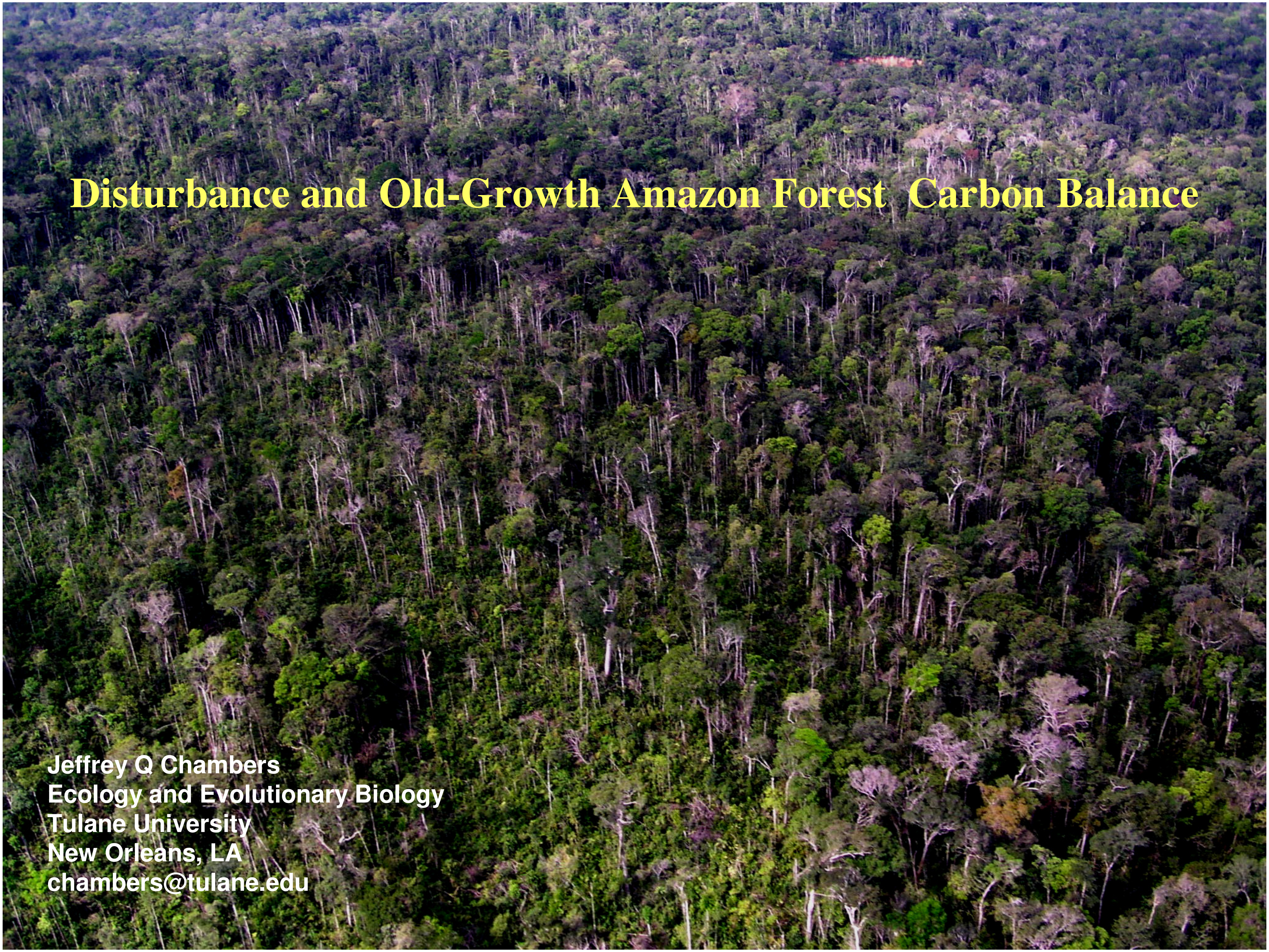

Disturbance and Old-Growth Amazon Forest Carbon Balance

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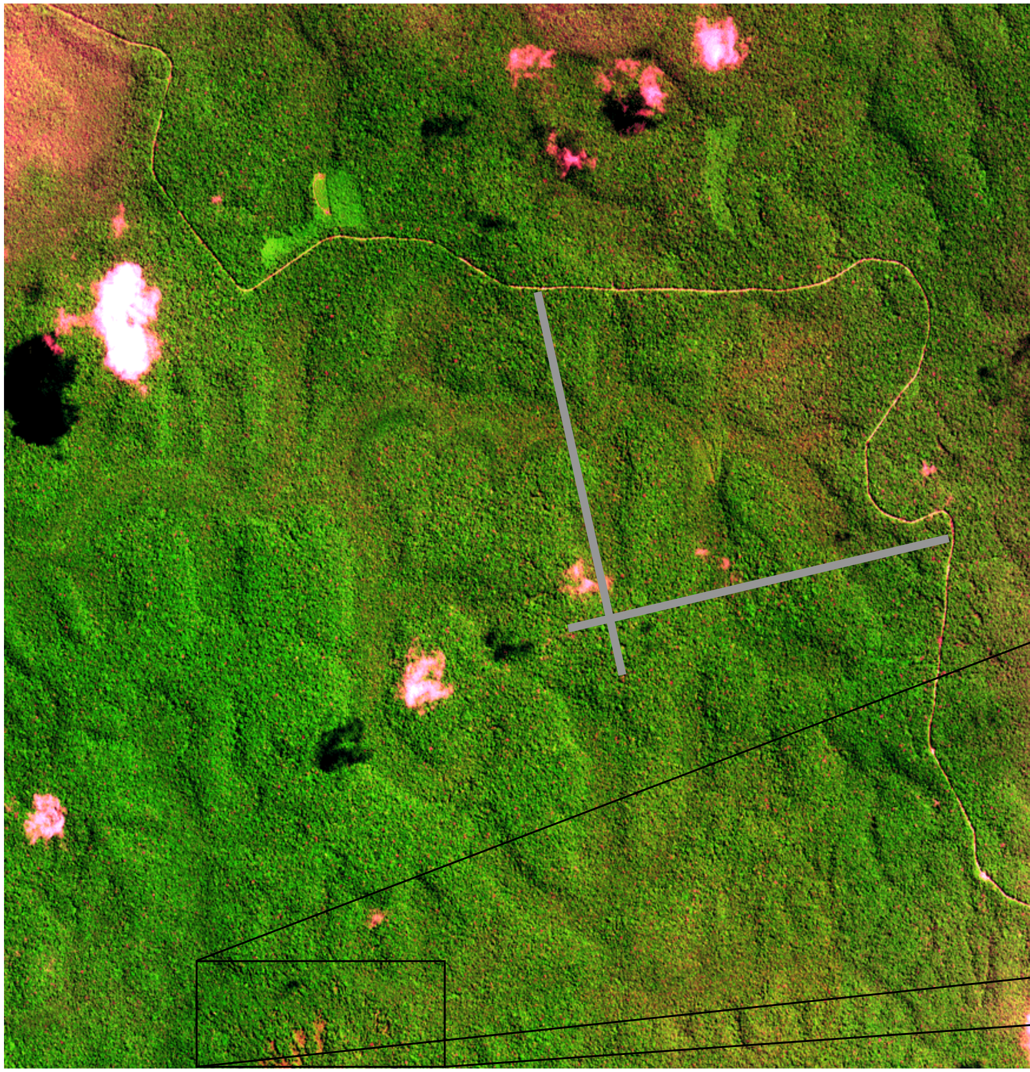
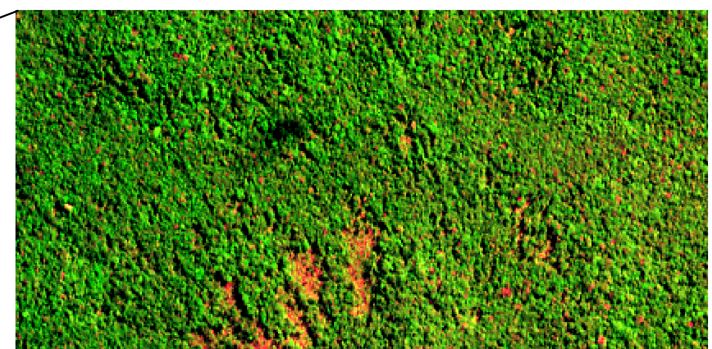
Catastrophic Tree Mortality and Microburst Winds



IKONOS image



Grey bars indicate permanent forest inventory plots managed by INPA (both 2.5 km x 20 m = 10 ha), off the ZF-2 road in the Central Amazon.

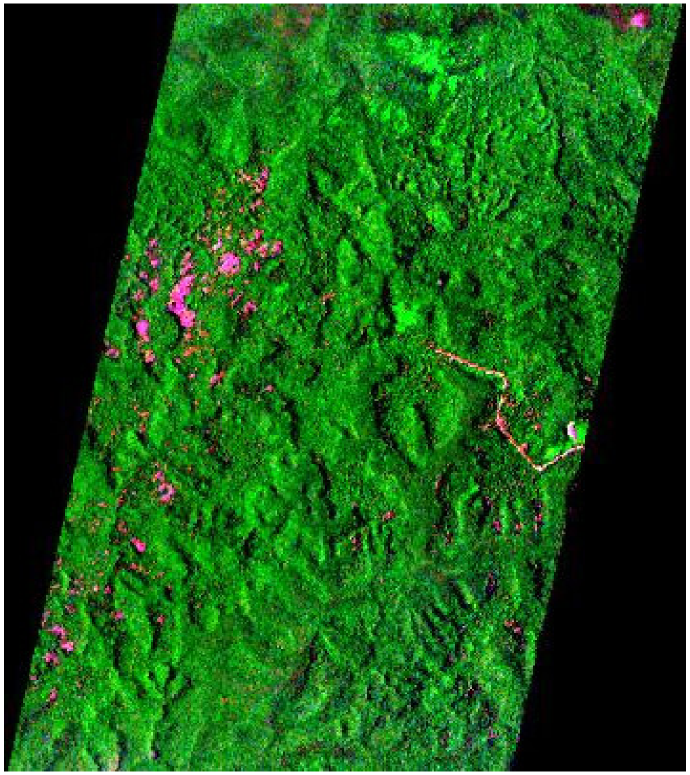
Do forest inventory plots capture the full range in disturbance and recovery dynamics?

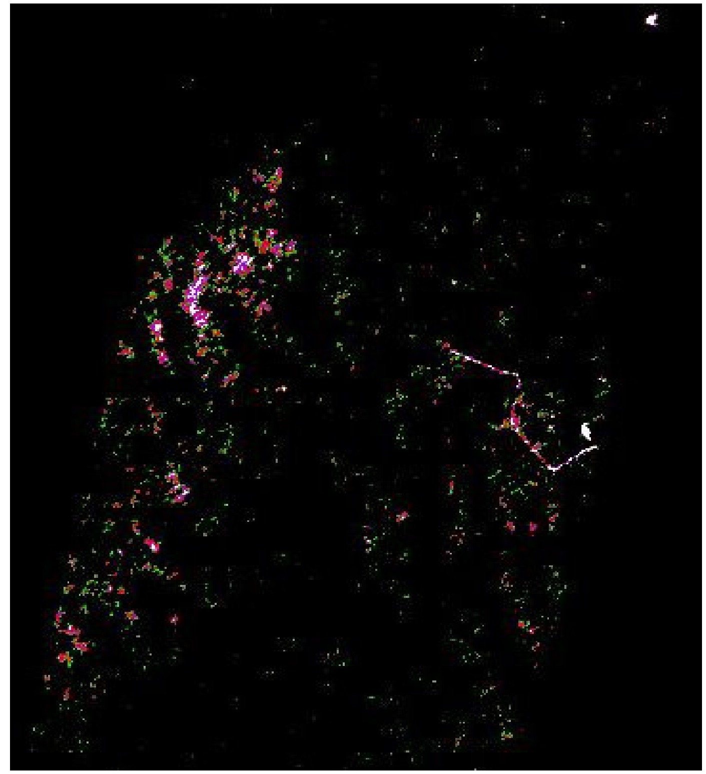
Severe downdraft winds often associated with late dry season storms

Background

- Forest inventory plots provide little information on catastrophic (gaps > 0.1 ha) mortality events.
- Example: Of 1284 gaps studied by Hubbell et al. (1999), only 9 > 0.04 ha with the largest gap occupying just 0.11 ha (1100 m^2).
- Conversely, Nelson et al. (1994) detected large natural gaps > 30 ha in size (*blowdowns* produced by high-velocity downburst winds) using spectral reflectance differences in Landsat TM images across the entire Brazilian Amazon.
- In the Nelson et al. (1994) study, only 19 new blowdown patches occupying 0.4% of scene area, predicting that if formed over a two-year period, and events did not strike the same area twice, forest turnover by large blowdowns would take about 5000 years [1/(0.0004/2)].
- However, in a more detailed analysis of one TM scene, inclusion of smaller blowdowns (5-30 ha) increased the number of disturbed patches by an order of magnitude – 500 years.
- There is a critical gap in studies of blowdowns and other catastrophic mortality events at the 0.1 to 5 ha, and this intermediate scale may be important for many ecological processes including the maintenance of tree species diversity and landscape carbon balance.
- For landscape carbon balance we need information on (1) size, (2) intensity and (3) return interval for all mortality events

Sampling the Disturbance Gradient Employing RS Metrics

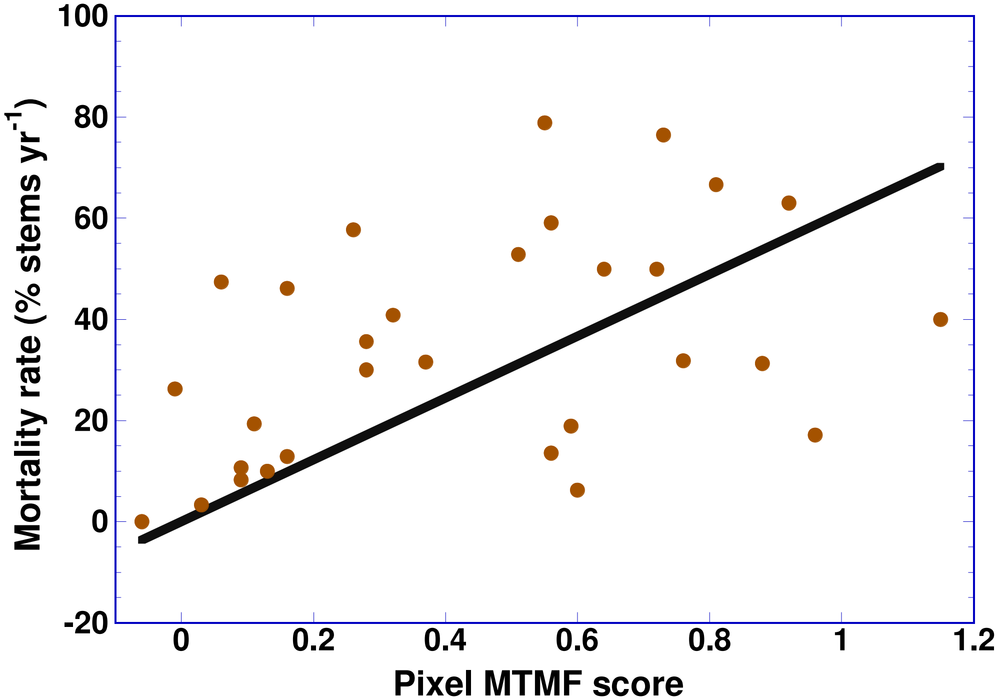




SITE 1

disturbance class	MTFM range	Lat	Long	pixel value	mortality rate
1	> 0.80	2° 35' 10.56"	60° 13' 33.15"	0.81	0.67
2	0.61 - 0.80	2° 35' 8.60"	60° 13' 37.03"	0.64	0.50
3	0.41 - 0.60	2° 35' 9.57"	60° 13' 37.03"	0.56	0.59
4	0.21 - 0.40	2° 35' 10.54"	60° 13' 39.94"	0.28	0.36
5	0.11 - 0.20	2° 35' 13.47"	60° 13' 40.92"	0.09	0.11
6	< 0.10	2° 35' 13.41"	60° 13' 41.88"	0.06	0.47

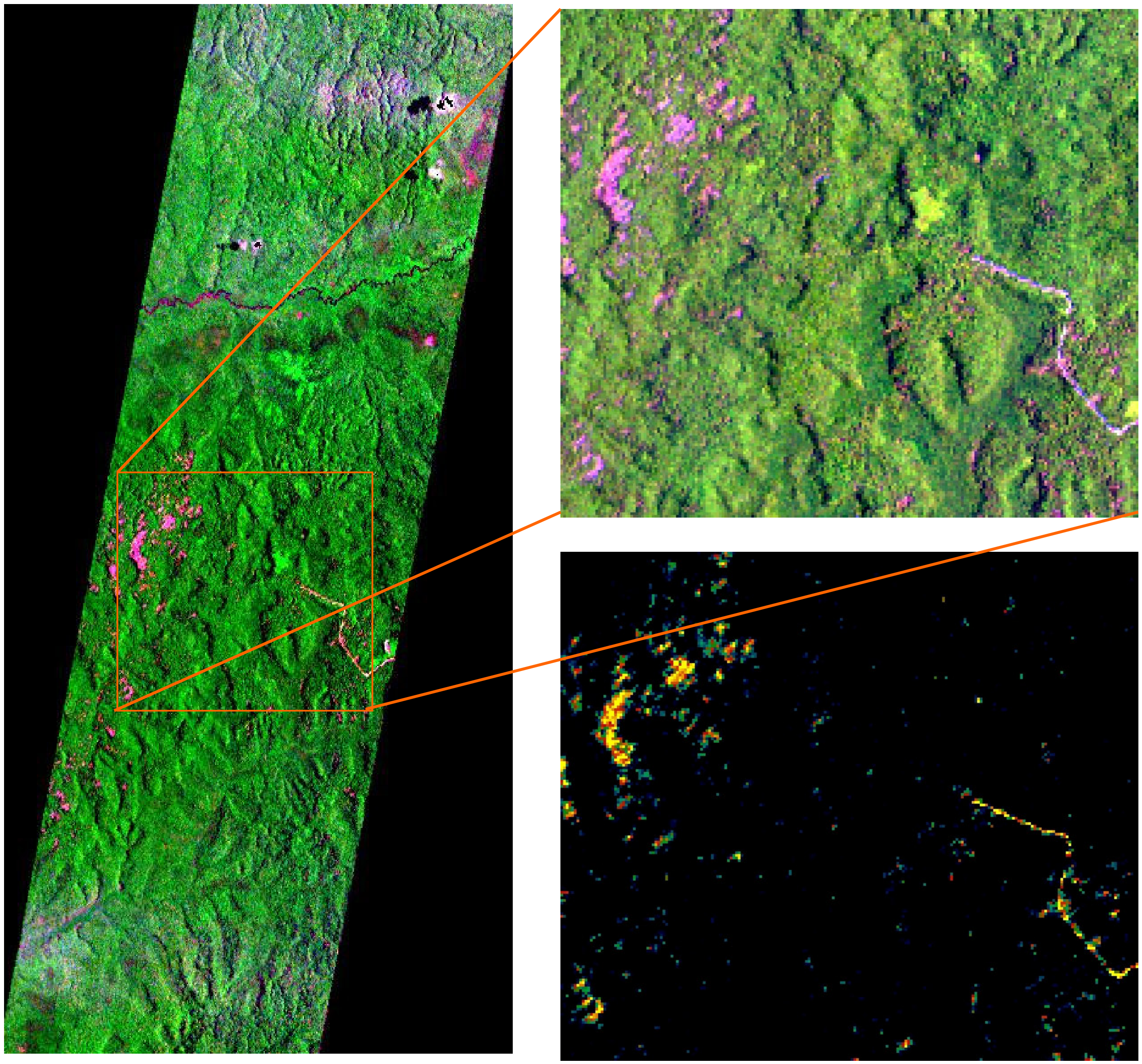
Developing relationships between remote sensing metrics and field-based mortality/damage rates



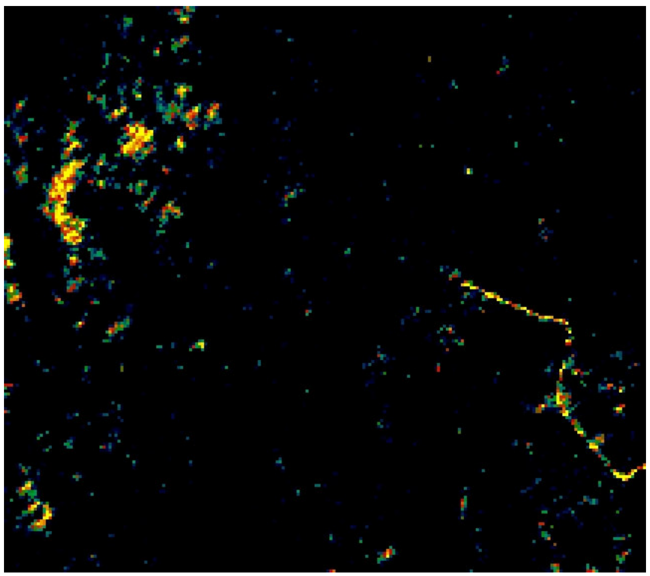
Each point from a randomly placed 400 m^2 inventory plot over a 25 km^2 area

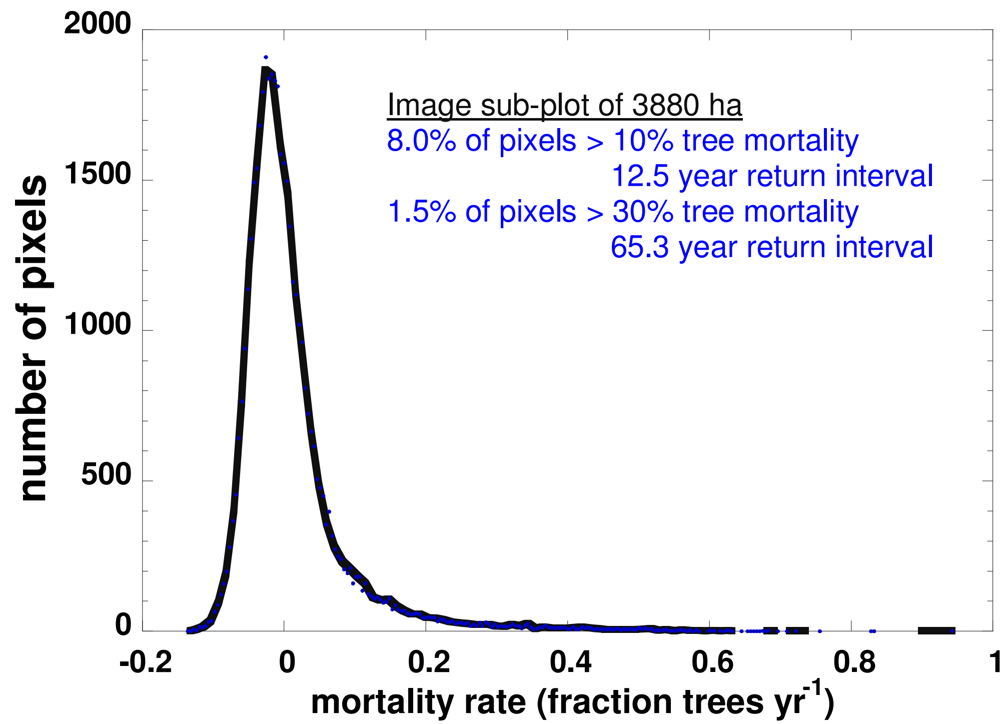
G. Guimarães
INPA Masters thesis

Spatial Distribution of Tree Mortality Rate

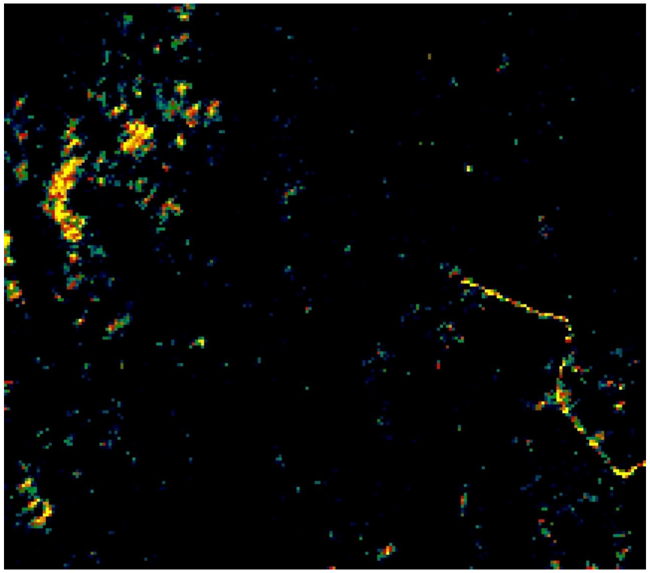


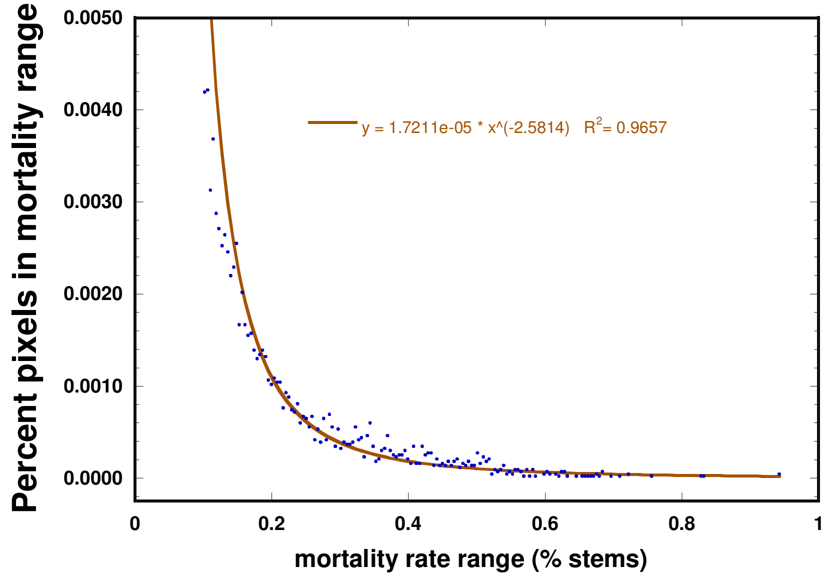
Frequency plot of Tree Mortality Rate Distribution at Landscape (> 1000 ha) Scale

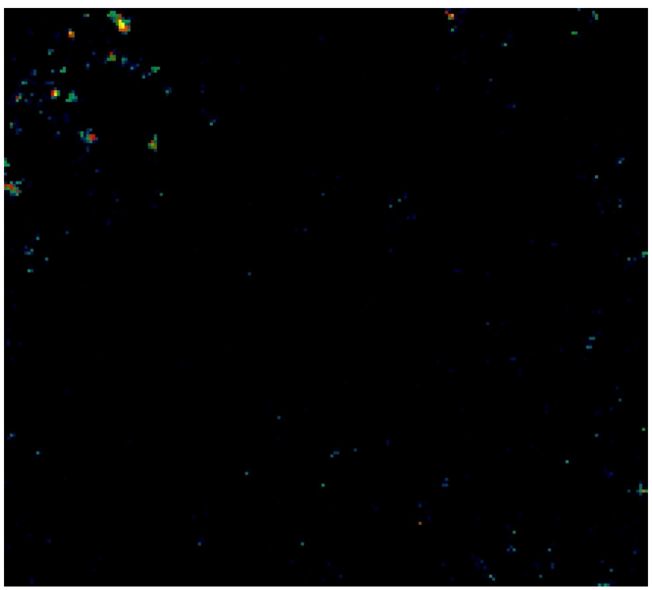




Frequency plot of Tree Mortality Rate Distribution at Landscape (> 1000 ha) Scale







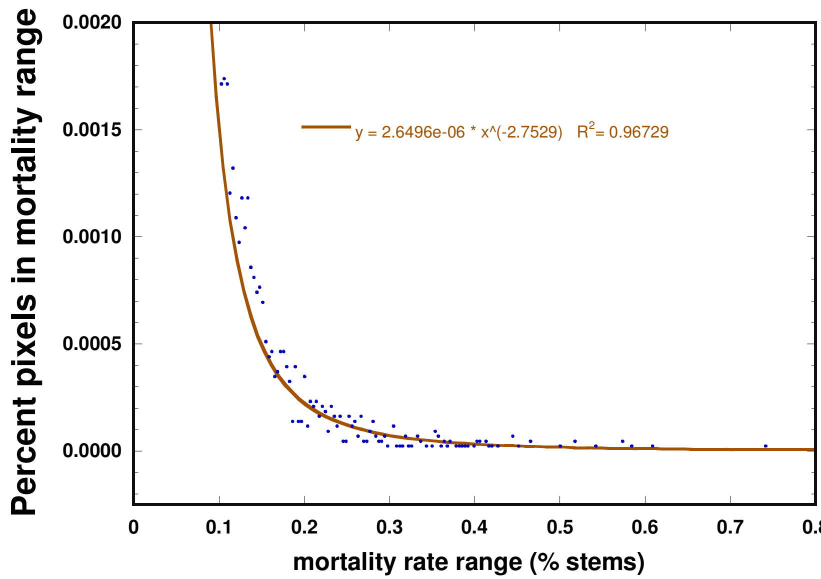
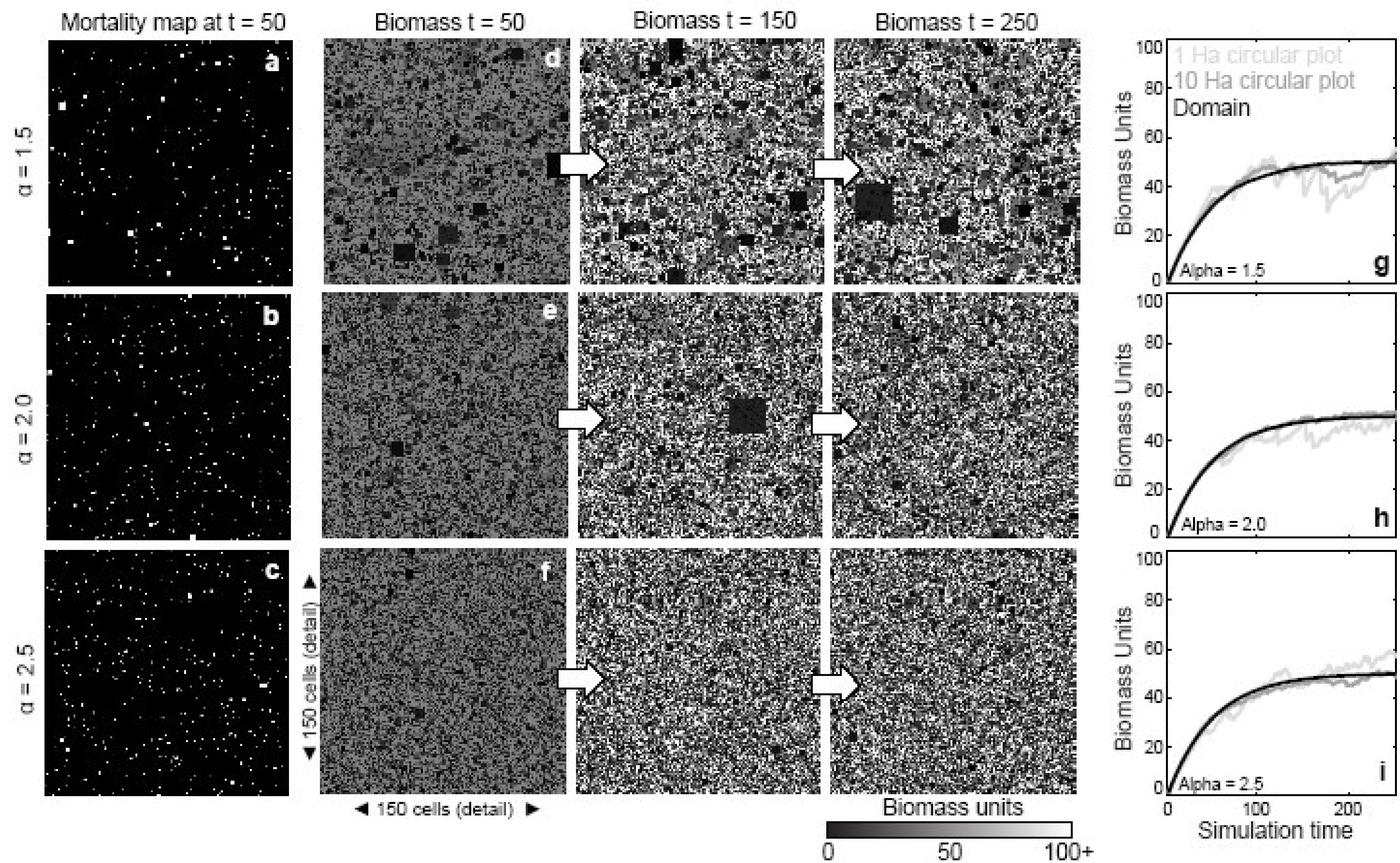
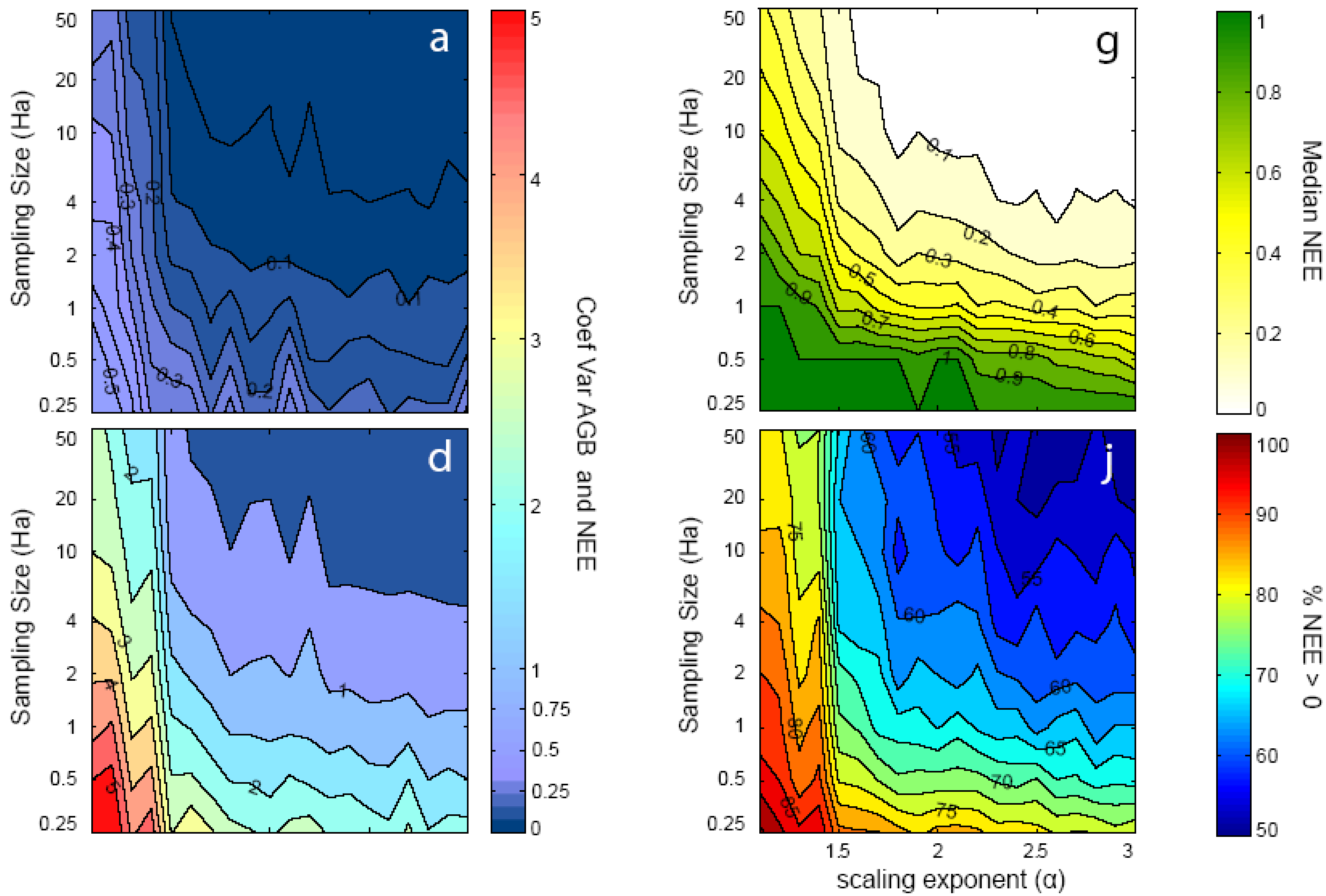


Figure 3

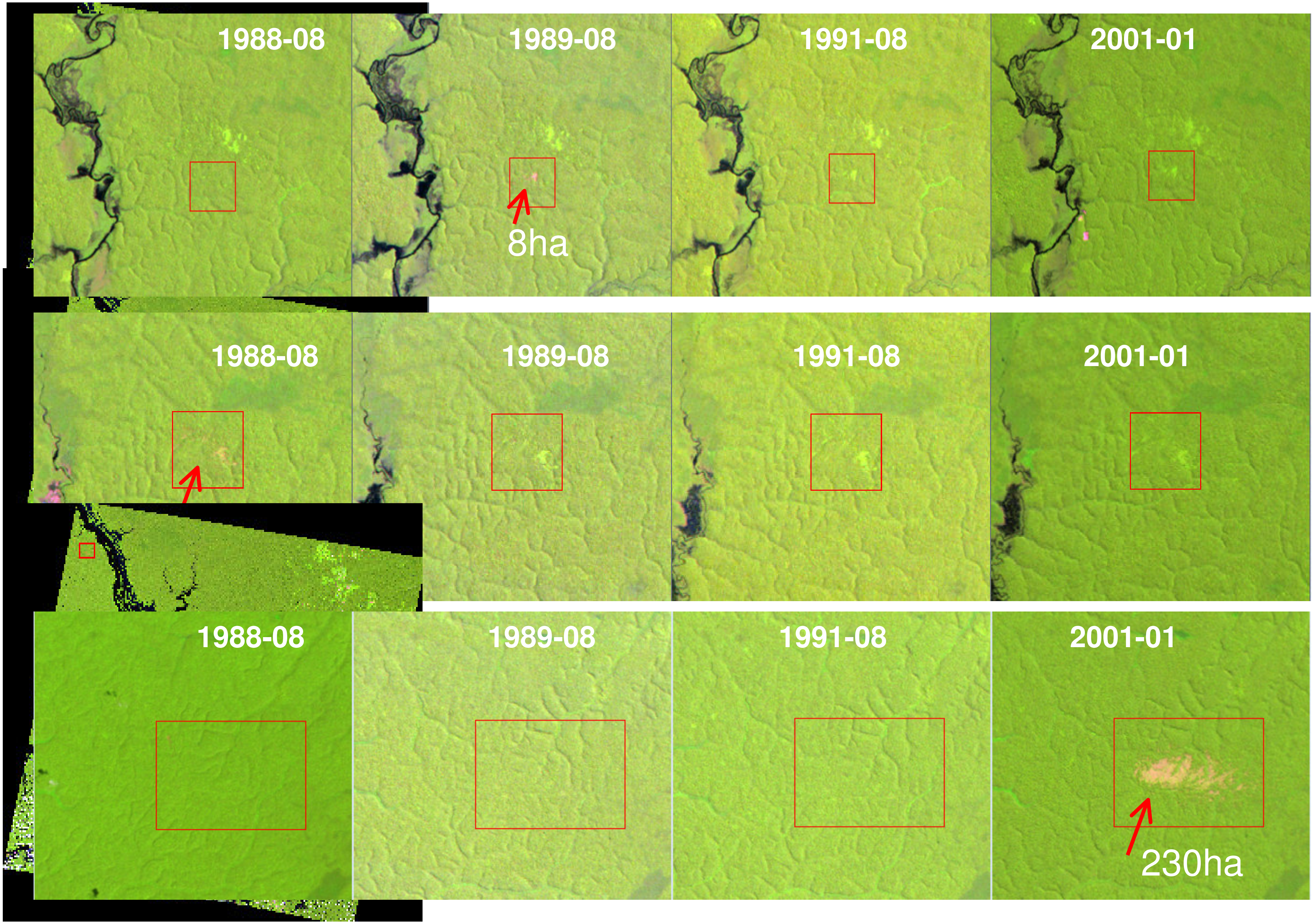


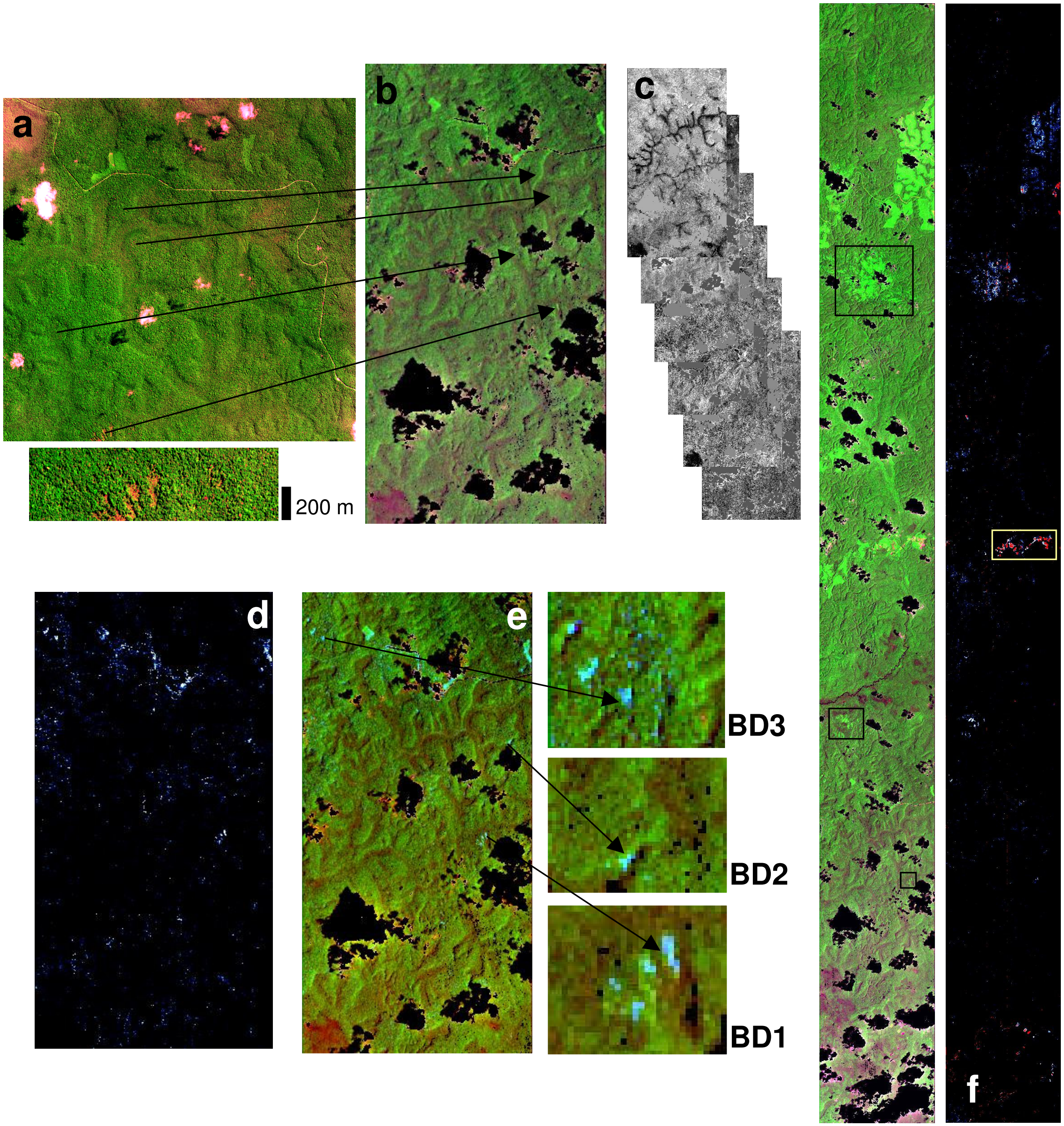
J. Fisher et al.



a
d
g
j
Sampling Size (Ha)
Coef Var AGB and NEE
Median NEE
% NEE > 0
scaling exponent (α)

Central Amazon blowdown time series





Spectral unmixing using image-derived endmembers:

a Ikonos image blowdown detection.

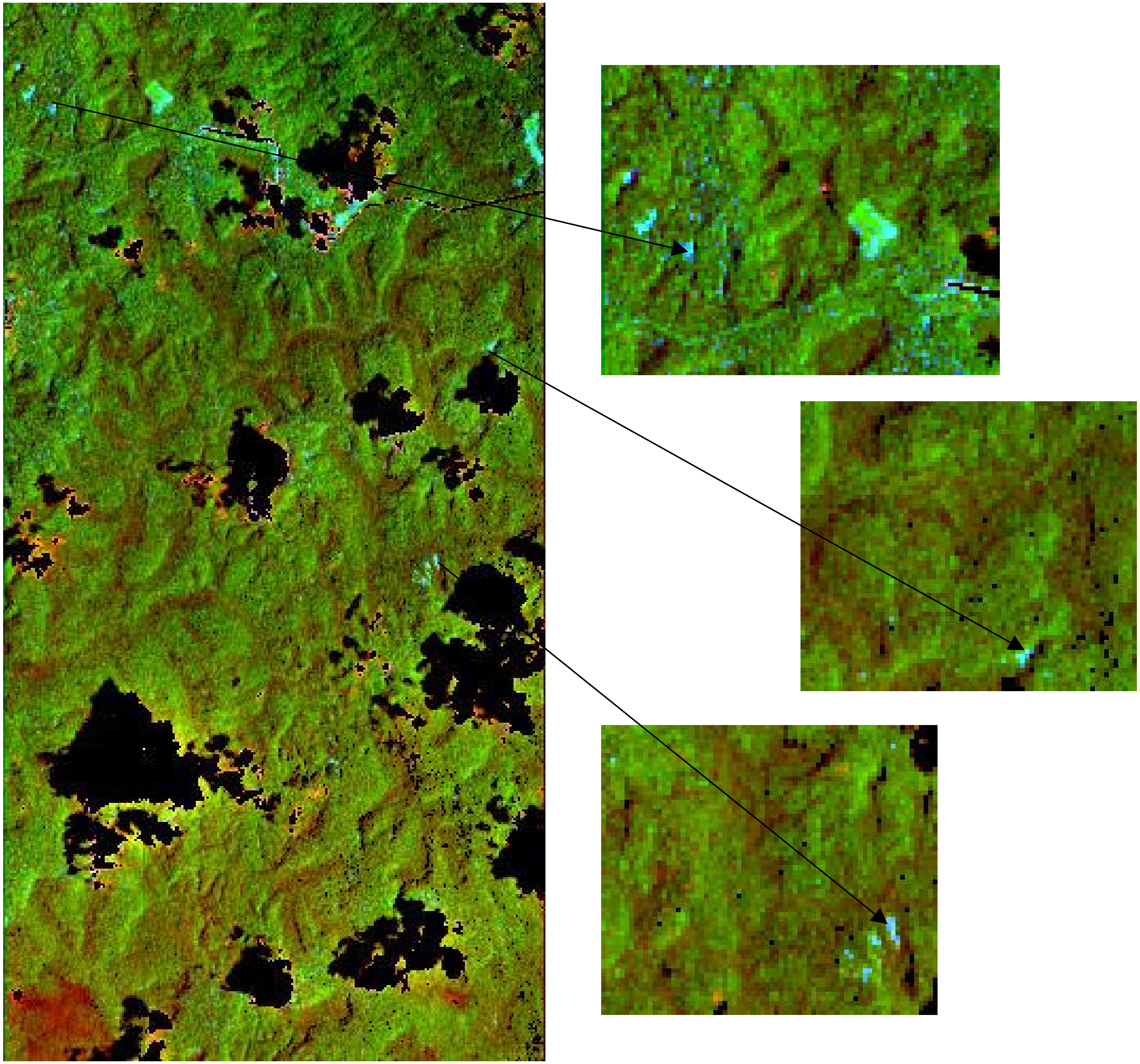
b Mapping blowdown onto Hyperion image captured 3 years after event.

c Reducing spectral data to lowest number of orthogonal data dimensions; transformed bands to generate pixel purity index (PPI).

d Mapping out relative abundance of blowdown vegetation.

e Identifying field sites for forest inventories

f Mapping out blowdown vegetation at the across the landscape



Species List for Hyperion-Identified Blowdown Toward Development of Spaceborne *Cecropia* Detector

No	DBH	Family	Species	No	DBH	Family	Species
1	6.8	Melastomataceae	*Bellucia dichotoma* Cogn.	31	5.4a/4.6b	Leg. Mimosoideae	*Inga thibaldiana* DC. ssp. *thibaldiana*
2	5.7	Rubiaceae	*Capirona dicorticans* Spruce	32	8.7	Violaceae	*Leonia glycycarpa* Ruiz & Pav.
3	8.5a/7.6b	Flacourtiaceae	*Casearia pitumba* Sleumer	33	5.1	Melastomataceae	*Loureya spruceana* Benth. ex Triana
4	16.6	Cecropiaceae	*Cecropia sciadophylla* Mart.	34	18.6	Euphorbiaceae	*Mabea speciosa* Müll. Arg.
5	13.5	Cecropiaceae	*Cecropia sciadophylla* Mart.	35	14.6	Euphorbiaceae	*Mabea speciosa* Müll. Arg.
6	7.5	Cecropiaceae	*Cecropia sciadophylla* Mart.	36	7.6	Leg. Caesalpinioideae	*Macrolobium* sp. 2
7	7.5	Cecropiaceae	*Cecropia sciadophylla* Mart.	37	14.6	Sapotaceae	*Micropholis venulosa* (Mart. & Eichler) Pierre
8	7.2	Cecropiaceae	*Cecropia sciadophylla* Mart.	38	6.8	Olacaceae	*Minquartia guianensis* Aubl.
9	5.3	Cecropiaceae	*Cecropia sciadophylla* Mart.	39	9.2	Myrtaceae	*Myrcia* cf. *fallax* (Rich.) DC.
10	6.7	Cecropiaceae	*Cecropia sciadophylla* Mart.	40	11.5	Nyctaginaceae	*Neea floribunda* Poepp. & Endl.
11	10.7	Euphorbiaceae	*Conceveiba* cf. *guianensis* Aubl.	41	9.6	Cecropiaceae	*Pourouma ferruginea* Standl.
12	8.8	Euphorbiaceae	*Croton draconoides* Müll. Arg.	42	29.2	Cecropiaceae	*Pourouma ovata* Trécul
13	9.4	Euphorbiaceae	*Croton lanjouwensis* Jabl.	43	9.7	Sapotaceae	*Pouteria venosa* (Mart.) Baehni ssp. *amazonica* T.D.Penn
14	5.9	Euphorbiaceae	*Croton lanjouwensis* Jabl.	44	8	Sapotaceae	*Pouteria venosa* (Mart.) Baehni ssp. *amazonica* T.D.Penn
15	5	Euphorbiaceae	*Croton lanjouwensis* Jabl.	45	6.6	Burseraceae	*Protium apiculatum* Swart
16	5.2	Lecythidaceae	*Eschweilera coriacea* (DC.) Mart. ex Berg.	46	6.8	Burseraceae	*Protium* cf. *rubrum* Cuatrec.
17	7	Lecythidaceae	*Eschweilera grandiflora* (Aulb.) Sandwith	47	8.2	Burseraceae	*Protium spruceanum* (Benth) Engl.
18	18.3	Lecythidaceae	*Eschweilera rhododendrifolia* (Kunth) A.C.Sm.	48	7.6	Burseraceae	*Protium spruceanum* (Benth) Engl.
19	11.4	Lecythidaceae	*Eschweilera tessmannii* Kunth	49	9.1	Annonaceae	*Rollinia insignis* R.E.Fr.
20	5.2	Myrtaceae	*Eugenia* sp.	50	9.1	Annonaceae	*Rollinia insignis* R.E.Fr.
21	10.4	Annonaceae	*Guatteria guianensis* (Aubl.) R.E.Fr.	51	12.4	Leg. Caesalpinioideae	*Sclerolobium* sp. 6
22	9.2	Annonaceae	*Guatteria guianensis* (Aubl.) R.E.Fr.	52	6.3	Siparunaceae	*Siparuna glycycarpa* (Ducke) S.S.Renner
23	7.2	Annonaceae	*Guatteria guianensis* (Aubl.) R.E.Fr.	53	6	Siparunaceae	*Siparuna poeppigii* (Tul.) A.DC.
24	7.1	Annonaceae	*Guatteria guianensis* (Aubl.) R.E.Fr.	54	6.2	Siparunaceae	*Siparuna sarmentosa* Perkins
25	5.5	Annonaceae	*Guatteria guianensis* (Aubl.) R.E.Fr.	55	7	Leg. Papilionoideae	*Swartzia reticulata* Ducke
26	13.5	Annonaceae	*Guatteria* sp. 3	56	6.4	Sapindaceae	*Talisia* cf. *praealta* Radlk
27	13.6	Moraceae	*Helicostylis tomentosa* (Planch. & Endl.) Rusby	57	6.3	Clusiaceae	*Vismia guianensis* (Aubl.) Choisy
28	5.7	Leg. Mimosoideae	*Inga paraensis* Ducke	58	6.1	Clusiaceae	*Vismia guianensis* (Aubl.) Choisy
29	6.5a/5.8b	Leg.Mimosoideae	*Inga pezizifera* Benth.	59	5.5	Clusiaceae	*Vismia guianensis* (Aubl.) Choisy
30	8.4	Leg. Mimosoideae	*Inga* sp	60	5.5	Leg. Mimosoideae	*Zygia racemosa (*Ducke) Barneby & J.W.Grimes

Classic pioneer species in genera *Cecropia* and *Vismia* represented 20% of stems > 5 cm DBH in this initial 400 m^2 plot, whereas in a nearby 9 ha plot these genera were only 1.3% – other blowdown sites has similar species composition.

Variables	Blowdown plots		Primary plots
Shannon's *H'*	4.71		4.16
Wood density	0.55	*	0.71
Basal area	1541.37	*	2991.82
Stem density	1525		1217

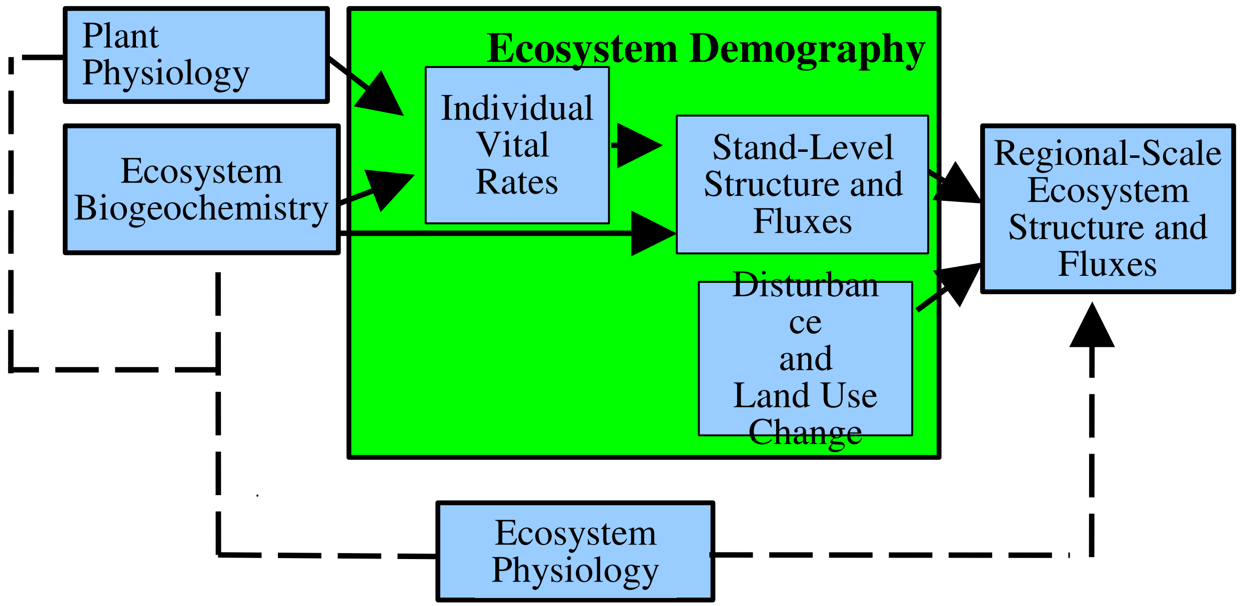
Blowdown plots detected using spectral unmixing of Hyperion imagery, although still high in species diversity, are structurally quite different from most primary forest plots

Table 2. Mean similarities of forest type comparisons using Sorenson's coefficient of similarity[a]

Comparisons between plot combinations:	Mean Sorenson's similarity and range
Blowdown x primary	0.059 (0.025 - 0.113)
Blowdown x blowdown	0.119 (0.086 - 0.160)
Primary x primary	0.115 (0.100 - 0.122)

[a] Means are compared using t-tests. All plot comparisons show significantly different mean values ($P < 0.05$) with the exception of blowdown x blowdown compared to primary x primary means.

Although these plots are scattered over a 5,000 ha area, species diversity in blowdown plots is similar to other blowdown plots implying niche partitioning by colonizing vegetation.



Scaling Method: Size- and Age- structured Approximation

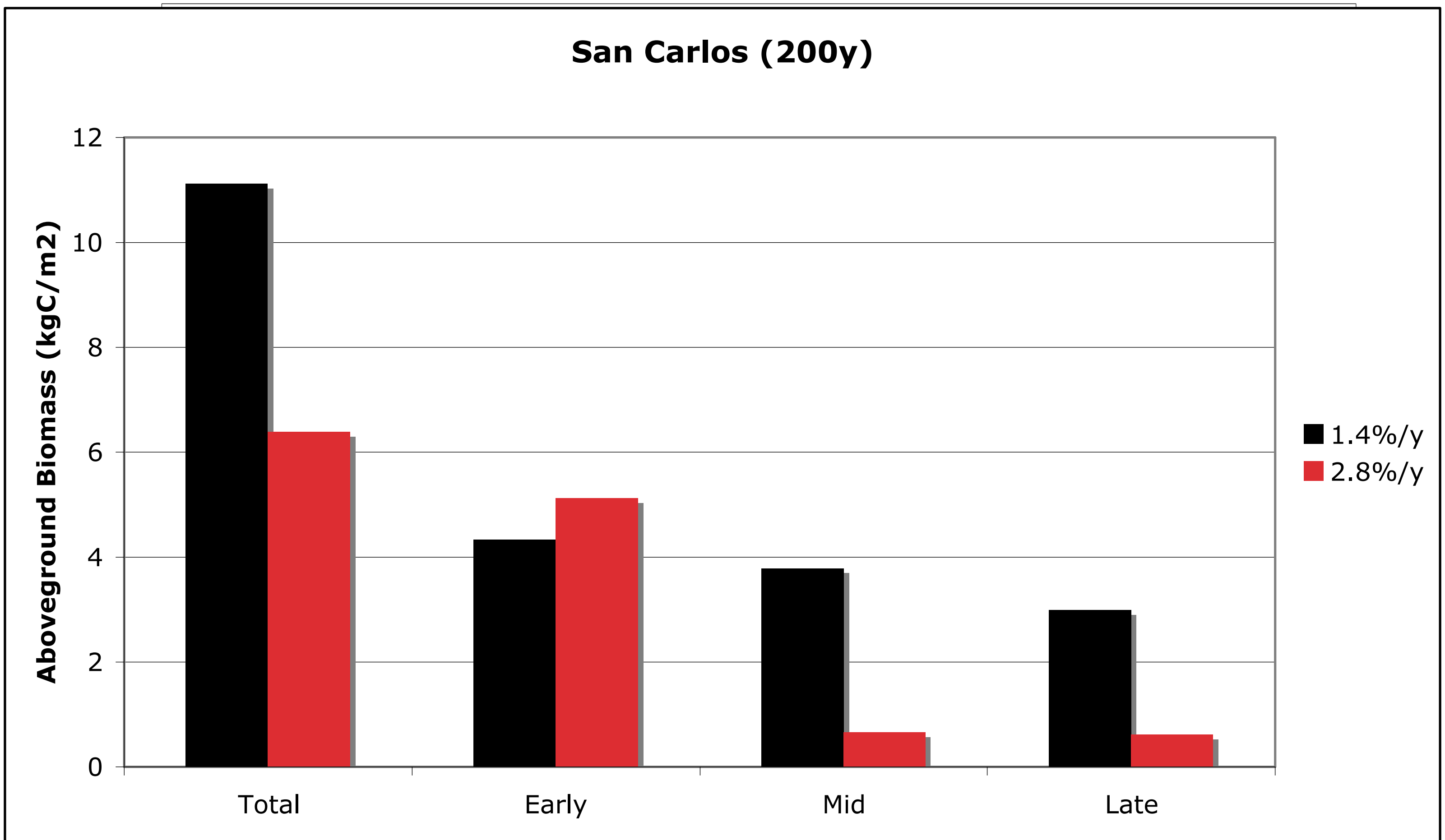
$$\frac{\partial}{\partial t} n(\underline{z}, \underline{x}, a, t) = -\frac{\partial}{\partial z_s}[g_s(\underline{z}, \underline{x}, \underline{\bar{r}}, t) n(\underline{z}, \underline{x}, a, t)] - \frac{\partial}{\partial z_a}[g_a(\underline{z}, \underline{x}, \underline{\bar{r}}, t) n(\underline{z}, \underline{x}, a, t)]$$
$$- \mu(\underline{z}, \underline{x}, \underline{\bar{r}}, t) n(\underline{z}, \underline{x}, a, t) - \frac{\partial}{\partial a} n(\underline{z}, \underline{x}, a, t)$$

$$\frac{\partial}{\partial t} p(a,t) = -\frac{\partial}{\partial a} p(a,t) - \lambda(a,t) p(a,t)$$

& other associated equations and boundary conditions

Ecosystem Demography Model

Preliminary Ecosystem Demography Model Results



Change in biomass and floristic composition with a doubling of turnover rate

G. Hurtt

Summary

- **Canopy gaps occurring within forest inventory plots only capture a small portion of the landscape distribution in tree mortality events: (1) size, (2) intensity, and (3) return interval.**

- **Critical gap in understanding of how large-scale mortality events (~0.1 to 5 ha in size, > 10% dead stem per event, and > ~20-30 year time intervals) affect ecological and ecosystem processes.**

- **Remote sensing methods useful for mapping the distribution of forest disturbance and recovery processes at the landscape scale.**

- **Catastrophic disturbances are important for determining landscape carbon balance and the distribution of tree species diversity.**

- **Tools and methods developed in the Amazon now being employed to quantify forest impacts from hurricane Katrina.**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